公益財団法人　8020 推進財団　指定研究事業報告書

多目的コホート研究（JPHC study）における口腔と全身の健康に関する研究

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はじめに

日本人の死因の上位に挙げられているがん、心筋梗塞、脳卒中などの疾病の発生には、食習慣や運動、喫煙、飲酒などの生活習慣が深く関わっており、生活習慣の改善によって、これらの疾病の発生をある程度予防することができると考えられています。しかし、具体的にどのような生活習慣を行えばこのような疾病を未然に防ぐことができるのか、日本人のデータは充分に揃っているとはいえないのが現状です。そこで、がん、心筋梗塞、脳卒中、糖尿病などさまざまな生活習慣病の原因究明と、それぞれに対する有効な予防法の開発を目的に、厚生労働省研究班による多目的コホート研究 JPHC Study（Japan Public Health Center-based prospective Study）が 1990 年に開始されました。

この多目的コホート研究は厚生労働省のがん研究助成金による研究で、全国の 11 保健所と国立がんセンター、国立循環器病センター、大学、研究機関、医療機関などの共同研究として実施されています。主任研究者は、津金昌一郎・国立がんセンターがん予防・検診研究センター予防研究部長です。

これまで多目的コホート研究では多くの研究成果が得られていますが、医科領域の疾患が中心で、歯科疾患は含まれていませんでした。そこで、8020 推進財団の指定研究として、歯科疾患に関する疫学研究が開始されることになりました。

東京医科歯科大学が、歯科班として多目的コホート研究の研究班に加わり、秋田県横手保健所管内の住民を対象として、地元の横手歯科医師会、ひらか歯科医師会の協力を得て、2005 年に歯科健診および質問票調査を実施いたしました。それにより、口腔保健状況のデータと多目的コホート研究から提供される同じ対象者の生活習慣や全身疾患に関するデータを組み合わせて、口腔と全身の健康に関する分析が行えるようになりました。

また、本研究を推進していく中で、地元歯科医師会や行政（秋田県、横手市）との十分な協力体制が得られたことから、同地域の成人の歯科保健に関するデータをさらに幅広く収集することも可能となりました。それらの結果を合わせて分析することで、我が国における成人歯科保健に関するさまざまなエビデンスを明らかにすることができ、研究成果を学術誌に発表することができました。本報告書は、それらの論文内容をまとめたものです。

なお、多目的コホート研究で歯科調査が実施されたのは 2005 年からであり、1990 年のベースライン調査には歯科に関するデータはありません。そのため、歯科の視点からコホート研究を行うにはデータが不十分でした。そこで、2012 年から新たに開始された次世代多目的コホート研究では、横手地域においてベースライン調査より歯科調査を実施しています。今後、研究を継続していくことで、口腔と全身の健康の関連を明らかにするエビデンスをさらに構築していくことができると期待しています。

本研究を実施するにあたり、多大なるご支援、ご協力をいただきました関係者の皆様に心より感謝申し上げます。

目次

Ⅰ．歯周病と冠動脈性心疾患との関連

Ueno M, Izumi Y, Kawaguchi Y, Ikeda I, Iso H, Inoue M, Tsugane S. Prediagnostic plasma antibody levels to periodontopathic bacteria and risk of coronary heart disease. Int Heart J 2012; 53: 209-214.

【背景と目的】

冠動脈性心疾患（Coronary Heart Disease: CHD）は、主にアテローム性動脈硬化症と呼ばれるプラーク（動脈内膜肥厚性病変）の脂肪性蓄積によって冠動脈が狭窄することにより起こる。2010 年の日本人口統計によれば、心臓疾患は癌に次いで死亡原因の 2 位であり、全死亡の 15.8%を占め、CHD がその約半分を占めている。CHD には喫煙、飲酒、肥満といった多くのリスク要因が挙げられる。さらに、これまでの疫学研究によって歯周病も CHD の発症や進行に関係していることが報告されている。すなわち、歯周病と CHD の発症リスクとの間には交絡因子調整後も正の関連があることが示されている。

しかし、ほとんどの研究において歯周病の診断は臨床的な歯周組織の検査や本人の自己申告に基づいて行われている。このように、歯周病の診断には標準化された基準がないため、これらの結果を解釈する際には注意が必要である。

歯周病による全身の免疫応答は、特定の歯周病原細菌に対する血清抗体価の上昇で測定することができる。歯周病原細菌の血清免疫抗体は歯周病の状態や進行と関連する細菌種の同定や個人の歯周病への易感染性や抵抗性の特定のために使用されている。歯周病原細菌に対する免疫抗体を用いたこれまでの研究から、主な歯周病原細菌である *Aggregatibacter actinomycetemcomitans*（*Aa* 菌）、*Porphyromonas gingivalis*（*Pg* 菌）、*Prevotella intermedia*（*Pi* 菌）によって引き起こされる感染が CHD 発症リスクの増加と関連していることが報告されている。

しかしながら、特定の歯周病原細菌に対する全身の免疫反応と CHD の発症との関連を縦断調査した研究は非常に少ない。特に、日本において歯周病と CHD の発症との関連を調査した大規模コホート研究はまだ行なわれていない。そこで、本研究では日本における大規模コホート研究の地域住民のデータを利用してコホート内症例・対照研究を行い、3 種類の主要な歯周病原細菌である *Aa* 菌、*Pg* 菌、*Pi* 菌に対する血漿抗体価が CHD の発症リスクを予測できるか検討を行った。

【方法】

1．対象者

本研究の対象者は多目的コホート（Japan Public Health Center-based: JPHC）研究ⅠあるいはⅡに参加した者である。JPHC 研究は大規模な日本人サンプルを用いた研究であり、癌や心臓血管疾患に代表される様々な疾患の罹患率や死亡率を経時的に調査し、生活

習慣病の科学的な予防法を明らかにするために行われている。 JPHC I は 1990 年に始まり、1989 年 12 月 31 日時点で 5 つの保健所区域に住む年齢 40~59 歳の住民を対象としている。JPHCⅡは 1993 年に始まり、1993 年 1 月 1 日時点で 6 つの保健所区域に住む年齢 40~69 歳の住民を対象としている。

今回の症例・対照研究ではコホート I においては 1990~1992 年、コホートⅡでは 1993~1995 年のベースライン時に、10mL の血液サンプルを提供し、その後 2007 年 12 月 31 日までの追跡期間の間に CHD を発症した 191 名を症例群とした。症例 1 名につき、2 名の対照者を、性別、年齢（3 歳以内）、調査地域（市あるいは町や村）、採血の日付（6 カ月以内）、採血時の最後の食事からの時間（5 時間以内）をマッチングさせて無作為に選んだ。したがって、対照群は 382 名である（図 1）。

2. 社会人口統計および保健行動に関する情報

1990 年または 1993 年のベースライン時に参加者に対して実施された自記式質問票により、身長、体重、喫煙状況、飲酒習慣、既往歴（高血圧および糖尿病）、余暇時の運動、精神的ストレスの自覚の程度などの情報を収集した。BMI は（体重（kg）/ 身長（m）^{2}）の公式を使用して算出した。

3. CHD 発症の診断

それぞれの地域において CHD 発症患者を受け入れ可能な合計 78 件の病院が JPHC 研究には参加している。CHD の診断は心臓血管疾患のモニタリング傾向と決定要因プロジェクト（Monitoring Trends and Determinants of Cardiovascular Disease：MONICA）の基準に基づき、心電図、心筋酵素あるいは剖検、血漿抗体価測定により行った。

4. 歯周病原細菌の血漿抗体価測定

血漿サンプルは 3 種類の歯周病原因菌（*Aa* 菌 ATCC 33384、*Pg* 菌 ATCC 33277、*Pi* 菌 ATCC 25611）の細胞表面抗原に対する IgG 抗体を ELISA 法によって測定した。歯周病原細菌の血漿抗体価（U /mL）は各歯周病原細菌の抗体濃度と吸光度密度の参照カーブから算出した。

5. 統計分析

症例群と対照群のベースライン時の特徴は Mantel-Haenszel 法によって分析した。それぞれの細菌の抗体価は全対象者の度数分布に基づいて 3 つ（低、中、高）に区分した：*Aa* 菌（低：＜31.7、中：31.7~184.9、高：＞184.9）、*Pg* 菌（低：＜57.0、中：57.0~134.9、高：＞134.9）、*Pi* 菌（低：＜235.9、中：235.9~414.1、高：＞414.1）。CHD リスクの粗オッズ比（OR）と 95%信頼区間（CI）はロジスティック回帰モデルを用いて、抗体価が低いグループを基準として算出した。調整済みオッズ比は、BMI（連続変数）、喫煙状況

（非喫煙者、過去喫煙者、喫煙者）、飲酒習慣（非飲酒者あるいは過去飲酒者、週に 1 回未満、＜150 g /週、150~299 g /週、300~449 g /週、≧450/週）、高血圧の既往（あり/なし）、糖尿病の既往（あり/なし）、余暇時の運動（めったにしない、1~3 回/月、1~2 回/週、3~4 回/週、ほとんど毎日）、精神的ストレスの自覚の程度（低、中、高）といった交絡因子を条件ロジスティック回帰モデルに加え算出した。

歯周病原細菌と CHD 発症との間には年齢による相互作用が示唆されたことから、オッズ比はベースライン時の平均年齢により 2 つの年齢層（40~55 歳、56~69 歳）に分けて算出した（年齢による相互作用の p 値：*Aa* 菌＝0.022、*Pg* 菌＝0.878、*Pi* 菌＝0.004）。すべての統計分析は SAS ソフトウェア、バージョン 9.2 で行った。

【結果】

1. 対象者の特徴

ベースライン時の症例群とそれにマッチングされた対照群の基本統計量を表 1 に示す。ベースライン時の平均年齢±SD は症例群が 56.7±7.7 歳、対照群が 56.6±7.6 歳であった。男性の割合は両群とも 62.3%であった。

症例群（40.8%）は対照群（27.5%）に比べ喫煙者の割合が有意に高く（p＝0.002）、高血圧の既往（31.9%）と糖尿病の既往の割合（18.3%）も対照群（15.2%、8.9%）に比べ有意に高かった（p＜0.001、p＝0.002）。さらに、症例群（20.4%）では対照群（12.8%）よりも精神的ストレスを自覚する者の割合が有意に高かった（p＝0.018）。BMI、飲酒、余暇時の運動、血漿中の 3 種類の歯周病原細菌抗体価に関しては差は認められなかった。

2. 菌抗体価からみた CHD の発症リスク

図 2 は、血漿中の 3 種類の歯周病原細菌抗体価による CHD 発症リスクのオッズ比を示す。*Pi* 菌抗体価の高いグループは低いグループに比べ CHD の発症リスク（粗オッズ比＝1.81；95%CI＝1.15~2.86、調整済みオッズ比＝1.89；95%CI＝1.10-3.23）が有意に高かった。CHD の発症リスクは *Pi* 菌の血漿抗体価と有意な量反応関係（粗オッズ比の傾向性 p ＝0.010、調整済みオッズ比の傾向性 p＝0.021）を示した。*Aa* 菌と *Pg* 菌の血漿抗体価と CHD 発症リスクとの間には関連はみられなかった。

3. 年齢階級別の CHD の発症リスク

40~55 歳においては、*Aa* 菌の抗体価が中程度のグループ（粗オッズ比＝2.55、95%CI＝1.14-5.72；調整済みオッズ比＝3.72；95%CI＝1.20-11.56）および高いグループ（粗オッズ比＝2.51；95%CI＝1.16-5.43；調整済みオッズ比＝4.64；95%の CI＝1.52-14.18）は低いグループに比べ CHD の発症リスクが有意に高かった。CHD の発症リスクは *Aa* 菌の抗体価が増加するにともない高くなる有意な量反応関係がみられた（粗オッズ比の傾向性 p＝0.019、調整済みオッズ比の傾向性 p＝0.007）。*Pg* 菌および *Pi* 菌の抗体価と CHD の

発生リスクとの間には関連は認められなかった（図 3)。

一方、56~69 歳においては、*Pi* 菌の抗体価が高いグループは低いグループに比べ CHD の発症リスクが有意に高かった（粗オッズ比＝2.45、95%CI＝1.29-4.65、調整済みオッズ比＝2.65、95%CI＝1.18－5.94)。*Pi* 菌の抗体価は CHD の発症リスクと有意な量反応関係がみられた（粗オッズ比の傾向性 p＝0.004、調整済みオッズ比の傾向性 p＝0.007)。*Aa* 菌と *Pg* 菌の抗体価と CHD の発症リスクとの間に関連はみられなかった（図 4)。

【考察】

本研究により、歯周病原細菌である *Aa* 菌 あるいは *Pi* 菌の血漿抗体価が高いと CHD の発症リスクが増加することが判明した。しかし、その関係は年齢層によって異なっていた。すなわち、ベースライン時の年齢が 40~55 歳で *Aa* 菌との関連、56~69 歳で *Pi* 菌との関連が強く認められた。

歯周病と CHD との関係は複雑であり、これまで多くの研究により因果関係について仮説が唱えられている。現在考えられているメカニズムには歯肉縁下のバイオフィルムによる直接的影響あるいはアテローム性動脈硬化プラーク形成過程における免疫反応や炎症の活性化などの間接的影響などがある。内皮機能障害はアテローム性動脈硬化進行の最初の過程である。歯周病が内皮機能障害と関連していることはこれまでの研究で証明されている。*Pg* 菌や *Pi* 菌のような歯周病原細菌が冠動脈細胞に浸潤すること、さらに、*Aa* 菌の血清 IgG の増加がアテローム性動脈硬化と関連していることが報告されている。

Aa 菌と CHD 発症リスクとの関係は先行研究においても確認されている。Spahr らは 43~73 歳の成人の歯肉縁下病原体を DNA-RNA ハイブリッド法で測定し、*Aa* 菌の量と CHD の発症リスク（オッズ比＝2.70；95%CI＝1.79-4.07）との間には正の関連があることを報告している。また、Pussinen らは 25~64 歳の対象者において、*Aa* 菌に対する IgG 抗体価の上昇と心臓血管疾患との間には関連性がある（オッズ比＝1.64 95％CI＝1.00-2.69）ことを報告している。*Aa* 菌は限局性の侵襲性歯周病の主要な病原細菌とされている。*Aa* 菌の血清抗体価の増加は歯周組織の破壊に関わっており、血管の活性化を起こす細菌の全身への拡散を引き起こすと考えられている。また、*Aa* 菌を保有する者は、その菌種特有の病原性により特に若年層において歯周病のリスクが高くなると言われている。さらに、*Aa* 菌は早期発症型歯周病の病原因子であるとされている。したがって、この研究において若い年齢層において *Aa* 菌と CHD の発症との間に強い関連がみられたことは、早い年齢において進行性の歯周病に罹患している者では CHD のリスクが高くなることを示唆していると推測される。

これまでの研究で、歯周ポケット中の *Pi* 菌の存在は 35~69 歳の対象者において、交絡因子調整後も心筋梗塞（オッズ比＝1.40、95%CI＝1.02-1.92）の発症リスクの増加と関連していることが証明されている。Nonnenmacher らの 48~80 歳の男性を対象に行った症例・対照研究により、喫煙習慣調整後も冠動脈疾患症例群では対照群と比較して、歯肉縁

下の *Pi* 菌の頻度が高いことが分かっている。 さらに、Spahr らは 43~73 歳の CHD 症例群は、年齢と性別をマッチングさせた対照群に比べ歯肉縁下バイオフィルム内の *Pi* 菌の数が多いと報告している。

これらの所見はすべて本研究の結果を支持するものである。しかし、上記の研究は歯肉縁下の *Pi* 菌を測定して行われたものであり、抗体価を用いたものではない。他の歯周病原細菌に比べ、*Pi* 菌の抗体価を用いて CHD 発症リスクとの関連を調べた報告は少ない。米国において 45~64 歳を対象者として行われた研究では、喫煙者において *Pi* 菌 に対する高 IgG 抗体価は CHD の発症リスクと関連していた。今回の研究では *Pi* 菌と CHD との関係はベースライン時の年齢が比較的高い 56~69 歳にのみ認められた。このことから、*Pi* 菌が組織破壊を起こす多様な炎症や免疫反応を調節することによって、より高齢になるほどみられる慢性歯周病において主要な役割を果たしているとも考えられる。

細菌の抗体価と CHD との関係を年齢で層別化して分析した研究はこれまでないため、なぜ異った歯周病原細菌が異なった年齢層において影響するかについては不明である。それゆえ、この研究で確認された *Pi* 菌および *Aa* 菌と CHD との関連性の年齢による違いのメカニズムを解明するためにはさらなる研究が必要と考えられる。

これまでの血清学的研究から *Pg* 菌による感染が CHD の発症リスクの増加に寄与していることが確認されている。Pussinen らは 45~74 歳の有歯顎者の男性において、CHD は *Pg* 菌に対し血清陰性の者より血清陽性の者で多く発症すると報告している。しかし、本研究ではこの菌種に対する血漿抗体価と CHD 発症リスクとの間には関連はみられなかった。同様に、いくつかの研究においても *Pg* 菌に対する IgG 抗体価と CHD との間に有意な関連は認められていない。特に、交絡因子調整後にそうした傾向がみられる。*Pg* 菌株はどれも類似の感染能力を持っているにもかかわらず、CHD の発症リスクは菌株によって異なる。つまり、強い病原性をもつ特定の遺伝子型の *Pg* 菌が CHD 発症とのメカニズムに関与しているとも考えられる。*Pg* 菌と CHD 発症に一貫性がみられない背景には、異なった病原性を持つ違った遺伝子型の *Pg* 菌の存在が寄与しているのかもしれない。

本研究には長所がいくつかある。先ず、歯周病の評価に細菌に対する抗体価を使用した点である。ポケットの深さあるいはアタッチメントレベルのような臨床的歯周組織指標により歯周病を定義することは、歯周病による全身的作用を反映していない。したがって、細菌の長期にわたる曝露がリスク要因であるとされる CHD との関係を検討する場合には適さないとこれまでも批判があった。歯周病原細菌の全身的な曝露を示す指標として最もよく使われるのが抗体価である。抗体価は歯周病原細菌の感染に対する免疫応答であり、炎症のマーカーであると考えられている。また、血清中の歯周病原細菌の抗体価は歯肉プラーク中の病原体の分布と強く関連していることが報告されている。

次に、歯周病と CHD の両方に影響を与える交絡因子の制御は結果を解釈するうえで重要である。今回、年齢、性別、その他の関連要因を個々にマッチングさせて症例群と対照群を選び、さらに適切な統計学的検出力を確保するために症例 1：対照 2 の割合で分析を

行った。また、多くの CHD 関連の健康パラメータを統計学的に制御することで、潜在的な交絡変数を減らすよう試みた。加えて、今回のコホート内症例・対照研究デザインは歯周病原細菌と CHD の発症との因果関係をより明確にすることができる。

一方、本研究には考慮すべき制約もある。血清あるいは血漿抗体価は長期間安定していると考えられているが、臨床的な歯周組織の状態や、対象者の歯周病原細菌の抗体価が以前に罹患した歯周病によるものなのか、あるいは現在起こっている感染によるものなのかは区別できない。加えて、抗体価のための重要な交絡因子である残存歯についての情報が欠如している。さらに、今回 3 種類の歯周病原細菌を調べたが、その他の種類の細菌に対する抗体反応や CHD 発症における役割は不明である。

しかしながら、今回の症例・対照研究において、CHD 発症リスク要因として歯周病原細菌の関与が示唆された。すなわち、これらの細菌の高抗体価は CHD 発症のリスクを高めると考えられる。したがって、口腔疾患と全身疾患の間の緊密な関係が確認できたといえる。公衆衛生学的にみると、歯周病が CHD 発症のリスク要因であるという本研究結果は重要である。歯周病は予防あるいは治療することが可能な疾患である 世界的にみて歯周病や CHD の罹患率が高いことを考えると、適切な予防的介入によって歯周病を予防し、治療することは CHD の予防にもつながると考えられる。

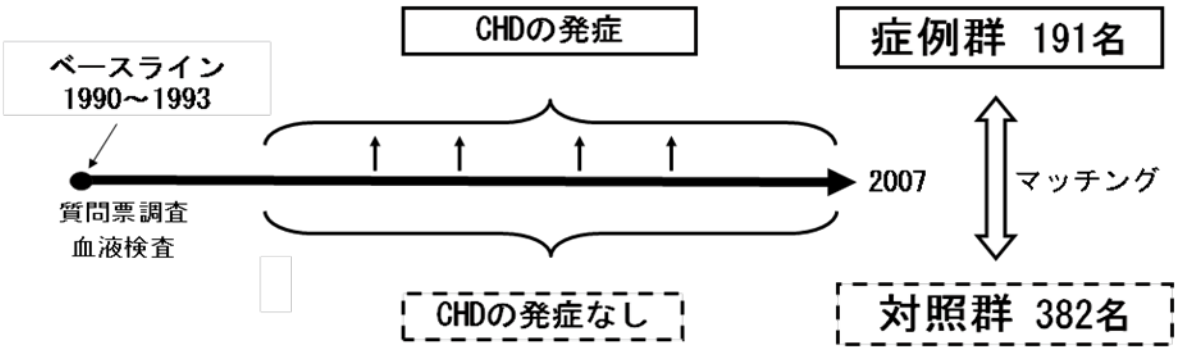


図１　コホート内症例・対照研究デザイン

表１　症例群と対照群の基本統計量

	症例群（N=191）		対照群（N=382）		p 値
	平均 / N	SD / %	平均 / N	SD / %	
年齢（歳）	56.7	7.7	56.6	7.6	-
性別（男性）、%	119	62.3	238	62.3	-
BMI、kg/cm^2	24.5	3.2	24.3	9.6	0.824
喫煙者、%	78	40.8	105	27.5	0.002
飲酒（≧450 mg/週）、%	16	8.4	45	11.8	0.271
高血圧の既往、%	61	31.9	58	15.2	<0.001
糖尿病の既往、%	35	18.3	34	8.9	0.002
余暇時の運動（≧1~2 回/週）、%	42	22.0	69	18.1	0.313
精神的ストレスの自覚（高）、%	39	20.4	49	12.8	0.018
Aa 菌抗体価、U/mL	269.7	441.5	249.6	439.7	0.606
Pg 菌抗体価、U/mL	148.2	164.1	136.8	144.3	0.397
Pi 菌抗体価、U/mL	395.9	248.8	358.1	233.6	0.075

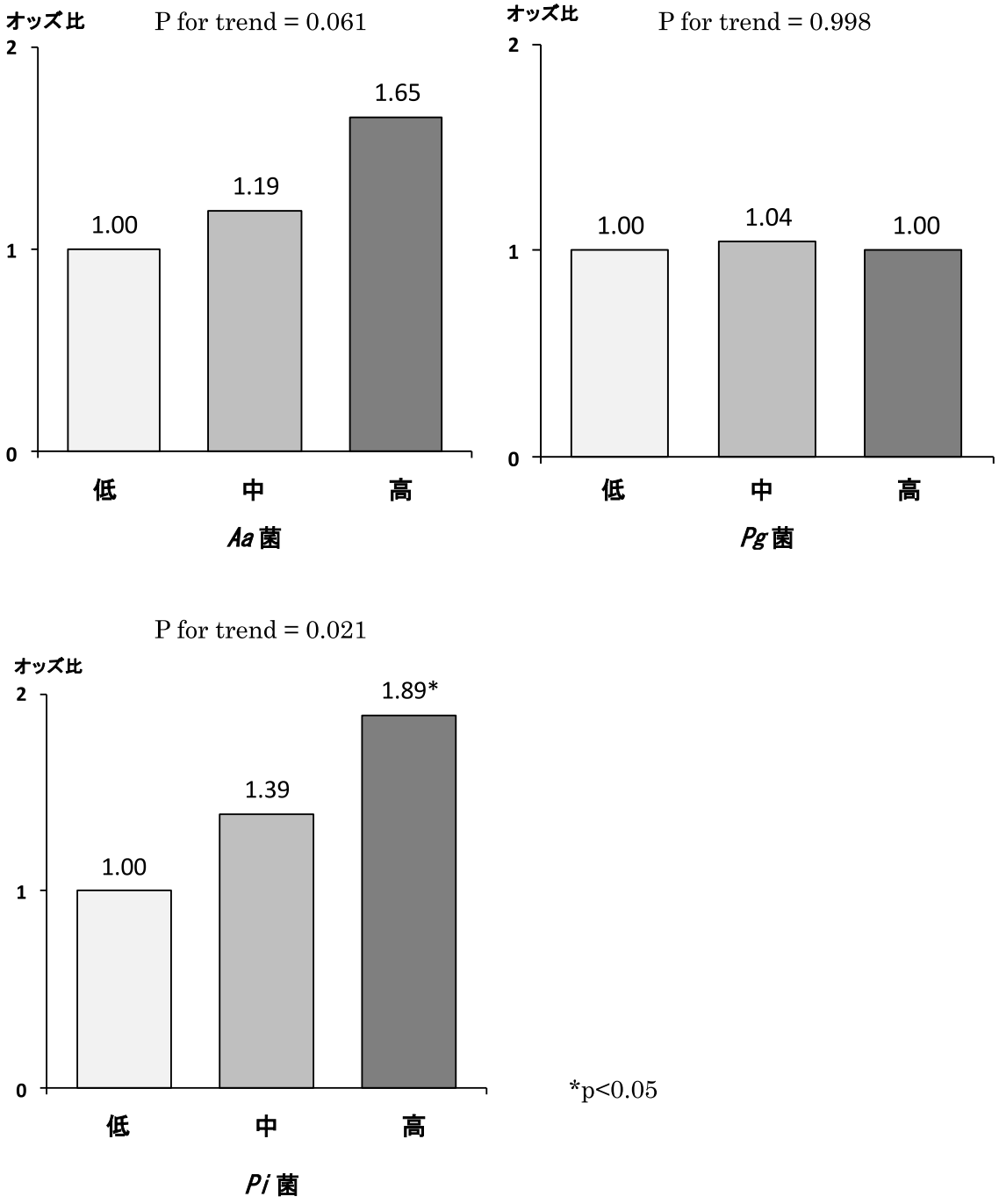


図 2　各歯周病原細菌に対する血漿抗体価による CHD 発症リスク（全対象者）
（調整因子：肥満、喫煙、飲酒、高血圧・糖尿病の既往、運動、ストレス）

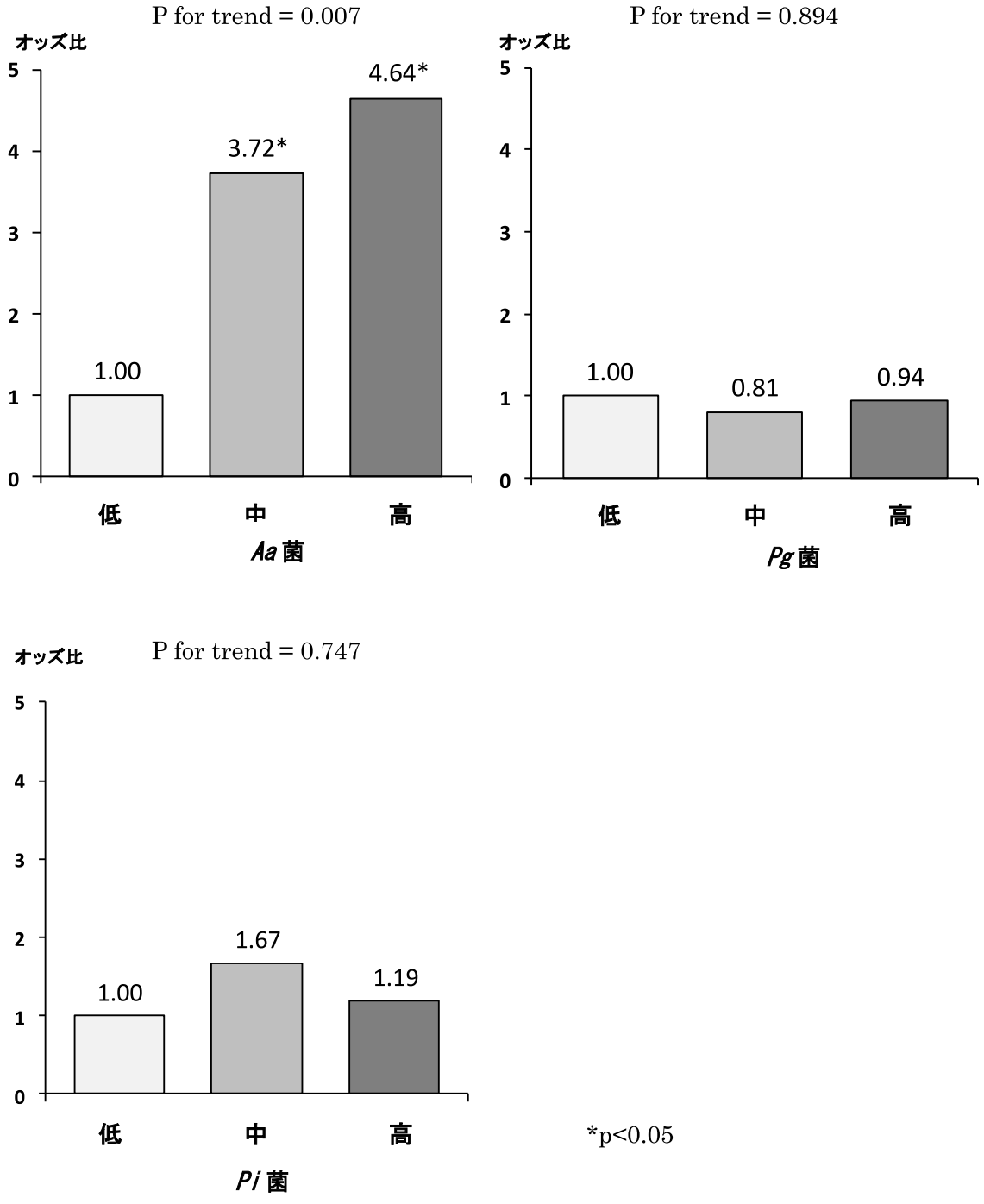


図 3　各歯周病原細菌に対する血漿抗体価による CHD 発症リスク（40~55 歳）
（調整因子：肥満、喫煙、飲酒、高血圧・糖尿病の既往、運動、ストレス）

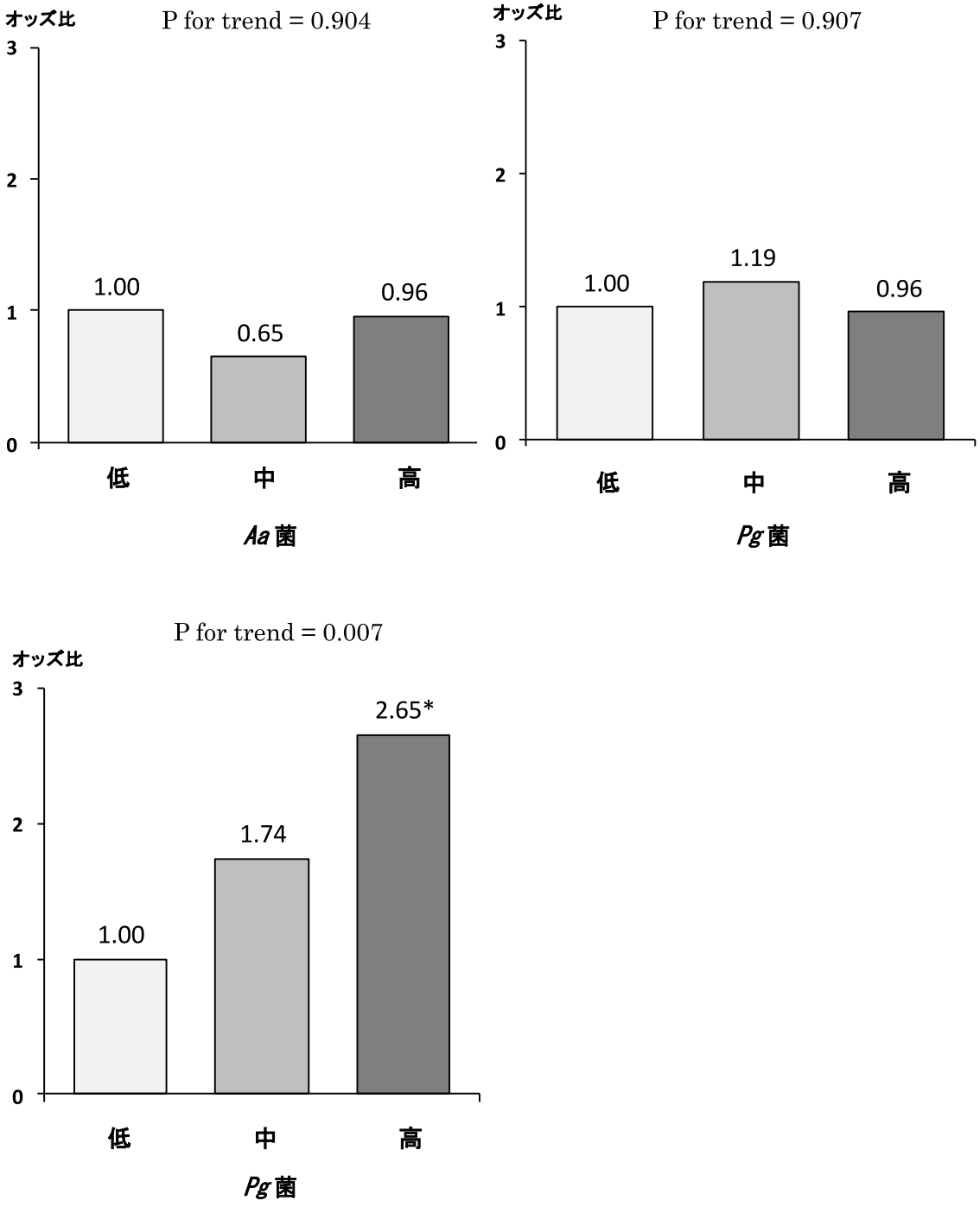


図 4　各歯周病原細菌に対する血漿抗体価による CHD 発症リスク（56~69 歳）
（調整因子：肥満、喫煙、飲酒、高血圧・糖尿病の既往、運動、ストレス）

Ⅱ．学歴と口腔保健状況との関連

Ueno M, Ohara S, Inoue M, Tsugane S, Kawaguchi Y. Association between education level and dentition status in Japanese adults: Japan public health center-based oral health study. Community Dent Oral Epidemiol 2012; 40: 481–487.

【背景と目的】

社会経済状況（Socio-Economic Status: SES）の評価に使われる指標にはいくつかあるが、一般的に収入、職業、学歴などがよく用いられている。SES の指標の中で収入と職業はその時代の経済状況により影響を受けやすいが、学歴は比較的安定しているため、調査・研究等で使われることが多い。

SES と健康との関連については多くの研究が行われており、緊密な関連があることが報告されている。これまでの研究で、SES の低い者では健康状態も不良であることが明らかになっている。学歴と健康との関係についての研究は欧米などでは盛んであるが、日本においてはほとんど行われてない。日本での研究では、学歴と健康行動との関係が他の先進国に比べ少ないと報告されている。一方、学歴が低い者では健康状態が悪いという報告もある。

SES の違いは口腔保健状況にも影響を及ぼすことが多くの研究で分かっている。SES の低い者は高い者に比べ、口腔の健康状態が悪いと報告されている。これまでの研究から、学歴の低い者は高い者と比較してより喪失歯が多いことが分かっている。また、学歴の低い者は学歴の高い者よりも齲蝕が多い傾向にあることも報告されている。一方、高学歴の者の方が修復歯の数が多いことも報告されている。さらに、高齢者においては低学歴は口腔保健の Quality of Life（QOL）にも影響すると言われている。

しかし、日本において欧米で確認されている学歴と口腔保健との関連についての研究はまだ十分行われていないのが現状である。したがって、学歴に関して同様の関係が日本においても存在するか否かを確認することはできない。日本は他の先進諸国に比べ SES の格差は少ないと考えられている。さらに、日本には 1961 年以降歯科治療を含む国民皆保険制度がある。

本研究では、国民皆保険制度のある日本において、学歴の違いにより口腔保健状況に差異がみられるか検討を行った。

【方法】

1．対象

1990 年より日本人の癌や心疾患の罹患率や死亡率を経時的に調査し、生活習慣病の科学的な予防法を明らかにする目的で多目的コホート調査が行われている（Japan Public Health Center-based Study Ⅰ：JPHC Ⅰ）。2005 年には、その一環として秋田県横手地域

において歯科の調査が初めて行われた。本研究では 1990 年のベースライン調査と 2005 年の歯科の調査の両方に参加した者を対象とした。

JPHC I に参加し 2005 年時点で 55~75 歳までの 15,782 人に対し、歯科研究参加の案内を郵送した。その結果、2005 年 7 月から 2006 年 1 月の間に合計 1,518 名が歯の健康に関する質問票調査および口腔内診査を受けた。そのうち、分析に用いたのは欠損データのない 1,201 名（男性 557 名、女性 644、平均年齢 65.5 歳）である。

2. 学歴

学歴は 1990 年のベースライン時の質問票調査に基づき情報を収集し、中学までの者を低学歴（402 名）、高校（602 名）までの者を中等度の学歴、大学かそれ以上（191 名）の者を高学歴と分類した。

3. 歯科保健行動

2005 年の歯科保健に関する自記式質問票により、甘いお菓子・飲み物の摂取頻度（めったにとらない、時々とる、毎日とる）、前年の歯科定期健診の受診（あり、なし）、喫煙状況（非喫煙、過去喫煙、喫煙）を調査した。

4. 口腔保健状況

口腔内診査は WHO の基準に基づき、研究に参加した 43 人の横手地域の歯科医師会会員である歯科医師によって行われた（第 3 大臼歯を除く）。診査項目は現在歯数、未処置歯数、修復歯数で、それに基づき無歯顎者および 20 歯以上の歯を有する者の割合を算出した。

臼歯の咬合状態を示す機能歯ユニット（Functional Tooth Units：FTU）は total-FTU（義歯も含めたすべての歯による FTU）の他、n-FTU（自分の歯による FTUs）と nif-FTU（自分の歯、ブリッジのポンティック、インプラントによる FTUs）を算出した。

口腔衛生状態は、全ての歯あるいは義歯を診査し、1）良好：歯表面の 3 分の 1 未満の歯垢付着、2）普通：3 分の 1 以上、3 分の 2 未満の歯垢付着、3)不良： 3 分の 2 以上の歯垢付着の 3 段階で評価した。

5. 統計分析

年齢、性別、歯科保健行動および口腔保健状況と学歴との関連は線形回帰モデルおよび Mantel-Haenzel の χ^2 乗検定によって分析した。歯の状態と学歴との関連は一般化線形モデルによって分析した。分析は IBM SPSS 18J ソフトウェアを用いて行った。

【結果】

1. 学歴と平均年齢および性別

各学歴の平均年齢±SD は、男性では低学歴が 66.8±5.8 歳、中学歴が 65.2±5.5 歳、高学歴が 64.8±6.0 歳であった。女性ではそれぞれ 67.5±5.5 歳、64.2±5.6 歳、63.8±5.5 歳であった。男性、女性とも平均年齢は学歴と有意な負の関係にあり、低い学歴の者ほど平均年齢が高かった（男性：傾向性 $p<0.01$、女性：傾向性 $p<0.001$）。

男性の各学歴の割合は低学歴が 30.7%（171 名）、中学歴が 51.3%（286 名）、高学歴が 18.0%（100 名)であった。女性ではそれぞれ 35.9%（231 名）、50.0%（322 名)、14.1%（91 名）であった。男性と女性で学歴の分布に有意な差がみられた（傾向性 $p=0.023$）。

2. 学歴と歯科保健行動および口腔衛生状態

学歴と歯科保健行動および口腔衛生状態との関連は、男性において低学歴の者ほど甘い飲料の摂取頻度が高い者の割合が有意に多かった（傾向性 $p=0.001$)。学歴と甘いお菓子の摂取頻度、歯の定期健診の受診の有無、喫煙状況、口腔衛生状態との間には関連はみられなかった。

3. 学歴と無歯顎者の割合および 20 歯以上自分の歯を有する者の割合

学歴と無歯顎者の割合および 20 歯以上自分の歯を有する者の割合との間に有意な関連が認められた。無歯顎者の割合は学歴が上がるにしたがい低くなり（傾向性 $p<0.001$)、逆に 20 歯以上自分の歯を有する者の割合は高くなった（傾向性 $p<0.001$）。交絡因子調整後は学歴と無歯顎者の割合との間の関連はみられなくなったが（図１）、20 歯以上自分の歯を有する者の割合との間には有意な関連が認められた（傾向性 $p<0.001$）（図２）。

4. 学歴と歯の状況

学歴と歯の状況との関係では交絡因子調整前および調整後どちらにおいても有意な関連が認められた。現在歯数（傾向性　調整前 $p<0.001$、調整後 $p=0.037$）（図３）、処置歯数（傾向性　調整前 $p<0.001$、調整後 $p=0.016$)（図５）、n-FTU（傾向性　調整前・調整後とも $p<0.001$）（図６）、nif-FTU（傾向性　調整前・調整後とも $p<0.001$）（図７）は学歴が上がるにしたがい有意に多くなった。学歴と未処置歯数（図４）および total-FTU（図８）との間には関連はみられなかった。

【考察】

今回、本研究では日本の成人の学歴と口腔保健状況との関連について検討した。その結果、国民皆保険制度のある日本においても学歴の違いにより口腔保健状況が異なることが明らかになり、この傾向は交絡因子調整後も認められた。具体的には、低学歴の者は高学歴の者に比べ有意に現在歯数、n-FTU、および nif-FTU が少なかった。多くの国々で、学歴は口腔保健状況に影響すると報告されているが、本研究によって日本でも同様に、学歴により口腔保健状況が異なることが証明されたことになる。

これまでの研究では、低学歴の者は高学歴の者に比べ無歯顎者の割合が高いと報告されている。本研究においても交絡因子調整前には学歴が低くなるにしたがい無歯顎者の割合が高くなったが、交絡因子調整後は関連はみられなくなった。これは調整に用いた年齢、性別、甘いお菓子や飲み物の摂取頻度、歯科定期健診、喫煙、口腔衛生状態などの交絡要因が学歴と無歯顎者の割合との関係に影響を与えているためと考えられる。

80 歳まで少なくとも 20 歯以上の歯を保持するという 8020 運動は日本において歯の健康目標になっている。同様な目標は WHO や FDI でも見受けられる。20 歯以上歯を有する者の割合は学歴が上がるにしたがい有意に増加する傾向がみられた。先行研究においても、20 歯以上歯を有する者の割合と学歴との間には同様の関係があると報告されている。さらに、24 歯未満の歯を有する者の割合と SES とは直線状の関係にあるという研究もある。すなわち、社会的なステータスが高い者では 24 歯未満の歯を有する者の割合が低いというものである。

本研究では、低学歴の者に比べ高学歴の者はより多くの修復歯を有することが明らかになった。同様の結果は 1999～2004 年に行われた米国での健康栄養調査（NHANES）を用いた研究でも報告されている。このことは、人の歯科医療に対する態度や行動と関係があると考えられている。学歴の高い者は低い者に比べ、より頻繁に歯科医院を受診する傾向にあることがその原因とされている。

学歴と未処置歯数との間には有意な関係は認められなかった。デンマークの高齢者を対象に行われた研究でも、低学歴の者は高学歴の者に比べ齲蝕歯面数は多い傾向にあるもののその差は有意でなかったと報告されている。本研究で有意差がみられなかった理由として、未処置歯数が約 1 歯と少なく、統計学上有意差を検出し難かったことに加え、日本においては歯科治療も公的医療保険の対象になっていることが考えられた。

臼歯の咬合関係の指標である FTU は咀嚼能力や食事と密接に関係している。FTU が多いほど臼歯部での咬合状態が良いことになる。total-FTU に関しては学歴による有意差はみられず、どの学歴の者も FTU は 10 以上であった。これは、これまでの研究で報告されているように、喪失歯が義歯などの人工歯によって回復され、結果として total-FTUs が増えたためである。実際、国民皆保険制度のある日本においては義歯は比較的安価で作製することができ、社会経済状況の影響は他国より少ないと考えられる。

一方、学歴による口腔保健状況の違いは n-FTU と nif-FTU でみられ、学歴の低い者では臼歯部での自分の歯や固定性補綴物による咬合が少ないことが明らかになった。このことは、咀嚼能力や食生活にも影響を及ぼすと考えられる。先行研究でも、義歯による FTU の回復は顕著な咀嚼機能の回復をもたらすものではないと報告されている。したがって、できるだけ多くの n-FTU や nif-FTU を維持することが、咀嚼機能の保持のためには重要である。

本研究は、日本の成人において学歴が口腔保健状況に影響を及ぼすことを明らかにした。低学歴の者は、より多くの歯を失い、義歯を装着する傾向にあるのに対し、高学歴の者は

より多くの歯を保有し、義歯よりも充填、固定性補綴物、およびインプラントなどの治療を受ける傾向にあることが判明した。

これらの結果は、個人の保健行動に注目した口腔疾患予防戦略では限局的な効果しか現れないことを示唆している。生活や仕事を形成する口腔保健に影響する社会経済的な決定要因にもより多く注目することが必要である。また、小中学校における義務教育の中で歯科健康教育などにより歯科に関する適切な情報を提供し、ヘルスリテラシーを高めることで、教育レベルの違いによる歯科保健の格差を少なくすることが重要だと考えられた。

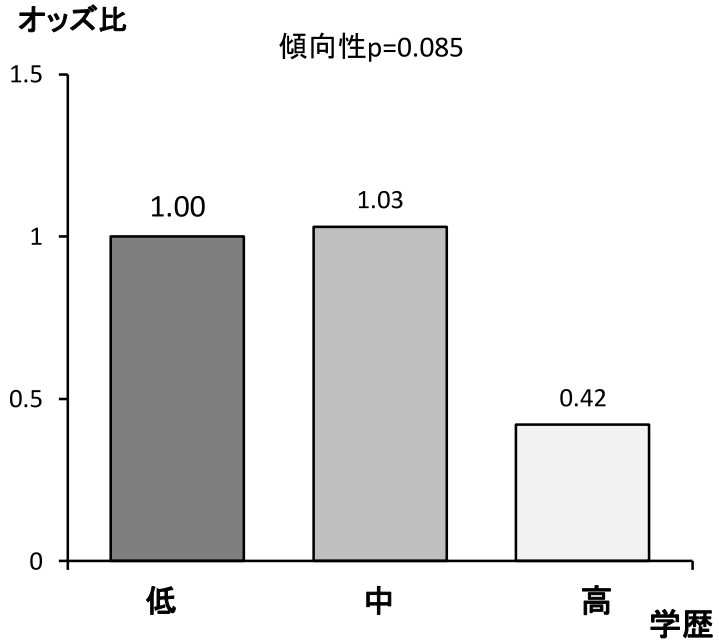


図１　学歴と無歯顎者の割合との関連（交絡因子調整済み）

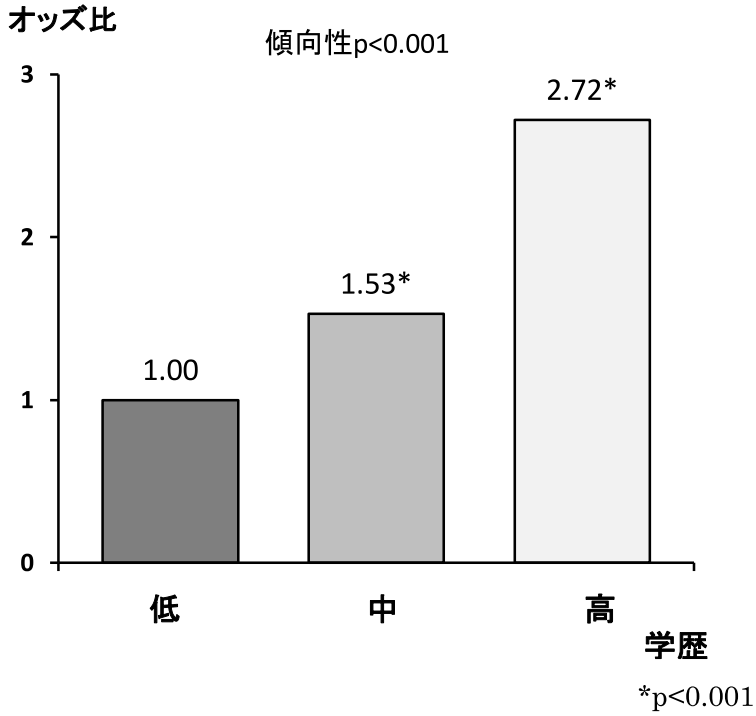


図２　学歴と 20 歯以上歯を有する者の割合との関連（交絡因子調整済み）

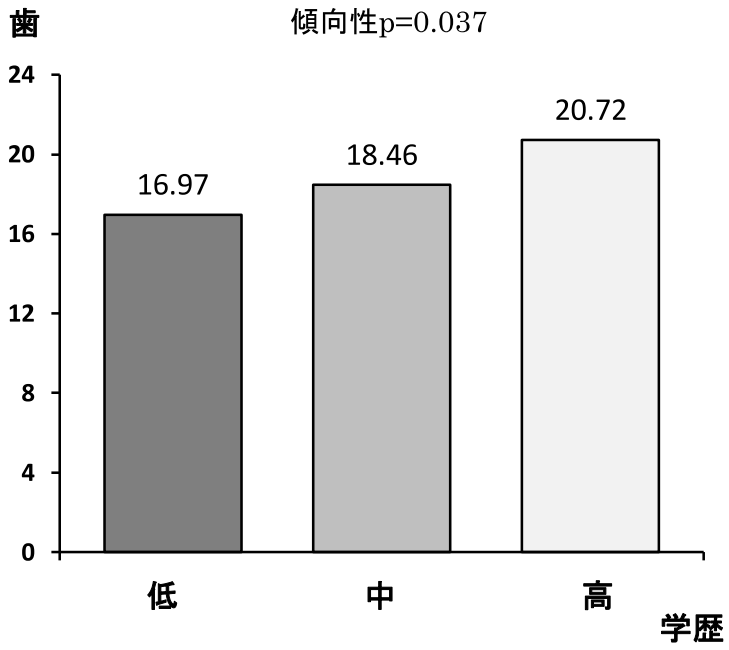


図３　学歴と現在歯数との関連（交絡因子調整済み）

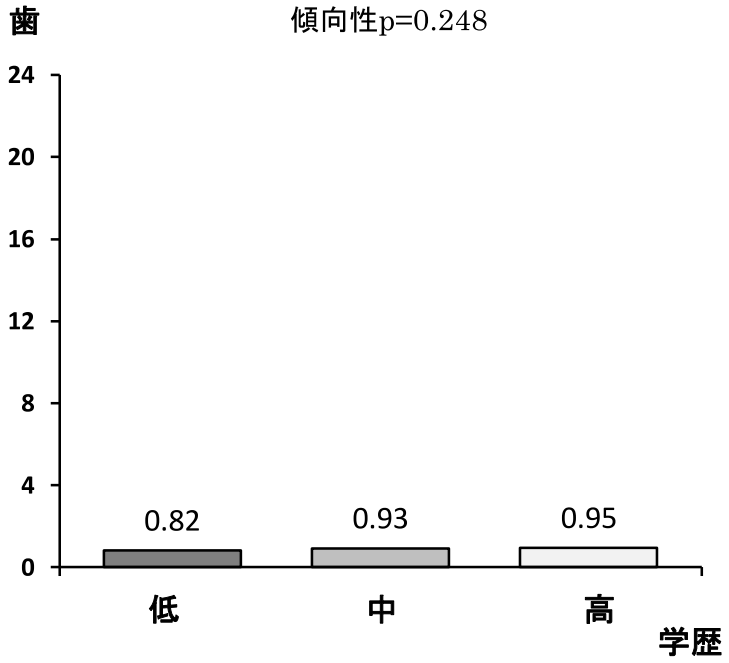


図４　学歴と未処置歯数との関連（交絡因子調整済み）

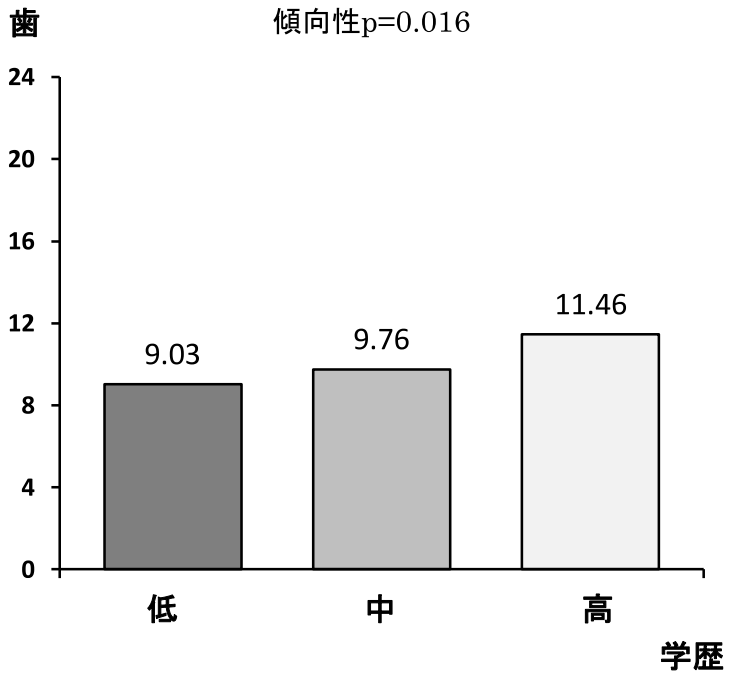


図 5　学歴と処置歯数との関連（交絡因子調整済み）

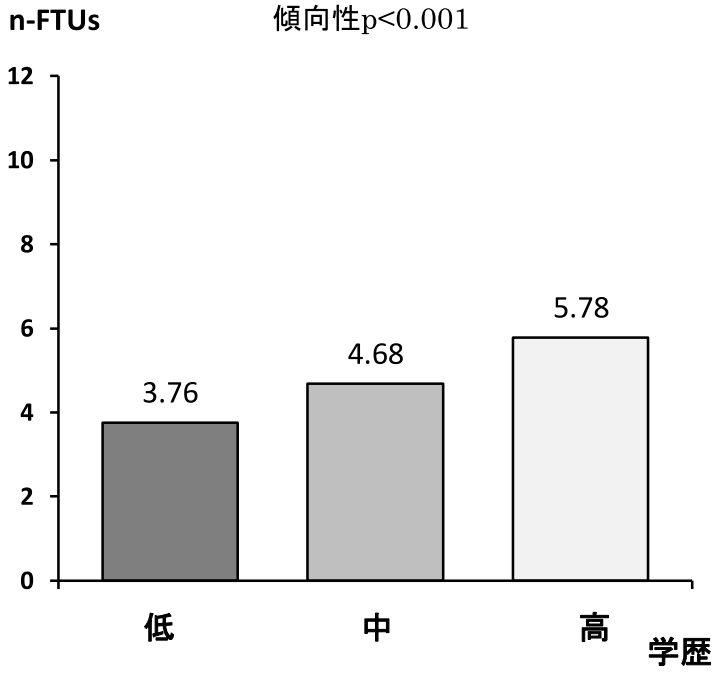


図 6　学歴と n-FTU との関連（交絡因子調整済み）

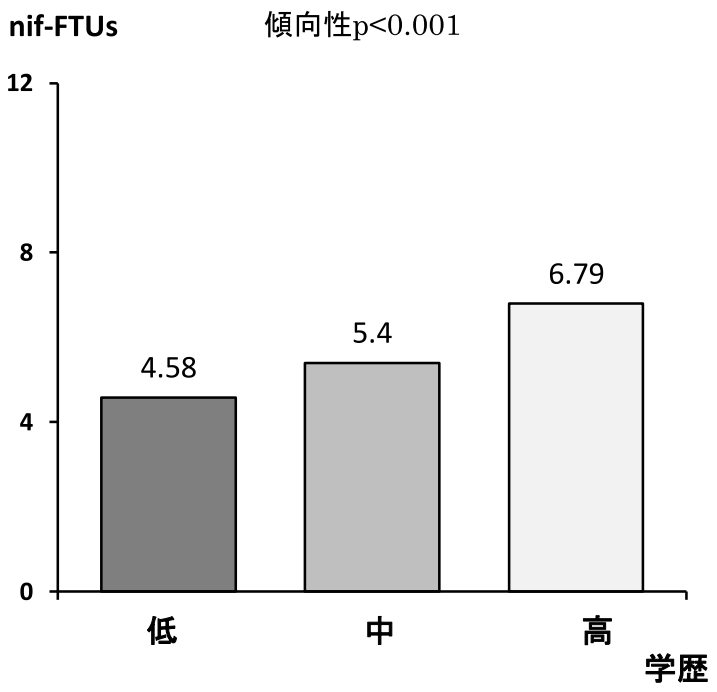


図 7　学歴と nif-FTU との関連（交絡因子調整済み）

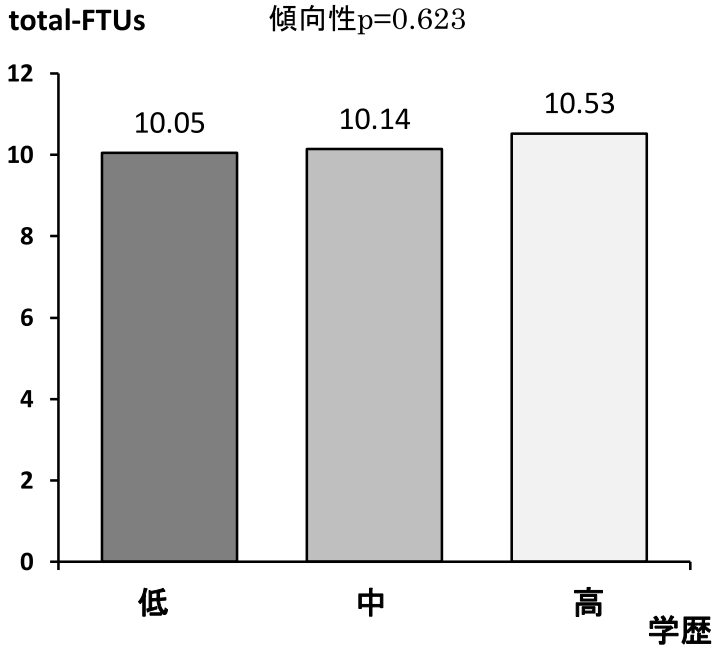


図 8　学歴と total-FTU との関連（交絡因子調整済み）

Ⅲ．喫煙および禁煙状況と現在歯数との関連

Yanagisawa T, Marugame T, Ohara S, Inoue M, Tsugane S, Kawaguchi Y. Relationship of smoking and smoking cessation with number of teeth present: JPHC Oral Health Study. Oral Dis 2009; 15: 69-75.

【背景と目的】

喫煙が肺がんや心疾患、脳血管障害などの全身疾患のリスクを高めること、また、禁煙をすることでそれらのリスクが低くなることが報告されている。歯科領域ではこれまで、「喫煙が歯の喪失のリスクを高める」という報告は行われているが、禁煙することが、歯の喪失リスクの低減にどのように影響するかを明らかにした報告はほとんどない。本研究では、多目的コホート研究と共同で、喫煙状況および禁煙状況と現在歯数との関連について検討を行った。

【方法】

2005 年に歯科健診を受診した秋田県横手保健所管内の 55~75 歳の住民 1,518 名（男性 706 名、女性 812 名）を対象とした。そのうち、女性は喫煙率が低かったため除外し、1990 年から 5 年おきに多目的コホート研究で実施した 3 回の質問票調査の結果を確認できた男性 547 名を解析対象とした。対象者を、喫煙者、過去喫煙者、非喫煙者の 3 群に分け、現在歯数（第三大臼歯は除外）を算出した。また、現在歯数が 20 歯未満か否かを目的変数、喫煙状況、喫煙年数、喫煙本数、禁煙年数を説明変数としたロジスティック回帰解析（年齢、BMI、ビタミン C 摂取量、アルコール摂取量、学歴を調整）を用い、現在歯数と喫煙および禁煙状況との関連について検討を行った。

【結果】

１．喫煙状況

2005 年の質問票調査でたばこを「吸っている」と回答した者は 135 名、「やめた」と回答した者は 212 名、「吸わない」と回答した者は 200 名であった。喫煙状況を過去の調査と照らし合わせて確認したところ、1990 年に「吸っている」と回答した 227 名のうち 92 名が、15 年の間に禁煙していた。一方、1990 年では「吸わない」と回答した者は 166 名であったが、2005 年には 200 名と増加していた。そこで、2005 年の段階で「吸わない」と回答した者の過去の喫煙状況を質問票を遡って調査したところ、39 名には過去に喫煙経験があることが判明した。本研究では、この 39 名を過去喫煙者に分類し、喫煙者 135 名（24.7%）、過去喫煙者 251 名（45.9%）、非喫煙者 161 名（29.4%）として解析を行った（図 1）。

2. 喫煙本数および喫煙年数別にみた現在歯数

現在歯数は非喫煙者の 21.1±0.6 歯と比較して、喫煙者は 19.0±0.7 歯、過去喫煙者は 18.8±0.5 歯で、それぞれ有意に少なかった（図 2)。現在歯数が 20 歯未満か否かを目的変数としたロジスティック回帰解析を行った結果、喫煙者あるいは過去喫煙者でタバコを 1 日 21 本以上吸う者では、現在歯数が 20 歯未満となるリスク、すなわち 8020 が達成できないリスクは、非喫煙者の約 2 倍であった（図 3)。また、喫煙年数が 41 年以上の喫煙者の現在歯数が 20 歯未満となるリスクは約 2 倍、31 年以上喫煙していた過去喫煙者では約 3 倍と高くなっていた（図 4)。喫煙者、過去喫煙者ともに、喫煙本数、喫煙年数が増加すると、現在歯数が 20 歯未満となるリスクは上昇した。

3. 禁煙年数別にみた現在歯数

過去喫煙者では、禁煙年数が長くなるほど現在歯数は多くなり、21 年以上禁煙している者の平均現在歯数は 20 歯以上であった（図 5)。現在歯数が 20 歯未満となるリスクは、非喫煙者と比べると、禁煙年数が 10 年以下では 3.0 倍、11-20 年では 2.7 倍と有意に高かったが、禁煙年数が 21 年以上になると非喫煙者との間にリスクの差は認められなかった（図 6)。

【考察】

本研究により、8020 が達成できるか否かをみるうえで喫煙状況が大きく影響していることが明らかになった。喫煙本数が多いほど、また、喫煙年数が長いほど現在歯数は少なくなり、20 歯未満となるリスクが高くなった。しかし、喫煙者であっても、禁煙することで現在歯数が 20 歯未満となるリスクは低減することが明らかになった。特に、21 年以上禁煙した場合のリスクは、非喫煙者と同等のレベルであった。したがって、喫煙しないこと、また、喫煙している場合には禁煙することが歯の喪失を防止し、8020 を達成するために有効であることが明らかになった。

本研究では、「現在、タバコは吸っていない」と回答した者のうち、約 20%に過去に喫煙経験があることが判明した。禁煙期間が長くなると、自分が過去にタバコを吸っていたことを忘れるか、吸っていなかったとする傾向があると考えられた。本研究は多目的コホート研究と共同で行われたので、対象者の喫煙歴を過去に遡って確認でき、喫煙状況をより正確に分類してリスクを計算することができた。

日本において、喫煙者に対する禁煙支援は主に医師が行っている。しかし、歯科専門家が禁煙支援を行う場合、全身疾患の症状がまだ現れていない早い段階で対応できるという大きな利点がある。また、口腔内や喫煙に関連した口腔疾患の兆候は自分自身で直接確認することができるため、禁煙への動機付けが行いやすいと考えられる。8020 を達成するためには喫煙しないこと、また、喫煙者であっても 21 年以上禁煙することで、非喫煙者と

ほぼ同等のレベルになることが、本研究によって明らかになった。今後、歯科の専門家が医科と連携して積極的に禁煙支援を行っていく上で、一つの指標となると考えられた。

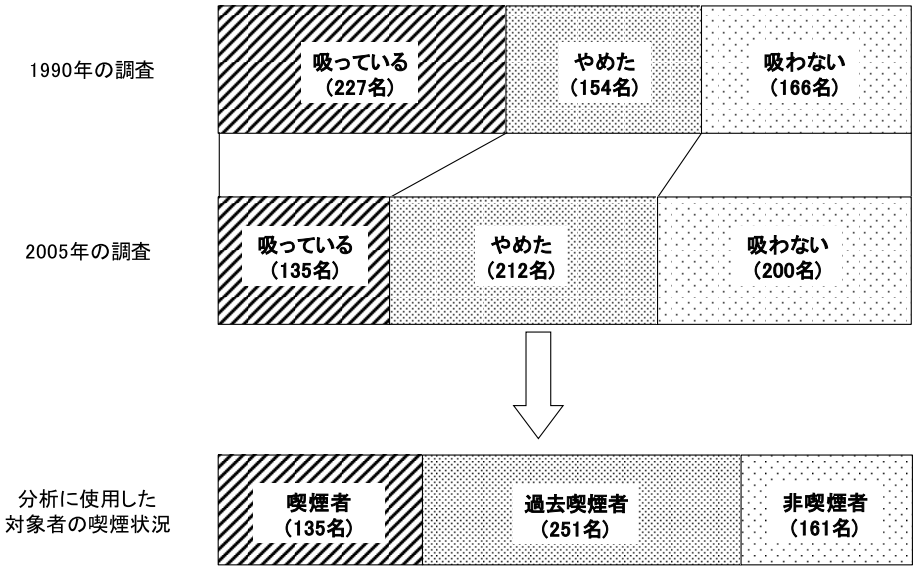


図１　喫煙状況

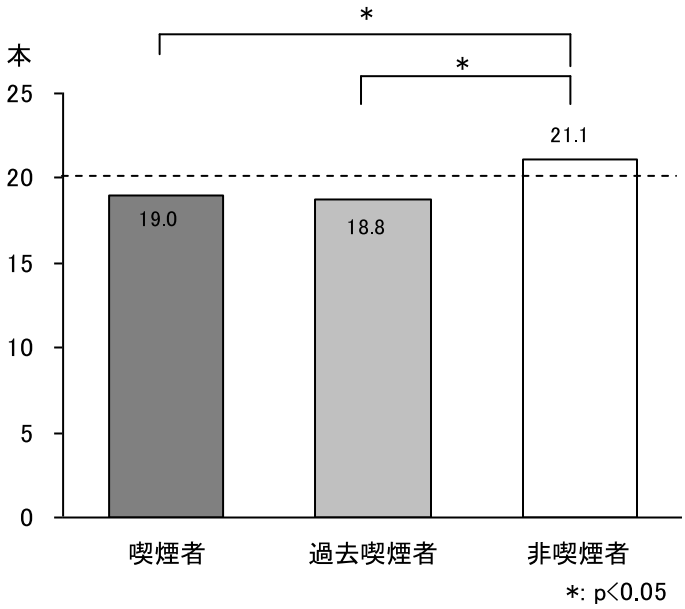


図２　喫煙状況別の平均現在歯数

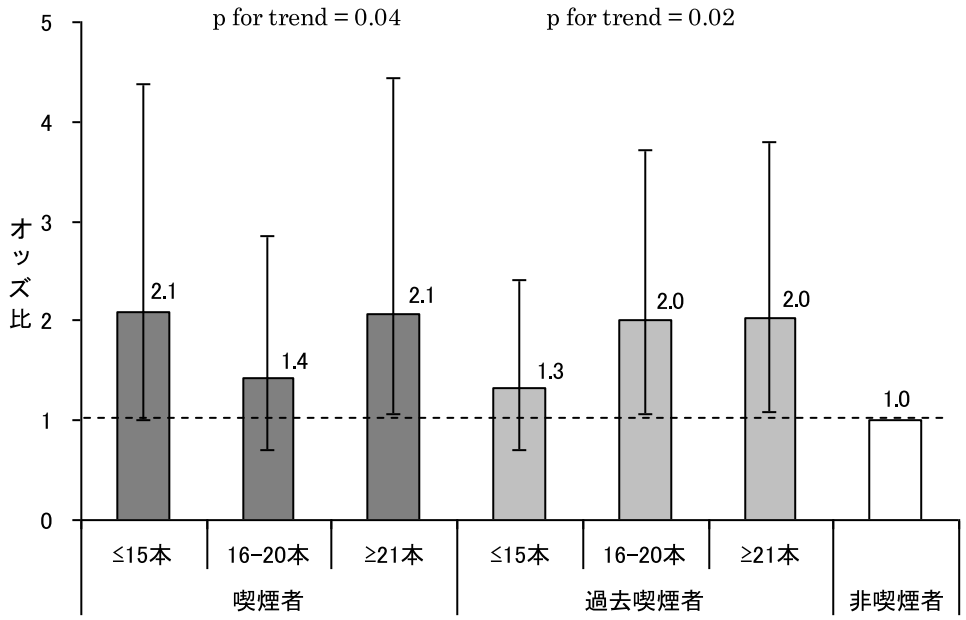


図 3　喫煙本数別にみた現在歯数が 20 歯未満となるリスク

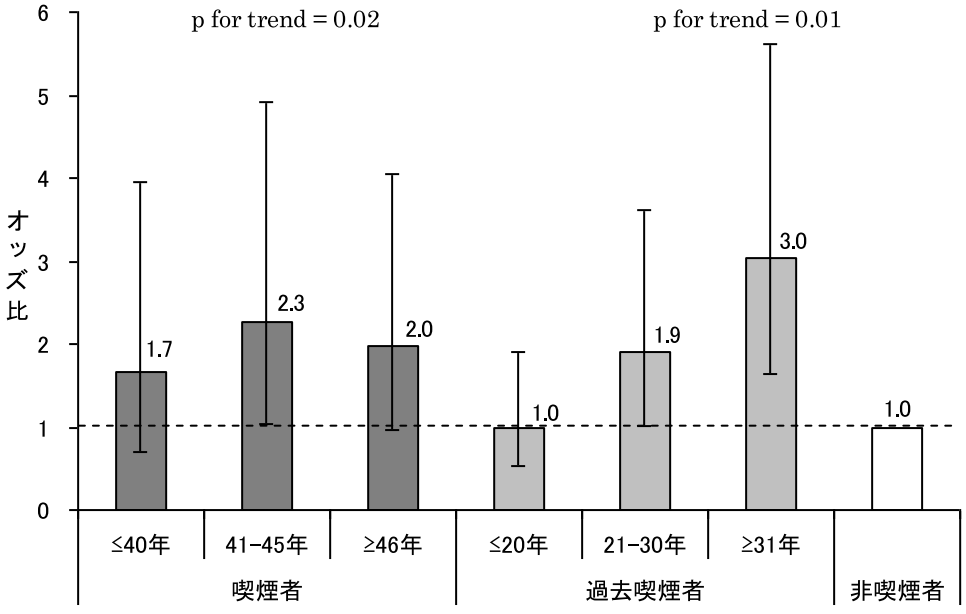


図 4　喫煙年数別にみた現在歯数が 20 歯未満となるリスク

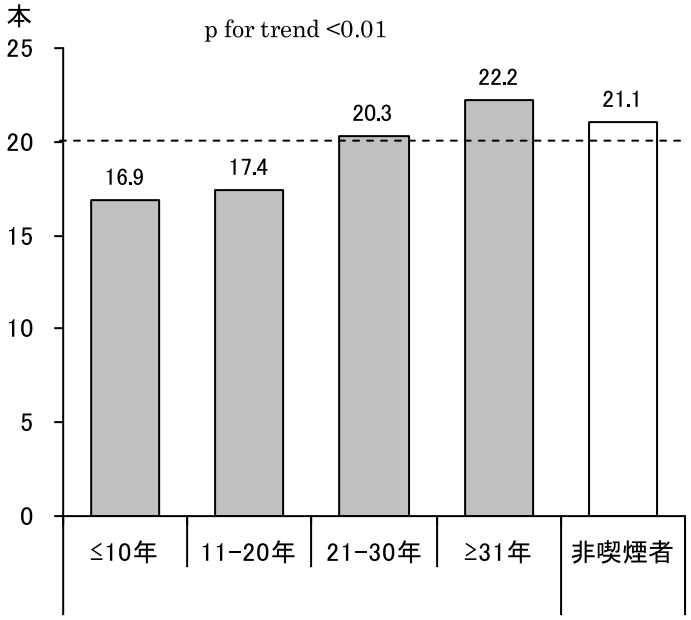


図 5　過去喫煙者における禁煙年数別にみた平均現在歯数

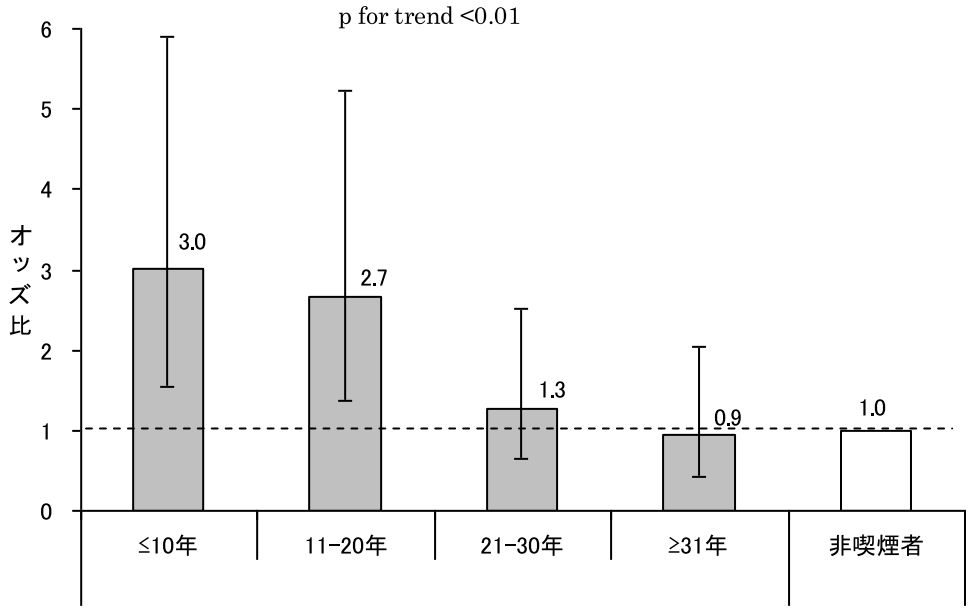


図 6　過去喫煙者における禁煙年数別にみた現在歯数が 20 歯未満となるリスク

Ⅳ．喫煙および禁煙状況と口腔保健状況との関連

Yanagisawa T, Ueno M, Shinada K, Ohara S, Wright C, Kawaguchi Y. Relationship of smoking and smoking cessation with oral health status in Japanese men. J Periodont Res 2010; 45: 277-283.

【背景と目的】

喫煙が肺がんや心疾患、脳血管障害などの全身疾患のリスクを高めること、また、禁煙することでそれらのリスクが低くなることが報告されている。歯科領域でも、歯の喪失に関して、禁煙によりそのリスクが低下することが報告されている。一方、歯の喪失の主要な原因とされる歯周疾患については、これまで「喫煙が歯周疾患罹患リスクを高める」という報告は行われているが、禁煙が歯周疾患罹患リスクの低減にどのように影響するかを明らかにした報告はほとんどない。本研究では、喫煙・禁煙状況と現在歯数および歯周疾患の罹患状況などの口腔保健状況との関連について検討を行った。

【方法】

2005~2007 年に歯科健診を受診した秋田県横手保健所管内の 40~75 歳の住民 2,681 名（男性 1,094 名、女性 1,587 名）を対象とした。そのうち、女性は喫煙率が低かったため除外し、質問票調査へ有効な回答をした有歯顎者の男性 1,058 名を解析対象とした。歯科医師による口腔内診査により歯および歯周組織の状況を調査した。歯周疾患罹患の有無については、残存歯全ての歯周ポケットを測定し、1 歯以上 6mm 以上の歯周ポケットがある者を、歯周疾患を有する者と定義した。解析では、喫煙状況により、対象者を喫煙者、過去喫煙者、非喫煙者の 3 群に分け、共分散分析を用い年齢、歯科保健行動などを調整し現在歯数を算出した。また、9 歯以上の喪失歯の有無および歯周疾患罹患の有無を目的変数に、喫煙状況、喫煙本数、禁煙年数を説明変数としたロジスティック回帰解析（年齢、歯科保健行動などを調整）を行い、喫煙および禁煙状況と口腔保健状況との関連について検討を行った。

【結果】

1．喫煙状況および現在歯数

対象者の喫煙状況は、喫煙者 317 名（29.1%）、過去喫煙者 421 名（38.7%）、非喫煙者 350 名（32.2%）であった。

9 歯以上歯を喪失している者の平均年齢は 65.8±7.6 歳、8 歯以下歯を喪失している者は 57.3±9.3 歳であり、有意な差がみられた。また、歯周疾患罹患者の平均年齢は 60.7±9.3 歳、非罹患者は 59.2±9.8 歳で、有意な差がみられた。

2. 喫煙本数別にみた現在歯数

現在歯数を目的変数とした共分散分析を行った結果､喫煙者でタバコを 1 日 15 本以下、16-20 本、21 本以上吸う者の現在歯数は、21.8±0.5 歯、21.2±0.7 歯、21.1±0.7 歯であった。一方、過去喫煙者でタバコを 1 日 15 本以下、16-20 本、21 本以上吸う者の現在歯数は、21.9±0.6 歯、20.3±0.5 歯、21.3±0.6 歯であり、喫煙者、過去喫煙者ともに喫煙本数と現在歯数との間に関連は認められなかった（図 1)。

9 歯以上の喪失歯の有無を目的変数としたロジスティック回帰解析を行った結果、喫煙者は 9 歯以上喪失するリスクが非喫煙者の約 1.7 倍であった。また、喫煙者でタバコを 1 日 21 本以上吸う者では､9 歯以上喪失するリスクが非喫煙者の約 2.3 倍であった｡さらに、過去喫煙者でタバコを 1 日 16-20 本吸う者では、9 歯以上喪失するリスクは、非喫煙者の約 1.7 倍であった（図 2)。

3. 喫煙本数別にみた歯周疾患罹患状況

歯周疾患を有する者は喫煙者が 31.1%、過去喫煙者が 26.2%、非喫煙者が 23.1%であった｡また喫煙者では喫煙本数が多い者ほど､歯周疾患を有する者の割合が高かった（図 3)。

歯周疾患罹患の有無を目的変数としたロジスティック回帰解析を行った結果、喫煙者でタバコを 1 日 21 本以上吸う者では､歯周疾患罹患のリスクは､非喫煙者の約 2.5 倍､16-20 本吸う者では約 1.8 倍であった（図 4)。過去喫煙者と非喫煙者との間にリスクの差は認められなかった。

4. 禁煙年数別にみた現在歯数

過去喫煙者において、禁煙年数が 10 年以下の者は禁煙年数が 31 年以上の者に比べ 3.9 歯、現在歯数が少なかった。禁煙年数が長くなるほど現在歯数が有意に多かった（図 5)。

また､禁煙年数が 10 年以下の者は､9 歯以上喪失するリスクは非喫煙者の約 2 倍であった｡禁煙年数が 11 年以上になると非喫煙者との間にリスクの差は認められなかった(図 6)。

5. 禁煙年数別にみた歯周疾患罹患

過去喫煙者の中で、歯周疾患を有する者は、禁煙年数が 10 年以下の者で 32.9%、11 年以上の者で約 20%であった（図 7)。

また、過去喫煙者では、禁煙年数が長くなるほど歯周疾患罹患の割合が減少し、歯周疾患罹患のリスクは､非喫煙者と比べると､禁煙年数が 10 年以下では 1.9 倍と有意に高かったが､禁煙年数が 11 年以上になると非喫煙者との間にリスクの差は認められなかった（図 8)。

【考察】

本研究により、現在歯数や歯周疾患罹患について喫煙が大きなリスクとなることが明ら

かになった。歯周疾患は齲蝕と並び、歯の喪失の大きな原因とされている。すなわち、喫煙は 8020 を達成する際の大きな阻害因子になってる。一般的に、年齢や口腔清掃状態は歯周疾患罹患状況に関連があるとされている。そこで本研究では、解析の際に年齢や口腔清掃状態による影響を調整して、喫煙のリスクを計算した。したがって、口腔清掃状態や年齢に関係なく、喫煙は歯の喪失および歯周疾患罹患のリスク要因であると言える。しかし、喫煙者であっても、禁煙することで歯の喪失や歯周疾患に罹患するリスクは低減することも判明した。特に、11 年以上禁煙した場合のリスクは、非喫煙者と同等のレベルになっていた。これらのことから、喫煙しないこと、また、喫煙している場合には禁煙することが歯周疾患罹患を防止でき、それによって歯の喪失が減少し、8020 を達成するために有効であることが明らかになった。

本研究の結果、歯科的にみても、禁煙を推奨すること、また喫煙を止めた場合はその状態を継続することが重要と考えられた。近年、糖尿病をはじめとする全身疾患と口腔との関連が示唆されている。歯科の専門家の場合、口腔清掃指導だけでなく禁煙指導を行うことで口腔保健の向上に寄与でき、そのことが全身の健康の維持につながると考えられる。こうした観点から、今後の医療施策の中で、現在医師が主体で行っている禁煙指導において、歯科専門家が大きな役割を果たしていくことが重要になってくると考えられた。

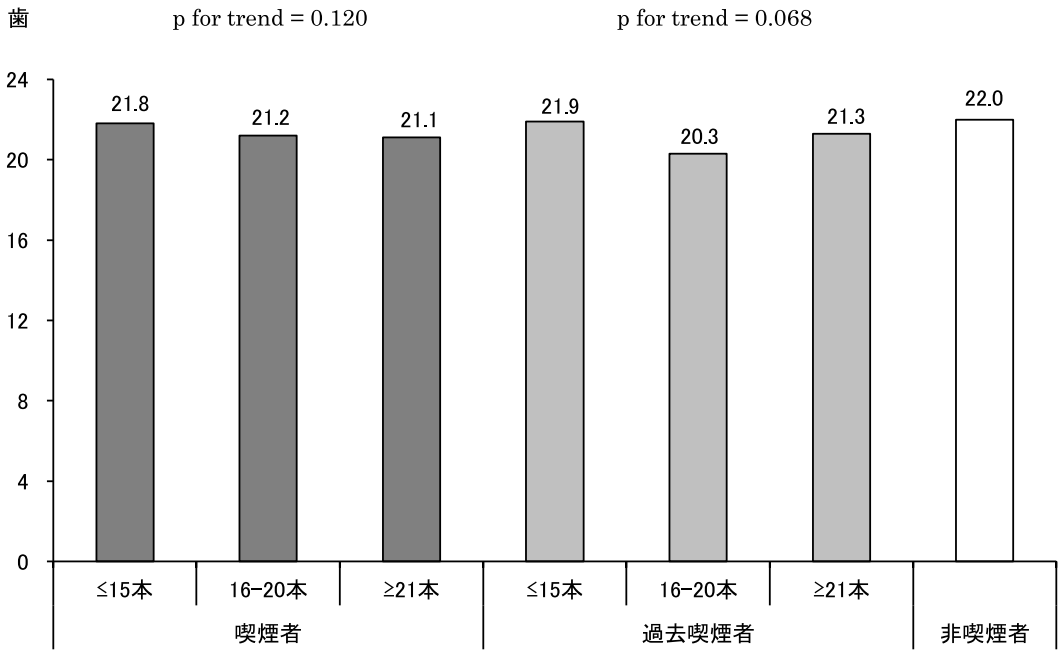


図 1　喫煙本数別にみた現在歯数

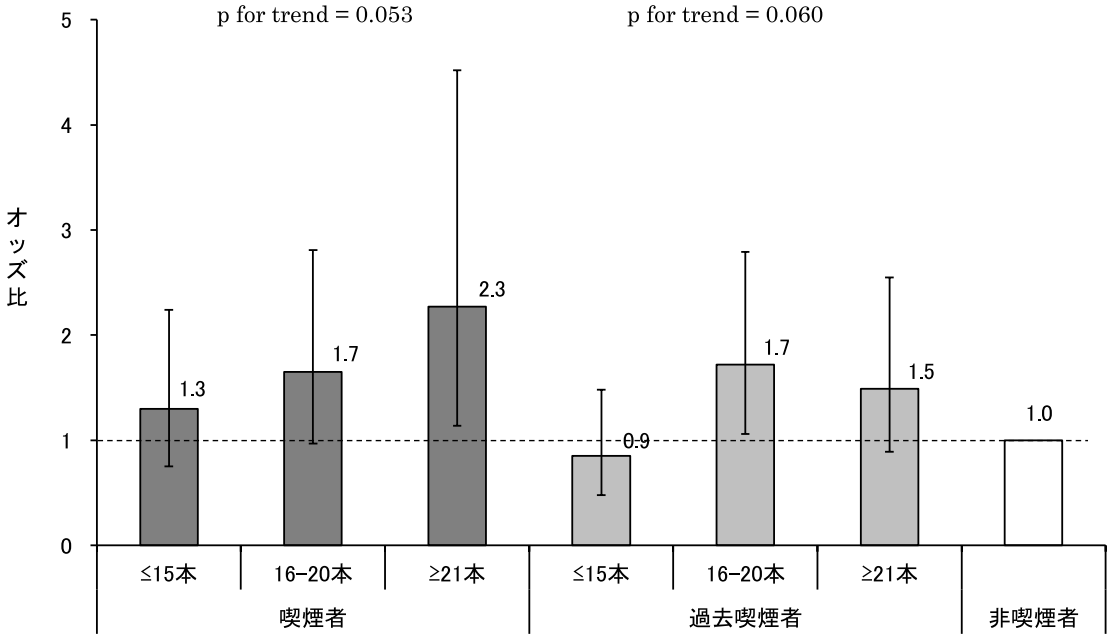


図 2　喫煙本数別にみた 9 歯以上喪失するリスク

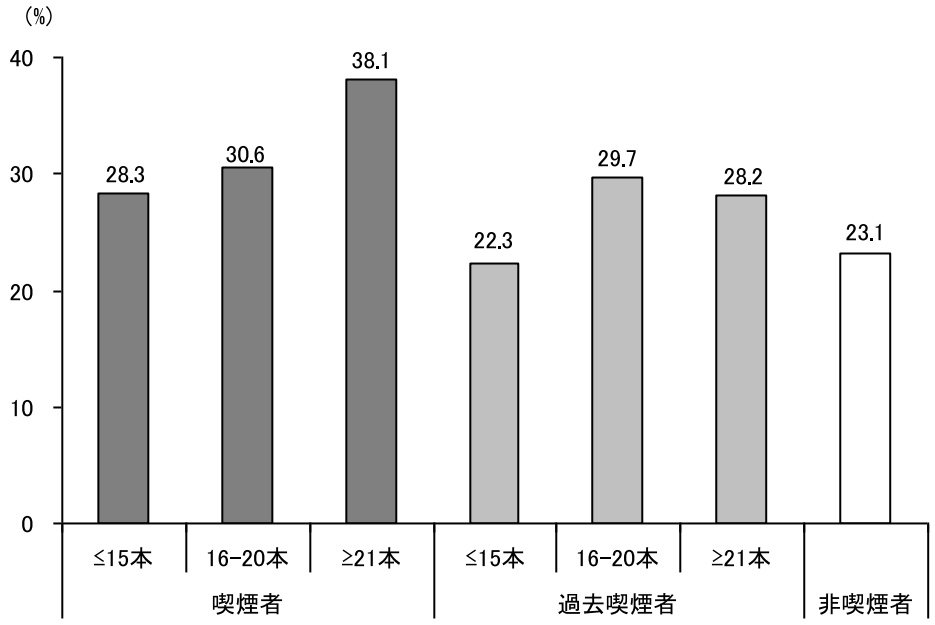


図 3　喫煙本数別にみた歯周疾患罹患状況

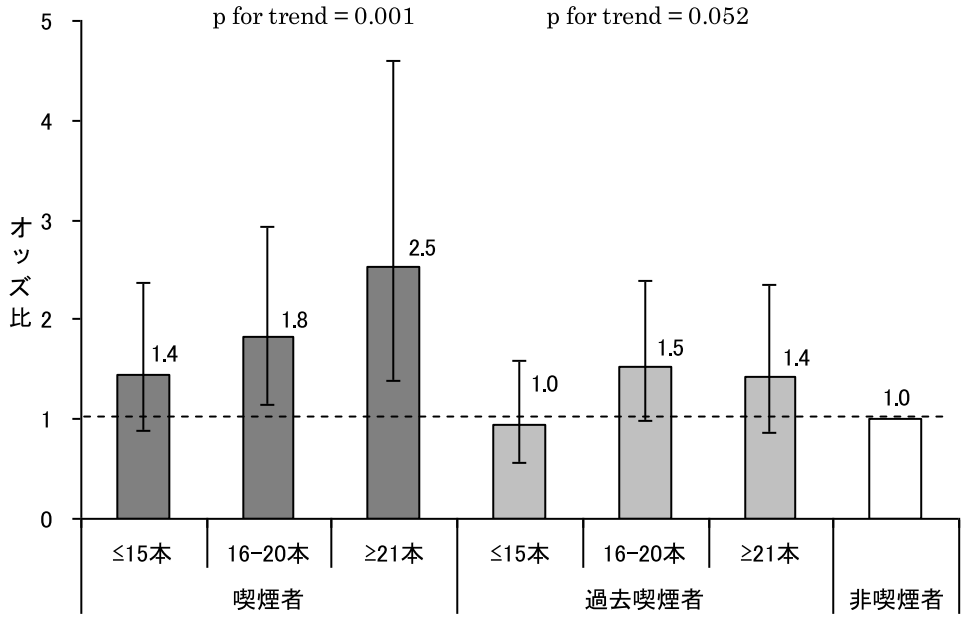


図 4　喫煙本数別にみた歯周疾患に罹患するリスク

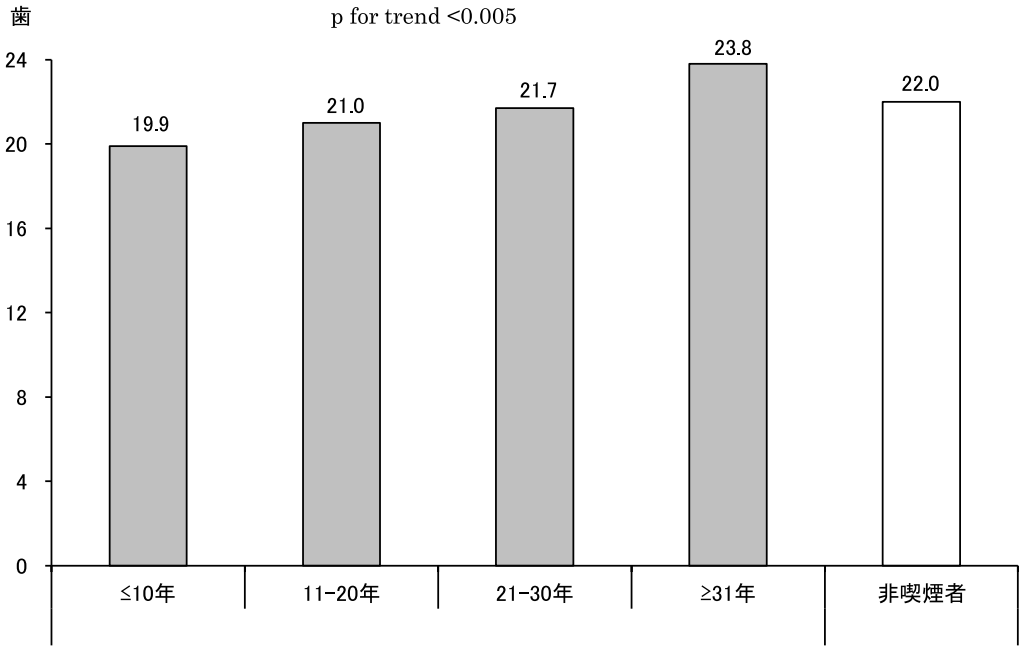


図 5　禁煙年数別にみた現在歯数

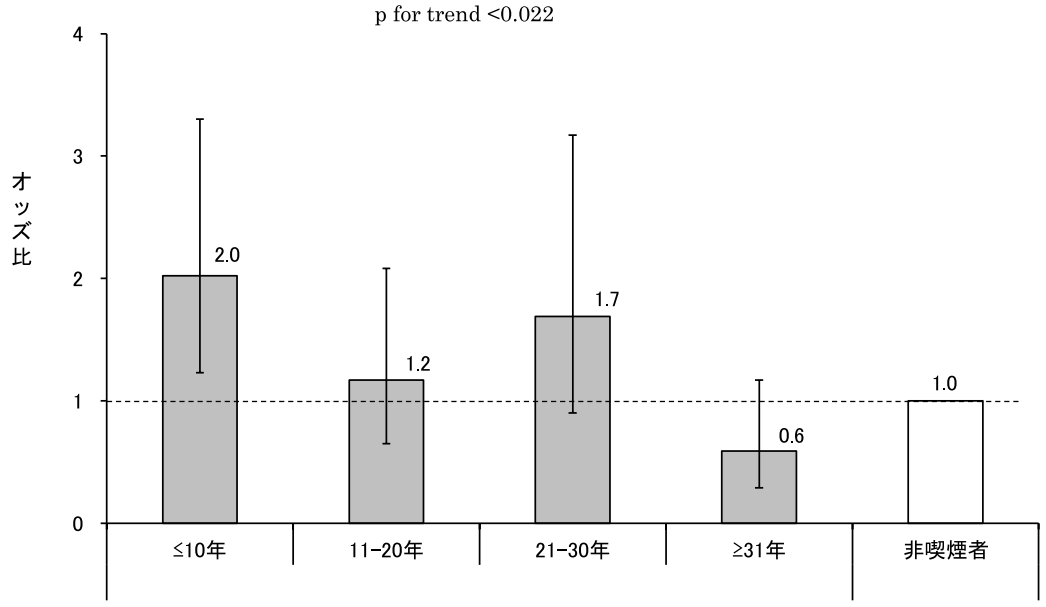


図 6　禁煙年数別にみた 9 歯以上喪失するリスク

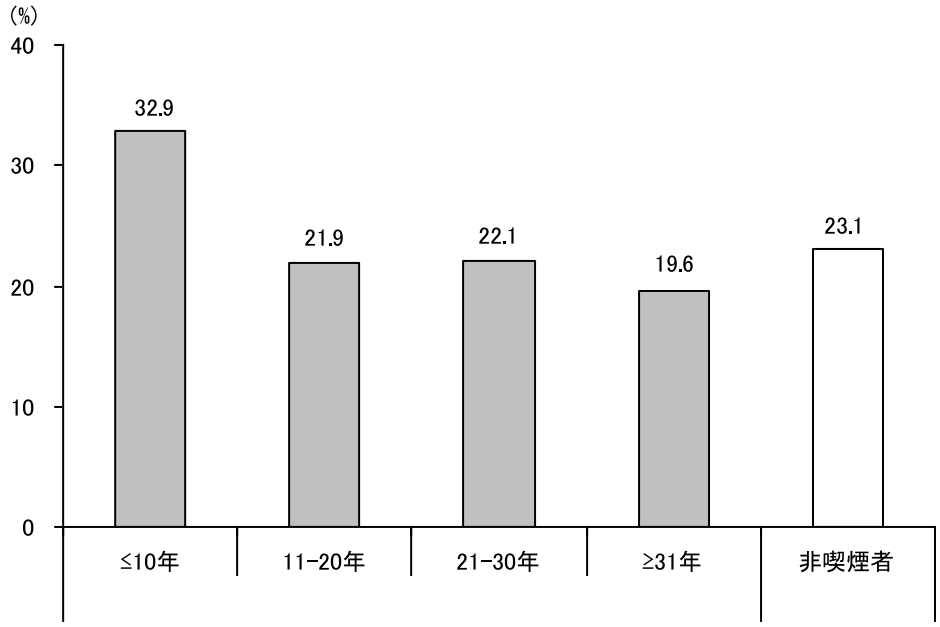


図 7　禁煙年数別にみた歯周疾患罹患状況

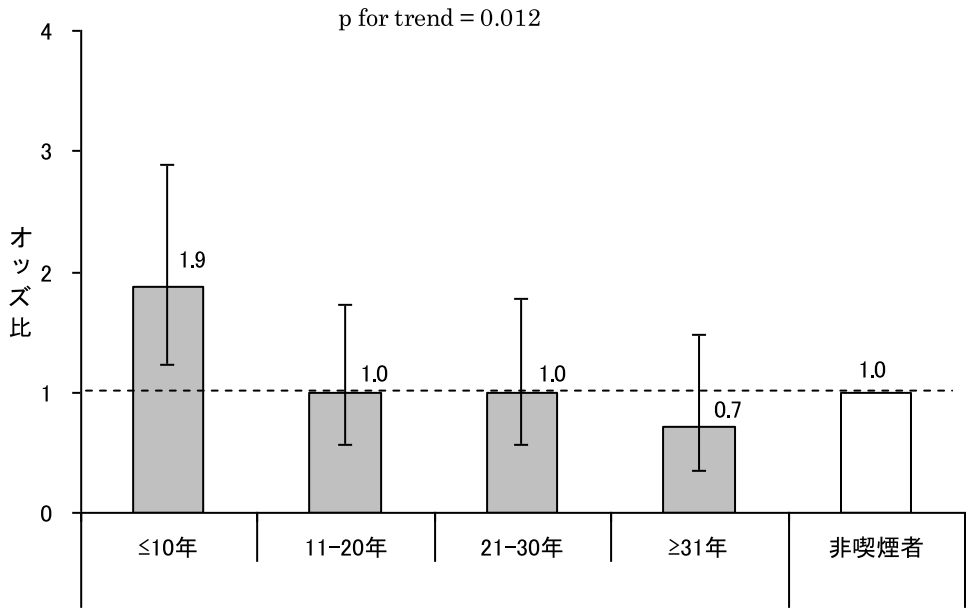


図 8　禁煙年数別にみた歯周疾患に罹患するリスク

Ⅴ．機能歯ユニットと咀嚼能力との関連

Ueno M, Yanagisawa T, Shinada K, Ohara S, Kawaguchi Y. Masticatory ability and functional tooth units in Japanese adults. J Oral Rehabil 2008; 35: 337–344.

【背景と目的】

生涯にわたり自分の歯をできるだけ多く保有することは咀嚼能力を維持していく上で重要である。現在、8020 を達成するためのさまざまな取組みが各地域で行われており、20 歯以上自分の歯を有することの重要性が人々に伝えられている。しかし、20 歯以上の歯を所有していても、その歯が残根状態（C4）であったり、重度の歯周病が原因で大きく動揺している場合には、咀嚼、発音、審美性など歯としての大切な機能を十分果たすことはできない。そこで、本研究では咀嚼機能に注目して、現在歯数および臼歯部の咬合状況を示す機能歯ユニット（FTU: Functional Tooth Unit）と咀嚼能力との関連、さらに十分な咀嚼能力を維持するために必要最小限の現在歯数と機能歯ユニット数について検討を行った。

【方法】

1．対象者

秋田県横手市の住民で、2005~2006 年に歯科健診および質問票調査を実施した 40~75 歳の男性 916 名（61.7±8.8 歳）、女性 1,248 名（59.8±9.2 歳）、計 2,164 名を対象とした。歯科健診は横手市（現横手）歯科医師会と平鹿郡（現ひらか）歯科医師会の協力を得て、各歯科診療所にて行った。歯科健診の結果より現在歯数および FTU を算出し、質問票調査で山本式咀嚼能力テストを実施した。

2．機能歯ユニット（FTU）

本研究では、臼歯部（第 3 大臼歯は除く）の咬合状況を評価する指標として、FTU を使用した（図 1）。FTU の算出方法は、上下顎の同名大臼歯が 2 歯揃っている場合は 2、上下顎の同名小臼歯が 2 歯揃っている場合は 1、片顎の臼歯のみ存在している場合や上下顎ともに臼歯がない場合は 0 と評価する。したがって、FTU の最小値は 0、最大値は 12 となる。FTU は現在歯だけでなく、補綴物も含めたすべての機能歯で評価を行う。健全歯、C1～C3 の齲歯、充填歯、義歯やクラウンなどの補綴歯、ブリッジのポンティック、インプラントは機能歯、C4 の齲歯、喪失歯、先欠歯は非機能歯とする。

FTU は通常、臼歯部の咬合状況を機能歯すべてを含め評価するが、本研究では、FTU を構成している機能歯を以下の 3 つに分類して検討を行った。①現在歯（natural teeth）のみで評価した n-FTU、②現在歯と固定性補綴物（natural, implanted and fixed prosthetic teeth）を合わせて評価した nif-FTU、③現在歯と固定性補綴物および可撤性補綴物、すなわち通常のすべての機能歯（total）をまとめて評価した total-FTU。

3. 山本式咀嚼能力テスト

咀嚼能力を評価する方法には、ピーナッツなどの食品を実際に噛んでもらう方法、咬合力計や咀嚼筋測定計などの器具を使う方法などがあるが、疫学調査などで大勢の人を対象とする場合、日本では山本式咀嚼能力テストが広く使用されている。本研究では、山本式咀嚼能力テストの中から、硬さの異なる 15 種類の食品（ピーナッツ、堅焼せんべい、たくわん、するめ、貝柱の干物、酢だこ、フランスパン、ビフテキ、らっきょう、イカの刺身、こんにゃく、ちくわ、うなぎの蒲焼き、マグロの刺身、ごはん）を選び、それぞれについて噛めるか否か、質問票を利用して調査した。

4. 統計分析

年齢階級別、性別に現在歯数、臼歯数、n-FTU、nif-FTU、total-FTU の平均値の比較を行った。また、山本式咀嚼能力テストの食品別に噛める群と噛めない群の 2 群に分けて現在歯数および FTU の比較を行った。さらに、山本式咀嚼能力テストの 15 食品をすべて噛めると回答した者と、1 つでも噛めない食品があると回答した者の 2 群に分け、現在歯数、n-FTU、nif-FTU、total-FTU の比較を行った。比較は、共分散分析により年齢・性別を調整して行った

【結果】

1. 現在歯数

40～59 歳、50～59 歳、60～69 歳、70～75 歳の性別の一人平均現在歯数を図 2 に示す。男性はそれぞれ 25.9 歯、23.3 歯、20.7 歯、15.9 歯、女性は 25.8 歯、23.3 歯、19.0 歯、13.3 歯で、男女とも年齢が高くなるにしたがい、現在歯数は少なくなった。どの年齢層においても女性は男性より低い値を示し、60～69 歳と 70～75 歳では性別で有意差が認められた。

2. 臼歯数

40～49 歳、50～59 歳、60～69 歳、70～75 歳の男女別の臼歯数を図 3 に示す。男性はそれぞれ 14.3 歯、12.4 歯、10.9 歯、8.1 歯、女性は 14.1 歯、12.4 歯、9.5 歯、6.3 歯と、年齢が高くなるにしたがい、臼歯数は少なくなった。また、どの年齢層においても女性は男性に比べ低い値を示し、60～69 歳と 70～75 歳では性別で有意差が認められた。

3. 年齢階級別および性別の 3 種類の FTU の比較

40～49 歳、50～59 歳、60～69 歳、70～75 歳の n-FTU は、男性ではそれぞれ 9.4、7.2、5.9、3.7、女性では 9.2、7.1、4.8、2.5 であり、男女とも年齢が上がるにしたがい、n-FTU は減少していた（図 4）。

40～49 歳、50～59 歳、60～69 歳、70～75 歳の nif-FTU は、男性ではそれぞれ 10.2、8.3、6.7、4.5、女性では 10.2、8.2、5.6、3.2 であり、男女とも年齢が上がるにしたがい、nif-FTU は減少していた（図 5）。

40～49 歳、50～59 歳、60～69 歳、70～75 歳の total-FTU は、男性ではそれぞれ 10.6、10.0、10.3、10.2、女性では 10.4、9.7、10.0、10.5 であり、いずれの年齢層においても約 9～10 とほとんど差はみられなかった（図 6）。

また、どの年齢層においても n-FTU、nif-FTU、total-FTU に性別による差は認められなかった。

5. 山本式咀嚼能力テストと現在歯数および FTU

山本式咀嚼能力テストの 15 種類の食品別に、噛めるか否かの 2 群に分け、年齢・性別を調整して現在歯数を比較した。その結果、すべての食品において「噛める（○）」と回答した者は、「噛めない（×）」と回答した者より一人平均現在歯数は多く、マグロの刺身、ごはん以外の 13 食品で「噛める」と回答した者の現在歯数は、「噛めない」と回答した者に比べ有意に高い値を示した（図 7）。

咀嚼能力テストの各食品について、噛める群と噛めない群の現在歯数を比較すると、ピーナッツ（○：21.6 歯、×：13.6 歯）、堅焼きせんべい（○：22.0 歯、×：15.1 歯）、たくあん（○：21.6 歯、×：13.1 歯）、するめ（○：23.0 歯、×：15.3 歯）、貝柱の干物（○：22.4 歯、×：16.0 歯）、酢だこ（○：22.3 歯、×：15.2 歯）、フランスパン（○：21.9 歯、×：16.1 歯）、ビフテキ（○：21.6 歯、×：15.6 歯）、らっきょう（○：21.1 歯、×：15.8 歯）、イカの刺身（○：21.3 歯、×：15.3 歯）、こんにゃく（○：20.9 歯、×：16.7 歯）、ちくわ（○：20.8 歯、×：17.5 歯）、うなぎの蒲焼き（○：20.9 歯、×：18.4 歯）、マグロの刺身（○：20.7 歯、×：19.3 歯）、ごはん（○：20.7 歯、×：18.9 歯）で、噛める群の現在歯数はすべて 20 歯を超えていた。

FTU に関しては、すべての食品において「噛める（○）」と回答した者は、「噛めない（×）」と回答した者より total-FTU は多く、マグロの刺身、ごはん以外の 13 食品で「噛める」と回答した者の total-FTU は、「噛めない」と回答した者に比べ有意に高い値を示した（図 8）。

咀嚼能力テストの各食品について、噛める群と噛めない群の total-FTU を比較すると、ピーナッツ（○：10.2 歯、×：9.4 歯）、堅焼きせんべい（○：10.3 歯、×：9.4 歯）、たくあん（○：10.2 歯、×：9.7 歯）、するめ（○：10.3 歯、×：9.8 歯）、貝柱の干物（○：10.3 歯、×：9.7 歯）、酢だこ（○：10.3 歯、×：9.8 歯）、フランスパン（○：10.3 歯、×：9.7 歯）、ビフテキ（○：10.2 歯、×：9.8 歯）、らっきょう（○：10.2 歯、×：9.2 歯）、イカの刺身（○：10.2 歯、×：9.8 歯）、こんにゃく（○：10.2 歯、×：9.1 歯）、ちくわ（○：10.2 歯、×：8.8 歯）、うなぎの蒲焼き（○：10.2 歯、×：9.7 歯）、マグロの刺身（○：10.1 歯、×：9.9 歯）、ごはん（○：10.1 歯、×：9.3 歯）で、噛める群の total-FTU

はすべて 10 を超えていた。

山本式咀嚼能力テストの 15 食品をすべて噛めると回答した者の年齢・性別を調整した現在歯数は 23.4 歯で、1 つでも噛めない食品があると回答した者の 17.2 歯と比較して、有意に高い値を示した。

同様に、年齢・性別を調整した 3 種類の FTU では、n-FTU は 15 食品をすべて噛めると回答した者は 7.6、1 つでもかめない食品があると回答した者は 4.0、nif-FTU はそれぞれ 8.6、4.7、total-FTU は 10.4、9.8 であった。いずれも 2 群間に有意な差が認められた。

【考察】

米国では上下顎の臼歯部の咬合状況を簡単に評価できる指標として FTU が使用されており、これまで食物の摂取パターンや咀嚼能力と強く関連していることが報告されている。我が国では、これまで FTU を使用した疫学調査や FTU と咀嚼能力との関係を調べた研究はほとんど行われていない。そこで、成人および高齢者を対象として 3 種類の FTU の実態調査を行い、現在歯数や咀嚼能力との関連について分析を行った。

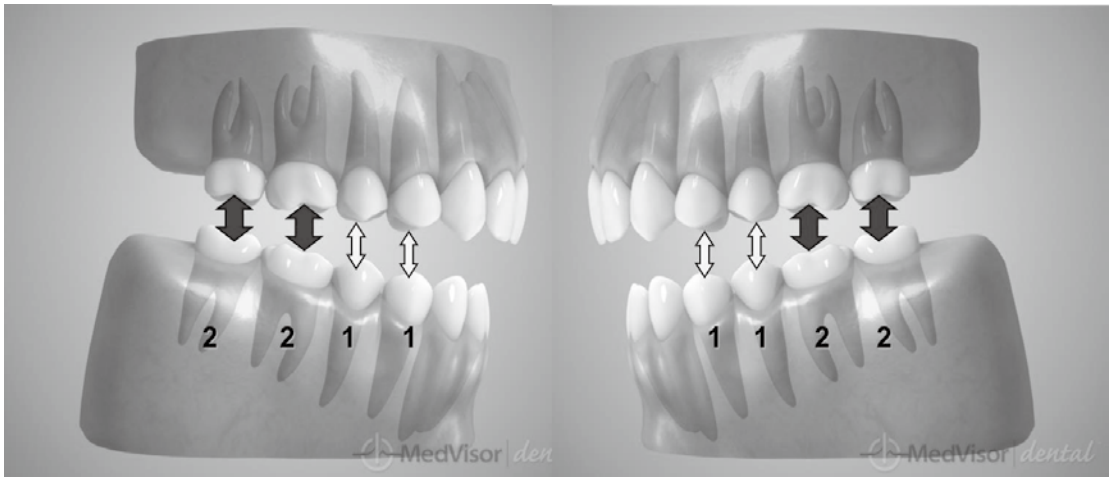
本研究の結果、年齢が上がるとともに現在歯数および臼歯数は減少していくが、total-FTU の値には年齢による差が認められないことが明らかになった。これは、対象者が歯科治療を受けて、歯の欠損部をブリッジ、インプラント、義歯などで修復し、咬合状況を回復していることを示している。性別による特徴では、男性と比較して女性の現在歯数、臼歯数は少ないにもかかわらず、FTU の値に性別差は認められず、女性は補綴処置をよく受けている傾向が認められた。

咀嚼能力と現在歯数との関連について調べたところ、各食品を噛めると回答した者の一人平均現在歯数はすべて 20 歯以上であった。また、山本式咀嚼能力テストの 15 食品をすべて噛めると回答した者の現在歯数も 20 歯を超えていた。したがって、自分の歯を少なくとも 20 歯以上保有することは、ほとんど全ての食品を噛むことができ、咀嚼能力において支障がないことを示す一つの指標になることが確認された。

一方、FTU においても各食品を噛めると回答した者の数値が有意に高く total-FTU はすべて 10 を超えていることが明らかになり、臼歯部の咬合状況が咀嚼能力に大きく影響を与えていることが示唆された。全食品噛める群と噛めない群の現在歯のみによる n-FTU の比較では 7.6 と 4.0、現在歯に固定性補綴物を加えた nif-FTU の場合には 8.6 と 4.7 と約 4 の差が認められたが、機能歯として義歯も加えた total-FTU の比較では、10.4 と 9.8 と、その差はわずか 0.6 しか認められなかった。したがって、義歯を装着して上下顎の臼歯部の咬合状況を回復しても、咀嚼能力を考えた場合には、義歯の適合状態やその機能状況を十分考慮しなければならないことが示唆された。

本研究により、生涯にわたり自分の歯を 20 歯以上保有することが咀嚼能力を維持していく上で重要であることが確認できた。また、FTU の結果から、歯の喪失が生じた場合には放置せず、積極的に歯科治療を行って咬合状態を回復することが大切であるが、その場

合に、義歯よりブリッジやインプラントなどの固定性補綴物で咬合を回復したほうが、咀嚼能力を維持する上で効果的であることが示唆された。



０：上下顎の同名臼歯なし

１：上下顎の同名小臼歯の存在

２：上下顎の同名大臼歯の存在

図１　機能歯ユニットの模式図

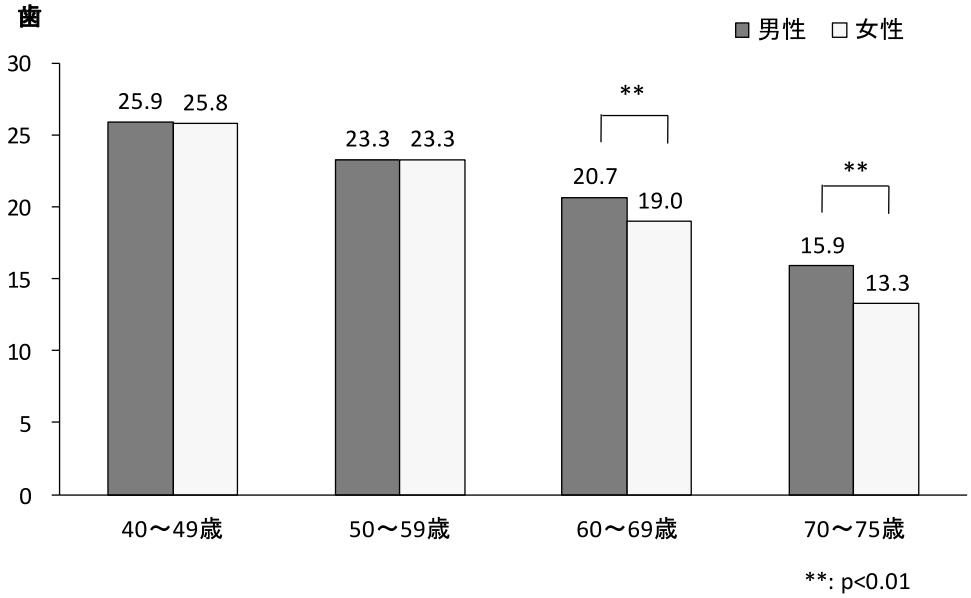


図２　年齢階級別、性別の現在歯数

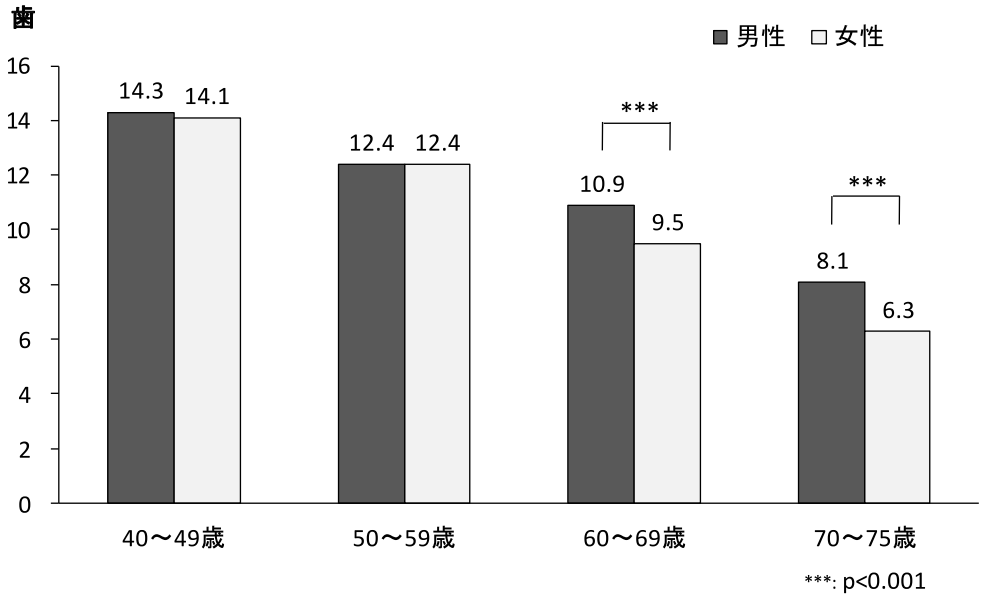


図 3　年齢階級別、男女別の臼歯数

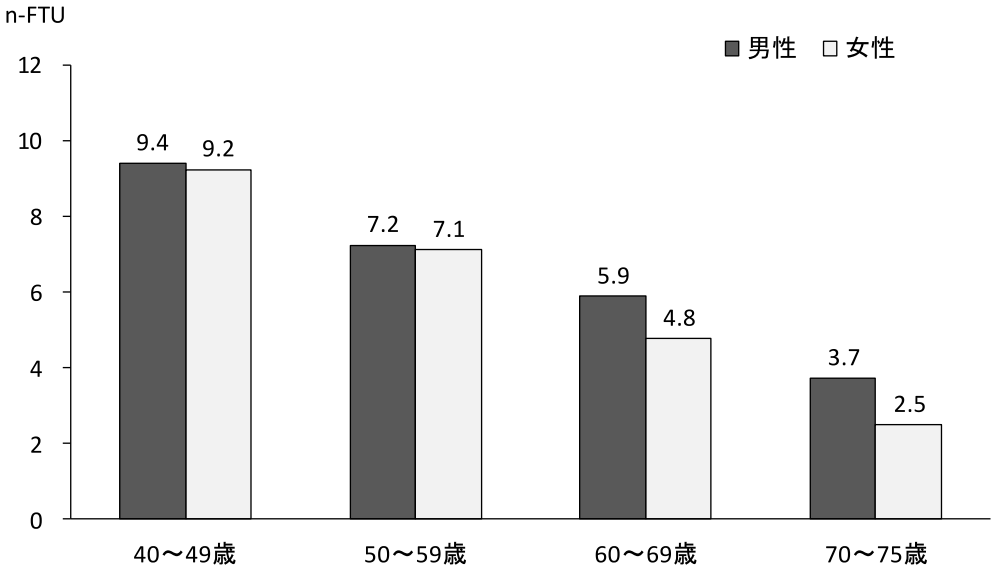


図 4　年齢階級別、性別の n-FTU

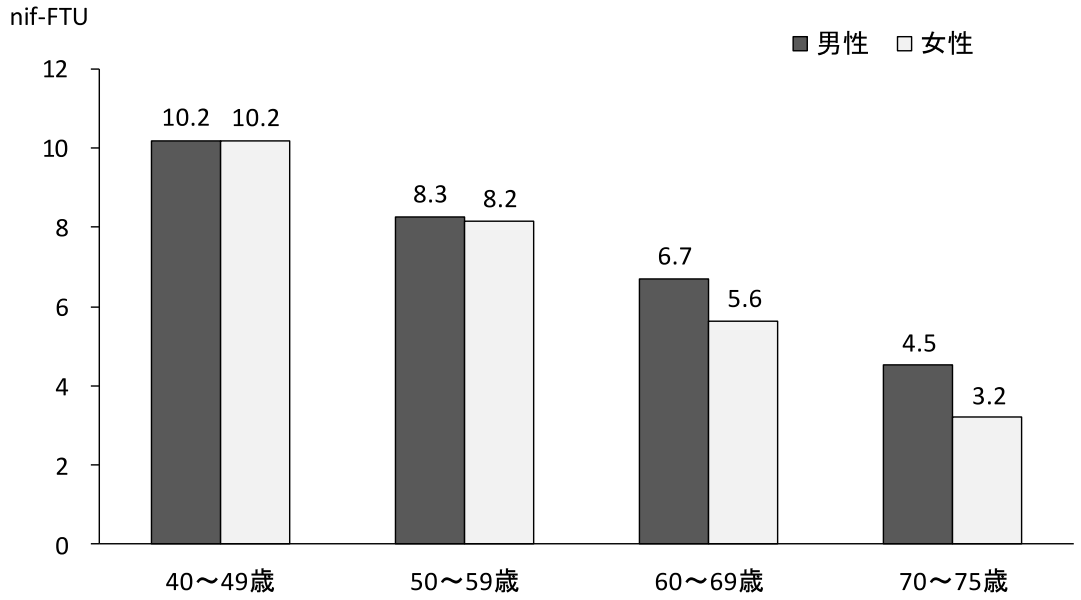


図 5　年齢階級別、性別の nif-FTU

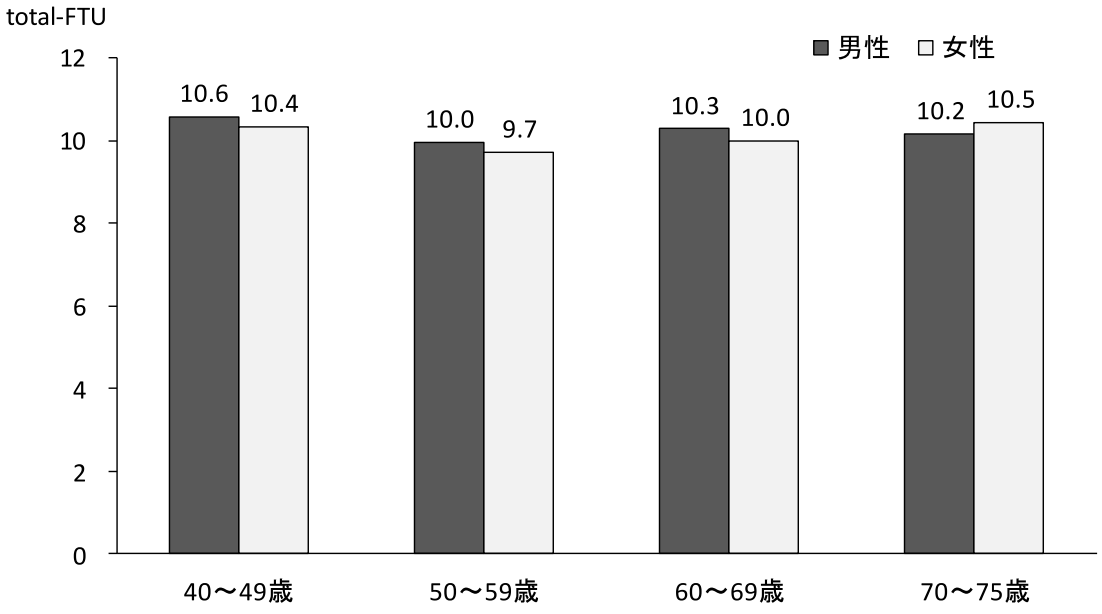


図 6　年齢階級別、性別の total-FTU

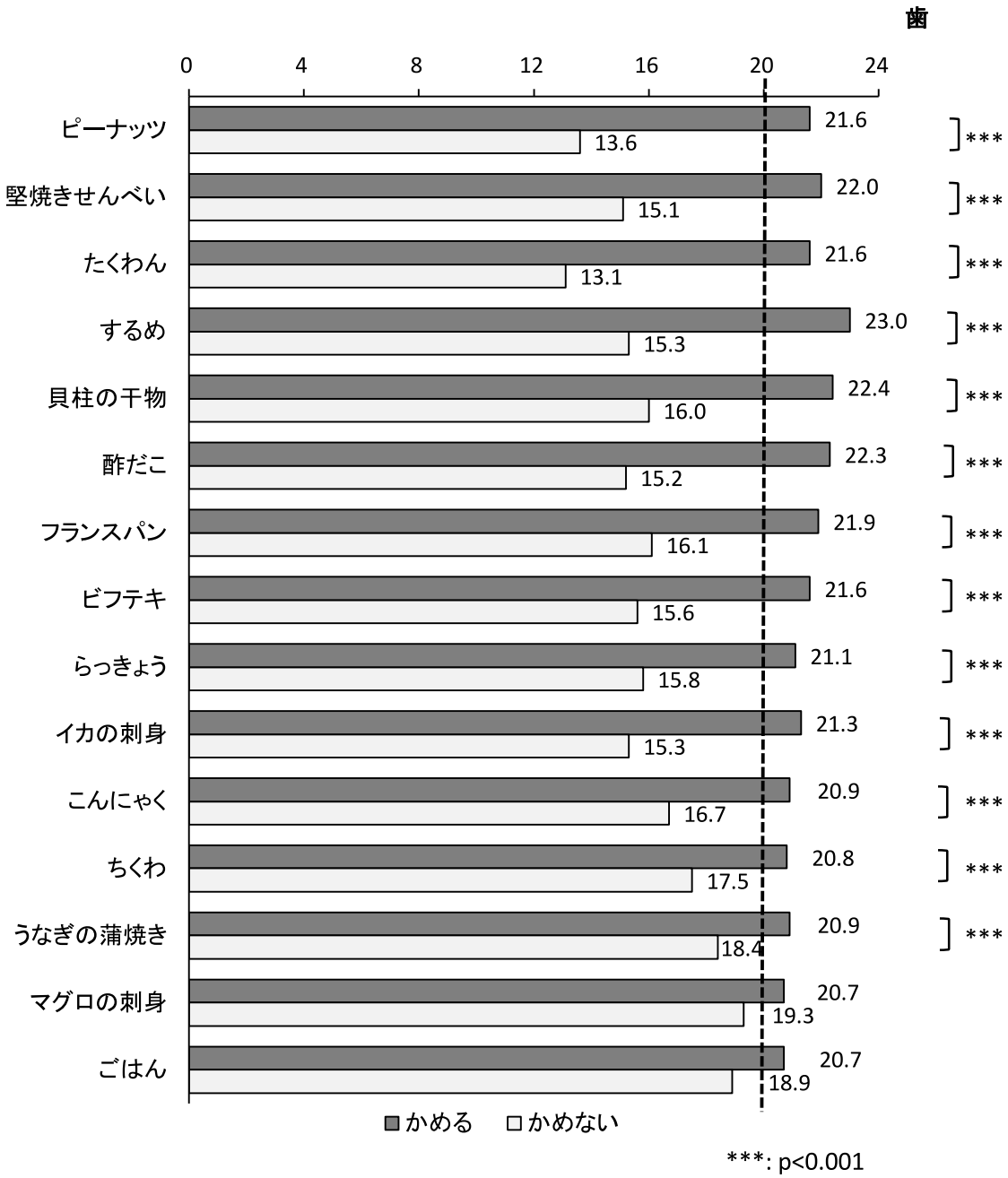


図 7　食品別にみた噛める群と噛めない群の現在歯数の比較

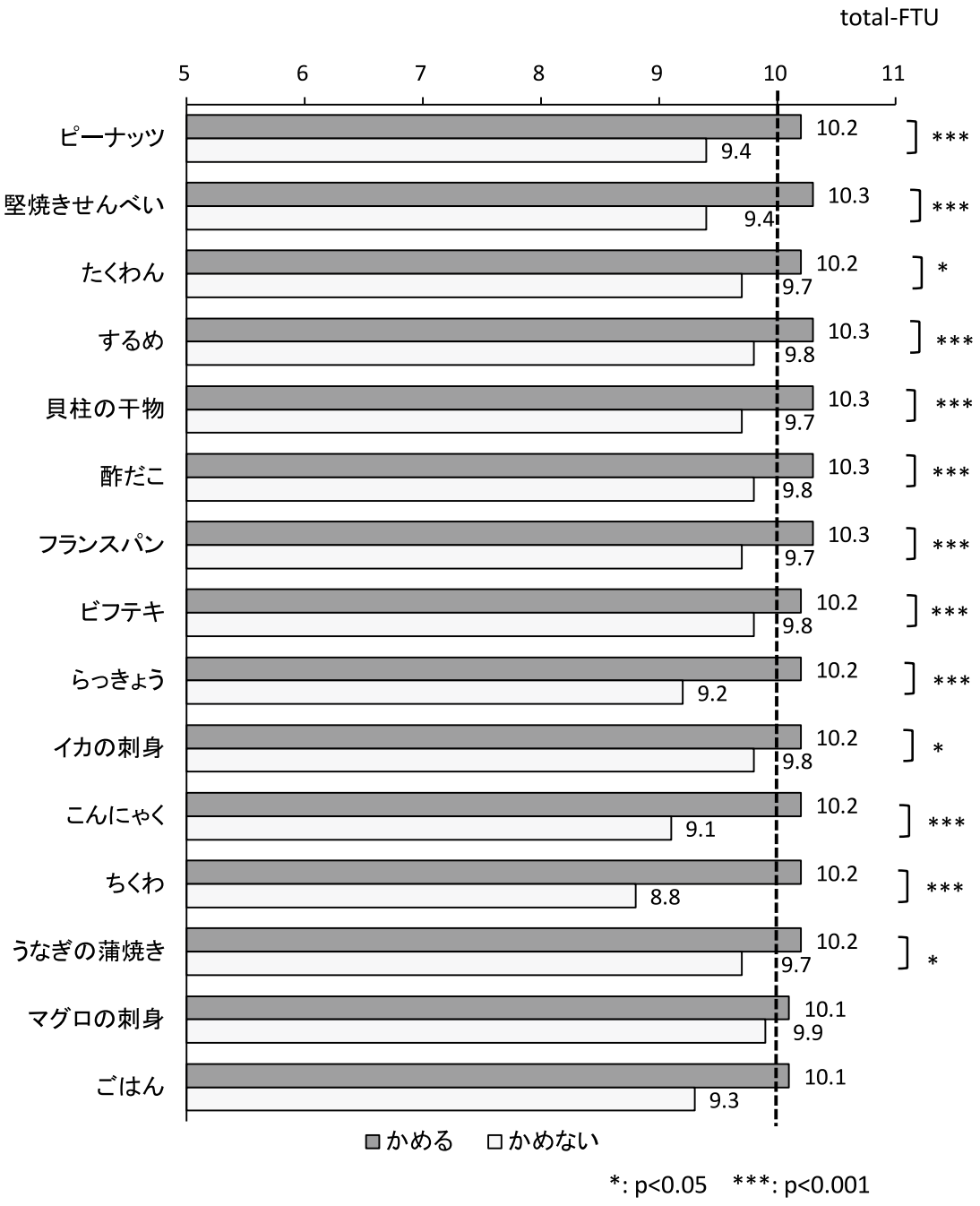


図 8　食品別にみた噛める群と噛めない群の total-FTU の比較

Ⅵ. 機能歯ユニットの構成内訳と咀嚼能力との関連

Ueno M, Yanagisawa T, Shinada K, Ohara S, Kawaguchi Y. Category of functional tooth units in relation to the number of teeth and masticatory ability in Japanese adults. Clin Oral Invest 2012; 14: 113-119.

【背景と目的】

咀嚼能力は、現在歯数や機能歯ユニット（FTU：Functional Tooth Unit）など様々な要因の影響を受ける。現在歯数や機能歯ユニットが少なくなると咀嚼能力も減少することになり、自分の歯をできる限り多く維持することが重要になる。現在、少なくとも自分の歯を20歯維持することが健全な咀嚼を行う上で必要であるとされている。20歯以上自分の歯を保有するという目標は、日本での8020運動をはじめ、WHOやFDIでも唱えられている。しかし、自分の歯を20歯保有することの重要性をFTUを指標として検討した研究はない。そこで、この研究の目的は、20歯以上自分の歯を保有する者と保有しない者において、FTUの構成内訳と咀嚼能力の比較・検討を行うことである。

【方法】

秋田県に居住する40~75歳の成人2,164名（男性：916名、女性：1,248名）を研究対象とし、質問票調査と歯科医師による口腔内診査を実施した。FTUは、上下顎の同名大臼歯が2歯揃っている場合は2、上下顎の同名小臼歯が2歯揃っている場合は1、片顎の臼歯のみ存在している場合や上下顎ともに臼歯がない場合は0と評価した（第3大臼歯は除く）。したがってFTUの最小値は0、最大値は12となる。FTUは現在歯だけでなく、固定および可撤性補綴物も含めたすべての機能歯で評価を行った。

さらにFTUはその構成内訳により、天然歯同士（natural-natural：n-n）、固定性補綴物のポンティックと天然歯（fixed-natural : f-n）、固定性補綴物のポンティック同士（fixed-fixed : f-f）、可撤性補綴物と天然歯（removable-natural：r-n）、可撤性補綴物と固定性補綴物（removable-fixed : r-f）、可撤式補綴物同士（removable-removable : r-r）の6つに分類した。

分析は、対象者を自分の歯を20歯保有するか否かで2群に分け行った。さらに、自記式質問票の山本式咀嚼能力テストを用い、15種類の食品をすべて咀嚼することができると回答した群とそうでない群の2群に分け比較・分析を行った。また、FTUの構成内訳の分析は、共分散分析により性別と年齢を調整して行った。

【結果】

1. 年齢階級別の20歯以上保有する者の割合

40-49 歳ではほとんどすべての者（98.0%）が 20 歯以上保有していたが、70~75 歳では半分以下（39.4%）であった。20 歯以上保有する者の割合は年齢が上がるにともない減少していた（図 1)。

2. 年齢階級別および保有歯数別の臼歯数と FTU

20 歯保有するか否かにかかわらず、臼歯数は年齢が上がるにしたがい減少していた（図 2)。一方、FTU は 20 歯以上保有する者では年齢が上がるにしたがい減少していたが、19 歯以下保有する者では年齢が上がるにしたがい増加していた。40-49 歳および 50-59 歳では、20 歯以上保有する者は 19 歯以下保有する者に比べ FTU が多かったが、60-69 歳および 70-75 歳ではほぼ同程度であった（図 3)。

3. 保有歯数別の FTU 構成内訳

20 歯以上保有する者の FTU は 10.14、19 歯以下保有する者では 10.11 であり差は認められなかった。しかし FTU の構成内訳では有意な差がみられた。20 歯以上保有する者の内訳では天然歯同士(n-n)が最も多く 8.02、次いで固定性補綴物のポンティックと天然歯(f-n)が 1.05 であった。その他の FTU 構成内訳はすべて 1 以下であった。

一方、19 歯以下の者では天然歯同士（n-n）は少なく 1.12 であり、可撤性補綴物同士（r-r）が 5.04 と最も多く、次いで可撤性補綴物と天然歯（r-n）が 3.33 と多かった。その他の FTU 構成内訳はすべて 0.5 以下であった（図 4)。

4. 対合歯ペア別の FTU 構成内訳

20 歯以上保有する者と 19 歯以下保有する者の対合歯ペア別の比較を行ったところ、FTU の存在する割合は、どちらとほぼ同程度であった。FTU の存在する割合は第 1 小臼歯で最も高く約 95%、後方歯になるにしたがいその割合は低くなり、第 2 小臼歯で約 90%、第 1 大臼歯で約 85%、第 2 大臼歯で約 75%であった。

20 歯以上保有する者の FTU 構成内訳はどの対合歯ペアにおいても天然歯同士（n-n）が大部分を占めていた。小臼歯部では 80~90%、大臼歯部では約 60%が天然歯同士（n-n）であり、第 1 小臼歯でその割合が最も高かった。

一方、19 歯以下保有する者では、可撤性補綴物同士（r-r)、可撤性補綴物と天然歯（r-n)、固定性補綴物のポンティックと天然歯（f-n）によるものが 70%から 80%を占めていた。天然歯同士（n-n）は、小臼歯部では 10~15%、大臼歯部ではわずか 2~3%であった。可撤性補綴物同士（r-r）の割合は大臼歯部（約 50%）が小臼歯部（30~40%）に比べ高く、逆に可撤性補綴物と天然歯（r-n）は小臼歯部（30~40%）が大臼歯部（25~30%）に比べ高かった（図 5)。

4. 保有歯数別の FTU 構成内訳と咀嚼能力との関連

20 歯以上保有する者と 19 歯以下保有する者のどちらにおいても、15 種類の食品をすべて咀嚼することができると回答した群とそうでない群とで FTU の数に差は認められなかった。しかし、FTU の構成内訳をみると、保有歯数にかかわらず、15 種類の食品をすべて咀嚼することができると回答した群はそうでない群に比べ、天然歯同士（n-n）の割合が高く、可撤性補綴物によるものが低かった（図 6）。

【考察】

一般の地域住民を対象とした今回の研究において、自分の歯を多く保有することは良好な口腔機能の維持に重要であることが明らかになった。また、20 歯以上保有しているか否かで FTU を比較したところ平均 FTU 数にはさほど違いがみられなかった。しかし、FTU の構成内訳は顕著に異なることが判明した。20 歯以上保有する者の FTU 構成内訳は、天然歯同士が多く、可撤性補綴物によるものが少なかった。逆に 19 歯以下保有する者の FTU 構成内訳は天然歯同士が少なく、可撤性補綴物によるものが多かった。

FTU と咀嚼能力との関連をみると、保有歯数にかかわらず、山本式咀嚼能力テストで 15 種類の食品をすべて咀嚼することができると回答した者はそうでない者に比べ、FTU 構成内訳で天然歯同士の割合が高かった。

本研究により、FTU の数だけではなくその構成内訳が重要であり、天然歯によるものなのか、それとも可撤性補綴物によるものなのかが咀嚼能力に大きく影響を与えていることが判明した。これらの結果から、できる限り自分の歯を維持し天然歯による FTU を多く保有することは、健全な口腔機能や口腔の健康を保つために重要であると考えられた。

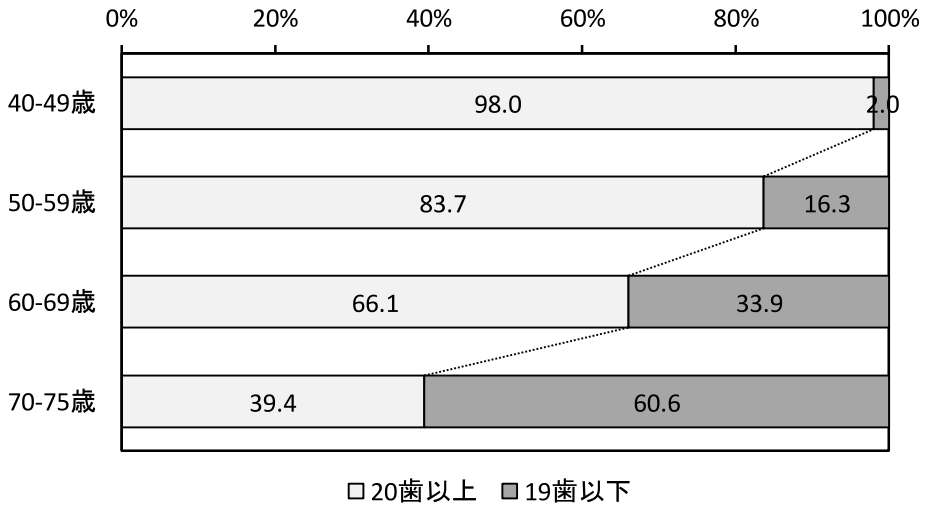


図 1　年齢階級別の 20 歯以上保有する者の割合

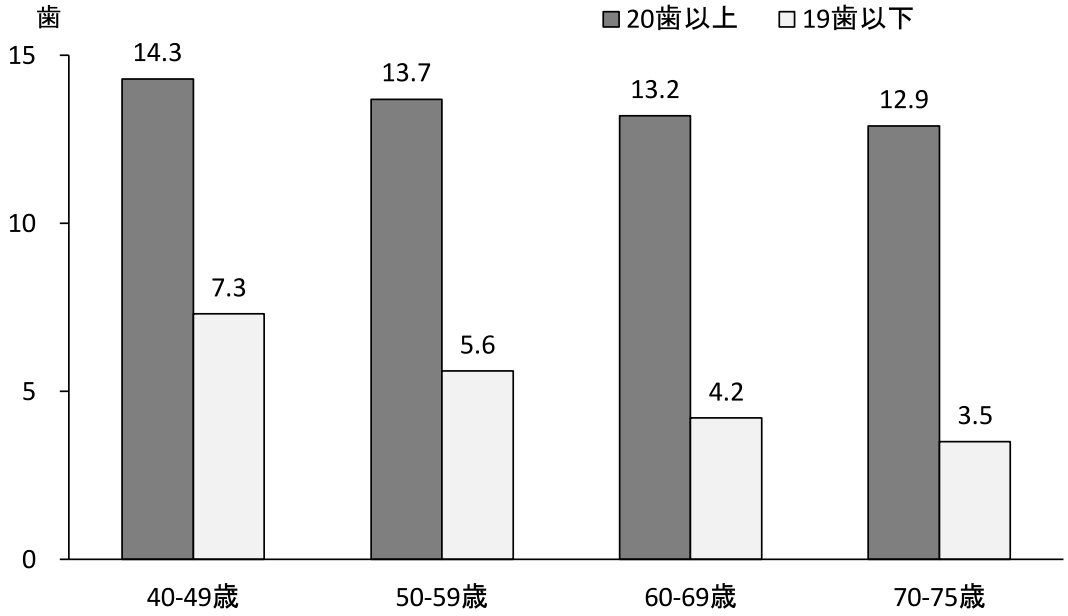


図 2　年齢階級別、保有歯数別の臼歯数

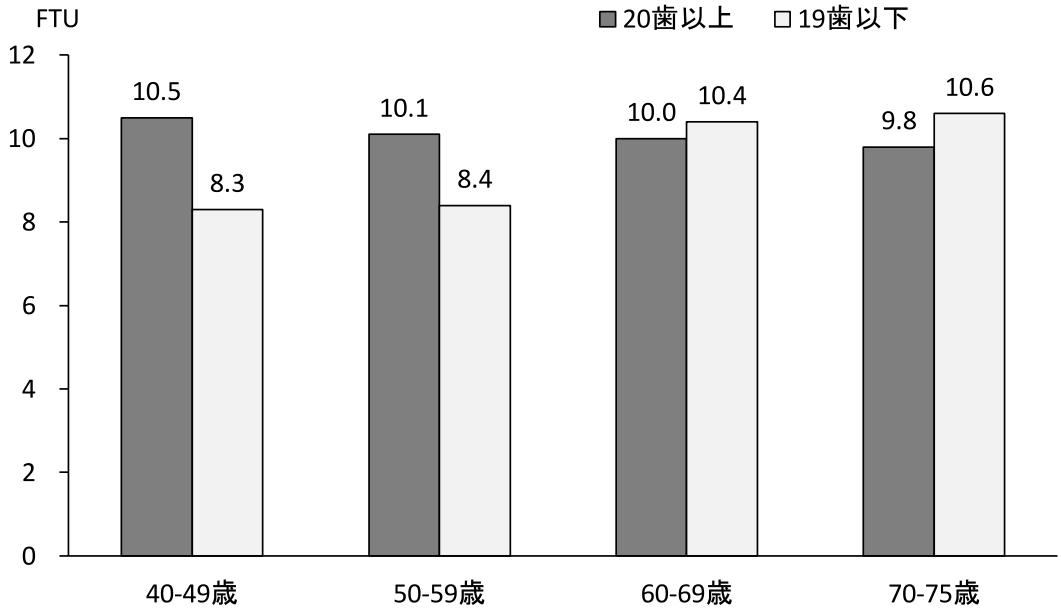


図 3　年齢階級別、保有歯数別の FTU

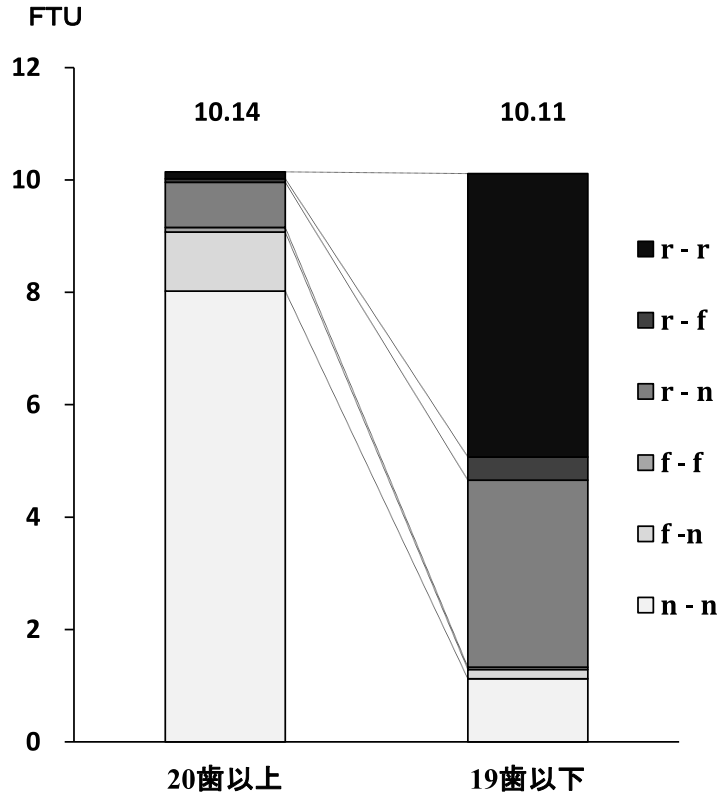
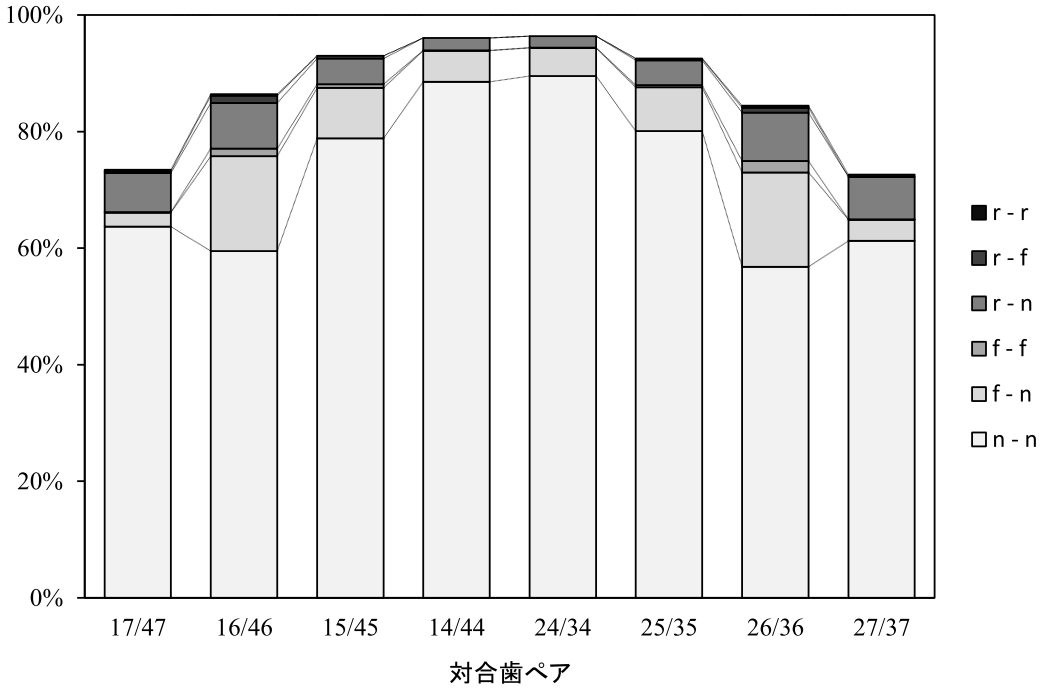


図 4　20 歯以上保有者と 19 歯以下保有者の FTU の構成内訳



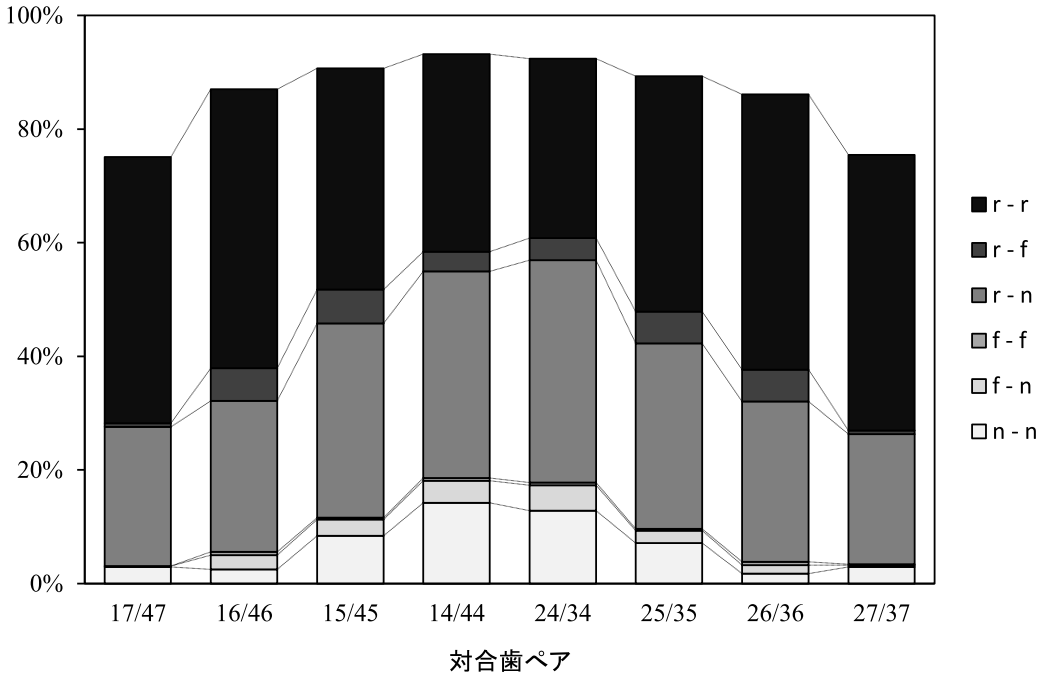


図 5　20 歯以上保有者（上）と 19 歯以下保有者（下）の対合歯ペア別の FTU 構成内訳

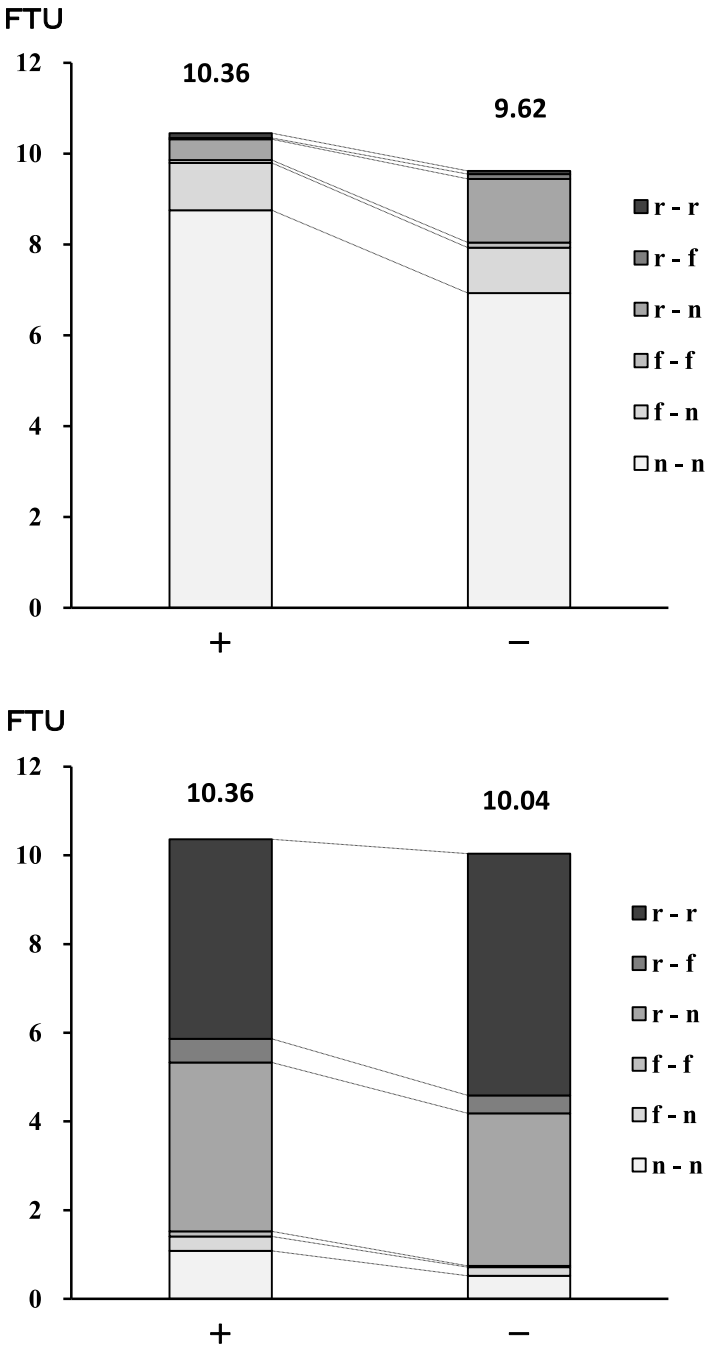


図 6　20 歯以上保有者（上）と 19 歯以下保有者（下）の咀嚼能力別の FTU 構成内訳

＋：15 種類の食品をすべて咀嚼することができると回答した群

－：咀嚼できない食品があると回答した群

Ⅶ. GOHAI および口腔の健康状態の自己評価と口腔保健状況との関連

Zaitsu T, Ueno M, Shinada K, Ohara S, Wright C, Kawaguchi Y. Association of clinical oral health status and self-rated oral health and GOHAI in Japanese adults. Community Dental Health 2011; 28: 297–300.

【背景と目的】

QOL は Quality of Life の略語であり、生活の質、生命の質、生存の質などと訳されている。QOL は、生活、高齢者、医学・医療の分野など、様々な領域で使用されているが、歯・口腔領域に特化した QOL は口腔関連 QOL（Oral Health Related QOL）と呼ばれている。口腔に関連した包括的な健康関連 QOL を評価する尺度として GOHAI（General Oral Health Assessment Index）が国内外で使用されている。QOL を評価するのは、医療者側ではなく患者側の考えを理解するためである。患者がどのように自分の口腔の健康について考えているのか知ることは健康の維持・増進のために重要である。本研究では、40～55 歳の地域住民を対象として、GOHAI および口腔の健康状態の自己評価と口腔保健状況との関連について分析を行った。

【方法】

本研究への参加に同意した秋田県横手市の 40～55 歳の住民 459 名（男性：154 名、女性：305 名）を対象とした。2007 年に横手市およびひらか歯科医師会の協力のもと、自記式質問票と口腔内診査を歯科診療所において実施した。

質問票は口腔関連 QOL の評価尺度として GOHAI の日本語版を利用した。GOHAI は 12 の質問項目で構成され、各項目に「いつも」「よく」「ときどき」「めったにない」「ない」の 5 段階で、直近 3 ヶ月間の状態を回答することになっている。GOHAI のスコアは 12～60 であり、スコアが高いほど口腔関連 QOL が高いと評価される。口腔の健康状態の自己評価については、「今のお口の健康状態はどうですか？」という質問項目に対して「よい」「まあよい」「ふつう」「あまりよくない」「よくない」の 5 段階で回答してもらった。

さらに、歯科医師による口腔内診査（第 3 大臼歯は除外）を行い、未処置歯数、喪失歯数、処置歯数、プロービングにより歯肉出血のある歯数、歯石付着のある歯数、歯周ポケット 4mm 以上の歯数、口腔乾燥の有無、口腔清掃状態を評価した。また、臼歯の咬合状態の評価のために機能歯ユニット（Functional Tooth Unit:FTU）を算出した。

【結果】

1．GOHAI および口腔の健康の自己評価

GOHAI の平均値は 53.6±6.1 であった。GOHAI の項目別でみると「いつも」「よく」「ときどき」と回答した者の割合が高い項目は、「口の中の見た目について、不満に思うことが

ある」「口の中の調子の悪さが、気になることがある」「口の中で、熱いものや冷たいものや甘いものがしみることがある」で、それぞれ 42.7%、30.1%、27.5%であった（図 1)。

また、口腔の健康状態の自己評価は「よい」が 7.2%、「まあよい」が 16.6%、「ふつう」が 52.9%、「あまりよくない」が 20.5%、「よくない」が 2.8%であった。

2. 口腔保健状況

平均未処置歯数、喪失歯数、処置歯数はそれぞれ 1.6 歯、2.7 歯、13.8 歯であった。プロービングにより歯肉出血のある歯数、歯石付着のある歯数、歯周ポケット 4mm 以上の歯数はそれぞれ、5.9 歯、8.6 歯、4.7 歯であった。また、口腔乾燥のある者は 3.7%、口腔清掃状態が不良の者は 12.6%、FTU の平均値は 10.3 であった。

3. GOHAI と口腔保健状況との関連

GOHAI の平均値をもとに、QOL の良好群（54 以上）と不良群（53 以下）の 2 群に分けて、口腔保健状況との関連をみると、QOL の不良群では良好群と比較して、喪失歯数が有意に多く、FTU が有意に少なかった（図 2)。

4. 口腔の健康状態の自己評価と口腔保健状況との関連

口腔の健康状態の自己評価により良好群（「よい」「まあよい」「ふつう」）と不良群（「あまりよくない」「よくない」）の 2 群に分けて、口腔保健状況との関連を分析した。その結果、自己評価の不良群は良好群と比較して、有意に未処置歯数が多く、FTU が少なかった。また、口腔乾燥のある者および口腔清掃状態が不良の者の割合が多く、歯周組織の状態（歯肉出血数、歯石付着数、4mm 以上の歯周ポケット数）も不良であった（図 3)。

5. GOHAI および口腔の健康状態の自己評価に関わる要因

年齢、性別を調整したうえで、GOHAI、口腔の健康状態の自己評価を従属変数、口腔保健状況を独立変数として線形回帰分析を行った。その結果、GOHAI と有意な関連が認められた項目は、未処置歯数、喪失歯数、口腔乾燥であった。口腔の健康状態の自己評価と有意な関連が認められた項目は、未処置歯数、口腔乾燥、口腔清掃状態であった。

【考察】

対象者の GOHAI スコアはこの年齢層の平均値とほぼ一致しており、DMFT に関しても歯科疾患実態調査と同様の値を示した。したがって、本研究の対象者は、わが国のこの年代の成人を代表するサンプルであると考えられる。

本研究で明らかになった中高年の成人が気にする口腔関連 QOL の項目は「審美性や痛み」であり、高齢者を対象とした調査での「咀嚼や嚥下」とは異なっていた。また、口腔保健状況のうち、齲蝕、歯の喪失、口腔乾燥が口腔関連 QOL に作用していることが判明

し、その背景として、疼痛や口腔機能障害が影響していると推察された。

一方、口腔の健康状態の自己評価に影響を与えていたのは、齲蝕、口腔乾燥、口腔清掃状態であった。齲蝕や口腔乾燥は口腔の健康問題として、本人が気づきやすく、それがQOLにも影響すると考えられる。

口腔関連 QOL に影響を与える歯の喪失の原因には、齲蝕だけでなく歯周疾患も大きく関与している。しかし、本研究の対象者において、齲蝕の有無は QOL と関連し、口腔の健康問題として自己認識しているのに対し、歯肉出血、歯石付着、ポケットの深さなどの歯周疾患の症状に対しては認識していないことが明らかになった。中高年において QOL を向上させるためには、歯の喪失の主な原因となる歯周疾患を予防することが必要であり、そのためには歯周疾患を認識できるような健康教育プログラムを提供することが重要と考えられた。

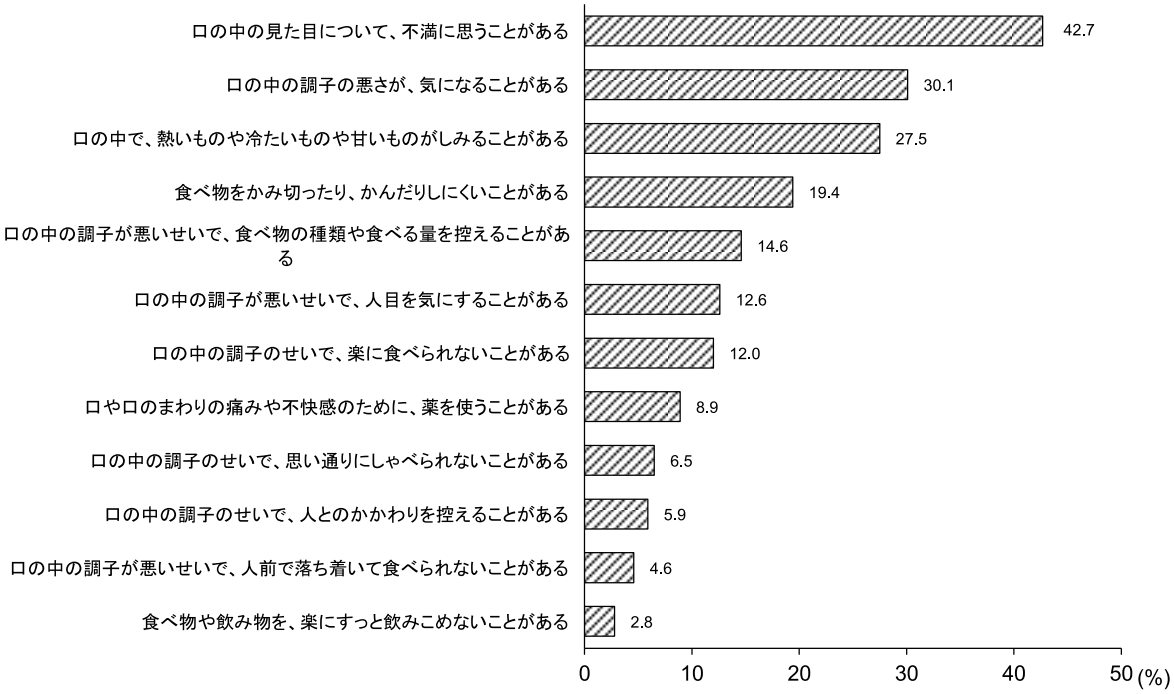


図 1　GOHAI の 12 項目に「いつも」「よく」「ときどき」と回答した者の割合

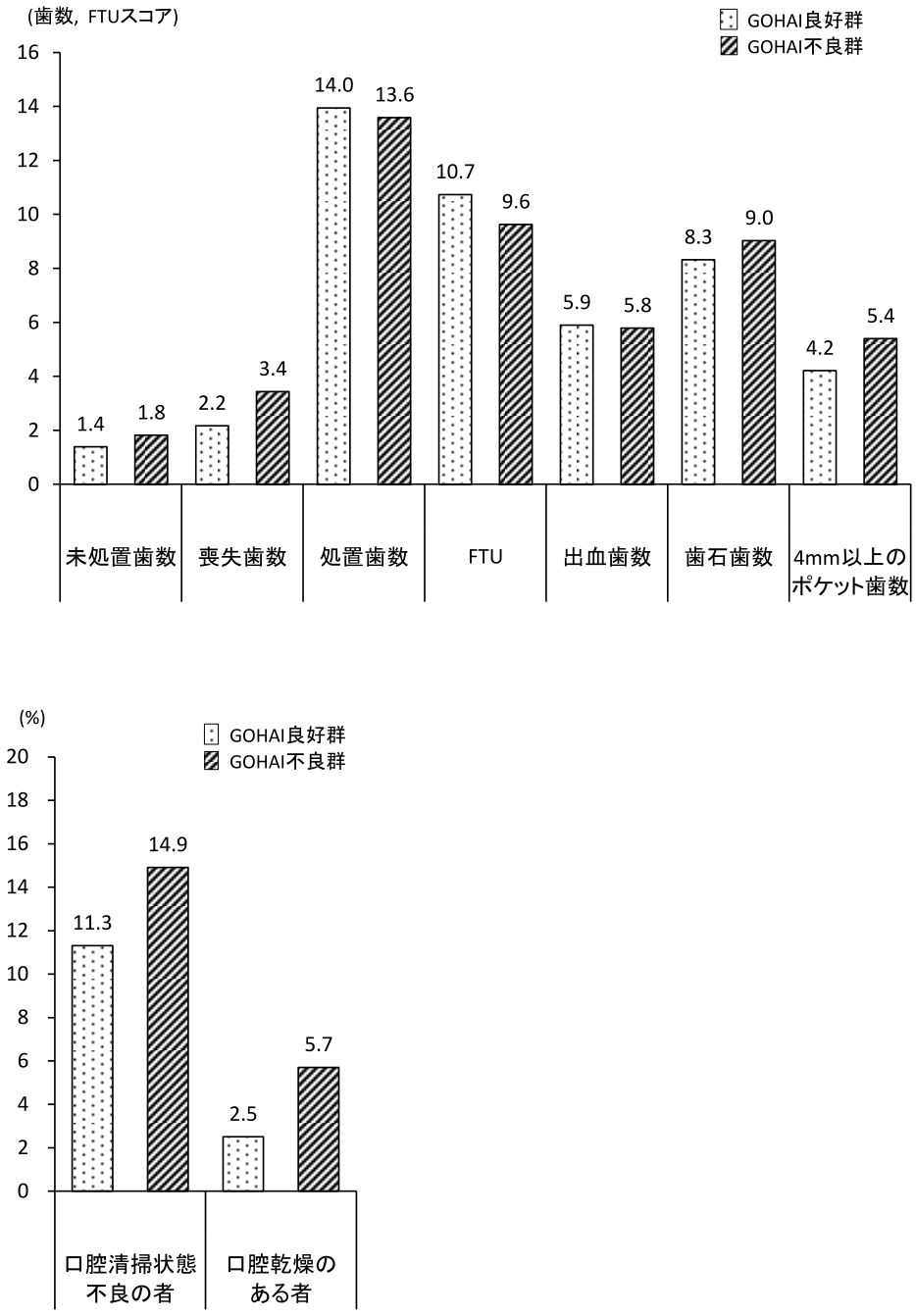
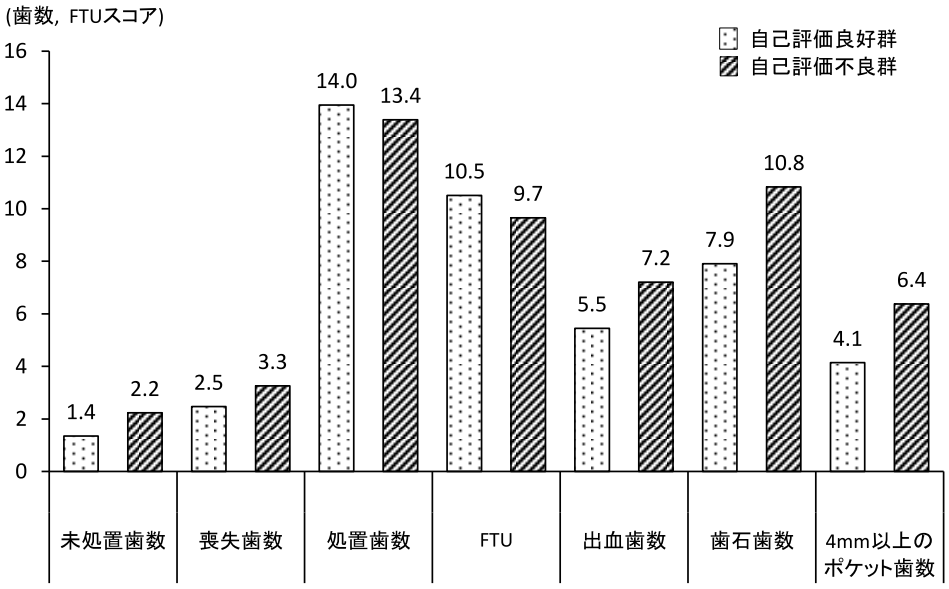


図 2　GOHAI と口腔保健状況との関連



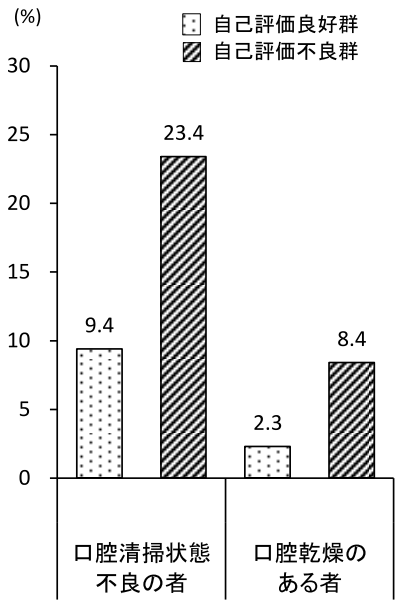


図 3　口腔の健康状態の自己評価と口腔保健状況との関連

Ⅷ. 質問票調査による咀嚼能力評価の妥当性について

Yanagisawa T, Ueno M, Shinada K, Ohara S, Kawaguchi Y. Validity of Self-reported Masticatory Function in a Japanese Population. J Dent Hlth 2012; 60: 214-223.

【背景と目的】

咀嚼能力は、全身の健康状態、精神・身体機能、栄養摂取量などと関係していることが報告されている。したがって、良好な咀嚼能力を維持することは、精神的かつ身体的健康を保持するために重要である。これまで、咀嚼能力は歯科医師が対象者の口腔内をひとりひとり診査して、その結果に基づき評価してきた。本研究では、歯科健診が実施できない状況において、質問票調査によって咀嚼能力のスクリーニングができるか否かを検討するために、咀嚼能力の自己評価と、実際の咀嚼能力の評価法との関連について分析を行った。

【方法】

2005～2006 年に成人歯科健診を受診した秋田県横手市の 40～75 歳の住民 2,668 名（男性 1,091 名、女性 1,577 名）を対象とした。自記式の質問票調査を行い、「自分の歯または入れ歯で、左右の奥歯をしっかりかみしめることができますか？」という質問に対して、「両方ともかめる」と回答した者は「良好」、「片方はかめる」と回答した者は「普通」、「両方ともかめない」と回答した者は「不良」と、3 つに分類した。また、15 種類の食品による山本式咀嚼能力テストも合わせて実施した。さらに、口腔内診査（第 3 大臼歯は除外）を行い、現在歯数、臼歯数、機能歯ユニット（Functional Tooth Units：FTU）を算出した。

FTU は通常、すべての機能歯による臼歯部の咬合状況を示す指標として用いられるが、本研究では、FTU を構成している機能歯を以下の 3 つに分類して検討を行った。①現在歯（natural teeth）のみで算出した n-FTU、②現在歯と固定性補綴物（natural, implanted and fixed prosthetic teeth）を合わせて算出した nif-FTU、③現在歯と固定性補綴物および可撤性補綴物、すなわちすべての機能歯（total）を含めて算出した total-FTU である。

性別、年齢階級別に、質問票による咀嚼能力の自己評価の分類結果と山本式咀嚼能力テスト、現在歯数、臼歯数、FTU との関連について検討を行った。

【結果】

1. 質問票による咀嚼能力の自己評価

質問票による咀嚼能力の自己評価は、「良好」が 2,021 名（75.7%）、「普通」が 447 名（16.8%）、「不良」が 200 名（7.5%）であった。「良好」群は、「普通」群や「不良」群に比べて平均年齢が若い傾向が認められた。

2. 年齢階級別の現在歯数、臼歯数、FTU

現在歯数、臼歯数、n-FTU、nif-FTU の平均値を年齢階級別に比較したところ、男女共に年齢が高くなると値が低くなった。一方、total-FTU では男女共に年齢による差は認められなかった（図 1、図 2)。

3. 咀嚼能力の自己評価と山本式咀嚼能力テストとの関連

質問票の結果と山本式咀嚼能力テストの結果を比較したところ、咀嚼能力の自己評価が「良好」群および「普通」群は、「不良」群と比較して、有意に高い割合でほとんどの食品を「咀嚼可能」と回答していた。一方、咀嚼能力の自己評価の「不良」群では、柔らかい食品については咀嚼可能であったが、ピーナッツ、せんべい、スルメ、フランスパンなど硬い食品に関しては、約 50%の者が「咀嚼できない」と回答していた。

4. 咀嚼能力の自己評価と現在歯数、臼歯数、FTU との関連

質問票の結果と現在歯数、臼歯数、FTU との関連を分析したところ、全ての年齢階級において、咀嚼能力の自己評価の「良好」群は、「普通」群および「不良」群と比較してすべての指標が高い数値を示した。また、すべての指標において咀嚼能力が「良好」→「普通」→「不良」となるにしたがい、値が減少した（図 3、図 4)。

【考察】

本研究の結果、質問票による咀嚼能力の自己評価と、山本式咀嚼能力テストや現在歯数、臼歯数、FTU との間に関連があることが確認された。特に、咀嚼能力が「良好」と自己評価した群は、「普通」群および「不良」群と比較して、すべての指標が高い数値を示した。

これまでの研究で、n-FTU が 7.6、nif-FTU が 8.6 以上であると、山本式咀嚼能力テストの 15 食品のほとんどを咀嚼することができるが、n-FTU が 4.0、nif-FTU が 4.7 以下であると、咀嚼できない食品があることが報告されている。本研究においても、咀嚼能力が「良好」と自己評価した群では n-FTU が 7.2、nif-FTU が 8.1 であり、ほとんど全ての食品を咀嚼できると回答していたが、「不良」と自己評価した群では n-FTU が 2.6、nif-FTU が 3.0 で、一部の食品、特に硬い食品は咀嚼できないことが明らかになった。

歯をできるだけ保有すること、また歯が喪失した場合には補綴処置をして咀嚼能力を維持していくことは重要である。この咀嚼能力の状況を簡便に評価するために、「自分の歯または入れ歯で、左右の奥歯をしっかりかみしめることができますか？」という質問項目は、臼歯の咬合状況を示す FTU や実際の食品の咀嚼状況と関連しており、妥当性があると考えられた。多数の地域住民を対象とした疫学調査を行う場合には、すべての対象者の歯科健診を実施することは不可能である。歯科医師が口腔内診査を実施できない状況において、本研究で使用した質問票による咀嚼能力のスクリーニング法は簡便で有用であると考えられた。

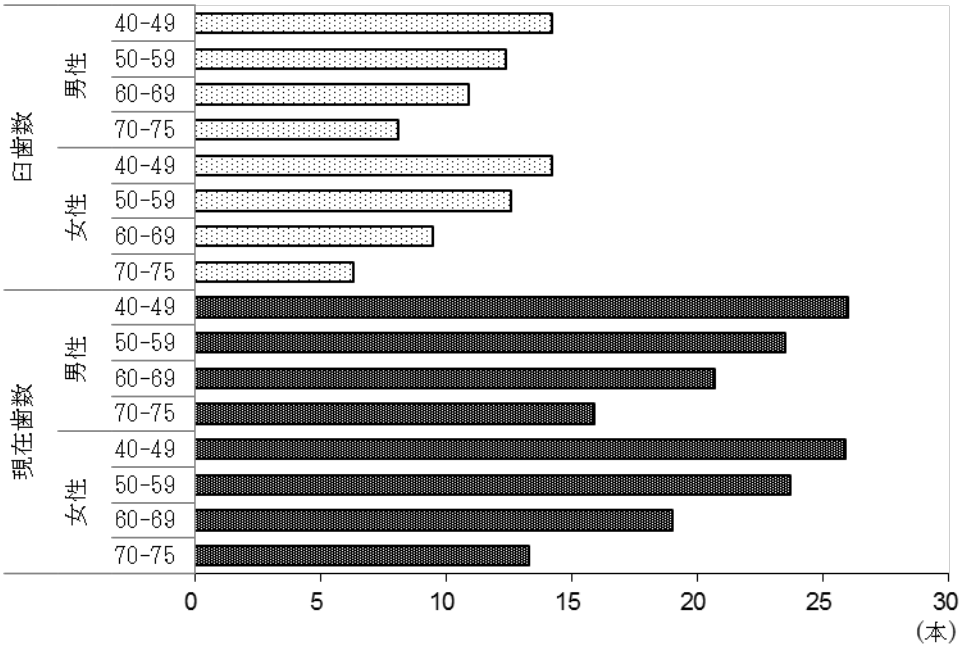


図１　年齢階級別および性別の現在歯数と臼歯数

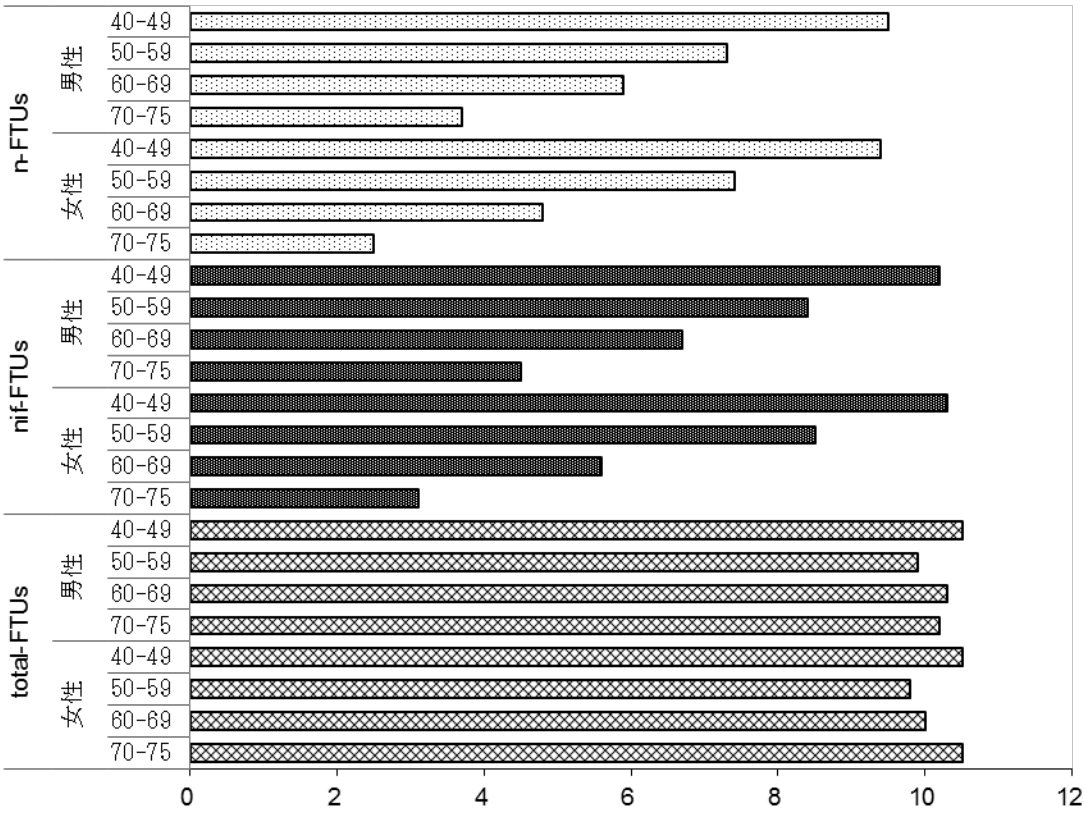


図 2　年齢階級別および性別の n-FTU、nif-FTU、total-FTU

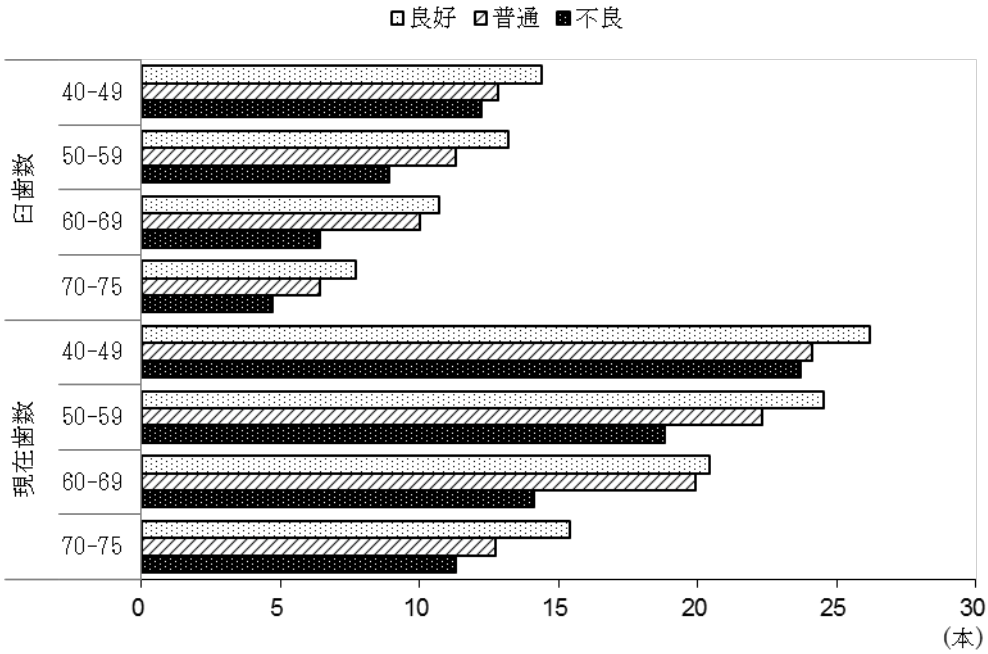


図 3　咀嚼能力の自己評価と現在歯数および臼歯数との関連

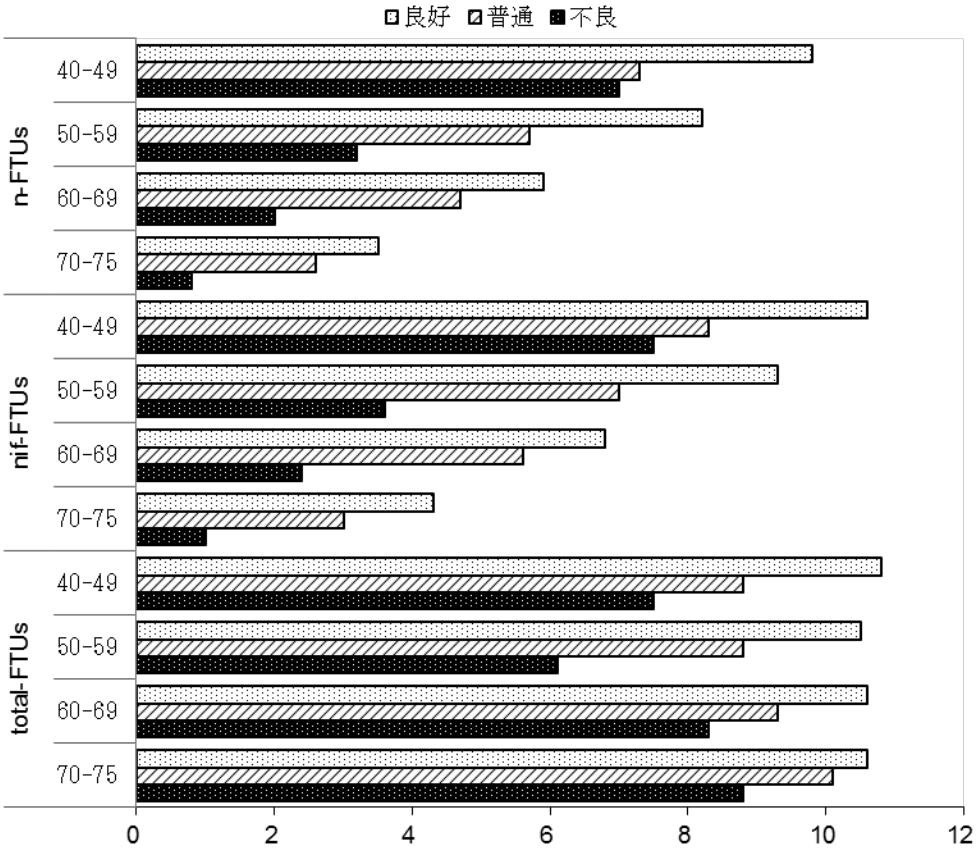


図 4　咀嚼能力の自己評価と n-FTU、nif-FTU、total-FTU との関連

Ⅸ．成人の口臭とそれに関わる要因の疫学研究

Ueno M, Yanagisawa T, Shinada K, Ohara S, Kawaguchi Y. Prevalence of oral malodor and related factors among adults in Akita Prefecture, J Med Dent Sci 2007; 54: 159–165.

【背景と目的】

口臭とは口腔から発せられる不快な臭いであり、口臭があると人とのコミュニケーションや社会生活に障害を与えることになる。口臭の原因の約 9 割は口腔内にあり、揮発性硫黄化合物（VSC）がその原因物質である。VSC は口腔内のグラム陰性嫌気性細菌がタンパク質を分解することにより産生される。

1999 年に実施された保健福祉動向調査によると、歯や口の中に自覚症状のある者のうち「口臭」で悩んでいる者の割合は約 15%であり、自覚症状としては 4 番目に多い悩みであった。「口臭」で悩む者の割合は年齢とともに増加し、15-24 歳で 7.6%、25-34 歳で 10.1%、35-44 歳で 17.7%、45-54 歳で 20.7%であり、45-54 歳までは増加傾向を示した。55-64 歳以降になると、口臭を訴える者の割合は徐々に減少していた。

このように日本では多くの人が口臭で悩んでいる。口臭の原因物質や口臭治療に関する研究は多数行われているが、一般の地域住民を対象とした口臭の疫学調査は少ない。今回、我々は秋田県横手市の地域住民を対象に質問票調査と口腔内診査を行い、成人における口臭の有無を調査し、口臭の発生に寄与する要因について検討した。

【方法】

秋田県横手保健所管内に居住する 40 歳から 75 歳までの住民約 25,000 名に対し調査への参加を郵送で依頼し、同意の得られた 2,141 名（男性 910 名：年齢 61.8±8.8 歳、女性 1,231 名：年齢 59.9±9.2 歳）を今回の研究の対象者とした。調査は、横手市および平鹿郡（現ひらか）歯科医師会の協力を得て、各歯科診療所において実施した。調査内容は歯科保健行動や知識、口腔清掃習慣、喫煙習慣などに関する自記式の質問票および歯科医師による口腔内診査である。

口臭の評価は、歯科医師による官能検査の結果（なし、中程度、強い）を用い、年齢、性別、口臭の自覚症状の有無、喫煙状況、未処置歯数、口腔乾燥の有無、歯・義歯・舌の清掃状態（良好、普通、不良）、歯肉出血・歯石沈着・5 ㎜以上の歯周ポケットのみられる歯数との関連を Kendall の τ を使って分析した。また、口臭の有無（口臭なしを 0、口臭ありを 1）を従属変数、年齢、性別、喫煙、現在歯数、未処置歯数、口腔乾燥、歯・義歯・舌の清掃状態、出血・歯石沈着・5 ㎜以上の歯周ポケットのみられる歯数を説明変数としてロジスティック回帰分析を行った。統計分析ソフトは SPSS13.0J を使用した。

【結果】

1．全対象者の口臭の実態

対象者 2,141 名中 785 名（36.7%）に中程度あるいは強い口臭が認められた。年齢階級別にみると、若年層では老年層に比べ口臭の認められる者の割合が低かった（図 1-a)。また、男性は女性に比べ口臭の認められる割合が有意に高かった（p<0.001）（図 1-b)。

歯科医師による口臭の官能検査結果と本人の自覚症状との関連をみたところ、口臭の自覚症状のある者の方が口臭ありと判定される割合が高かった（p<0.001）（図 1-c)。

喫煙者（図 1-d)、舌の清掃状態が不良な者（図 1-e)、口腔乾燥がみられる者（図 1-f) はそうでない者より、口臭の認められる割合が高かった（p<0.001)。

2．有歯顎者の口臭の実態

有歯顎者 2,039 名において、未処置歯数が多い者（図 2-a)、歯の清掃状態が不良な者（図 2-b)、歯肉出血のみられる歯数が多い者（図 2-c)、歯石沈着のみられる歯数が多い者（図 2-d)、5 ㎜以上の歯周ポケットのみられる歯数が多い者（図 2-e）ほど口臭の認められる割合が高かった（p<0.001)。

3．義歯使用者の口臭の実態

義歯使用者 863 名においては、義歯の清掃状態が不良な者ほど口臭が認められる割合が高かった（図 3）（p<0.001)。

4．有歯顎者の口臭に関わる要因

有歯顎者 2,039 名のロジスティック回帰分析の結果、歯の清掃状態（中程度：OR=5.4、不良：OR=14.3)、舌の清掃状態（中程度：OR=2.3、不良：OR=4.3)、5 ㎜以上の歯周ポケットのみられる歯数（6 歯以上：OR=2.8)、口腔乾燥（OR=2.6)、歯肉出血のみられる歯数（1-5 歯：OR=1.4、6 歯以上：OR=1.9)、歯石沈着のみられる歯数（6 歯以上：OR=1.6)、性別（女性：OR=0.7)、年齢階級（55-59：OR=1.8、60-64：OR=1.8 、65-69：OR=1.7、70+：OR=1.6）が口臭の有無に有意に関与していた（表 1)。

5．有歯顎者で義歯使用者の口臭に関わる要因

有歯顎者で義歯使用者 770 名のロジスティック回帰分析の結果、歯の清掃状態（中程度：OR=5.3、不良：OR=13.1)、5 ㎜以上の歯周ポケットのみられる歯数（6 歯以上：OR=4.3)、舌の清掃状態（中程度：OR=1.7、不良：OR=4.0)、口腔乾燥（OR=2.4)、義歯の清掃状態（不良：OR=2.4)、歯肉出血のみられる歯数（6 歯以上：OR=1.9)、歯石沈着のみられる歯数（6 歯以上：OR=1.9）が口臭の有無に有意に関与していた（表 2)。

【考察】

今回の一般の地域住民を対象とした疫学調査では、対象者の約 40%に口臭が認められ、これまでの報告に比べ高い値を示した。日本での先行研究では、宮崎らの調査で 6~23%と報告されている。また、外国での調査では Meskin によると 10~30%、Liu らによると 20.3~35.4%と報告されている。年齢階級による口臭の割合に差はみられなかったが、男性は女性に比べ口臭の認められる割合が高かった。また、口臭の自覚症状がある者で官能検査により口臭があると判定される割合が高かった。

口臭の有無に寄与する要因をロジスティック回帰分析で検討したところ、歯や舌の清掃状態、5 ㎜以上の歯周ポケットのみられる歯数、歯肉出血のみられる歯数、歯石沈着のみられる歯数、口腔乾燥が口臭に強く影響していることが明らかになった。その中でも歯の清掃状態が口臭の有無に最も大きく寄与していた。

この地域において口臭の認められた者の割合は高く、口臭においても齲蝕などの歯科疾患と同様地域差がみられることが判明した。今回の結果では、歯や舌の汚れ、歯周病、口腔乾燥などが口臭に影響を与える要因であった。したがって、今後地域住民に対する口臭予防のために、歯や舌の清掃指導、歯周病治療、口腔乾燥対策などの健康教育および予防措置を講じることは口腔保健全般の改善にもつながり、地域歯科保健活動の一環として実施する必要があると思われた。

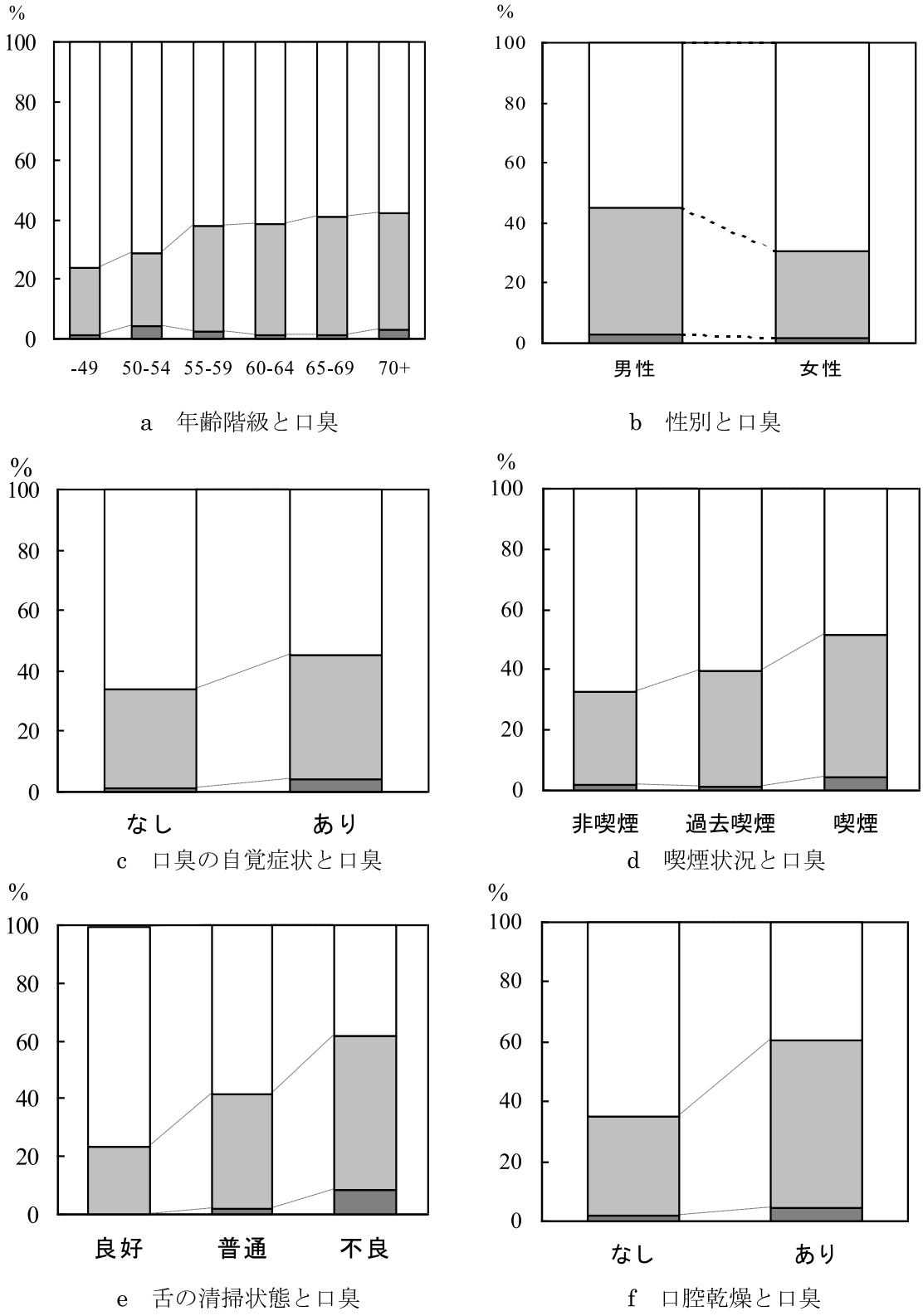
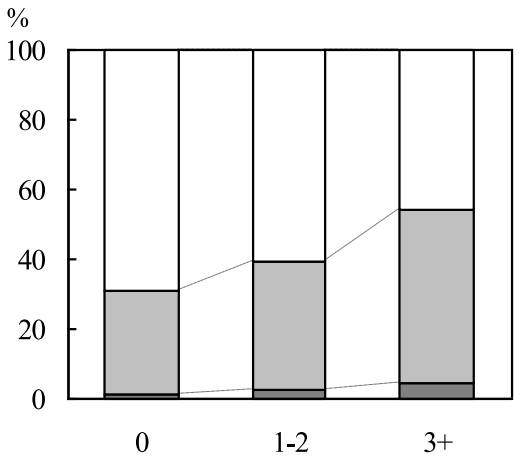
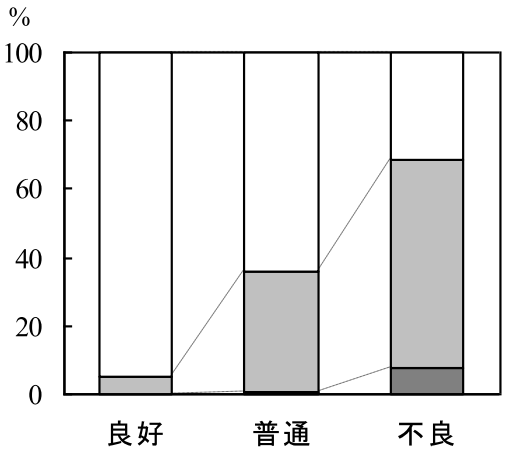


図１　全対象者（2,141 名）における各要因と口臭との関連

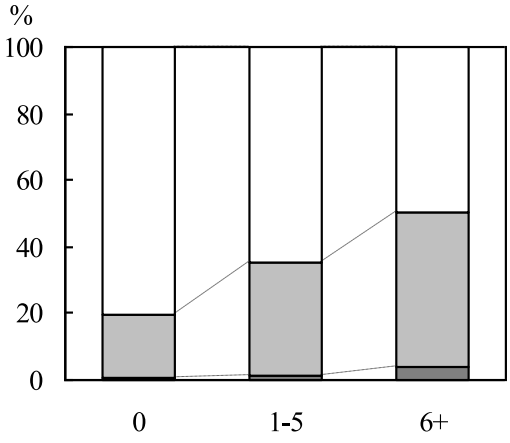
（□口臭なし　　□中程度の口臭　　■強い口臭）



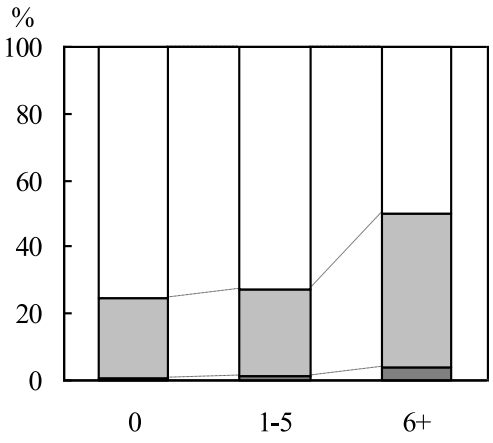
a　未処置歯数と口臭



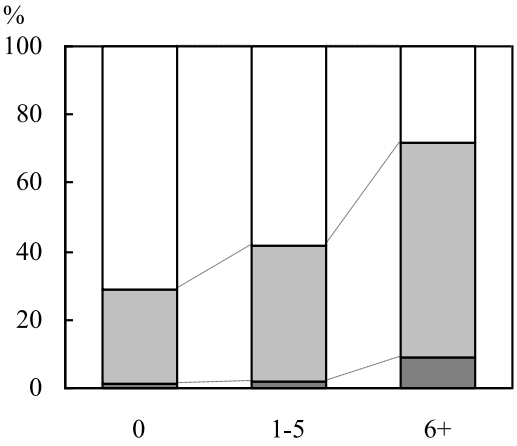
b　歯の清掃状態と口臭



c　歯肉出血と口臭



d　歯石沈着と口臭



e　歯周ポケットと口臭

図 2　有歯顎者（2,039 名）における各要因と口臭との関連
（□ 口臭なし　　□ 中程度の口臭　　■ 強い口臭）

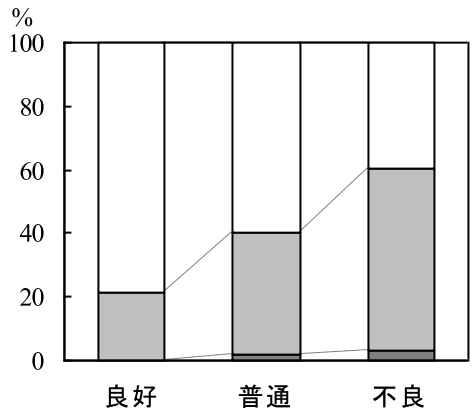


図 3　義歯使用者（863 名）における義歯の清掃状態と口臭との関連
（□ 口臭なし　□ 中程度の口臭　■ 強い口臭）

表１　有歯顎者におけるロジスティック回帰分析（2,039 名）

説明変数		人数	p値	オッズ比	95%信頼区間	
				（OR）	下限	上限
年齢階級	–49 (参照)	286				
	50–54	220	.176	1.379	.866	2.196
	55–59	**410**	**.003**	**1.813**	**1.220**	**2.694**
	60–64	**375**	**.003**	**1.828**	**1.220**	**2.739**
	65–69	**349**	**.015**	**1.668**	**1.103**	**2.522**
	70+	**399**	**.023**	**1.623**	**1.068**	**2.466**
性別	男性 (参照)	877				
	女性	**1162**	**.019**	**.710**	**.533**	**.944**
喫煙状況	非喫煙 (参照)	1379				
	過去喫煙	378	.590	1.104	.769	1.585
	喫煙	282	.621	.917	.651	1.292
現在歯数	1–9 (参照)	194				
	10–19	358	.982	1.005	.663	1.523
	20+	1487	.452	.861	.582	1.273
未処置歯数	0 (参照)	1155				
	1–2	553	.752	1.041	.813	1.332
	3+	331	.314	1.165	.865	1.568
口腔乾燥	なし (参照)	1894				
	あり	**145**	**.000**	**2.607**	**1.749**	**3.886**
歯の清掃状態	良好 (参照)	370				
	普通	**1264**	**.000**	**5.348**	**3.246**	**8.811**
	不良	**405**	**.000**	**14.265**	**8.243**	**24.687**
舌の清掃状態	良好(参照)	507				
	普通	**1379**	**.000**	**2.302**	**1.706**	**3.105**
	不良	**153**	**.000**	**4.284**	**2.692**	**6.818**
歯肉出血	0 (参照)	529				
	1–5	**763**	**.048**	**1.355**	**1.002**	**1.832**
	6+	**747**	**.000**	**1.865**	**1.356**	**2.563**
歯石沈着	0 (参照)	561				
	1–5	553	.478	.895	.659	1.216
	6+	**925**	**.002**	**1.592**	**1.186**	**2.138**
5mm以上のポケット	0 (参照)	1221				
	1–5	628	.432	1.098	.870	1.387
	6+	**190**	**.000**	**2.780**	**1.879**	**4.113**

表２　義歯使用有歯顎者のロジスティック回帰分析（770 名）

説明変数		人数	p値	オッズ比 (OR)	95%信頼区間 下限	上限
年齢階級	–49 (参照)	23				
	50–54	39	.456	1.709	.417	7.004
	55–59	126	.348	1.801	.527	6.161
	60–64	140	.366	1.760	.517	5.991
	65–69	185	.416	1.654	.493	5.552
	70+	257	.607	1.371	.411	4.573
性別	男性 (参照)	328				
	女性	442	.062	.635	.394	1.023
喫煙状況	非喫煙 (参照)	530	.			
	過去喫煙	139	.932	1.027	.559	1.886
	喫煙	101	.295	.733	.410	1.311
現在歯数	1–9 (参照)	192				
	10–19	321	.921	.977	.622	1.536
	20+	257	.263	.750	.453	1.241
未処置歯数	0 (参照)	488	.			
	1–2	184	.807	.950	.631	1.432
	3+	98	.522	.843	.499	1.424
口腔乾燥	なし (参照)	**690**				
	あり	**80**	**.001**	**2.412**	**1.402**	**4.149**
歯の清掃状態	良好 (参照)	92				
	普通	**499**	**.001**	**5.257**	**1.967**	**14.048**
	不良	**179**	**.000**	**13.095**	**4.632**	**37.024**
義歯の清掃状態	良好 (参照)	192				
	普通	496	.452	1.199	.747	1.925
	不良	**82**	**.013**	**2.395**	**1.199**	**4.784**
舌の清掃状態	良好(参照)	168				
	普通	**531**	**.026**	**1.742**	**1.068**	**2.842**
	不良	**71**	**.000**	**4.014**	**1.969**	**8.183**
歯肉出血	0 (参照)	195				
	1–5	356	.141	1.418	.891	2.258
	6+	**219**	**.023**	**1.875**	**1.089**	**3.229**
歯石沈着	0 (参照)	278				
	1–5	229	.861	1.039	.675	1.601
	6+	**263**	**.034**	**1.633**	**1.037**	**2.571**
5㎜以上のポケット	0 (参照)	448	.			
	1–5	250	.815	1.046	.719	1.522
	6+	**72**	**.000**	**4.288**	**2.147**	**8.564**

X．口腔の健康に対する自己認識に関わる要因について

Ueno M, Zaitsu T, Ohara S, Wright C, Kawaguchi Y. Factors influencing perceived oral health of Japanese middle-aged adults, Asia Pacific J Public Health, published online on December 20, 2011.

【背景と目的】

本人の口腔の健康に対する認識にどのような要因が関わっているかを理解することは、口腔の健康の向上を図るために重要となる。本研究の目的は、口腔の自覚症状や臨床所見などが口腔の健康に対する自己認識にどのように関連しているか検討することである。

【方法】

2005～2007 年に秋田県で実施された自記式質問票調査と歯科医師による口腔内診査を受けた 40 歳から 64 歳までの有歯顎の成人 1,799 名を対象とした。口腔の健康に対する自己認識には、口腔の状態の自己評価として“今のお口の健康状態はどうですか？”と食生活の自己評価として“食事の状態はどうですか？”の 2 つの質問票項目を用いた。対象者はそれぞれの項目に、「よい」「まあよい」「普通」「あまりよくない」「よくない」の 5 段階で回答した。口腔の自覚症状では、「歯の冷水痛」「歯の温熱痛」「歯肉出血」「口臭」「歯の動揺」「口腔乾燥」の 6 つを調査した。

口腔内診査では、歯の状態、機能歯ユニット（Functional Tooth Unit：FTU）、歯周組織の状態、口臭、口腔乾燥および口腔粘膜疾患を調査した。

口腔の健康に対する自己認識に関わる要因は共分散構造分析（Structural Equation Modeling：SEM）を用いて解析した。表 1 に示すように、SEM では潜在変数として“口腔の健康に対する自己認識”、“口腔の自覚症状”、“歯の臨床所見”、“歯周組織の臨床所見”、“その他の口腔の臨床所見”の 5 つを用いた。

【結果】

表 2 に示すように、5 つの潜在変数における測定変数の standardized parameter estimate（SPE）は口腔粘膜疾患を除いてすべて有意であった。“口腔の健康に対する自己認識”における SPE で“口腔の状態の自己評価”（SPE=0.74）は“食生活の自己評価”（SPE=0.27）に比べ高い値を示した。“口腔の状態の自己評価”や“食生活の自己評価”が低いほど“口腔の健康に対する自己認識”が低かった。

“口腔の自覚症状”のうち“歯肉出血”が最も高い値（SPE=0.38）を示し、次いで口臭（0.33）、歯の冷水痛（0.33）、歯の動揺（0.31）、歯の温熱痛（0.30）、口腔乾燥（0.22）の順であった。これらの症状が多いほど“口腔の自覚症状”も強くなった。

歯の臨床所見では、現在歯数が少なく、未処置歯数が多く、FTU が少ないと歯の状態が

悪くなった。FTU と現在歯数の SPE（0.48、0.37）は未処置歯数の SPE（0.22）に比べ高い値を示した。

“その他の口腔の臨床所見”では、口臭の SPE（0.35）が最も高く、次いで口腔乾燥（0.30）、口腔粘膜疾患（0.07）の順であった。こうした所見が多いほど“その他の口腔の臨床所見”も高くなった。

図 1 に示すように、5 つの潜在変数間の 7 つの SPE のうち 5 つは有意であった。“口腔の健康に対する自己認識”に対する SPE のうち、“口腔の自覚症状”（0.72）が最も高く、次いで“歯の臨床所見”（0.30）であった。“歯周組織の臨床所見”や“その他の口腔の臨床所見”から“口腔の健康に対する自己認識”への SPE（-0.11、0.13）は有意ではなかった。口腔内の自覚症状が多かったり、歯の臨床所見が悪いほど自分の口腔の健康はよくないと認識していることになる。

“歯の臨床所見”“歯周組織の臨床所見”“その他の口腔の臨床所見”から“口腔の自覚症状”への SPE はすべて有意であった。つまり、“歯の臨床所見”、“歯周組織の臨床所見”、“その他の口腔の臨床所見”が悪いほど“口腔の自覚症状”も強くなった。“その他の口腔の臨床所見”の SPE（0.60）は“歯周組織の臨床所見”（0.27）や“歯の臨床所見”（0.23）の SPE に比べ高い値を示した。

【考察】

今回の研究において、口腔の自覚症状が口腔の健康に対する自己認識に強い影響を及ぼしていることが判明した。しかしながら、特に歯周病のような口腔疾患では、症状が現れた時には病状がすでに進行していることが多い。したがって、歯科の専門家は一般の人々に対して、良好な口腔内の状態を保つためには定期的な歯科健診が重要であることを強調する必要があると考えられた。また、今回の結果は地域レベルにおいて口腔保健向上のための介入計画を策定・実践する際にも有用であると思われた。

表１　潜在変数と観測変数

変数	回答/範囲	人数/平均	%/SD
口腔の健康に対する自己認識			
口腔の状態の自己評価	よい	180	10.0
	まあよい	258	14.3
	普通	910	50.6
	あまりよくない	375	20.9
	よくない	76	4.2
食生活の自己評価	よい	462	25.7
	まあよい	789	43.8
	普通	534	29.7
	あまりよくない	10	0.6
	よくない	4	0.2
口腔内の自覚症状			
歯の冷水痛	ある	466	25.9
	ない	1333	74.1
歯の温熱痛	ある	106	5.9
	ない	1693	94.1
歯肉出血	ある	471	26.2
	ない	1328	73.8
口臭	ある	646	35.9
	ない	1153	64.1
歯の動揺	ある	192	10.7
	ない	1607	89.3
口腔乾燥	ある	312	17.3
	ない	1487	82.7
歯の臨床所見			
現在歯数	1-28	23.9	5.0
未処置歯数	0-26	1.3	2.5
FTU	0-12	10.1	2.6
歯周組織の臨床所見			
歯肉出血数	0-28	5.4	6.0
歯石沈着数	0-28	7.3	7.6
歯周ポケット数	0-28	3.8	5.6
その他の口腔内の臨床所見			
口臭	強い	46	2.6
	中程度	571	31.7
	ない	1182	65.7
口腔乾燥	ある	84	4.7
	ない	1715	95.3
口腔粘膜疾患	ある	33	1.8
	ない	1766	98.2

表 2　測定変数の標準パラメーター推定値（SPE）

変数	SPE	p 値
口腔の健康への自己認識		
口腔の状態の自己評価	0.74	0.001
食生活の自己評価	0.27	0.001
口腔内の自覚症状		
歯の冷水痛	0.33	0.001
歯の温熱痛	0.30	0.001
歯肉出血	0.38	0.001
口臭	0.33	0.001
歯の動揺	0.31	0.001
口腔乾燥	0.22	0.001
歯の臨床所見		
現在歯数	0.37	0.001
未処置歯数	0.22	0.011
FTU	0.48	0.001
歯周組織の臨床所見		
歯肉出血	0.75	0.001
歯石沈着	0.61	0.001
歯周ポケット	0.66	0.001
その他の口腔内の臨床所見		
口臭	0.35	0.001
口腔乾燥	0.30	0.001
口腔粘膜疾患	0.07	N.S.

N.S.=not significant

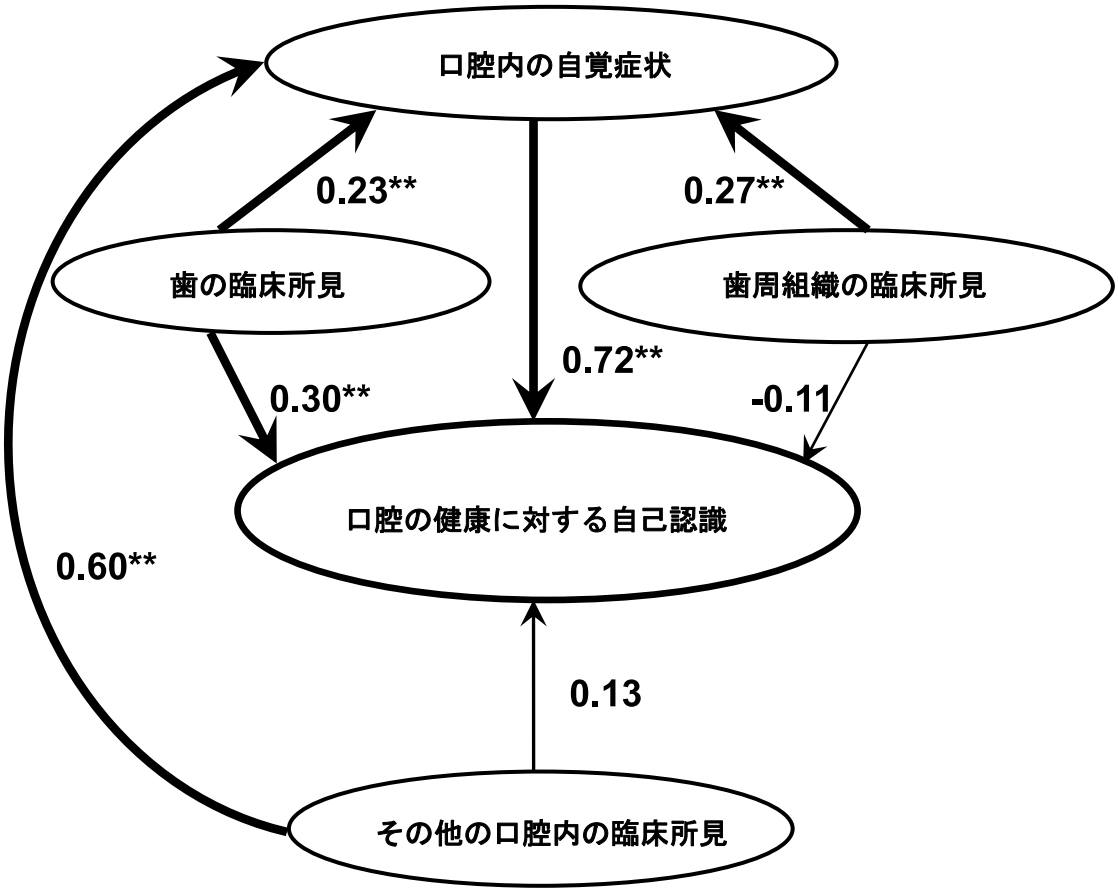


図１　口腔の健康に対する自己認識とそれに関わる変数

Clinical Studies

Prediagnostic Plasma Antibody Levels to Periodontopathic Bacteria and Risk of Coronary Heart Disease

Masayuki Ueno,[1] PhD, Yuichi Izumi,[2] PhD, Yoko Kawaguchi,[1] PhD, Ai Ikeda,[3] PhD, Hiroyasu Iso,[3] PhD, Manami Inoue,[4] PhD, Shoichiro Tsugane,[4] PhD, for the JPHC Study Group

Summary

Many epidemiological studies have indicated that periodontitis is an important risk factor for coronary heart disease (CHD). We examined whether plasma antibody levels to 3 major periodontal pathogens, Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis, and Prevotella intermedia predicted the risk of CHD events.

A nested case-control research design (case: n = 191, control: n = 382), by matching gender, age, study area, date of blood collection, and time since last meal at blood collection, was employed in a large cohort of Japanese community residents.

Antibody levels of periodontopathic bacteria were associated with risk of CHD after adjusting for BMI, smoking status, alcohol intake, history of hypertension, history of diabetes mellitus, exercise during leisure time, and perceived mental stress. The association was different by age subgroup. For subjects aged 40-55 years, the medium (31.7-184.9 U/mL) or high tertile plasma antibody level (> 184.9 U/mL) of A. actinomycetemcomitans showed higher risk of CHD (medium: OR = 3.72; 95% CI = 1.20-11.56, high: OR = 4.64; 95% CI = 1.52-14.18) than the low tertile level (< 31.7 U/mL). The ORs of CHD incidence became higher with an increase in IgG level of A. actinomycetemcomitans (P for trend = 0.007). For subjects aged 56-69 years, the high tertile level (> 414.1 U/mL) of P. intermedia was associated with higher risk of CHD (OR = 2.65; 95% CI = 1.18-5.94) in a dose-response fashion (P for trend = 0.007).

The possible role of periodontopathic bacteria as a risk factor for CHD incidence was suggested by the results of this study by the elevated antibody level to these bacteria with the increased risk of CHD. (Int Heart J 2012; 53: 209-214)

Key words: Plasma antibody, Periodontopathic bacteria, Coronary heart disease

Periodontal diseases such as gingivitis and periodontitis are infectious disorders of the periodontal tissues caused by dental plaque accumulation. Gingivitis is a disease with reversible inflammation of the gingival tissues, whereas periodontitis is a chronic inflammation involving not only gingival tissues but also the periodontal membrane and alveolar bone.[1)] Specific gram-negative anaerobic bacterial species, including Aggregatibacter actinomycetemcomitans (A. actinomycetemcomitans), Porphyromonas gingivalis (P. gingivalis), Prevotella intermedia (P. intermedia), Treponema denticola (T. denticola), Tannerella forsythia (T. forsythia) and Fusobacterium nucleatum (F. nucleatum) have been consistently associated with periodontal diseases.[2,3)]

Periodontal diseases are highly prevalent dental diseases, along with dental caries.[4)] A Japanese national survey of dental diseases conducted in 2005 reported that more than 80% of Japanese aged 45 years or older had some periodontal disease symptoms (ie, gingival bleeding or calculus deposition) and 42.2% of those aged 45 to 55 years had periodontal pockets.[5)]

Coronary heart disease (CHD) is primarily caused by a condition called atherosclerosis, which is the narrowing of the coronary arteries that supply blood and oxygen to the heart due to fatty buildup of plaque. According to the 2010 Japanese vital statistics, heart diseases ranked as the second leading cause of mortality in Japan after cancer, accounting for 15.8% of all deaths, approximately half of which were CHD.[6)]

CHD has a number of risk factors, including smoking, alcohol, and obesity.[7-10)] Furthermore, many epidemiological studies have indicated that periodontitis is involved in the initiation and progression of CHD. They showed a positive association between various measures of periodontal diseases and CHD risk, even after adjustment for a variety of potential confounders of these associations.[11)] However, the status of periodontal disease in most of the studies was based on clinical periodontal examinations or self-reporting. Therefore, the interpretation of such results should be made cautiously because standardized measures for periodontal disease were lacking.

The systemic immunological response to periodontitis can be measured as elevated serum antibody levels against cer-

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This study was partly supported by grants-in-aid for health and labor scientific research from the Ministry of Health, Labor and Welfare of Japan, and the 8020 Promotion Foundation.

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Received for publication February 21, 2012.
Revised and accepted April 16, 2012.

tain periodontopathic bacteria. Serum antibodies to such periodontal pathogens have been used to identify microbial species that are associated with status and progression of periodontal disease, and to define disease-susceptible or disease-resistant individuals.[12)]

Previous studies that employed the antibody levels of periodontal pathogens have provided evidence that infections caused by main periodontal pathogens like A. actinomycetemcomitans and P. gingivalis are associated with an increased risk of myocardial infarction and acute coronary syndrome.[13,14)] Pussinen, *et al* reported that high serum antibody levels to A. actinomycetemcomitans were associated with the subclinical, prevalent, and future incidence of CHD.[15)] A Japanese study demonstrated that serum antibody levels against periodontopathic bacteria were higher among periodontitis patients with CHD than those without CHD.[16)]

However, very few longitudinal studies have investigated a relationship between the systemic immune response to a particular strain of periodontopathic bacteria and the incidence of CHD. In particular, a large-scale prospective cohort study to assess the association between periodontitis and the development of CHD has not yet been conducted in Japanese populations. Therefore, the objective of the current study was to prospectively examine whether plasma antibody levels to 3 major periodontal pathogens, A. actinomycetemcomitans, P. gingivalis and P. intermedia, predicted the risk of CHD events in a large cohort of Japanese community residents.

Methods

Study cohort: Subjects in this nested case-control study were those who had participated in the Japan Public Health Center-based (JPHC) prospective studies I and II, which intended to prospectively follow the morbidity and mortality of various diseases, such as cancer and cardiovascular diseases, in a large population-based Japanese sample. The JPHC Study Cohort I was initiated in 1990 and included residents aged 40-59 years as of December 31, 1989 in 5 public health center areas. The second group (Cohort II) involved 6 public health center areas, was started in 1993 and included residents aged 40-69 years as of January 1, 1993. Details of this study are described in previous articles.[17,18)]

In this study, 191 subjects voluntarily provided 10 mL of blood samples at baseline from 1990 to 1992 in Cohort I or 1993 to 1995 in Cohort II and were diagnosed with CHD during the follow-up period. For each case, two controls were selected by matching gender, age (within 3 years), study area (city or town and village), date of blood collection (within 6 months), and time since last meal at blood collection (within 5 hours). Thus, the number of controls in this study was 382.

Ethical approval of this study was granted by the Ethics Committee of the National Cancer Center in Tokyo, and Ethical Committees of Osaka University and Tokyo Medical and Dental University, Japan.

Socio-demographic and health behavioral information: A self-administered questionnaire, which inquired about height, weight, smoking and drinking habits, medical history (hypertension and diabetes mellitus), leisure time physical activity, and perceived mental stress was distributed to all participants at baseline in 1990 or 1993. BMI was calculated using the formula (weight (kg)/height $(m)^2$).

Confirmation of CHD incidence: A total of 78 hospitals were registered within the sampling area of the JPHC cohort. They were all major hospitals at which CHD disease patients could be admitted. The medical records were reviewed by physicians, blinded to the patient's lifestyle data. CHD events were included in the study if they occurred after the date of return of the baseline questionnaire and before December 31, 2007. The details of the surveillance for CHD were described in a previous paper.[7)] Briefly, CHD was confirmed in the medical records according to the criteria of the Monitoring Trends and Determinants of Cardiovascular Disease (MONICA) project, which requires evidence from ECGs, cardiac enzymes, or autopsy.[19)]

Plasma antibody titer measurement: The plasma and buffy layer of the baseline blood sample were divided into 4 tubes holding 1.0 mL each (3 tubes for plasma and one for the buffy layer) and stored at -80°C until analysis.

Plasma samples were analyzed for the IgG antibody against cell surface antigens for the following 3 suspected periodontal pathogens: A. actinomycetemcomitans ATCC 33384, P. gingivalis ATCC 33277 and P. intermedia ATCC 25611, using an enzyme-linked immunosorbant assay (ELISA) with sonicated whole cell extracts of each periodontal pathogen. The microtiter plates coated with sonicated extracts (100 μL) were stored for 1 day at 4°C and washed 3 times with PBS-T (0.05% Tween-20/PBS), following which they were blocked with 350 μL of 2% BSA + 5% Sucrose + 0.1% NaN3/PBS (pH = 7.0) solution. The plates were incubated for 4 hours at 37°C.

Plasma samples were diluted 420-fold with 1% BSA (Sigma, A-4503) + 0.4% hydrolyzed gelatin (Sigma, G-0262) + 0.1% NaN3 + 5mM magnesium chloride + 5mM EDTA-Na2/0.1M phosphoric acid buffer solution (pH 7.0) and 6 different concentrations of reference solution were prepared with the same diluted solution.

Subsequently, 100 μL of the diluted plasma sample and reference solution were applied to each well, stored for 1 hour at 20-30°C, and washed with 350 μL of 0.05% (w/v) Tween-20/PBS 6 times. To each well was added 100 μL of labeled antibody (IgG antibody: anti-human IgG (rabbit) conj. POD (DAKO), Antibody Aa: 7500IgG, Antibody Pg: 3000IgG, Antibody Pi: 2000IgG), stored 1 hour at 20-30°C and washed with 350 μL of 0.05% (w/v) Tween-20/PBS 8 times.

After adding 100 μL of enzyme substrate solution (DAKO, TMB+) and stopping the reaction with 100 μL of 2N sulfuric acid, the absorbance of each well was read using a Microplate Reader (SOFT MaxTM) at 450 nm with a 650 nm reference wavelength. Individual plasma antibody levels of periodontal pathogens (U/mL) were calculated from the reference curves of antibody concentrations of periodontal pathogens and absorbance density.

Statistical analysis: Baseline characteristics of the cases and controls were evaluated by the Mantel-Haenszel test with matched set strata. Crude odds ratios (ORs) and 95% confidence interval (CIs) for CHD risk were estimated by the tertile level of plasma antibody of the 3 periodontopathic bacteria using a conditional logistic regression model. Tertile cutoff points of each bacterium were based on the frequency distribution of all subjects: A. actinomycetemcomitans (< 31.7, 31.7-184.9, > 184.9), P. gingivalis (< 57.0, 57.0-134.9, > 134.9) and P. in-

termedia (< 235.9, 235.9-414.1, > 414.1). Adjusted ORs were computed by entering the following potential confounding variables: BMI (continuous), smoking status (never, past, current), alcohol intake (nondrinkers or former drinkers, less than week-

Table I. Characteristics of Cases and Matched Control Subjects

	Cases (n = 191)		Controls (n = 382)		P
	Mean / N	SD / %	Mean / N	SD / %	
Age, years	56.7	7.7	56.6	7.6	-
Gender (male), %	119	62.3	238	62.3	-
BMI, kg/cm^2	24.5	3.2	24.3	9.6	0.824
Current smoking, %	78	40.8	105	27.5	0.002
Heavy alcohol intake (≧ 450 mg/week), %	16	8.4	45	11.8	0.271
History of hypertension, %	61	31.9	58	15.2	< 0.001
History of diabetes mellitus, %	35	18.3	34	8.9	0.002
Leisure exercise time (≧ 1-2 times/week), %	42	22.0	69	18.1	0.313
High mental stress, %	39	20.4	49	12.8	0.018
Aggregatibacter actinomycetemcomitans IgG, U/mL	269.7	441.5	249.6	439.7	0.606
Porphyromonas gingivalis IgG, U/mL	148.2	164.1	136.8	144.3	0.397
Prevotella intermedia IgG, U/mL	395.9	248.8	358.1	233.6	0.075

Table II. Odd Ratios (95% CI) of CHD According to Tertiles of Antibody Levels to Periodontopathic Bacteria

	Antibody Tertiles			P for Trend
	Low	Medium	High	
Total subjects				
Aggregatibacter actinomycetemcomitans, U/mL	< 31.7	31.7-184.9	> 184.9	
Cases / Controls	56 / 135	68 / 123	67 / 124	
Crude OR (95% CI)	1.00	1.34 (0.87-2.07)	1.31 (0.85-2.03)	0.227
Adjusted OR (95% CI)	1.00	1.19 (0.71-1.99)	1.65 (0.98-2.80)	0.061
Porphyromonas gingivalis, U/mL	< 57.0	57.0-134.9	> 134.9	
Cases / Controls	62 / 129	67 / 124	62 / 129	
Crude OR (95% CI)	1.00	1.13 (0.74-1.72)	1.00 (0.65-1.53)	0.993
Adjusted OR (95% CI)	1.00	1.04 (0.63-1.71)	1.00 (0.59-1.70)	0.998
Prevotella intermedia IgG, U/mL	< 235.9	235.9-414.1	> 414.1	
Cases / Controls	54 / 137	60 / 131	77 / 114	
Crude OR (95% CI)	1.00	1.18 (0.75-1.86)	1.81 (1.15-2.86)	0.010
Adjusted OR (95% CI)	1.00	1.39 (0.81-2.39)	1.89 (1.10-3.23)	0.021
Age 40-55 years				
Aggregatibacter actinomycetemcomitans, U/mL	< 31.7	31.7-184.9	> 184.9	
Cases / Controls	16 / 61	24 / 33	32 / 50	
Crude OR (95% CI)	1.00	2.55 (1.14-5.72)	2.51 (1.16-5.43)	0.019
Adjusted OR (95% CI)	1.00	3.72 (1.20-11.56)	4.64 (1.52-14.18)	0.007
Porphyromonas gingivalis, U/mL	< 57.0	57.0-134.9	> 134.9	
Cases / Controls	28 / 51	18 / 46	26 / 47	
Crude OR (95% CI)	1.00	0.73 (0.35-1.52)	0.90 (0.46-1.76)	0.757
Adjusted OR (95% CI)	1.00	0.81 (0.27-2.42)	0.94 (0.36-2.46)	0.894
Prevotella intermedia IgG, U/mL	< 235.9	235.9-414.1	> 414.1	
Cases / Controls	26 / 54	22 / 42	24 / 48	
Crude OR (95% CI)	1.00	1.21 (0.58-2.52)	0.86 (0.42-1.79)	0.695
Adjusted OR (95% CI)	1.00	1.67 (0.62-4.46)	1.19 (0.41-3.47)	0.747
Age 56-69 years				
Aggregatibacter actinomycetemcomitans, U/mL	< 31.7	31.7-184.9	> 184.9	
Cases / Controls	40 / 74	44 / 90	35 / 74	
Crude OR (95% CI)	1.00	0.90 (0.53-1.53)	0.85 (0.48-1.48)	0.556
Adjusted OR (95% CI)	1.00	0.65 (0.33-1.26)	0.96 (0.47-1.94)	0.904
Porphyromonas gingivalis, U/mL	< 57.0	57.0-134.9	> 134.9	
Cases / Controls	34 / 78	49 / 78	36 / 82	
Crude OR (95% CI)	1.00	1.29 (0.75-2.23)	0.97 (0.55-1.71)	0.910
Adjusted OR (95% CI)	1.00	1.19 (0.60-2.37)	0.96 (0.45-2.04)	0.907
Prevotella intermedia IgG, U/mL	< 235.9	235.9-414.1	> 414.1	
Cases / Controls	28 / 83	38 / 89	53 / 66	
Crude OR (95% CI)	1.00	1.31 (0.71-2.43)	2.45 (1.29-4.65)	0.004
Adjusted OR (95% CI)	1.00	1.74 (0.76-3.94)	2.65 (1.18-5.94)	0.007

Adjusted for BMI, smoking status, alcohol intake, history of hypertension, history of diabetes mellitus, exercise during leisure time, and perceived mental stress.

ly, < 150 g/week, 150-299 g/week, 300-449 g/week, and ≧ 450 g/week), history of hypertension (yes/no), history of diabetes mellitus (yes/no), exercise during leisure time (rarely, 1-3 times/month, 1-2 times/week, 3-4 times/week, almost every day) and perceived mental stress (low, moderate, high) into the conditional logistic regression model. Since the interaction term suggested that the relationship of periodontopathic bacteria and CHD varied by age, ORs were further computed stratified by two baseline age subgroups using the mean age: 40-55 years and 56-69 years (*P* for interaction by age: A. actinomycetemcomitans = 0.022, P. gingivalis = 0.878, and P. intermedia = 0.004). All statistical analyses were performed with SAS software, version 9.2.

Results

The basic characteristics of cases and matched controls at baseline are presented in Table I. The mean age at baseline in the cases was 56.7 (± 7.7 SD) and that in controls was 56.6 (± 7.6 SD). The percentage of males was 62.3% in each group.

The cases (40.8%) smoked more than the controls (27.5%, $P = 0.002$) and also had higher percentages of history of hypertension (31.9%) and diabetes mellitus (18.3%) compared to controls (15.2%, $P < 0.001$ and 8.9%, $P = 0.002$, respectively). Further, the cases (20.4%) were more likely to perceive high mental stress than controls (12.8%, $P = 0.018$).

No differences were detected regarding BMI, alcohol intake, exercise during leisure time, and the 3 periodontopathic bacterial antibody titers in the plasma.

Table II shows ORs and 95% CIs of CHD incidence risk according to tertile antibody values of the 3 periodontopathic bacteria in the plasma. Subjects with the high tertile of P. intermedia antibody titer had a higher incidence of CHD (crude OR = 1.81; 95%CI = 1.15-2.86 and adjusted OR = 1.89; 95% CI = 1.10-3.23) than those with a low tertile, and there was a dose-dependent increase in incidence of CHD (*P* for trend = 0.010 for crude OR, *P* for trend = 0.021 for adjusted OR) with the plasma antibody of P. intermedia. There were no associations of CHD incidence with plasma antibody levels of A. actinomycetemcomitans and P. gingivalis.

The associations between the bacteria antibody titers and risk of CHD were analyzed for two baseline age subgroups: 40-55 years and 56-69 years. For subjects aged 40-55 years, a medium tertile (crude OR = 2.55, 95% CI = 1.14-5.72; adjusted OR = 3.72; 95% CI = 1.20-11.56) or a high tertile plasma antibody level (crude OR = 2.51; 95% CI = 1.16-5.43; adjusted OR = 4.64; 95% CI = 1.52-14.18) for A. actinomycetemcomitans showed a higher incidence of CHD than a low tertile plasma antibody level. The ORs of CHD incidence became higher with an increase in IgG titer level of A. actinomycetemcomitans (*P* for trend = 0.019 for crude OR, *P* for trend = 0.007 for adjusted OR). No associations with CHD incidence were observed for antibody levels of P. gingivalis and P. intermedia.

For subjects aged 56-69 years, a high tertile titer of P. intermedia (crude OR = 2.45, 95% CI = 1.29-4.65 and adjusted OR = 2.65, 95% CI = 1.18-5.94) had a higher incidence of CHD compared to a low tertile titer, and the titer of P. intermedia was associated with a dose-dependent increase in incidence of CHD (*P* for trend = 0.004 for crude OR. and *P* for trend = 0.007 for adjusted OR). Antibody levels of A. actinomycetemcomitans and P. gingivalis were not related with the incidence of CHD.

Discussion

In this population-based, longitudinal study, higher levels of periodontopathic bacteria A. actinomycetemcomitans and P. intermedia, measured as the plasma antibody titer, were significantly associated with an increased risk of CHD events. The association was different by age subgroup, ie, the relationship with A. actinomycetemcomitans was accentuated in subjects aged 40-55 years and that with P. intermedia in those aged 56-69 years.

The link between periodontal disease and CHD is complex and many publications have provided support to the hypothesis of a causal association.[3,20,21] Hypothesized mechanisms include the direct effect of a subgingival biofilm or an indirect effect through an immunologic response and activation of inflammation is involved in the pathogenesis of atherosclerotic plaque formation.[20,21] Endothelial dysfunction is the first step in the development of atherosclerosis. Periodontitis has been demonstrated to be related with endothelial dysfunction.[22] Dorn, *et al* show that periodontopathic bacteria such as P. gingivalis and P. intermedia invade coronary artery cells at a significant level.[23] Further, an elevated serum IgG level of A. actinomycetemcomitans is reported to be associated with atherosclerosis.[24]

The possible relationship of A. actinomycetemcomitans with CHD incidence has been documented in several studies. Spahr, *et al* measured subgingival pathogens in subjects aged 43 to 73 years with DNA-RNA hybridization, and found a positive association of the amount of A. actinomycetemcomitans with risk of CHD (OR = 2.70; 95% CI = 1.79-4.07).[25] Pussinen, *et al* reported significant associations between elevated levels of IgG antibodies against A. actinomycetemcomitans and cardiovascular disease events in subjects aged 25 to 64 years (OR = 1.64, CI = 1.00-2.69).[26]

A. actinomycetemcomitans is the major etiologic agent of localized aggressive periodontitis, and an increased level of serum antibody to A. actinomycetemcomitans is considered to represent a destruction of the periodontal structures; thereby posing a systemic challenge that disseminates the bacteria, leading to vascular activation.[27] Individuals who carry A. actinomycetemcomitans have a higher risk of periodontitis, particularly among a younger age population (35 years or younger), because this species possesses certain disease-relevant virulence.[27] A. actinomycetemcomitans is also reported to be an etiological agent in early-onset periodontal disease.[15,28,29] Thus, the augmented association of CHD with A. actinomycetemcomitans observed in the younger age subgroup of this study implies that people who already develop advanced periodontal disease at an early age may have a higher risk of CHD.

A previous study demonstrated that the presence of P. intermedia in periodontal pockets was associated with an increased risk of myocardial infarction (OR = 1.40 and 95% CI = 1.02-1.92) in subjects aged 35 to 69 years, after adjusting for potential confounding factors.[30] A case-control study among males aged 48 to 80 years by Nonnenmacher, *et al* documented a significantly higher frequency of subgingival P. intermedia in patients with coronary artery disease when compared to the

controls, after adjusting for smoking.[31] Further, Spahr, *et al* found a markedly higher number of P. intermedia in the subgingival biofilm of 43 to 73 year-old patients with CHD compared to age- and sex-matched controls. All these findings support our current results.[25]

However, the above studies were based on the amount of P. intermedia in the subgingiva. Few reports have used the antibody level of P. intermedia, in contrast to other periodontopathic bacteria, to examine the relationship with CHD. In a population-based study conducted for 45 to 64 year-olds in the United States, a high serum IgG antibody level to P. intermedia was associated with risk of CHD among never smokers.[32]

A relationship between P. intermedia and CHD was only detected in subjects aged 56-69 years in this study. This might be linked to the fact that P. intermedia play a major role during chronic periodontitis, with which older people are more likely to be afflicted, by regulating diverse inflammatory and immune responses to tissue destruction.[33]

Since no studies have investigated the association between bacteria antibody and CHD by stratifying for age, it is unknown why different pathogens play a role in the different age groups. Therefore, further research will be needed to clarify the molecular-biological mechanisms of the age-related relationships between CHD and P. intermedia and A. actinomycetemcomitans found in this study.

Serological evidence confirms that an infection caused by P. gingivalis is a contributor to an increased risk for CHD. Pussinen, *et al* reported in a dentate male population aged 45 to 74 years that CHD was more common among subjects who were seropositive for P. gingivalis compared to those who were seronegative.[34] However, we found no association between the plasma antibody to this species and risk of CHD. Similarly, several studies showed no significant connection between the presence of IgG antibodies to P. gingivalis and CHD, especially after adjusting for confounding variables.[15,32,35]

In spite of the similar infectious capability of P. gingivalis strains, the risk of CHD differs depending on the strain; a particular genotype of P. gingivalis with strong virulence is considered to be involved more in the mechanisms linking periodontitis and CHD.[16] The existence of different genotypes of P. gingivalis with different virulence may also contribute to the inconsistent relationship with CHD.

Our study had several strengths. We used antibodies to bacteria in examining the association between periodontal disease and CHD. Defining periodontal disease by clinical periodontal parameters, such as pocket depth or clinical attachment level, has been criticized when investigating the relationship with CHD, where long-standing exposure to the bacteria is the hypothesized risk factor, because they do not represent any systemic effect incurred by the periodontal disease. The most commonly used surrogates for systemic exposure are antibody titers, which indicate an immunological response against the periodontopathic bacterial infection and are thought to be a marker of inflammation. Antibody levels to serum periodontopathic bacteria are also closely related to the distribution of organisms in gingival plaque.[32]

Further, the control of important confounders that would strongly affect both periodontal health and cardiovascular outcomes is important in interpreting the findings. We used controls and cases, individually matched for age, sex and other related factors, and a sampling ratio of 1:2 was intended to ensure adequate statistical power. We also attempted to reduce potential confounding variables by statistically controlling for a number of CHD-related health indicators. In addition, the current prospective case-control design allows assessment of the causal role of periodontal pathogens in the development of CHD.

There are also limitations of our study that deserve consideration. Although serum antibody levels are considered stable over time, clinical periodontal status was not available, and it is not known whether the levels of antibody to periodontal organisms are the result of a prior incident or to active infection in the study population. In addition, information on remaining teeth, an important confounder for the antibody values,[31] was missing. Further, only 3 periodontopathic species were investigated in this study, and antibody responses to other kinds of bacteria and their role in CHD incidence are unknown.

The possible role of periodontopathic bacteria as a risk factor for CHD incidence was demonstrated in this prospective study, where the elevated antibody level to these bacteria appeared to increase the risk of CHD. Therefore, a close relationship between oral disease and systemic disease was confirmed. From a public health standpoint, our result on periodontal disease as a risk factor for CHD is important, because periodontal disease can be prevented or treated. Given the high prevalence of both periodontal disease and CHD globally, the prevention and treatment of periodontal disease by appropriate oral health interventions might contribute to the prevention of CHD.

Acknowledgments

The authors thank all JPHC staff members in each study area and the central office for their painstaking efforts to conduct the baseline survey and follow-up research. We are also indebted to the Tokyo College of Medical Technology for their technological support of plasma antibody titer measurement.

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Community Dent Oral Epidemiol 2012; 40: 481–487

COMMUNITY DENTISTRY AND ORAL EPIDEMIOLOGY

Association between education level and dentition status in Japanese adults: Japan public health center-based oral health study

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Ueno M, Ohara S, Inoue M, Tsugane S, Kawaguchi Y. Association between education level and dentition status in Japanese adults: Japan public health center-based oral health study. Community Dent Oral Epidemiol 2012; 40: 481–487. © 2012 John Wiley & Sons A/S

Abstract – *Objectives:* The aim of this study was to examine whether there is an educational gradient in dentition status among Japanese adults who are under the universal public health insurance system. *Methods:* Subjects were 1201 community residents aged 55–75 years as of May 2005 who completed a self-administered questionnaire and had a standard clinical oral examination. Analysis focused on the association of three education levels (junior high school, senior high school, and any college or higher education) with dentition status. *Results:* The proportion of subjects with 20 or more teeth ($P < 0.001$), number of teeth present ($P = 0.037$), number of filled teeth ($P = 0.016$), and two types of functional tooth units (FTUs): FTUs with natural teeth (n-FTUs) ($P < 0.001$) and FTUs with natural teeth and artificial teeth on implant-supported and fixed prostheses (nif-FTUs) ($P < 0.001$) were significantly associated with education level after adjusting for confounders. The significant trend of these values in dental indexes indicated a poorer dentition status with a lower education level. *Conclusions:* The results suggest that the level of education has an independent impact on dentition status in a group of Japanese adults, even after taking into account oral health-related factors. Therefore, providing appropriate oral health information from an early age within a compulsory school education program appears necessary to enhance health literacy and lessen the inequalities in dental health by educational level.

Key words: education level; functional tooth units; oral health status; universal public health insurance

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Submitted 11 July 2011;
accepted 24 March 2012

There are several indicators employed in the evaluation of socioeconomic status (SES). Generally, SES is measured by income, occupational status, or education level as the proxy, and these have been used singularly or in combination (1, 2). Education level is often used in research to distinguish people with a high status in society from those with a low status. Among SES measures, education level is fairly stable for most adults throughout their life, while income and occupational status are greatly influenced by economic fluctuations (3).

The relationship between SES and general health has been widely investigated, and the close link between SES and health is well established. An unfavorable health status is often found among people with a lower SES (4, 5). The association of a lower education level with a higher risk of general health problems has been often investigated among people in Europe and the United States (4, 6), but few

doi: 10.1111/j.1600-0528.2012.00697.x

studies have been conducted in the Japanese population (7–9). An earlier Japanese study reported that the relationship between education level and health behaviors was weaker in Japan than in other developed countries (7). There is, however, evidence that lower education levels are associated with worse general health conditions in Japan (8, 9).

Socioeconomic disparities in oral health have also been repeatedly demonstrated in many countries (10). People in lower SES groups are reported to have markedly poorer oral health than those in higher SES counterparts (11). There is also substantial evidence of a strong association between education level and oral health from many countries (12–14). One previous study reported that subjects with a low education level had a larger number of missing teeth compared with those with a high education level (15). Further, elderly Danes with a low education level had a tendency to have more decayed tooth (DT) surfaces compared with those with a high education level. On the other hand, individuals with a high education level had significantly more filled teeth (FT) than those with a low education level (16). A low education level in older people also has an independent negative impact on oral health-related quality of life (17).

To date, no study has assessed whether education level contributes to the inequalities of oral health in Japanese people. Thus, it is not possible to verify whether the relationship between education level and oral health status, identified in Europe and the United States, also exists in Japan. Japan is known to have a less marked socioeconomic differential compared with other developed countries. In addition, Japan has had a universal health insurance system, including dentistry, since 1961 (18). Thus, every Japanese person can receive most dental treatments, including restorations, prostheses, and oral surgery for the same price at any dental clinic by paying 30% of the cost.

Therefore, the aim of this study was to examine whether there is an educational gradient in dentition status among Japanese adults who are under the universal public health insurance system.

Methods

Subjects

The Japan Public Health Center-Based (JPHC) Study Cohort I was initiated in 1990 for the purpose of prospectively following the morbidity and mortality of various diseases, such as cancer and cardiovascular diseases, in a large population-based Japanese sample of administrative districts supervised by five public health centers (19).

In 2005, a dental survey was conducted for the first time in a cohort from the Yokote health center jurisdiction, Akita Prefecture. Thus, subjects in this study were a subsample in the Yokote health center jurisdiction, who had participated both in the JPHC Study Cohort I in 1990 and the dental survey in 2005.

Invitation letters were mailed to 15 782 residents (aged 55–75 years as of May 2005) who had joined the JPHC Study Cohort I, informing them about the purposes and procedures of the study and seeking their participation in the research. A total of 1518 subjects completed a self-administered dental questionnaire and presented for a clinical oral examination between July 2005 and January 2006. Information on demographics (date of birth and gender) and education was obtained from a self-completed questionnaire administered in 1990 as a part of the JPHC Study Cohort I. The final number of subjects used for the analysis was 1201 after excluding those with missing data for either the outcome or any explanatory variable. Ethical approval of this study was granted by the Ethics Committee of the National Cancer Center in Tokyo and Tokyo Medical and Dental University Ethical Committee, Japan.

Education levels

The response options of the question inquiring about the highest education level achieved by subjects were junior high school, senior high school, junior college or vocational school, and university or higher. The education level was then collapsed into three groups: low (junior high school), middle (senior high school), and high (any college or higher education) education levels.

Health behaviors

A self-completed dental questionnaire, administered at the time of the presentation for the oral examinations in 2005, consisted of health-behavior-related questions such as intake of sweet snacks or drinks (rarely, sometimes and everyday), dental check-up in the previous year (yes or no) and smoking status (nonsmoker, past smoker, and current smoker).

Dentition status

Clinical oral examinations of dentition status (excluding third molars) were conducted in 2005

according to the World Health Organization guidelines (20). The standardized clinical oral examinations were performed by one of 43 participating dentists trained in the survey methods. A handbook describing the clinical criteria was distributed to all participating dentists prior to the examination. The examination included the number of teeth present, DT, and FT, following which the prevalence of edentulousness and proportion of subjects with 20 or more teeth were calculated.

The total number of Functional Tooth Units (total-FTUs) was defined as the number of pairs of opposing natural teeth (i.e., sound, restored, and carious teeth) and artificial teeth on implant-supported, fixed (bridge pontics), and/or removable prostheses in posterior teeth occlusion. Carious teeth with extensive coronal destruction and missing teeth were regarded as nonfunctional. Two opposing premolars were defined as one FTU, and two opposing molars were defined as two FTUs. Therefore, a person with a complete dentition had 12 FTUs. The FTUs were further divided by tooth composition into n-FTUs (FTUs of natural teeth) and nif-FTUs (FTUs of natural teeth and artificial teeth on implant-supported and fixed prostheses).

Oral hygiene of teeth or dentures was visually evaluated by examining all teeth present or on the dentures and was scored as: (i) good = plaque covering less than one-third of tooth surfaces; (ii) fair = plaque covering more than one-third but less than two-thirds of tooth surfaces; and (iii) poor = plaque covering more than two-thirds of tooth surfaces. The worst score was recorded as representative for the subject.

Statistical analysis

The two-sample *t*-test was used for testing the difference of mean age between two groups, and chi-square test for the relationship of categorical values such as gender or education level. The linear trend of education level with demographics, health behaviors, and oral hygiene was analyzed by a linear regression model for continuous data and by the Mantel–Haenzel's chi-square test for categorical data. The linear trend of education level with each clinical dental outcome was assessed using a logistic regression for binary data and generalized linear regression of the negative binominal model with logit built-in link function for count data. The analysis was performed both unadjusted and adjusted for age, gender, intake of sweet snacks and drinks, dental check-up, smoking, and oral hygiene of teeth or dentures. All analyses were conducted using SPSS (SPSS Japan Inc., Tokyo, Japan) 18J software.

Results

The nonresponse analyses to compare participants and nonparticipants on socio-demographics assessed at baseline in 1990 indicated that the number of nonparticipants of the study (excluding those with missing data) was 10 236 (mean age: 66.2 ± 7.96, 5005 men, 5231 women) (Table 1). Nonparticipants had a similar mean age to participants (65.5 ± 5.77 years), although the difference was significant ($P = 0.003$). Male to female ratio of nonparticipants (48.9–51.1%) was similar to that of participants (46.4–53.6%) ($P = 0.102$). However, nonparticipants had a higher proportion of low education level (low: 49.8%, middle: 37.5%, and high: 12.7%) compared with participants in this study (low: 33.5%, middle: 50.6%, and high: 15.9%).

Mean ages (±SD) of men in the low, middle, and high education levels were 66.8 ± 5.8, 65.2 ± 5.5, and 64.8 ± 6.0, respectively, and those of women were 67.5 ± 5.5, 64.2 ± 5.6, and 63.8 ± 5.5, respectively. Age was inversely related with education level in both men (P for trend < 0.01) and women (P for trend < 0.001), with older ages in the lower education levels.

The proportions of men in the low, middle, and high education levels were 30.7% ($N = 171$), 51.3% ($N = 286$), and 18.0% ($N = 100$), respectively, and those of women were 35.9% ($N = 231$), 50.0% ($N = 322$), and 14.1% (N = 91), respectively. There was a significant distributional difference in gender by education level (P for trend = 0.023).

Intake of sweet drinks in men was significantly associated with education level (Table 2). More

Table 1. Socio-demographics of participants and nonparticipants

	Participants (n = 1201)	Nonparticipants (n = 10 236)	P value
Age			
Mean (SD)	65.5 (5.77)	66.2 (7.96)	0.003
Gender, *n* (%)			
Male	557 (46.4)	5005 (48.9)	0.102
Female	644 (53.6)	5231 (51.1)	
Education level, *n* (%)			
Low	402 (33.5)	5098 (49.8)	<0.001
Middle	608 (50.6)	3838 (37.5)	
High	191 (15.9)	1300 (12.7)	

Table 2. Health behaviors and oral hygiene among the study subjects by gender (n = 1201)

	Male education level				Female education level			
	Low	Middle	High	P for trend	Low	Middle	High	P for trend
Sweet snacks, n (%)								
Rarely	26 (11.2)	54 (18.9)	21 (21.0)	0.204	19 (8.2)	18 (5.6)	3 (3.3)	0.961
Sometimes	108 (63.2)	184 (64.3)	60 (60.0)		119 (51.5)	161 (50.0)	59 (64.8)	
Everyday	37 (21.6)	48 (16.8)	19 (19.0)		93 (40.3)	143 (44.4)	29 (31.9)	
Sweet drinks, n (%)								
Rarely	36 (21.1)	97 (33.9)	43 (43.0)	0.001	109 (47.2)	145 (45.0)	52 (57.1)	0.490
Sometimes	83 (48.5)	130 (45.5)	45 (45.0)		78 (33.8)	118 (36.6)	21 (23.1)	
Everyday	52 (30.4)	59 (20.6)	12 (12.0)		44 (19.0)	59 (18.3)	18 (19.8)	
Dental check-up, n (%)								
Yes	74 (43.3)	135 (47.2)	51 (51.0)	0.216	102 (44.2)	143 (44.4)	44 (48.4)	0.597
No	97 (56.7)	151 (52.8)	49 (49.0)		129 (55.8)	179 (55.6)	47 (51.6)	
Smoking, n (%)								
Nonsmoker	69 (40.4)	108 (37.8)	24 (24.0)	0.213	227 (98.3)	313 (97.2)	87 (95.6)	0.350
Past smoker	57 (33.3)	112 (39.2)	52 (52.0)		3 (1.3)	2 (0.6)	4 (4.4)	
Current smoker	45 (26.3)	66 (23.1)	24 (24.0)		1 (0.4)	7 (2 .2)	0 (0.0)	
Oral hygiene, n (%)								
Good	17 (9.9)	35 (12.2)	16 (16.0)	0.379	26 (11.3)	60 (18.6)	14 (15.4)	0.064
Fair	112 (65.5)	177 (61.9)	61 (61.0)		157 (68.0)	44 (13.7)	16 (17.6)	
Poor	42 (24.6)	74 (25.9)	23 (23.0)		48 (20.8)	74 (25.9)	23 (23.0)	

subjects who drank sweet drinks everyday were observed in the lower education levels (P for trend = 0.001). Intake of sweet snacks, dental check-up in the previous year, smoking status and oral hygiene of teeth or dentures were not significantly related with education level.

In the bivariate analysis, without adjustment by demographic and oral health-related variables, there were significant linear trends in dentition status by education level (Table 3). Prevalence of edentulousness declined with the rise of education level (P for trend < 0.001), whereas the proportion of subjects with 20 or more teeth increased as the education level went up (P for trend < 0.001).

No significant trends were observed in the number of DT and total-FTUs by education level (Table 4). Numbers of teeth present and FT showed an ascending trend by education level (P for trend < 0.001). Further, significantly more n-FTUs and nif-FTUs were found in subjects with a higher education level (P for trend < 0.001).

After adjustment for demographic and oral health-related variables, the significant association between edentulousness and education level disappeared. The proportion of subjects with 20 or more teeth (P for trend < 0.001), numbers of teeth present (P for trend = 0.037), FT (P for trend = 0.016), n-FTUs (P for trend < 0.001), and nif-FTUs (P for trend < 0.001) remained significantly related with education level. The values of these variables had a significantly increasing trend with the rise in education level.

Table 3. Prevalence of edentulousness and proportion of subjects with 20 or more teeth by education level

	Education level			
	Low	Middle	High	P for trend
Edentulousness				
% (No. of cases/subjects)	8.5 (34/402)	5.1 (31/608)	2.1 (4/191)	
OR (95% CI)	1.00	0.58 (0.35–0.96)	0.23 (0.08–0.66)	<0.001
Adjusted OR[a] (95% CI)	1.00	1.03 (0.58–1.83)	0.42 (0.14–1.27)	0.085
20 or more teeth				
% (No. of cases/subjects)	45.8 (184/402)	62.5 (380/608)	74.9 (143/191)	
OR (95% CI)	1.00	1.98 (1.53–2.55)	3.53 (2.41–5.17)	<0.001
Adjusted OR[a] (95% CI)	1.00	1.53 (1.16–2.01)	2.72 (1.81–4.07)	<0.001

[a]Adjusted for age, gender, intake of sweet snacks, intake of sweet drinks, dental check-up, smoking, oral hygiene of teeth or dentures.

Table 4. Mean numbers of teeth present, decayed teeth (DT), filled teeth (FT), and functional tooth units (FTUs) by education level

	Education level Low	Middle	High	*P* for trend
Number of teeth present				
Mean (SD)	16.33 (8.76)	19.21 (8.52)	21.71 (7.00)	<0.001
Adjusted Mean (SD)[a]	16.97 (17.80)	18.46 (19.09)	20.72 (21.35)	0.037
Number of DT				
Mean (SD)	1.01 (1.96)	1.20 (2.38)	1.28 (2.54)	0.184
Adjusted Mean (SD)[a]	0.82 (1.26)	0.93 (1.38)	0.95 (1.38)	0.248
Number of FT				
Mean (SD)	8.94 (6.16)	10.21 (6.22)	11.84 (6.03)	<0.001
Adjusted Mean (SD)[a]	9.03 (9.72)	9.76 (10.33)	11.46 (12.07)	0.016
Number of n-FTUs				
Mean (SD)	3.65 (4.01)	5.11 (4.42)	6.28 (4.32)	<0.001
Adjusted Mean (SD)[a]	3.76 (4.33)	4.68 (5.20)	5.78 (6.29)	<0.001
Number of nif-FTUs				
Mean (SD)	4.42 (4.58)	5.87 (4.75)	7.37 (4.64)	<0.001
Adjusted Mean (SD)[a]	4.58 (5.15)	5.40 (5.94)	6.79 (7.31)	<0.001
Number of total-FTUs				
Mean (SD)	10.09 (2.67)	10.14 (2.68)	10.49 (2.18)	0.084
Adjusted Mean (SD)[a]	10.05 (10.75)	10.14 (10.70)	10.53 (11.13)	0.623

[a]Adjusted for age, gender, intake of sweet snacks, intake of sweet drinks, dental check-up, smoking, oral hygiene of teeth or dentures.

Discussion

This cross-sectional study explored the association between education level and dentition status in a sample of Japanese adults. Even in Japan, where a universal public health insurance system is instituted, there existed a gradient in oral health by education level, and the gradient still persisted while controlling for other relevant demographic and health behavioral variables commonly used in many studies (11, 21, 22).

Health behaviors and oral hygiene used in this study have been demonstrated to be associated with dentition status (23–26). Dietary habit such as consumption of sweet snacks or sweet drinks is still one of risk factors of dental caries despite of the widely use of fluoride (23). Dental visit pattern is contributory to periodontal disease (24). Smoking has a positive association with missing teeth and periodontal disease (25, 26). Oral hygiene condition, especially plaque accumulation, is closely related with the development of dental diseases (27).

These possible confounding variables used to control for variability were not related with education level except for intake of sweet drinks in men. These findings were align with the report by Paulander et al. (15) who found no association of education level with dietary habit, dental care habits, and oral hygiene. Similarly, in respect to smoking status, Anzai et al. (7) also reported no differences by education level in Japanese men aged 50–59 years and 70 years or older as well as women aged 60–69 years and 70 years or older. Male subjects with a higher education level were less likely to take sweet drinks in this study.

The former studies reported that the percentage of edentulous subjects in low education level groups were significantly higher than that in higher education level groups (10, 15, 28). The unadjusted bivariate analysis in this study showed a similar trend, although this trend was attenuated and was not marginally significant ($P = 0.085$) after adjusting for confounders. Therefore, confounding factors influence the relationship between edentulousness and the education level to some degree.

Keeping at least 20 or more natural teeth until the age of 80 is the goal of the national oral health campaign in Japan (29). People with 20 or more teeth are reported to be able to eat most types of Japanese foods (30). Similar goals of having 20 and more functional natural teeth exist in the World Health Organization (31) and Federation Dentaire Internationale (32). There was a significant increasing trend in the proportion of subjects with 20 or more teeth as education level increased. Previous research has also indicated that there were fewer persons with 20 or more teeth in less educated groups (10). A further study showed a linear relationship between the prevalence of having fewer

than 24 teeth and SES, with prevalence decreasing at higher levels of perceived social status (11).

The present study showed that persons with a higher education level had significantly more FT compared with those with a low education level. Similar results were found in the National Health and Nutrition Examination Survey 1999–2004 (28). This trend might be explained by people's attitude and behavior toward oral health care utilization (10).

On the other hand, there was no significant association between education level and number of DT, confirming previous reports. For example, in a Danish study of the elderly, those with a lower education level tended to have more decayed surfaces compared with their counterparts, but the difference was not significant (16). A possible reason for not detecting a significant difference in this study is that the mean number of DT was very small, that is, close to 1, making statistical significance difficult to detect.

No difference by education level was found regarding total-FTUs, which were more than 10 at all education levels. This high number could be explained by missing teeth being replaced with the artificial teeth of dentures, resulting in the recovery of FTUs when calculated as total-FTUs, as has also been reported in previous studies (30, 33). In fact, any Japanese person can afford to have dentures made regardless of their SES, because it is relatively inexpensive under the Japanese universal public health insurance system. On the other hand, a significant oral health gradient was found in n-FTUs and nif-FTUs, indicating that less educated people were more likely to lose posterior occlusal relations with natural, implanted, and fixed prosthetic teeth. A previous study reported that recovery of total-FTUs by removable prosthodontic treatments might not yield a significantly improved masticatory function. Therefore, maintenance of occluding pairs with as many n-FTUs or nif-FTUs as possible is important in reducing the likelihood of chewing difficulty (30).

This study had certain limitations. The subjects used in this study may not have been representative of the general adult population in Japan, because their participation was voluntary. Intra- or interexaminer reliability was not obtained because of a large number of participating dentists. In addition, we only used the education level as a proxy for SES. It would be preferable to use multiple indicators, because each indicator covers a different aspect of SES. The nonresponse analyses indicate that there is a possibility that participants may have a little different socio-demographic characteristic from nonparticipants. Future research will be needed to confirm the current findings using a representative sample with multiple SES indicators.

This is the first study demonstrating that the level of education has an independent impact on dentition status, as a consequence of different treatment options by education level, in a group of Japanese adults. People with a lower education level tended to lose more teeth and wear removable prostheses, whereas those with a higher education level had more teeth and tended to receive treatments such as fillings, fixed prostheses, and implants.

The findings indicate that oral disease prevention strategies solely focusing on personal health behaviors may have a limited effect. Therefore, it is necessary to focus on the socioeconomic determinants of oral health that form the living and working environments in which oral health behaviors are created. Nine years of elementary and junior high school education are compulsory in Japan. The present study suggests that providing appropriate information from an early age through oral health education in compulsory school health programs is necessary to enhance health literacy and lessen the inequalities of dental health by educational level.

Acknowledgements

This study was partly supported by the Ministry of Health, Labour and Welfare Grants-in-Aid for Scientific Research, and the 8020 Promotion Foundation. The authors thank all staff members in each study area and in the central office for their painstaking efforts to conduct the baseline survey and follow-up.

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Oral Diseases (2009) 15, 69–75. doi:10.1111/j.1601-0825.2008.01472.x

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ORIGINAL ARTICLE

Relationship of smoking and smoking cessation with number of teeth present: JPHC Oral Health Study*

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BACKGROUND: Smoking is associated with the number of teeth. The purpose of this study was to determine the relationship of number of teeth with smoking and smoking cessation.
METHODS: Subjects included 547 males aged between 55 and 75 years. Oral examinations were conducted in 2005. Smoking status information was collected from questionnaire surveys conducted in 1990, 1995, 2000, and 2005. The relationship between having more than eight missing teeth and smoking status was estimated with adjusted odds ratio.
RESULTS: Comparing with never smokers, odds ratios of having more than eight missing teeth among current and former smokers were 1.96 and 1.86, respectively. The odds ratios in those who had stopped smoking for ≤10 years was 3.02, and for those who had ceased smoking for 11–20 years was 2.66. In those who stopped smoking for 21 years or more, there was no increase in the odds ratio.
CONCLUSION: Smoking had a positive association with the number of missing teeth and smoking cessation is beneficial for maintaining teeth. The odds of having more than eight missing teeth in those who had never smoked was equal to that of individuals who reported that they had stopped smoking for 21 years or more.
Oral Diseases (2009) **15**, 69–75

Keywords: missing teeth; smoking; smoking cessation

Introduction

Tooth loss affects activities such as speaking, smiling, chewing and tasting. In 1989, the Japanese Ministry of Health and Welfare proposed the 8020 Campaign, and since then this national oral health campaign has been conducted with the co-operation of the Japanese Dental Association throughout Japan. The concept behind the 8020 program is to maintain a high quality of life by preventing tooth loss throughout life. The '80' signifies the average life expectancy of Japanese people, and the '20' indicates the critical number of natural teeth needed to maintain a good eating and chewing function throughout life (Hashimoto *et al*, 2006a,b). According to the national dental survey in 2005, however, the current mean number of teeth present in those 80 years of age is 8.8 (The Statistical Analysis Committee on the Survey of Dental Diseases, 2006).

Smoking has been associated with a higher prevalence of edentulousness and fewer remaining teeth (Ahlqwist *et al*, 1989; Linden and Mullally, 1994; Krall *et al*, 1997, 2006b; Axelsson *et al*, 1998; Ylostalo *et al*, 2004; Dietrich *et al*, 2007). The main biological causes of tooth loss are periodontal disease and dental caries (Morita *et al*, 1994). A complex relationship among bacteria, the host, and behavioral and environmental factors determines the onset and progress of these oral diseases. Smoking is one important risk factor for periodontal disease (Osterberg and Mellstrom, 1986; Grossi *et al*, 1994, 1995; Albandar *et al*, 2000; Tomar and Asma, 2000; Bergström, 2003). A causal association has been established between smoking and periodontal disease (U.S. Department of Health and Human Services, 2004). As periodontal disease progresses, the gingival margins regress and root surfaces are exposed to acid-producing bacteria. Therefore, periodontal disease also increases the risk of caries on the root surfaces of teeth (U.S. Department of Health and Human Services, 2004).

Because various factors influence tooth loss, confounding factors should therefore also be considered while investigating the relationship of smoking and smoking cessation with tooth loss. Body mass index (BMI), vitamin C intake, alcohol consumption and educational background can all be associated with tooth loss (Gilbert *et al*, 2003; Klein *et al*, 2004).

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Received 28 November 2007; revised 5 June 2008; accepted 15 June 2008

In Japan, an association between smoking and tooth loss has been identified by a number of researchers (Yoshida *et al*, 2001; Yoshihara *et al*, 2005; Hanioka *et al*, 2007), but most such investigations have been cross-sectional, with only a few retrospective studies (Okamoto *et al*, 2006). In particular, few epidemiological studies have investigated the relationship of smoking cessation with the risk of tooth loss.

The purpose of this study was to investigate the relationship of smoking and smoking cessation with the number of teeth. The association between the number of smoking cessation years and having more than eight missing teeth (i.e. fewer than 20 teeth present) was analyzed using the data of an ongoing prospective study, the Japanese Public Health Center-based Prospective Study (JPHC Study).

Methods

The subjects in the present study included a subsample of participants in the district of the Yokote Public Health Center belonging to the JPHC Study Cohort I (Tsugane and Sobue, 2001). In this district, 15,782 subjects (7,559 men, 8,223 women) who were 40–59 years of age as on December 31, 1989, were respondents to the JPHC study and 11,754 subjects (5,471 men, 6,283 women) answered the questionnaire. The subjects were recruited by mail to participate in a dental health checkup at district dental clinics in May 2005. A total of 1,518 subjects (706 men, 812 women) underwent clinical dental examination between July 1, 2005 and January 31, 2006.

The number of teeth present was objectively determined by dental examination by the district's dentists at the dental clinics of Yokote city and Hiraka County Dental Association members in 2005. Only 28 permanent teeth were examined and third molars were excluded.

The smoking status of the subjects was derived from a self-completed questionnaire administered in 1990, 1995, 2000, and 2005, in which the questionnaire items asked about smoking status at the time of the survey. The response options were: 'Currently smoking'; 'Quit smoking'; and 'Not smoking'. Based on these four questionnaires, smoking status was categorized into three groups: 'Never smokers', 'Current smokers' and 'Former smokers'. 'Never smokers' were persons who answered 'Not smoking' in both 1990 and 2005 and answered 'Not smoking' in 1995 and 2000 or had a missing value in 1995 and 2000. 'Current smokers' were individuals who answered 'Currently smoking' in 2005, regardless of answers in 1990, 1995 and 2000. 'Former smokers' were persons who answered 'Quit smoking' in 2005 or those who answered 'Not smoking' in 2005 but 'Currently smoking' or 'Quit smoking' in 1990. We excluded the subjects whose information of smoking status at the 1990 questionnaire was not available and whose information of smoking status during 15 years showed a discrepancy such as 'Quit smoking' in 2005 and 'Not smoking' in 1990.

The question about the age when subjects started smoking was asked in 1990, and the questions about the number of cigarettes smoked per day and the age when they quit smoking were asked in 2005. In case the data in 2005 were not available, we used the data at latest available questionnaires between 1990 and 2000. The number of cigarettes smoked per day and the total number of smoking years were calculated for current smokers and former smokers. To calculate the smoking years for current smokers, a calculation was made using the age of start of smoking from the 1990 questionnaire and age in 2005. For smoking years for former smokers, the age of quitting smoking from the 2005 questionnaire and the age of starting smoking from the 1990 questionnaire or the age of quitting smoking from latest available questionnaire between 1990 and 2000 and the age of starting smoking from the 1990 questionnaire were used for the calculation. Finally, the smoking-cessation years for former smokers were calculated with the age of quitting smoking from the 2005 questionnaire and the age in 2005 or the age of quitting smoking from latest available questionnaires between 1990 and 2000 and the age in 2005.

For current smokers, the level of smoking exposure was categorized in terms of smoking years (≤40, 41–45, ≥46 years) and the number of cigarettes smoked per day (≤15, 16–20, ≥21 cigarettes). For former smokers, smoking exposure was categorized in terms of smoking years (≤20, 21–30, ≥31 years), the number of cigarettes smoked per day (≤15, 16–20, ≥21 cigarettes), and smoking cessation years (≤10, 11–20, 21–30, ≥31 years).

Body mass index, vitamin C intake, alcohol consumption and educational background of the subjects were obtained from the self-completed questionnaires conducted as the baseline survey of the JPHC Study in 1990. Vitamin C intake was calculated from food frequency questionnaires, which asked about the average consumption of 44 food items, during the previous month and adjusted by energy intake. These variables were categorized as following; BMI (24.9 kg/m^2 or less, or 25.0 kg/m^2 or more), vitamin C intake (100 mg/day or more, or less than 100 mg/day), alcohol consumption (never, sometimes, everyday), educational background (junior high school, high school, university or college).

The percentages of current smokers and former smokers among female subjects in 1990 were only 2.1% and 1.0%, respectively. This number was too low for statistical analysis, thus female subjects were excluded from analyses. After further exclusion of subjects with missing covariate information used for the adjustment in the statistical analysis, 547 men were considered in the final analysis. This survey was approved by the Ethics Committee of Tokyo Medical and Dental University and the Ethics Committee of the National Cancer Center, Tokyo, Japan.

Statistical analysis

The chi-squared test and one-way analysis of variance were used to detect the differences of the distribution by the number of teeth present. Analysis of covariance was used to calculate adjusted mean number of teeth present

by controlling for age, BMI, vitamin C intake, alcohol consumption and educational background according to smoking status, smoking years, the number of cigarettes smoked per day and smoking-cessation years.

Then, we used a logistic regression to obtain adjusted odds ratios (ORs) and 95% confidence intervals (CIs) to examine the association between having more than eight missing teeth and smoking status. In this analysis, dependent variables were dichotomized in terms of 8020 achievement; the subjects were classified into two categories in terms of 8020 achievement: (i) more than eight missing teeth, i.e. retaining fewer than 20 teeth and (ii) eight or less missing teeth, i.e. retaining 20 or more teeth. Statistical adjustments were made for age, BMI, alcohol consumption, vitamin C intake, and educational background because previous studies reported positive association between these factors and tooth loss (Gilbert *et al*, 2003; Klein *et al*, 2004). We estimated ORs of having more than eight missing teeth according to number of cigarettes smoked per day and smoking years among current and former smokers compared with that among never smokers by including both variables simultaneously into the model to weigh their relative importance. Two-sided *P*-values less than 0.05 were considered to be statistically significant. SPSS14.0J (SPSS Japan, Tokyo, Japan) was used to analyze the data.

Results

Participation rate

In this study, the participation rate was 12.9% among the males who answered the baseline questionnaire survey of the JPHC Study (1990) among the Yokote districts residents.

Distribution of smoking status

At the 2005 questionnaire survey, 135 subjects (24.7%) answered 'Currently smoking', 212 (38.8%) answered 'Quit smoking', and 200 (36.6%) answered 'Not smoking'. The subject's smoking history was confirmed by reference to the 1990, 1995, and 2000 questionnaires. Figure 1 shows the changing pattern of smoking status from the data obtained from the 1990 questionnaire to the data within the final questionnaire. The number of subjects who answered 'Currently smoking' in 1990 was 227, and of these subjects, 97 (42.7%) later stopped smoking while 130 (57.3%) continued smoking until 2005. The number of those who answered 'Quit smoking' in 1990 was 154, and of these subjects, 4 (2.6%) had started smoking again by 2005 while 150 (97.4%) continued not to smoke. The number of subjects who answered 'Not smoking' in 1990 was 166, and of these subjects, 161 (97.0%) continued not to smoke, 1 (0.6%) began smoking, and 4 (2.4%) started but then stopped smoking again by 2005. In the 2005 questionnaire, 200 subjects answered that they were 'Not smoking'. However, 39 (19.5%) of these were, in fact, former smokers. They had answered 'Not smoking' instead of 'Quit smoking', even though they had smoked in the past. The final grouping of smoking status therefore was: 135 current smokers (24.7%), 251 former smokers (45.9%), and 161 who had never smoked (29.4%).

Characteristics by number of teeth present

Age of the subjects ranged from 55 to 75 years in 2005 (mean = 65.6, s.d. = 5.8). The mean age by the number of teeth present was 67.7 ± 5.8 for subjects with 0–19 teeth (i.e. more than eight missing teeth) and 64.4 ± 5.5 for subjects with 20–28 teeth (i.e. eight or less missing teeth). The difference between the two groups was statistically significant ($P < 0.001$). Table 1 shows the distributions of age group, BMI, vitamin C intake, alcohol consumption, and educational background by the number of teeth present. Subjects with more than eight missing teeth were older ($P < 0.001$), had a lower BMI ($P = 0.021$), and a lower educational background ($P < 0.001$).

Mean number of teeth present, and percentage of subjects and ORs of having more than eight missing teeth, by smoking status

Table 2 shows the adjusted mean number of teeth present by smoking status, the percentage of subjects having more than eight missing teeth and ORs of having more than eight missing teeth among current smokers and former smokers compared with that among never smokers. Current smokers ($P = 0.050$) and former smokers ($P = 0.010$) had fewer teeth than never smokers. In comparison with never smokers, ORs of having

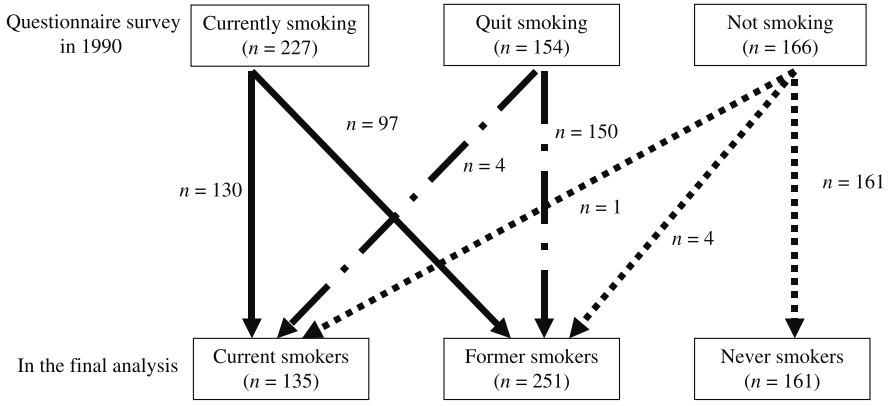

Figure 1 Changing pattern of smoking status

Table 1 Characteristics of the subjects by the number of teeth present

		Number of teeth present				
		0–19		*20–28*		
	n	n	*%*	n	*%*	P *value*
Age in 2005 (years)						
55–59	101	21	10.7	80	22.9	<0.001
60–64	140	34	17.3	106	30.3	
65–69	128	44	22.3	84	24.0	
70–75	178	98	49.7	80	22.9	
BMI (kg/m^2)						
−24.9	407	157	79.7	250	71.4	0.021
25.0+	140	40	20.3	100	28.6	
Vitamin C intake (mg/day)						
100+	306	103	52.3	203	58.0	0.115
<100	241	94	47.7	147	42.0	
Alcohol consumption						
Never	59	24	12.2	35	10.0	0.201
Sometimes	187	58	29.4	129	36.9	
Everyday	301	115	58.4	186	53.1	
Educational background						
Junior high school	168	81	41.1	87	24.9	<0.001
High school	282	94	47.7	188	53.7	
University or college	97	22	11.2	75	21.4	

Table 2 Mean number of teeth present, and percentage of subjects and ORs of having more than eight missing teeth, by smoking status

	Adjusted mean number of teeth present[a]		*Percentage of subjects with more than eight missing teeth*	*Adjusted ORs of having more than eight missing teeth*[a]	
Smoking status	*Mean*	*SE*		*ORs*[b]	*95% CIs*
Current smokers	19.0	0.7	39.3% (53/135)	1.96	1.16–3.31
Number of cigarettes smoked per day[c]					
≥ 21	18.6	1.2	38.1% (16/42)	2.07	1.06–4.44
16–20	20.2	1.1	35.8% (19/53)	1.43	0.71–2.85
≤ 15	19.0	1.3	43.6% (17/39)	2.08	1.00–4.37
P for trend	0.826			0.037	
Smoking years[c]					
≥ 46	18.5	1.6	50.0% (25/50)	1.98	0.97–4.04
41–45	19.1	1.3	41.0% (16/39)	2.26	1.04–4.92
≤ 40	20.5	1.6	24.4% (11/45)	1.66	0.70–3.94
P for trend	0.030			0.022	
Former smokers	18.8	0.5	39.0% (98/251)	1.86	1.18–2.95
Number of cigarettes smoked per day[c]					
≥ 21	18.4	0.9	38.0% (30/79)	2.03	1.08–3.80
16–20	18.1	0.9	45.2% (33/73)	2.00	1.07–3.71
≤ 15	20.4	0.8	33.0% (30/91)	1.32	0.71–2.41
P for trend	0.102			0.020	
Smoking years[c]					
≥ 31	16.6	0.9	55.6% (45/81)	3.03	1.64–5.62
21–30	18.9	0.9	36.0% (27/75)	1.91	1.01–3.62
≤ 20	21.4	0.9	24.1% (21/87)	0.99	0.52–1.90
P for trend	<0.001			0.010	
Never smokers	21.1	0.6	28.6% (46/161)	1.00	(Reference)

[a]Adjusted for age, BMI, vitamin C intake, alcohol consumption and educational background. Number of cigarettes smoked per day and smoking years are mutually adjusted.
[b]Never smokers as a reference.
[c]One case in 'Current smokers' and eight cases in 'Former smokers' were deleted because of missing values.

more than eight missing teeth among current smokers and former smokers were 1.96 and 1.86 ($P = 0.010$ and 0.009, respectively).

In current smokers, there was no significant association between the adjusted mean number of teeth and number of cigarettes smoked per day. However, the greater the number of smoking years the smaller the adjusted mean number of teeth (P for trend $= 0.030$). Current smokers who had smoked for 46 years or more had 2.0 fewer teeth than those who had smoked 40 years or less. Former smokers who had smoked either 16–20 or 21 or more cigarettes per day had fewer teeth (2.3 and 2.0, respectively) than those who had smoked 15 or less cigarettes. Furthermore, the greater the smoking years, the less the adjusted mean number of teeth (P for trend <0.001). Former smokers who had smoked for 31 years or more had, on average, 4.8 fewer teeth than those who smoked for 20 or less years.

The adjusted odds of having more than eight missing teeth were significantly higher in current smokers who smoked 21 or more cigarettes per day *vs* never smokers. In regard to smoking years, in comparison with never smokers, the adjusted odds among current smokers who had smoked for 41 years or more were higher. The adjusted odds of having more than eight missing teeth among former smokers who had smoked 16 or more cigarettes per day, or had smoked for 21 years or more, were higher in comparison with never smokers.

An increasing tendency was observed among former smokers. Namely, the ORs of having more than eight missing teeth among former smokers compared with that among never smokers increased with the number of cigarettes smoked per day (P for trend $= 0.020$) and the number of smoking years (P for trend $= 0.010$).

Mean number of teeth present, percentage of subjects and ORs of having more than eight missing teeth, by smoking cessation years

Table 3 shows the adjusted mean number of teeth present, the percentage of subjects who had more than eight missing teeth, and ORs of having more than eight missing teeth with never smokers as the reference, by smoking cessation years. Former smokers with fewer

Table 3 Mean number of teeth present, and percentage of subjects and ORs of having more than eight missing teeth, by smoking cessation years

Smoking cessation years	*Adjusted mean number of teeth present*[a]		*Percentage of subjects with more than eight missing teeth*	*Adjusted ORs of having more than eight missing teeth* [a]	
	Mean	*SE*		*ORs* [b]	*95% CIs*
≤ 10	16.9	1.0	48.6% (35/72)	3.02	1.54–5.90
11–20	17.4	1.0	42.2% (27/64)	2.66	1.36–5.23
21–30	20.3	1.0	29.0% (20/69)	1.27	0.64–2.51
≥ 31	22.2	1.2	33.3% (15/45)	0.94	0.43–2.04
P for trend	<0.001			<0.001	

[a]Adjusted for age, BMI, vitamin C intake, alcohol consumption and educational background.
[b]Never smokers as a reference.

than 11 or 11–20 smoking cessation years had fewer teeth than those with 31 years or more of smoking cessation (the differences were 5.3 and 4.8, respectively). There was an increasing trend in the adjusted mean number of teeth with the increasing smoking cessation years (P for trend <0.001). In addition, the adjusted mean number of teeth in those who ceased smoking for 21 years or more was 20 or more.

The percentage of subjects with more than eight missing teeth was over 40% in former smokers with fewer than 11 or 11–20 smoking cessation years, while it was about 30% in former smokers with 21 or more smoking cessation years. Using never smokers as a reference, the ORs of having more than eight missing teeth in those who had stopped smoking within less than 11 or 11–20 years were 3.02 and 2.66, respectively. ORs of having more than eight missing teeth tended to decrease with an increasing value in the number of smoking cessation years (P for trend <0.001). In those who had stopped smoking for 21 years or more, no significant increase in ORs was seen.

Discussion

After confirming any status changes in the subjects' smoking behavior from 1990 to 2005, we examined the association between smoking status and number of teeth. The odds of having more than eight missing teeth among current smokers were higher in comparison with never smokers. In addition they had, on average, about two fewer teeth than never smokers. A significant negative association between number of teeth and smoking status was reported, using Japanese National Survey data, where the adjusted OR of current smokers in comparison with never smokers among male was 2.22 (Hanioka *et al*, 2007). The present results are consistent with that report. Many studies have also shown the number of cigarettes and smoking years to be related to tooth loss comparing current *vs* never smokers (Osterberg and Mellstrom, 1986; Ahlqwist *et al*, 1989; Krall *et al*, 1997; Axelsson *et al*, 1998; Albandar *et al*, 2000; Gilbert *et al*, 2003). We also found that the ORs of having more than eight missing teeth tended to increase when comparing current *vs* never smokers and for a declining number of teeth with increasing smoking years even after adjustment for the number of cigarettes smoked per day compared with never smokers.

Previous Japanese reports found no significant differences in the number of teeth retained or the odds of having more than eight missing teeth between former smokers and never smokers (Yoshida *et al*, 2001; Yoshihara *et al*, 2005; Hanioka *et al*, 2007). In contrast, this study did find differences, but these differences depended upon the number of years since smoking ceased. Subjects who ceased smoking for 21 years or more had, on average, 20 or more teeth present, and had odds of having more than eight missing teeth nearly equal to those who had never smoked. We should consider how the risk of tooth loss changes with smoking cessation in order to understand this finding. The reduction in the increased odds of having more than eight missing teeth in those who stopped smoking may be relatively rapid, but it takes many years before the odds of having more than eight missing teeth in former smokers equal that of never smokers.

Smoking cessation decreases the risk of certain diseases and in some cases reduces the risk to the same level as in those who had never smoked. The risk of lung cancer in males returns to the level of never smokers 30 years after quitting smoking among light smokers (i.e. fewer than 10 cigarettes per day) and more than 40 years after quitting among heavy smokers (National Cancer Institute, 1997). The risk of coronary heart disease decreases within 2 years of smoking cessation (Baba *et al*, 2006), and approximately 15 years after smoking cessation, the mortality rates from coronary artery disease and stroke among former smokers approach those of never smokers (Burns, 2003). Total mortality and cancer mortality rates among male former smokers remain higher than those who never smoked even 20 years after quitting (LaCroix *et al*, 1991).

There are very few studies regarding dental diseases to assess the length of smoking cessation required for gaining health benefits. The risk of tooth loss among subjects who had quit smoking for 13 years was not very different from those who never smoked (Krall *et al*, 2006b), and our results are similar to this previous report. We could not measure risk in this study; nonetheless, we found that the adjusted ORs of having more than eight missing teeth did not significantly differ from unity when comparing subjects who had quit smoking for 21 years or more and those falling in the category of never smokers.

The mechanism behind the decreasing risk of tooth loss with smoking cessation could be attributed to a reduction in periodontal tissue damage. Smoking influences periodontal tissue because nicotine and other toxins contained in cigarettes suppress immunoactivity when absorbed into the bloodstream (Kornman and di Giovine, 1998). When oxygen in the periodontal pocket decreases (Hanioka *et al*, 2000), anaerobes that cause periodontal disease (e.g. *Actinobacillus actinomycetemcomitans*, *Porphyromonas gingivalis* and *Tannerella forsythensis*) increase (Shiloah *et al*, 2000). Finally, the toxins directly destroy periodontal tissue (Sayers *et al*, 1999). These phenomena produce numerous deep periodontal pockets, an increased absorption of the alveolar bone supporting the teeth and increased tooth mobility, leading to tooth loss. There is, furthermore, emerging evidence suggesting that the progression of periodontal disease may or may not be amplified by unavoidable microbial colonization. In addition, it has been speculated that interference with vascular and inflammatory phenomena may be one potential mechanism for the induction of periodontal disease because of smoking (Bergström, 2004).

Associations have been reported between smoking and root caries (Hahn *et al*, 1999), coronal caries (Axelsson *et al*, 1998) and endodontic treatment (Krall *et al*, 2006a,b). A causal association with smoking has been suggested for root caries; however, the mechanism of action and the reason for this association with coronal dental caries by smoking is not clear.

One advantage of the current study design was that the subjects' history of smoking status could be confirmed from four self-completed questionnaires during the 15-year period from 1990 to 2005. In the 2005 questionnaire, about 20% of subjects who answered 'Not smoking' had answered 'Currently smoking' or 'Quit smoking' at least one time in the 1990 to 2000 questionnaires. If they had been categorized as 'Never smokers', then the odds of having more than eight missing teeth among never smokers would have been overestimated. In the present study, however, a never smoker was strictly defined as a person who answered 'Not smoking' at both the 1990 and 2005 questionnaires and never answered 'Currently smoking' or 'Quit smoking' in the 1995 or 2000 questionnaires. The measurement of smoking status from a single questionnaire would be more vulnerable to misclassification and recall bias. Although if a slight misclassification remained, this type of misclassification would result in an attenuation of estimation of ORs. Nonetheless, we observed a significant positive association between having more than eight missing teeth and current smoking and past smoking.

This study had some limitations. Participation rate in the dental survey was low among the males who answered the baseline questionnaire survey of JPHC study (1990) of the Yokote districts residents. However, the frequencies of smoking status and the percentage of those having more than eight missing teeth were similar to those of the national survey conducted in the same year (Ministry of Health Law, 1991; The Statistical Analysis Committee on the Survey of Dental Diseases, 2006) in Japan. In that survey among males over 60 years of age, 28.9% answered 'Currently smoking', 35.0% answered 'Quit smoking', and 36.1% answered 'Not smoking' (compared with 24.7%, 38.8%, and 36.6% in this study, respectively). The percentage of subjects having more than eight missing teeth in 55- to 74-year-old males was 62.6% in the national survey (compared with 64.0% in this study). Therefore, both smoking and dental status of this sample were considered close to those of all Japanese males in the national survey. The information of past oral health practices and past regular dental visits was not available for this study, although these behavioral factors may influence tooth loss (Kressin *et al*, 2003; Cunha-Cruz *et al*, 2004). Previous studies have reported an increased risk of tooth loss with smoking and a decreased risk with smoking cessation after adjusting for oral health behavior (Krall *et al*, 2006b). We therefore consider the results of this study to be not far from the actual situation in Japan. The participants' dentate status was unknown at baseline; therefore, it was not possible to model incident tooth loss.

This study examined only males, because of the low prevalence of female smokers in the 1990 baseline survey. However, smoking prevalence among females in their twenties and thirties has recently increased in Japan. Among 38- to 60-year-old Swedish females, the mean number of lost teeth during a 12-year follow up was 3.5 among current smokers and 2.1 among those who had never smoked (Ahlqwist *et al*, 1989). In Japan, the association between the number of teeth and smoking status was significant in a study using Japanese National Survey data. The adjusted OR of having more than eight missing teeth in current female smokers compared with those who had never smoked was 2.14 (Hanioka *et al*, 2007). Hence, we recommend smoking cessation for both males and females.

In Japan, recommendations to stop smoking are made to patients mainly in medical settings. However, smoking cessation promotion by dentists and dental hygienists has an advantage over promotion by other health professionals. Because current smokers can directly see and recognize the symptoms of tobacco-related oral diseases, it should be helpful to motivate them to stop smoking and, thereby, help prevent the development of other severe health hazards at an early stage. Dental professionals should actively co-operate with medical professionals to conduct effective smoking cessation programs.

Acknowledgements

This study was supported by a grant from the 8020 Promotion Foundation and Grants-in-Aid for Cancer Research and for the Third Term Comprehensive 10-Year-Strategy for Cancer Control from the Ministry of Health, Labor, and Welfare of Japan. The authors thank all staff members in each study area for their efforts to conduct the baseline and follow-up surveys. We would like to remember Dr Kazuhiro Usui for the great contribution of planning of this study, who passed away in 2005.

Author contributions

Tomohito Yanagisawa, Tomomi Marugame, Satoko Ohara, Manami Inoue, Shoichiro Tsugane and Yoko Kawaguchi contributed to the research design. Tomohito Yanagisawa and Tomomi Marugame contributed to analysis of data. Tomohito Yanagisawa contributed in drafting the paper. Tomomi Marugame, Satoko Ohara, Manami Inoue, Shoichiro Tsugane and Yoko Kawaguchi worked on the critical revision of the paper.

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Appendix

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Journal of
PERIODONTAL RESEARCH

J Periodont Res 2010; 45: 277–283

JOURNAL OF PERIODONTAL RESEARCH
doi:10.1111/j.1600-0765.2009.01233.x

Relationship of smoking and smoking cessation with oral health status in Japanese men

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Yanagisawa T, Ueno M, Shinada K, Ohara S, Wright FAC, Kawaguchi Y. Relationship of smoking and smoking cessation with oral health status in Japanese men. J Periodont Res 2010; 45: 277–283. © 2009 John Wiley & Sons A/S

Background and Objective: Smoking has been associated with the number of natural teeth a person has and with the likelihood of periodontitis. The purpose of this study was to determine the relationships between the number of teeth present and periodontal diseases with smoking habits in a cohort of Japanese men.

Material and Methods: The study group comprised 1088 men, 40–75 years of age. Oral examinations were conducted in dental clinics. Information on smoking status and on oral health behavior was collected from self-administered questionnaires. The relationship between oral health status and smoking status was estimated using adjusted odds ratios.

Results: Compared with those whom had never smoked, the odds ratios of having more than eight missing teeth and having periodontitis, among current smokers, were 1.67 and 1.74, respectively. In those who had stopped smoking for 11 years or longer, there was no increase in the odds ratio of having more than eight missing teeth and periodontitis, compared with those whom had never smoked.

Conclusion: Smoking has a positive association with missing teeth and periodontitis. However, smoking cessation is beneficial for oral health. The odds of having more than eight missing teeth, or of having periodontitis, in those who had never smoked was similar to that of individuals who reported that they had stopped smoking for 11 years or more.

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Key words: tooth loss; periodontitis; smoking; smoking cessation

Accepted for publication April 23, 2009

Tooth loss affects the daily activities of humans, such as speaking, smiling, chewing and tasting; therefore, tooth-loss prevention helps to maintain a high quality of life. Previous studies have reported that smoking is associated with tooth loss, a higher prevalence of edentulousness and fewer remaining teeth (1–6). The main biological causes of tooth loss are periodontal disease and dental caries (7). A complex relationship among bacterial, host, behavioral and environmental factors determines the onset and progress of these oral diseases. Smoking is an important risk factor for periodontal disease (8–13) and a clear causal association has been established (14). Promoting smoking cessation on the advice of dental professionals may therefore be an effective tool in preventing periodontal disease and tooth loss in smokers.

Smoking has major effects on the host response, but there are also a number of studies that show some microbiological differences between smokers and nonsmokers. The biological mechanisms underpinning the adverse effects of smoking have been comprehensively reviewed by Palmer *et al.* (15).

However, in Japan, few epidemiological studies have investigated the relationship between smoking cessation and the risk of tooth loss and periodontal diseases (16–18). Similarly, there are few studies on dental diseases that have assessed the length of smoking cessation required to gain measurable oral health benefits (19,20). It has been reported that smoking

cessation decreases the risk of certain diseases, and in some cases reduces the risk to the same level as in never-smokers. The risk of lung cancer in men, for example, returns to the level found in never-smokers 30 years after quitting smoking among light smokers (i.e. fewer than 10 cigarettes per day) and more than 40 years after quitting among heavy smokers (21). The risk of coronary heart disease decreases within 2 years of smoking cessation (22); and approximately 15 years after smoking cessation, the mortality rates from coronary artery disease and stroke among former smokers approach the level found in never-smokers (23).

The central aim of this study was to investigate whether we could explain variation in the length of smoking-cessation years regarding oral health gain in the same manner as in general health studies. The purpose of this study therefore was to investigate the relationship between smoking and smoking cessation with the number of teeth present and periodontal status.

Material and methods

Subjects

This study was designed to investigate the relationship between general lifestyle and oral health status, and was conducted in co-operation with the Akita prefecture local government, whose advice was followed. The subjects in the present study were residents in Yokote city, Akita prefecture. In this district, about 33,000 residents were 40–75 years of age. Subjects were recruited by letter to participate in this study. All 33,000 residents were included in the sampling. Some 2681 participants agreed to join the study and signed the informed consent form in 2005 to 2007. Self-administered questionnaires were given to participants, and dental examinations were conducted at local dental offices with the co-operation of the Yokote and Hiraka Dental Associations. Subjects were given a list of participating dentists and were free to attend the office of their choice that was closest to their residence.

Dental examination

Clinical examinations for dental status and periodontal tissue condition (third molars were excluded) were performed by local dentists who were provided with special information and training specific to this study. Training consisted of circulating a manual of the constituents and standards for conducting dental examinations and having a meeting with dentists to explain the procedures and to answer any concerns. Subjects were dentally examined in a dental chair using an operatory light, a dental mirror, a periodontal probe and an explorer, which were routinely used in the dental clinic of each participating dentist. Probing pocket depth was measured at all sites for all natural teeth. The deepest pocket depth was recorded for each tooth, excluding third molars. Periodontitis was defined as an individual having 'at least one tooth with severe pocket depth, i.e. pocket depth of 6 mm or greater'. The World Health Organization, in the Community Periodontal Index (CPI) definition for code 4, describes a pocket depth of 6 mm or more as 'severe periodontitis'. No inter-reliability or intrareliability tests were carried out.

Self-reported questionnaire

Prior to the clinical examination, the participants were asked to complete a self-reported questionnaire regarding their smoking habits and oral health behavior. Information collected on smoking habits included participants' current smoking status, the number of cigarettes smoked per day and the age when subjects either commenced or quit smoking. Smoking status was categorized into three groups: 'never smoked'; 'current smokers'; and 'former smokers'. The number of cigarettes per day was calculated for current smokers and former smokers, and the smoking-cessation years were calculated for former smokers. For current smokers, the level of smoking exposure was categorized into three groups depending upon the number of cigarettes ($\leq$ 15, 16–20, or $\geq$ 21) smoked per day. For former smokers, smoking exposure was categorized in the same way, that is, number of cigarettes ($\leq$ 15, 16–20, or $\geq$ 21) previously smoked per day. Smoking-cessation years were categorized into four groups depending on time since stopping ($\leq$ 10, 11–20, 21–30, or $\geq$ 31 years).

Information regarding oral health behavior included the following: frequency of daily toothbrushing; using dental floss or an interdental brush; experience of toothbrushing instruction; self-check of teeth and gums using a mirror; and whether subjects had undergone a dental check-up within the previous 12 mo. Frequency of daily toothbrushing was categorized as 'twice or more', or 'less than twice'; other variables were all 'yes' or 'no' responses.

The percentages of current smokers and former smokers among female subjects were only 4.6% and 2.6%, respectively. This number was considered to be too low for statistical analysis, and thus female subjects were excluded. Subjects with missing covariate information were also excluded, resulting in a total of 1088 men who were used in the final analysis. Thirty subjects were edentulous and were excluded from the analyses on periodontal diseases. All variables analyzed in this study were part of a single database. This survey was approved by the Ethics Committee of Tokyo Medical and Dental University, Tokyo, Japan.

Statistical analysis

The chi-square test and the *t*-test were used to detect statistical differences in the distribution of the number of teeth present and the periodontal status. Negative binomial regression was used to calculate adjusted mean numbers of teeth present, by controlling for age and oral health behavior according to smoking status, the number of cigarettes per day and smoking-cessation years.

The 8020 Campaign is a national oral health campaign in Japan, jointly proposed by the Ministry of Health and Welfare and the Japanese Dental Association. The '80' signifies the average life expectancy for Japanese people, and the '20' indicates the critical number

of natural teeth needed to maintain good eating and chewing function throughout life (24,25). In the analyses in this study, dependent variables were dichotomized in terms of the 8020 aspirations. That is, subjects were classified into two categories in terms of whether (i) they had more than eight missing teeth (i.e. retained fewer than 20 teeth) or (ii) they had eight or fewer missing teeth (i.e. they retained 20 or more teeth, in line with the current 8020 goal).

With respect to periodontal status, subjects were also classified into two groups, namely (i) those with periodontitis (one or more teeth with a pocket depth of 6 mm or more) or (ii) no periodontitis (no teeth with a pocket depth of 6 mm or more). Logistic regression was used to obtain adjusted odds ratios (ORs) and 95% confidence intervals (CIs), which were then used to examine the associations between 'having more than eight missing teeth' and smoking status, and between those classed as with/without periodontal disease and smoking status. These categories appear to be consistent with the findings and suggestion of previous reports (26,27).

Statistical adjustments were made for age and oral health behavior as previous studies had reported a positive association between these factors and tooth loss and periodontal diseases (28,29). Two-sided p-values of < 0.05 were considered to be statistically significant. SPSS 16.0J (SPSS Japan, Tokyo, Japan) was used to analyze the data.

Results

Distribution of smoking status

From the questionnaire survey, 317 subjects (29.1%) responded that they were 'current smokers', 421 (38.7%) that they were 'former smokers' and 350 (32.2%) stated that they had 'never smoked'.

Characteristics categorized by number of teeth present and periodontal status

The age of the subjects ranged from 40 to 75 years (mean = 59.6, standard deviation = 9.7). The mean age, categorized by the number of teeth present, was 65.8 ± 7.6 years for subjects with 0–19 teeth (i.e. more than eight missing teeth) and 57.3 ± 9.3 years for subjects with 20–28 teeth (i.e. eight or fewer missing teeth). The difference between the two groups was statistically significant ($p < 0.001$). The mean age, categorized according to the periodontal status, was 60.7 ± 9.3 years for those with periodontitis and 59.2 ± 9.8 years for those without periodontitis. The difference between the two groups was statistically significant ($p = 0.024$). When age was grouped by decade from 40 years upwards (40–49, 50–59, 60–69, 70–75), the relationship between age and 20 or more teeth was retained, but the relationship with periodontitis did not reach statistical significance, although a trend was evident.

Table 1 shows the distributions by age group and oral health behavior and by the number of teeth present and periodontal status. Subjects with more than eight missing teeth were older ($p < 0.001$), had a lower frequency of daily toothbrushing ($p < 0.001$), a lower prevalence of using interdental brushing tools ($p = 0.002$), lower experience of toothbrushing instruction ($p < 0.001$) and lower self-check-up of their intra-oral condition using a mirror ($p = 0.005$). A higher prevalence of dental check-up within a year was associated with a higher level of periodontitis ($p = 0.029$).

Mean number of teeth present, percentage of subjects and ORs of having more than eight missing teeth, categorized by smoking status

Table 2 shows the adjusted mean number of teeth present, when categorized by smoking status, the percentage of subjects who had more than eight missing teeth and the ORs of having more than eight missing teeth, among current smokers and former smokers compared with those who had never smoked. There was no significant relationship between the adjusted mean number of teeth and smoking

Table 1. Characteristics of the subjects by number of teeth and periodontal status

		Number of teeth					Periodontal status				
		≥ 20		≤ 19			Perio-dontitis[a]		Not perio-dontitis		
	n	*n*	%	*n*	%	*p* value	*n*	%	*n*	%	*p* value
Age in 2005 (years)											
40–49	216	205	25.5	11	3.9	< 0.001	44	15.6	172	21.3	0.094
50–59	303	256	31.8	47	16.6		74	26.2	229	28.4	
60–69	349	244	30.3	105	37.1		102	36.2	247	30.6	
70–75	220	100	12.4	120	42.4		62	22.0	158	19.6	
Frequency of daily toothbrushing											
≥ 2	697	542	67.3	155	54.8	< 0.001	185	65.6	512	63.5	0.291
< 2	391	263	32.7	128	45.2		97	34.4	294	36.5	
Using dental floss or interdental brush											
Yes	378	300	37.3	78	27.6	0.002	92	32.6	286	35.5	0.214
No	710	505	62.7	205	72.4		190	67.4	520	64.5	
Experience of toothbrushing instruction											
Yes	722	565	70.2	157	55.5	< 0.001	188	66.7	534	66.3	0.480
No	366	240	29.8	126	44.5		94	33.3	272	33.7	
Self-check of teeth and gums using a mirror											
Yes	508	395	49.1	113	39.9	0.005	139	49.3	369	45.8	0.172
No	580	410	50.9	170	60.1		143	50.7	437	54.2	
Dental check-up within a year											
Yes	436	313	38.9	123	43.5	0.100	127	45.0	309	38.3	0.029
No	652	492	61.1	160	56.5		155	55.0	497	61.7	

[a]At least one site with pocket depth of 6 mm or more.

Table 2. Mean number of teeth present, percentage and odds ratios (ORs) of more than eight teeth lost, by smoking status

	Adjusted mean number of teeth present[a]		Percentage of subjects with more than eight teeth lost		Adjusted ORs of more than eight teeth lost[a]	
Smoking status	Mean	SE	%	(n/N)[b]	ORs[c]	95% CIs
Current smokers	21.4	0.5	26.2	(83/317)	1.67	1.12–2.50
Number of cigarettes per day						
≥ 21	21.1	0.7	28.6	(13/63)	2.27	1.14–4.52
16–20	21.2	0.5	24.1	(33/137)	1.65	0.97–2.81
≤ 15	21.8	0.5	27.0	(31/115)	1.30	0.75–2.24
p-for-trend	0.120				0.053	
Former smokers	21.4	0.4	26.8	(113/421)	1.35	0.94–1.94
Number of cigarettes per day						
≥ 21	21.3	0.6	28.3	(32/113)	1.49	0.89–2.55
16–20	20.3	0.5	31.2	(49/157)	1.72	1.06–2.79
≤ 15	21.9	0.6	20.5	(25/122)	0.85	0.48–1.48
p-for-trend	0.068				0.060	
Never smoked	22.0	0.5	24.9	(87/350)	1.00	Reference

[a]Adjusted for age and oral health behavior. Two cases in current smokers and 29 cases in former smokers were deleted as a result of missing values.
[b]n/N where n = subjects with > 8 lost teeth and N = total sample.
[c]Never smoked as a reference.
CI, confidence interval; SE, standard error.

status; however, current smokers and former smokers had fewer teeth (0.6 and 0.6, respectively) than those who had never smoked. In comparison to those whom had never smoked, the OR was 1.67 (p = 0.011) for having more than eight missing teeth among current smokers. However, there was no difference between former smokers and those who had never smoked.

The adjusted ORs of having more than eight missing teeth were significantly higher in current smokers who smoked 21 or more cigarettes per day and in former smokers who smoked 16–20 cigarettes per day compared with those who had never smoked. However, an increasing tendency was not observed among current smokers. Namely, there was not a tendency for an increased OR of having more than eight missing teeth among former smokers compared with those who had never smoked.

Percentage and ORs of periodontitis categorized by smoking status

Table 3 shows the percentage and adjusted ORs of subjects with periodontitis among current smokers and former smokers compared with those who had never smoked. In comparison with those who had never smoked, the OR of subjects with periodontitis among current smokers was 1.74 (p = 0.003); however, there was no significant difference between former smokers and those who had never smoked.

The adjusted ORs of subjects with periodontitis were significantly higher in current smokers who smoked 16 or more cigarettes per day than in those who had never smoked, and an increasing tendency was observed among current smokers. However, the increased ORs of subjects with periodontitis among former smokers, compared with those who had never smoked, was not as strong, although the trend approached significance (p = 0.052).

Mean number of teeth present, percentage of subjects and ORs of having more than eight missing teeth, categorized by smoking-cessation years

Table 4 shows the adjusted mean number of teeth present, the percentage of subjects who had more than eight missing teeth and the ORs of having more than eight missing teeth, when categorized by smoking-cessation years. The reference was those who had never smoked. There was an increasing trend in the adjusted mean number of teeth present with an increase in the number of smoking-cessation years (p for trend = 0.005). Former smokers, with fewer than 11 smoking-cessation years, had 3.9 fewer

Table 3. Percentage and odds ratios (ORs) of subjects with periodontitis by smoking status

	Percentage of subjects with periodontitis[a]		Adjusted ORs of subjects with periodontitis[b]	
Smoking status	%	(n/N)[c]	ORs[d]	95% CIs
Current smokers	31.1	(97/312)	1.74	1.21–2.50
Number of cigarettes per day				
≥ 21	38.1	(24/63)	2.53	1.39–4.60
16–20	30.6	(41/134)	1.83	1.14–2.93
≤ 15	28.3	(32/113)	1.44	0.88–2.37
p-for-trend			0.001	
Former smokers	26.2	(107/408)	1.27	0.90–1.78
Number of cigarettes per day				
≥ 21	28.2	(31/110)	1.43	0.87–2.34
16–20	29.7	(44/148)	1.53	0.99–2.38
≤ 15	22.3	(27/121)	0.95	0.57–1.58
p-for-trend			0.052	
Never smoked	23.1	(78/338)	1.00	Reference

[a]At least one site with pocket depth 6 mm or more. Two cases in current smokers and 29 cases in former smokers were deleted as a result of missing values.
[b]Adjusted for age and oral health behavior.
[c]n/N where n = subjects with periodontitis and N = total sample.
[d]Never smoked as a reference.
CI, confidence interval.

Table 4. Mean number of teeth present, percentage and odds ratios (ORs) of more than eight teeth lost, by smoking cessation years in former smokers

	Adjusted mean number of teeth present[a]		Percentage of subjects with more than eight teeth lost		Adjusted ORs of more than eight teeth lost[a]	
Smoking cessation years	Mean	SE	%	(n/N)[b]	ORs[c]	95% CIs
≤ 10	19.9	0.5	27.6	(48/174)	2.02	1.23–3.30
11–20	21.0	0.6	25.7	(26/101)	1.17	0.65–2.08
21–30	21.7	0.7	25.6	(22/86)	1.69	0.90–3.17
≥ 31	23.8	0.8	26.3	(15/57)	0.59	0.29–1.17
p-for-trend	0.005				0.022	

[a]Adjusted for age and oral health behavior.
[b]n/N where n = subjects with > 8 lost teeth and N = total sample.
[c]Never smoked as a reference.

teeth than those with 31 or more years of smoking cessation.

Using never-smokers as a reference, an OR of 2.02 was found for having more than eight missing teeth in those who had stopped smoking 11 years ago or less. The OR of having more than eight missing teeth tended to decrease with an increase in the number of smoking-cessation years (p for trend = 0.022). In those who had stopped smoking for 11 or more years, no significant increase in ORs was seen.

Percentage and ORs of periodontitis, categorized by the number of smoking-cessation years

Table 5 shows the percentage and the adjusted ORs of subjects with periodontitis when categorized by smoking-cessation years. The reference group was those who had never smoked. The percentage of subjects with periodontitis was over 30% in former smokers with fewer than 11 smoking-cessation years and about 20% in former smokers with 11 or more smoking-cessation years.

Using never-smokers as a reference, an OR of 1.88 was obtained for subjects with periodontitis who had stopped smoking less than 11 years ago. The ORs of subjects with periodontitis tended to decrease as the number of smoking-cessation years increased (p for trend = 0.012). In those who had stopped smoking for 11 or more years, no significant increase in the ORs was seen.

Discussion

This study had some limitations. The participation rate in the dental survey was low overall (about 10%) and especially among the male residents. However, the frequencies of smoking status and the percentages of those with more than eight missing teeth and periodontal diseases were similar to those of the national survey conducted in 2005 in Japan (30,31). Therefore, both the smoking status and the dental status of this sample were considered to be close to that of Japanese men in the national survey. Because of the low prevalence of female smokers, this study examined only men. However, the prevalence of smoking among women in their 20s and 30s has recently increased in Japan (30). The association between number of teeth and smoking status was significant in a study using Japanese National Survey data in 2006 (16). The adjusted OR of having more than eight missing teeth in current female smokers compared with those who had never smoked was 2.14, and meaningful differences between current smokers and never-smokers were evident in the > 40 years age-group in women (16). Hence, we suggest that further research is needed into smoking cessation in both men and women and on its relationship with other lifestyle health-behavior activities.

A further limitation may also be the definition of periodontal diseases used in this study. Subjects having one or more teeth with a pocket depth of 6 mm or more were defined as having periodontitis. In other studies, periodontal diseases have been defined by clinical attachment loss or alveolar bone level, and bleeding points, which together may reflect the periodontal status more accurately (32–35). However, pocket depth alone is a useful indicator that reflects the periodontal status (36,37). In Japan, most dentists do not measure attachment loss but they do measure pocket depth routinely in their dental work. In this study, many dentists who participated and were therefore trained in the study protocol were familiar with pocket depth as an indicator of periodontal disease. Therefore, pocket depth was included in the training manual as the study indicator of periodontitis. In addition, in the national survey in

Table 5. Percentage and odds ratios (ORs) of subjects with periodontitis by smoking cessation years in former smokers

	Adjusted ORs of subjects with periodontitis[a]		Percentage of subjects with periodontitis[b]	
Smoking cessation years	%	(n/N)[c]	ORs[d]	95% CIs
≤ 10	32.9	(55/167)	1.88	1.23–2.88
11–20	21.9	(21/96)	0.99	0.57–1.72
21–30	22.1	(19/86)	0.99	0.56–1.77
≥ 31	19.6	(11/56)	0.71	0.35–1.48
p-for-trend			0.012	

[a]At least one site with a pocket depth of 6 mm or more.
[b]Adjusted for age and oral health behavior.
[c]n/N where n = subjects with periodontitis and N = total sample.
[d]Never smoked as a reference.

Japan, periodontal disease was measured using the CPI. A CPI code of 3 (mild periodontitis) means that subjects had one or more teeth with a pocket depth of 4–6 mm, and a CPI code of 4 (severe periodontitis) means that subjects had one or more teeth with a pocket depth of 6 mm or more (31). The present study thus provided a good comparative indicator with the code 4 CPI indicator in defining severe periodontitis. In this study, pocket depth was measured using pocket probes that were used in each dental clinic; however, no information was collected on the type of probe used in each practice and no reproducibility tests of clinical assessment were conducted. Therefore, some misclassification might exist in the results. However, clinical assessment in this study was carried out in a manner similar to that of the regular therapeutic intervention of participating dentists.

With respect to smoking status, the Comprehensive Smoking Index has been used as an effective index for analysis (38); however, as we did not collect information about smoking years, we could not use this index.

In addition, we could not include the socioeconomic status (SES) of subject in the model. The SES is often cited as a potential confounder. Self-rated health may be associated with social inequality in Japan (39). Furthermore, a negative association reported between smoking and SES, such as estimated by educational background (40), has been reported in Japan. That is, smoking is more prevalent in those of a higher educational status. Furthermore, in a previous report, some variables used for adjustment, for example, frequency of daily toothbrushing, could compensate for the direct effect of SES (16).

This study examined the association between smoking status and number of teeth and periodontal status. The odds of having more than eight missing teeth among current smokers, and the odds of periodontitis, were higher in current smokers than in those who had never smoked. A significant, negative association between number of teeth and smoking status was reported. This is consistent with other reports and also in the Japanese National Survey data, where the adjusted OR of current smokers, in comparison with those who had never smoked, among men, was 2.22 (16). The national report also found a significant, negative association between severe periodontitis and smoking status where the adjusted OR of current smokers was 1.40 (10).

Previous Japanese reports have not found any significant differences in the number of teeth retained, the odds of having more than eight missing teeth and the presence of periodontitis between former smokers and those who had never smoked (16–18). Our results were also consistent with these reports. However, the risk for some former smokers of having tooth loss and periodontal diseases were different from those who had never smoked. Consideration should also be given to those who have ceased smoking. In this study, subjects who had ceased smoking for 11 or more years had the same odds of having more than eight missing teeth, and the same level of periodontitis, as those who had never smoked. By contrast, those who had ceased smoking for a shorter period of time (10 years or less) had an OR of 2.02 of having more than eight missing teeth and an OR of 1.88 for the presence of periodontitis. Therefore, ceasing smoking may be a potentially influential factor for improving oral health.

There are few studies on dental diseases regarding the relationship with the length of time of smoking cessation required to gain health benefits (41). In USA, the risk of tooth loss among subjects who had ceased smoking for 13 years was not very different from those who had never smoked. In Japan, it was reported that more than 21 years of smoking cessation is necessary for smokers to have the same number of teeth as nonsmokers, and the ORs of having more than eight missing teeth tended to decrease with an increasing number of smoking-cessation years (19). Our results are similar to these previous reports. The results of this study suggest that the risk of tooth loss and periodontitis decreases with smoking cessation, but that it may take at least 10 years of abstinence for the risk to return to the level of those who have never smoked.

These findings should be of importance to the Japanese healthcare strategy, as a lifestyle intervention that could encourage current smokers to quit and to remain abstinent. It would be most opportune for dental personnel to encourage patients to not only stop smoking but also to practice good oral health behavior to maintain their oral health status.

Based on the relationships shown in this study, it is suggested that the dental profession should take a more prominent role in advising patients to stop smoking.

Acknowledgements

This study was supported by a grant from the 8020 Promotion Foundation and the Grants-in-Aid for Scientific Research by the Ministry of Health, Labour and Welfare, Japan (H18-Iryo-Ippan-037). We thank to the members of Yokote and Hiraka Dental Associations.

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Journal of Oral Rehabilitation 2008 **35**; 337–344

Masticatory ability and functional tooth units in Japanese adults

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SUMMARY **The purposes of this study were (i) to examine the relationship between the number of natural teeth and the number of functional tooth units in Japanese adults, (ii) to evaluate how functional tooth units relate to subjective masticatory ability and (iii) to determine the minimum number of natural teeth and functional tooth units needed to maintain adequate self-assessed chewing function. A self-administered questionnaire was given and dental examination was conducted for 2164 residents aged 40 to 75 years. Counts were made on the number of functional tooth units of natural teeth (n-functional tooth units), the sum of natural teeth and artificial teeth on implant-supported and fixed prostheses (nif-functional tooth units) and the sum of natural teeth and artificial teeth on implant-supported, fixed and removable prostheses (total-functional tooth units). The average number of natural teeth, n-functional tooth units and nif-functional tooth units decreased with age, but these were often replaced by functional tooth units from artificial teeth on removable prostheses. Total-functional tooth units in 50–59 year old people were slightly lower compared with those in other age groups. Subjects who reported that they could chew every food item on an average had 23·4 total natural teeth, 12·6 posterior natural teeth, 7·6 n-functional tooth units, 8·6 nif-functional tooth units and 10·4 total-functional tooth units, and subjects without chewing difficulties had fewer functional tooth units from removable prostheses. Maintaining 20 and more natural teeth and at least eight nif-functional tooth units is important in reducing the likelihood of self-assessed chewing difficulties.**

KEYWORDS: **masticatory ability, functional tooth units, tooth loss, dentition, chewing**

Accepted for publication 9 December 2007

Introduction

A number of factors could influence masticatory function, including loss of teeth and restorations (1–9), bite force (10–12) and malocclusion (13). Tooth loss is related not only to impairment of chewing efficiency but also to other health problems (e.g., lower extremity strength, agility and balance) in elderly population (14). To rehabilitate masticatory function, missing teeth are often replaced with fixed or removable dental prostheses.

There are many methods for evaluating masticatory function: the modified Mastication Performance Index (15–17), the Craniomandibular Index (18, 19), bite force (7, 20) and electromyography (21). Chewing tests have shown a clear relationship between dental state and objective masticatory performance (1, 22–26). Subjective masticatory ability, as determined from questionnaires is closely related to the number of remaining natural teeth (3, 5, 24, 27–29). Yamamoto's chewing-ability test, which measures subjective masticatory ability has been widely used for many years in Japan, because it contains typical Japanese food items (30, 31).

Functional tooth units (FTUs), defined as pairs of opposing teeth have been used to evaluate masticatory function as well as oral condition and dietary intake (17, 32–37). The number of FTUs is an important

 doi: 10.1111/j.1365-2842.2008.01847.x

determinant of masticatory performance (17, 37). A smaller number of FTUs is associated with chewing difficulties, and an association exists between the lack of FTUs and poor dental functional status (37). Loss of posterior FTUs, in particular is thought to be a key variable towards the loss of masticatory function. However, very few studies using FTUs have been carried out previously in Japan (38).

Because masticatory impairment has a negative impact both on dental health and general health, the relationship between FTUs and masticatory function should be examined. We evaluated different types of FTUs that are composed of natural teeth, artificial teeth on fixed and removable prostheses. No previous studies have examined the influence of tooth composition on FTUs' relationship to masticatory function.

We hypothesized that the number of natural teeth was closely related to FTUs and chewing ability was positively influenced with the number of natural teeth and FTUs. Thus, the purposes of this study were (i) to examine the relationship of the number of natural teeth to the number of FTUs in Japanese adults, (ii) to evaluate how different types of FTUs contribute to subjective masticatory ability and (iii) to determine the number of natural teeth and FTUs needed to maintain adequate self-assessed chewing function.

Methods

Subjects

We mailed invitation letters to about 25 000 residents ages 40 to 75 years who dwelt in jurisdiction of Yokote Health Centre, Akita Prefecture, Japan and informed them about the purposes and the design of the study to seek their participation in the research. This convenience sample consisted of 2177 participants who agreed to join the study and signed the informed consent form. Investigation was carried out from July 2005 through December 2006. Self-administered questionnaires were given and dental examinations were conducted at local dental offices with the cooperation of the Yokote and Hiraka Dental Associations. A total of 2164 people (916 men: mean age = 61·7; s.d. = 8·8, 1248 women: mean age = 59·8; s.d. = 9·2) were used for the analysis after excluding subjects who had incomplete data on the studied variables. This study protocol was approved by the Tokyo Medical and Dental University Ethical Committee.

Questionnaire

The self-administered questionnaire items consisted of demographic information (gender and age) and Yamamoto's chewing-ability test questions that asked whether the subject was able to chew the following 15 items that were arranged from hard to easy chewable food: peanuts, hard rice cracker, pickled radish, dried squid, dried scallop, boiled octopus, french bread, beef steak, pickled scallion, raw squid, konjac (jelly made from arum root), fishcake, broiled eel, raw tuna and steamed rice.

Dental examination

Clinical examinations of dental status (third molars were excluded) were performed, by trained and calibrated dentists, by making the subjects sit in a dental chair with an operatory light, a dental mirror and an explorer. The dentists examined carious status as well as types of prosthetic restoration. Standardized clinical criteria based on the WHO format (39) were described in detail in a handbook distributed to all participating dentists.

Functional tooth units

The total number of FTUs (total-FTUs) were defined as pairs of opposing natural teeth (i.e., sound, restored and D_1–D_4 scale carious teeth) and artificial teeth on implant-supported, fixed (bridge pontics) and removable prostheses. D_4 scale carious teeth with extensive coronal destruction and missing teeth were regarded as non-functional. Only FTUs from posterior teeth, in which two opposing premolars were defined as one FTU and two opposing molars were defined as two FTUs were investigated. Therefore, a person with a complete dentition had 12 FTUs (third molars/wisdom teeth excluded). The number of FTUs was further divided by tooth composition into n-FTUs (FTUs of natural teeth) and nif-FTUs (FTUs of natural teeth and artificial teeth on implant-supported and fixed prostheses).

Statistical analysis

Mean differences of natural teeth and the three sets of FTUs were analysed with ANOVA followed by the Bonferroni's multiple comparison method. An association among variables was investigated using Pearson's

Table 1. Mean (s.d.) number of total and posterior natural teeth by gender and age group

		Total natural teeth		Posterior natural teeth	
Age group	*n*	Male (*n* = 916)	Female (*n* = 1248)	Male (*n* = 916)	Female (*n* = 1248)
40–49	300	25·9 (2·5)	25·8 (2·6)	14·3 (2·0)	14·1 (2·3)
50–59	650	23·3 (5·8)	23·3 (5·1)	12·4 (4·0)	12·4 (3·6)
60–69	755	20·7 (7·7)	19·0 (8·4)	10·9 (4·8)	9·5 (5·1)
70–75	459	15·9 (9·2)	13·3 (9·3)	8·1 (5·5)	6·3 (5·2)
Total	2164	20·8 (7·9)	20·4 (8·2)	11·0 (4·9)	10·5 (5·1)

correlation analysis. Age and gender adjustment was made by specifying these variables as covariates in the ANCOVA. The statistical analysis was performed with the SPSS 15·0J software.

Results

Of the 2164 subjects, 93 were edentulous and complete-denture wearers. The numbers of total and posterior natural teeth by age group are presented in Table 1. The numbers of both total and posterior natural teeth decreased with age and both males and females showed significant differences ($P < 0·001$) among all age groups. For both the number of total and posterior natural teeth, significant gender differences were found within age groups of 60–69 (total: $P < 0·01$, posterior: $P < 0·001$) and 70–75 years (total: $P < 0·01$, posterior: $P < 0·001$). However, for the FTUs, no significant gender differences were detected, and the values of males and females were combined in Table 2.

Both n-FTUs and nif-FTUs decreased with age and significant differences were found among all age groups ($P < 0·001$), however, the number of total-FTUs remained relatively constant. The 50–59 year old age group had a slightly lower total-FTUs value compared with other age groups, and significant differences were found between the following age groups: 40–49/50–59 ($P < 0·01$) and 50–59/70–75 ($P < 0·05$). Comparison of the numbers of nif-FTUs and total-FTUs indicated that the number of artificial teeth on removable prostheses increased with age. This was most noticeable in the age group of 70–75 years who had six FTUs from removable prostheses.

Table 2. Mean (s.d.) number of different types of FTUs by age group

Age group	*n*	n-FTUs	nif-FTUs	total-FTUs
40–49	300	9·3 (3·0)	10·2 (2·6)	10·4 (2·3)
50–59	650	7·2 (4·0)	8·2 (4·0)	9·8 (2·9)
60–69	755	5·3 (4·4)	6·1 (4·7)	10·1 (2·6)
70–75	459	3·1 (3·9)	3·8 (4·5)	10·3 (2·7)
Total	2164	5·9 (4·5)	6·8 (4·7)	10·1 (2·7)

FTUs, functional tooth units; n-FTUs, number of FTUs of natural teeth; nif-FTUs, number of natural, implant-supported and fixed prostheses FTUs.

Pearson's correlation coefficients showed that all variables were significantly associated except the number of total natural teeth and total-FTUs. The correlation coefficients among natural teeth, n-FTUs and nif-FTUs were greater than 0·84 ($P < 0·001$). Although significant associations of total-FTUs with posterior natural teeth ($r = 0·10$, $P < 0·001$), n-FTUs ($r = 0·27$, $P < 0·001$) and nif-FTUs ($r = 0·27$, $P < 0·001$) were seen, their correlation coefficients were relatively small.

Figures 1 and 2 present the gender and age-adjusted mean number of natural teeth and the three types of FTUs for each of the 15 food items in Yamamoto's chewing ability test. For all 15 food items, subjects who reported that they could chew every food item had a higher mean number of natural teeth and FTUs compared with those who could not. The differences were more obvious in hard food items such as peanuts and hard rice cracker than in soft food items such as raw tuna and steamed rice. Mean differences were significant at $P < 0·05$ for most food items except steamed rice and for natural teeth and total-FTUs with raw tuna.

Subjects were divided into two groups depending on whether they stated that they could chew all 15 food items or not. Subjects who reported that they could chew all 15 food items had a significantly higher mean number of natural teeth and all types of FTUs compared

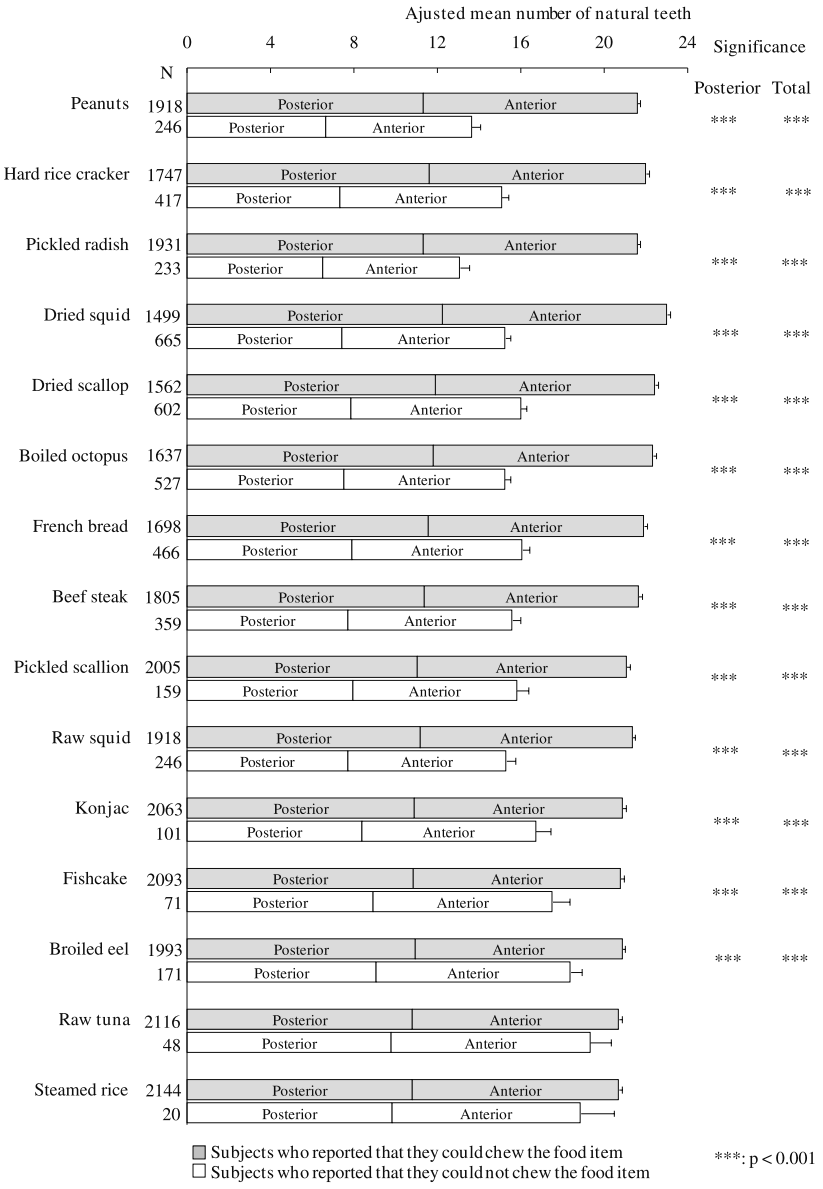

Fig. 1. Adjusted mean number of natural teeth by Yamamoto's chewing-ability test on 15 food items. Left of the line is the number of posterior natural teeth, right of the line is the number of anterior natural teeth and whole bar is the number of total natural teeth. Arrow bars represent s.e. of number of total natural teeth.

with those who could not ($P < 0{\cdot}001$) (Table 3). Overall, subjects who answered that they could chew every food item had 23·4 total natural teeth, 12·6 posterior natural teeth, 7·6 n-FTUs, 8·6 nif-FTUs and 10·4 total-FTUs. Subjects without chewing difficulties had fewer FTUs by removable prostheses (approximately two) in contrast to subjects with difficulties (approximately five).

Discussion

The mean number of both total and posterior natural teeth decreased with age in this sample and a significant correlation was seen between these two numbers. The trends in which the number of natural teeth decreases with age, and that elderly males retain more natural teeth than elderly females are comparable with the results of a Japanese survey of dental diseases conducted in 2005 (40). The number of natural teeth in our sample is only slightly smaller (by up to two teeth) compared with reports from the Japanese survey.

Masticatory function can be measured using self-reporting or a clinical test. Objective measurements with chewing of a test food may be preferable because they are reliable indicators of masticatory performance (12, 33, 41). For very large samples, chewing tests take

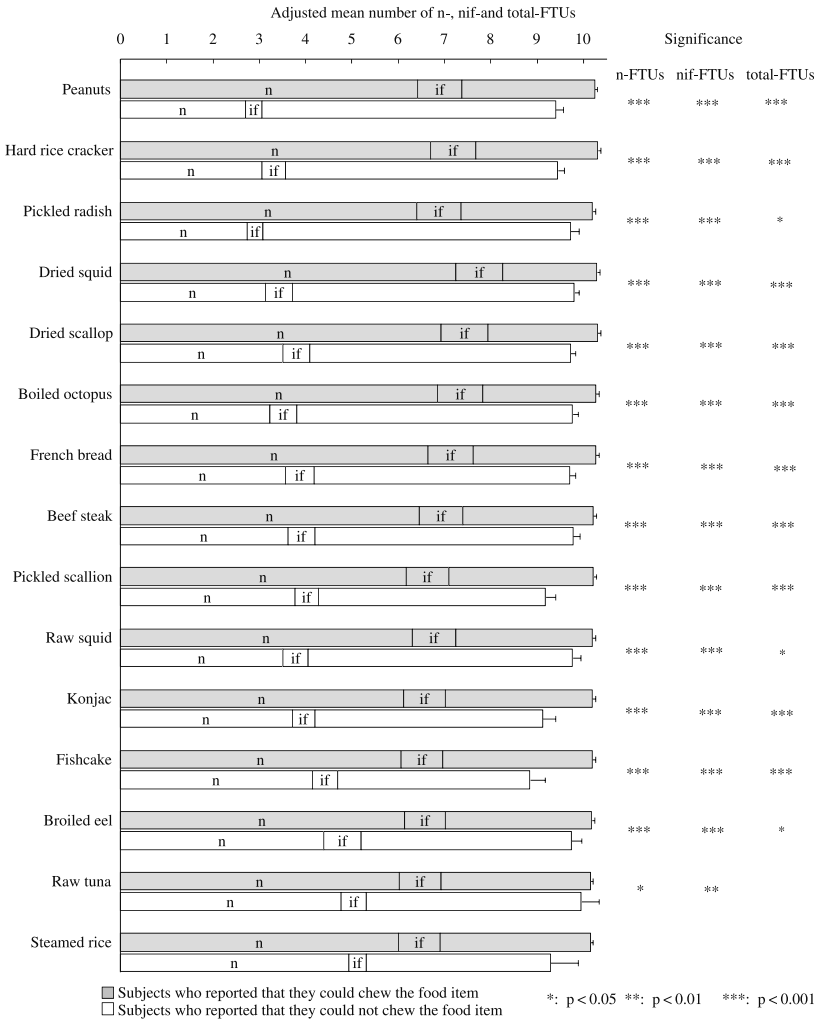

Fig. 2. Adjusted mean number of FTUs by Yamamoto's chewing-ability test on 15 food items. n, number of FTUs of natural teeth (n-FTUs); nif, number of natural, implant-supported and fixed prostheses (nif-FTUs); and whole bar is the number of total-FTUs. Arrow bars represent s.e. of number of total-FTUs.

too much time and need special instruments. The self-reported assessment of chewing ability is simple, informative and valid for large samples (42). Yamamoto's chewing ability test relies on the subject's judgment of various Japanese food items that are most commonly eaten in Japan.

The current findings suggest that the poorer the dentition status, worse the masticatory ability. Subjects who answered that they could chew every food item had a higher number of natural teeth compared with their counterparts. That is, chewing is easier with a greater number of natural teeth. In contrast, subjects were more likely to experience chewing difficulty if they had lost more natural teeth.

In 1982, the World Health Organization adopted 'retention throughout life of a functional, aesthetic, natural dentition of not less than 20 teeth' as a goal for oral health (43). FDI also determined a goal that recommended 50% of individuals of 65 years and above to have 20 or more teeth (44). In Japan, the Ministry of Health and Welfare launched a campaign in 1989 (the 8020 campaign) to encourage the Japanese population to retain at least 20 or more own natural teeth up to the age of 80 years (45–47). In 2000, a national health plan, 'Healthy Japan 21' was begun, with the oral health goal to help people prevent tooth loss so that they could retain at least 20 teeth throughout their lifetimes.

Our results show that having an average of 23·4 total natural teeth allow subjects to eat all 15 food items. The subjects having problems with one or more food items have significantly lower number of total natural teeth (17·2). These findings are in agreement with former studies, which showed that impairment of masticatory

Table 3. Adjusted mean number of natural teeth and FTUs by Yamamoto's chewing ability test status

	Status	*n*	Mean (s.d.)	*P*
Total natural teeth	+	1195	23·4 (6·6)	*
	−	969	17·2 (6·9)	
Posterior natural teeth	+	1195	12·6 (4·2)	*
	−	969	8·6 (4·4)	
n-FTUs	+	1195	7·6 (3·8)	*
	−	969	4·0 (3·7)	
nif-FTUs	+	1195	8·6 (3·8)	*
	−	969	4·7 (4·1)	
total-FTUs	+	1195	10·4 (2·5)	*
	−	969	9·8 (3·1)	

FTUs, functional tooth units; n-FTUs, number of functional tooth units of natural teeth; nif-FTUs, number of natural, implant-supported and fixed prostheses FTUs.
+: Subjects who reported that they could chew all 15 food items.
−: Subjects who reported that they could not chew some of 15 food items.
*$P < 0{\cdot}001$.

function occurred when fewer than 20 teeth are present (27), and people retaining 20 or more natural teeth could eat most types of Japanese foods (45–48). Furthermore, this study shows that people with an average of 8·6 posterior natural teeth are likely to have problem in chewing one or more food items. This result is not in agreement with previous studies (24, 29, 49, 50) which suggested that as long as people maintain at least eight premolars, it is possible to maintain adequate oral function (i.e., satisfactory biting and chewing). On an average, 12·6 posterior natural teeth were needed to chew all food items without problems in this sample.

Subjects with fewer FTUs are thought to be substantially at increased risk for chewing difficulties as Hatch *et al.* (17) reported that the single best predictor of masticatory performance was the number of FTUs. In this study, it was found that people with an average of 7·6 n-FTUs (or 8·6 nif-FTUs) did not have problems with the 15 food items. The subjects having problems with one or more food items had significantly lower values: 4·0 n-FTUs (or 4·7 nif-FTUs). Thus the number of FTUs of natural teeth or/and artificial teeth on fixed prostheses should on an average be eight or more, in other words, four pairs of premolars and two pairs of molars to avoid chewing problems. These findings are different from the studies, which report that having 10 occluding pairs from premolar to premolar, namely four FTUs have been recognized as providing function at a sub-optimal but acceptable level for older people (50, 51), and intact premolars and at least one pair of occluding molars, that is, six FTUs, provide sufficient chewing ability (52). Current results, however are similar to the studies indicating that five or fewer FTUs define a threshold for problematic dental functional status. (35, 37).

Analysis of the different types of FTUs indicated that subjects without chewing difficulties had fewer FTUs supplied by removable prostheses compared with their counterparts. In other words, those who reported difficulties in chewing food items had many missing teeth restored by dentures. In particular, elderly subjects who lose their natural teeth recover their FTUs mainly with removable prostheses. The strong correlations in the number of natural teeth, n-FTUs and nif-FTUs indicate that subjects who had more natural teeth were more likely to have FTUs with natural teeth and fixed prostheses. Very weak correlations of total-FTUs with natural teeth, n-FTUs and nif-FTUs suggest that once a subject loses many natural teeth the missing teeth are restored with removable prostheses.

Removable prosthodontic treatments provided the current subjects, especially the elderly, with up to six additional FTUs. Subjects who reported that they could and could not chew all food items had on an average 10·4 and 9·8 total-FTUs, respectively. Although the difference was very small, real oral function between two groups would be very different. FTUs based on removable prostheses may add very little in avoiding chewing problems. Hence, it is apparent that total-FTUs are not a good index to distinguish groups with and without chewing problems and are irrelevant for the actual oral functional status.

Masticatory function with dentures is thought to be affected by many factors such as retention and stability of the denture, denture shape and the action of the soft tissues. There are also reports that the subjective masticatory ability becomes less reliable as the number of teeth decreases (53); some subjects report a high chewing ability even when their number of teeth is close to zero (54). Future research should examine the relationship between subjective and objective masticatory function, and how the number of FTUs affecting masticatory function is related to conditions of the dentures, such as adaptation, retention and extension.

We evaluated a convenience sample which is derived from a community; therefore, the present report may not be generalizable if there are differences in the

demographic characteristics of the sample from the overall Japanese population. However, the study subjects were community residents, not patients; and the numbers of natural teeth were very similar to those of Japanese survey data. Therefore, we consider this sample as an approximate profile of the adult Japanese population even if it is not representative for the Japanese population. In a future study, we will test whether these results can be generalized to other populations.

Our study confirms that the numbers of natural teeth and FTUs are key components of chewing ability, and suggests that maintenance of these factors may be of primary importance for promoting healthy oral function. Our community-based research adds evidence that maintaining 20 and more natural teeth and eight and more FTUs based on natural and fixed prosthetic teeth is important in reducing the likelihood of chewing difficulties, and primary interventions to maintain or improve masticatory function in subjects should be aimed at the preservation and restoration of FTUs, preferably with fixed prostheses.

Acknowledgments

This work was partly supported by the 8020 Promotion Foundation.

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Clin Oral Invest (2010) 14:113–119
DOI 10.1007/s00784-009-0270-8

ORIGINAL ARTICLE

Category of functional tooth units in relation to the number of teeth and masticatory ability in Japanese adults

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Received: 16 September 2008 / Accepted: 16 March 2009 / Published online: 31 March 2009

Abstract The purposes of this study were (1) to examine differences in dental status among various age groups, particularly, focusing on whether subjects retained 20 or more natural teeth, and (2) to investigate the relationship among dental status, the number and categories of functional tooth units (FTUs), and masticatory ability. A dental examination and self-administered questionnaire were conducted in a total of 2,164 residents aged 40 to 75 years who dwelt in Japan. The percentage of subjects with 20 and more natural teeth and their number of posterior teeth decreased with age. There was not much difference in the mean number of FTUs in subjects with and without 20 or more natural teeth, but those with 20 natural teeth had fewer numbers of FTUs than those with more than 20 natural teeth. The categories of the FTUs were extremely different. Subjects with 20 or more natural teeth had FTUs consisting mostly of natural to natural teeth. Subjects with 19 or fewer natural teeth had many FTUs consisting of removable prosthetic teeth. The subjective chewing ability test was significantly correlated with the number of natural teeth. Subjects could chew the higher number of test foods as the number of natural teeth increased. Not only the number of natural teeth but the categories of FTUs appear to be key factors of chewing ability. It is important to keep as many natural teeth as possible so that the person's categories of FTUs are mainly composed of natural to natural teeth to maintain better oral function.

Keywords Functional tooth units · Masticatory ability · Tooth loss · Shortened dental arch · Prostheses

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Introduction

Dental status can be evaluated with a variety of indexes. One important index representing oral health is the number of natural teeth [1–4]. Tooth loss can occur either from loss due to progressive dental disease (e.g., dental caries and periodontal disease) or trauma. Our preceding study has reported that loss of natural teeth will decrease masticatory function [5].

Another significant index is a functional tooth units (FTUs) that is defined as pairs of opposing teeth. It has been used to evaluate oral function and masticatory performance [6–17]. Our previous study also demonstrated that the number of FTUs is an important determinant of masticatory performance [5]. A lower number of FTUs is not only associated with chewing difficulties but an association also exists between a reduced number of FTUs and physical disabilities [12].

Internationally, the World Health Organization set "the retention, throughout life, of a functional, esthetic, natural dentition of not less than 20 teeth and not requiring recourse to prostheses" as a goal for oral health in 1982 [18]. The Federation Dentaire Internationale also recommended a goal of 50% of individuals 65 years and older having 20 and more natural teeth [19].

In Japan, the Ministry of Health and Welfare and the Japan Dental Association jointly began the 8020 Campaign in 1989 to encourage the Japanese to keep at least 20 or more natural teeth until the age of 80, the approximate Japanese life expectancy. In 2000, the national "Healthy Japan 21" plan was initiated, focusing on health promotion and increased life expectancy. The plan included the promotion of better oral health to achieve its goals, which were to help people prevent tooth loss so that they could retain at least 20 teeth throughout their lifetimes.

Although the goal of maintaining 20 and more natural teeth has been announced worldwide, no study has investigated in detail the importance and significance of keeping one's own natural teeth using an index like FTUs. Thus, the purposes of this study were (1) to examine the dental condition in Japanese adults, particularly focusing on whether they retain 20 or more natural teeth, and (2) to investigate the relationship among natural teeth, FTUs, and masticatory ability.

Materials and methods

Details of the sampling method, examination procedure, and indexes used have been described in a preceding paper [5].

Subjects

Subjects were community residents aged 40 to 75 years, who dwelt in Yokote Health Center Jurisdiction, Akita Prefecture, Japan. Invitation letters informing about the purposes and the design of the study and seeking participation in the research were mailed to all subjects. Convenience sample consisted of 2,177 subjects who agreed to participate and signed the informed consent form. Investigation was carried out from July, 2005 through December, 2006. After excluding subjects who had incomplete data, a total of 2,164 people (916 men, mean age=61.7, SD=8.8 years old; 1,248 women: mean age=59.8, SD=9.2 years old) were used for the analysis.

Clinical dental examination

Clinical dental examinations of tooth status (third molars were excluded) were performed by trained and calibrated dentists. Standardized clinical dental criteria [20] were instructed beforehand at the meeting, and a handbook describing the detailed criteria was also distributed to all participating dentists. The dentists examined caries status as well as types of prosthetic restoration.

Functional tooth units

The number of FTUs was defined as pairs of opposing posterior natural (i.e., sound, restored and D_1–D_4 scale carious teeth) and artificial teeth on implant-supported, fixed (bridge pontics), and removable prostheses. D_4 scale carious teeth with extensive coronal destruction and missing teeth were regarded as non-functional. Two opposing premolars were defined as one FTU and two opposing molars were defined as two FTUs with 12 FTUs of a complete dentition (third molars were excluded). The total number of FTUs, divided into six categories (natural to natural teeth, fixed prosthetic to natural teeth, fixed to fixed prosthetic teeth, removable prosthetic to natural teeth, removable to fixed prosthetic teeth, and removable to removable prosthetic teeth), was evaluated at the subject level and at the opposing tooth pair level (i.e., 17/47, 16/46, 15/45, 14/44, 24/34, 25/35, 26/36, and 27/37).

Questionnaire

Self-administered questionnaire items consisted of demographic information (age and sex) and Yamamoto's chewing ability test questions that asked if the subject was able to chew the 15 test foods [5, 21, 22].

Statistical analysis

The number of subjects with or without 20 and more natural teeth by age group (40–49, 50–59, 60–69, and 70–75 years) was calculated, and the distributional differences of frequency were analyzed with chi-square tests. The mean numbers of posterior teeth and FTUs by age group were examined in subjects with and without 20 or more natural teeth. Age and sex adjustment was done by specifying these variables as covariates in the ANCOVA, after which the differences of the adjusted mean number of each FTU category between the two groups were analyzed with the *t* test. The proportion of each FTU category by opposing tooth pair was also investigated. The relationship between Yamamoto's chewing ability test and the number of natural teeth was assessed with Pearson's correlation. The statistical analysis was performed with the SPSS15.0J software.

Ethics

This study protocol was approved by the Tokyo Medical and Dental University Ethical Committee.

Results

Proportion of subjects with and without 20 or more natural teeth

Almost all subjects in the 40–49 age group had 20 or more natural teeth, but fewer than half of subjects in the 70–75

Table 1 Frequency and mean number of posterior teeth and FTUs in subjects with and without 20 or more natural teeth by age group

Age group	Number of natural teeth					
	20 and more	19 and less	20 and more	19 and less	20 and more	19 and less
	Number (%) of subjects		Number (95% CI) of posterior teeth		Number (95% CI) of FTUs	
40–49	294 (98.0)	6 (2.0)	14.3 (14.1, 14.5)	7.3 (3.9, 10.8)	10.5 (10.2, 10.7)	8.3 (3.9, 12.8)
50–59	544 (83.7)	106 (16.3)	13.7 (13.5, 13.9)	5.6 (5.1, 6.2)	10.1 (9.9, 10.3)	8.4 (7.6, 9.2)
60–69	499 (66.1)	256 (33.9)	13.2 (13.0, 13.4)	4.2 (3.8, 4.5)	10.0 (9.8, 10.3)	10.4 (10.0, 10.7)
70–75	181 (39.4)	278 (60.6)	12.9 (12.6, 13.2)	3.5 (3.1, 3.8)	9.8 (9.4, 10.2)	10.6 (10.3, 11.0)
Total	1518 (70.0)	646 (30.0)	13.5 (13.4, 13.7)	4.1 (3.9, 4.4)	10.1 (10.0, 10.2)	10.1 (9.9, 10.4)

age group had 20 or more natural teeth (Table 1). The percentage of subjects with 20 or more natural teeth decreased with age, and a significant distributional difference was observed ($p<0.001$).

Number of posterior teeth and FTUs

The mean number of posterior teeth declined with age regardless of the fact that subjects had 20 or more natural teeth or not. The mean number of FTUs in subjects with 20 or more natural teeth had a decreasing trend with age, while among those with 19 or fewer natural teeth, there was an increasing trend with age. In the 40–49 and 50–59 age groups, the mean numbers of FTUs in subjects with 20 or more natural teeth were slightly higher than those with 19 or fewer natural teeth, but the mean numbers of FTUs were almost the same in the 60–69 and 70–75 age groups.

Number of FTU categories by subject level

As displayed in Table 2, the mean numbers of total FTUs were 10.14 in subjects with 20 or more natural teeth and 10.11 in those without, and no significant difference was detected. However, the mean number of each FTU category differed significantly between the two groups at $p<0.05$. Among subjects with 20 or more natural teeth, FTUs with natural to natural teeth was predominant (8.02), followed by fixed prosthetic to natural teeth (1.05). The other FTU categories were all less than 1.00. In contrast, among those with 19 or fewer natural teeth the mean number of FTUs based on natural to natural teeth was very small (1.12), and removable to removable prosthetic teeth (5.04) and removable prosthetic to natural teeth (3.33) were the two main categories. All other FTU categories were less than 0.50.

Subjects with 20 or more natural teeth were further divided into two groups: subjects with more than 20 natural teeth including first molars ($N=1,427$) and those with 20 natural teeth ($N=70$). Subjects with more than 20 natural teeth had similar numbers of each FTU category to those with 20 or more natural teeth (Table 3). Among subjects with 20 natural teeth, the mean number of total FTUs was slightly low (8.10), and FTUs with natural to natural teeth (3.58) and removable prosthetic to natural teeth (2.96) were the two major categories.

Table 2 Adjusted mean number (adjusted for sex and age; 95% CI) of FTUs categories in subjects with and without 20 or more natural teeth

FTUs	Number of natural teeth		*p* value
	20 and more teeth	19 and less teeth	
n–n	8.02 (7.88, 8.16)	1.12 (0.89, 1.35)	<0.001
f–n	1.05 (0.99, 1.12)	0.17 (0.06, 0.28)	<0.001
f–f	0.08 (0.06, 0.10)	0.04 (0.01, 0.07)	<0.05
r–n	0.81 (0.68, 0.93)	3.33 (3.13, 3.53)	<0.001
r–f	0.06 (0.03, 0.09)	0.41 (0.36, 0.46)	<0.001
r–r	0.12 (0.00, 0.26)	5.04 (4.82, 5.27)	<0.001
Total	10.14 (10.00, 10.28)	10.11 (9.89, 10.33)	n.s.

n.s. not significant, *n–n* natural to natural teeth, *f–n* fixed prosthetic to natural teeth, *f–f* fixed to fixed prosthetic teeth, *r–n* removable prosthetic to natural teeth, *r–f* removable to fixed prosthetic teeth, *r–r* removable to removable prosthetic teeth

Table 3 Adjusted mean number (adjusted for sex and age; 95% CI) of FTUs categories in subjects with more than 20 natural teeth including first molars and 20 natural teeth

FTUs	Number of natural teeth		*p* value
	More than 20 teeth	20 teeth	
n–n	8.52 (8.37, 8.68)	3.58 (2.89, 4.26)	<0.001
f–n	1.04 (0.96, 1.12)	0.85 (0.50, 1.20)	n.s.
f–f	0.07 (0.05, 0.09)	0.06 (0.00, 0.14)	n.s.
r–n	0.60 (0.51, 0.70)	2.96 (2.52, 3.39)	<0.001
r–f	0.04 (0.02, 0.06)	0.34 (0.26, 0.42)	<0.001
r–r	0.01 (0.00, 0.02)	0.31 (0.24, 0.38)	<0.001
Total	10.28 (10.16, 10.40)	8.10 (7.53, 8.64)	<0.001

n.s. not significant, *n–n* natural to natural teeth, *f–n* fixed prosthetic to natural teeth, *f–f* fixed to fixed prosthetic teeth, *r–n* removable prosthetic to natural teeth, *r–f* removable to fixed prosthetic teeth, *r–r* removable to removable prosthetic teeth

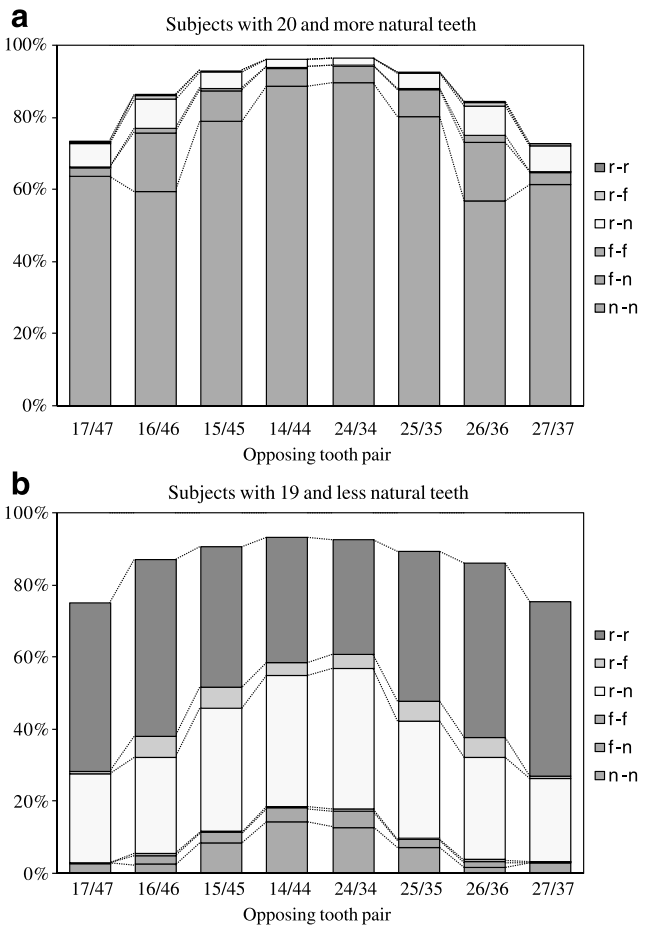

Fig. 1 Percentage of FTU categories at opposing tooth pair level in subjects with (**a**) and without (**b**) 20 or more natural teeth (*n–n* natural to natural teeth, *f–n* fixed prosthetic to natural teeth, *f–f* fixed to fixed prosthetic teeth, *r–n* removable prosthetic to natural teeth, *r–f* removable to fixed prosthetic teeth, *r–r* removable to removable prosthetic teeth)

Percentage of FTU categories by opposing tooth pair level

There was no apparent difference in the percentage of total FTUs at each opposing tooth pair between subjects with and without 20 natural teeth (Fig. 1). The percentage of total FTUs was highest in first premolars and gradually decreased toward second molars in both groups: approximately 95% in first premolars, 90% in second premolars, 85% in first molars, and 75% in second molars.

FTUs with natural to natural teeth were dominant in subjects with 20 or more natural teeth, while FTUs composed of removable prostheses (i.e., removable to removable prosthetic teeth, removable prosthetic to natural teeth, and removable to fixed prosthetic teeth) were 70% to 80% in subjects with 19 or fewer natural teeth. Among subjects with 20 or more natural teeth, approximately 60% for molars and 80% to 90% for premolars were FTUs with natural to natural teeth, and the percentage was higher for second molars than for first molars. Among subjects with 19 or fewer natural teeth, only 2% to 3% for molars and 10% to 15% for premolars were FTUs with natural to natural teeth. The FTUs with removable to removable prosthetic teeth were slightly higher for molars (around 50%) than for premolars (30% to 40%). In contrast, FTUs from removable prosthetic to natural teeth were slightly higher for premolars (30% to 40%) compared to molars (25% to 30%).

The percentage of each FTU category in subjects with more than 20 natural teeth was very similar to that in those with 20 or more natural teeth (Fig. 2). On the other hand, the percentage of total FTUs was lower, especially in molars, among subjects with 20 natural teeth. The percentages of FTUs with natural to natural teeth were around 60% in premolars and less than 20% in molars, and higher percentages of FTUs with removable prosthetic to natural teeth were observed in second premolars and molars.

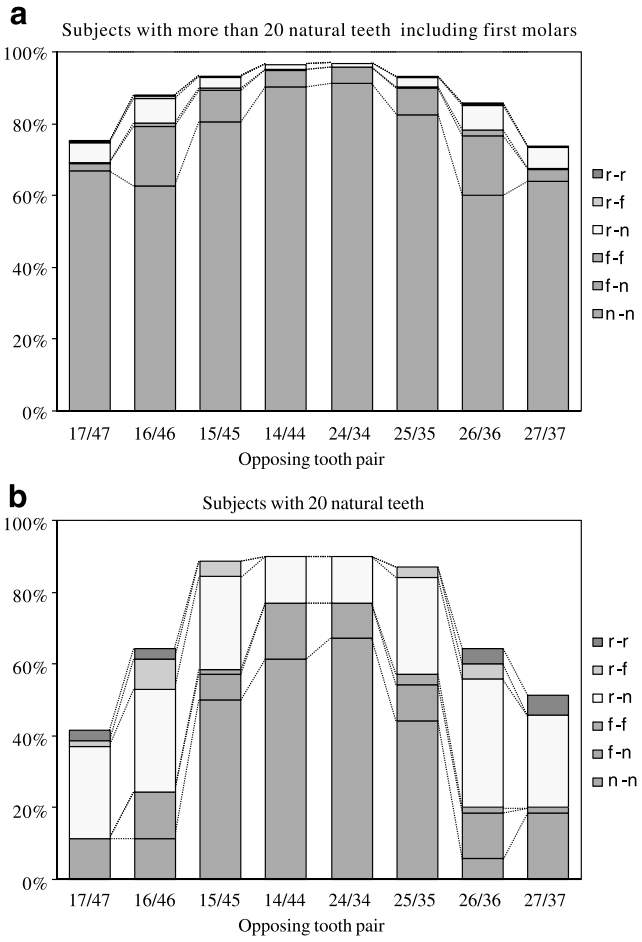

Fig. 2 Percentage of FTU categories at opposing tooth pair level in subjects with (**a**) more than 20 natural teeth including first molars and with (**b**) 20 natural teeth (*n–n* natural to natural teeth, *f–n* fixed prosthetic to natural teeth, *f–f* fixed to fixed prosthetic teeth, *r–n* removable prosthetic to natural teeth, *r–f* removable to fixed prosthetic teeth, *r–r* removable to removable prosthetic teeth)

Masticatory ability and number of teeth

There was a significant correlation between the number of Yamamoto's 15 chewing ability test foods which subjects reported they could chew and the number of natural teeth (r= 0.55, p<0.001). Subjects could chew the higher number of foods as the number of natural teeth increased. A higher proportion of subjects with 20 or more natural teeth could chew all 15 foods (70.6%) compared to those with 19 or fewer natural teeth (19.2%). Among subjects with 20 or more natural teeth, 72.9% of subjects with more than 20 natural teeth could chew all 15 foods and 28.6% of those with 20 natural teeth.

Discussion

This study of the relationship among dental status, the number and categories of FTUs, and masticatory ability indicated that retaining as many natural teeth as possible is preferable to maintain appropriate oral function. Käyser [23–25] reported that at least 12 anterior teeth and eight premolars are necessary for satisfactory biting and chewing. Witter [26] also suggested that, as long as people maintained 20 well-distributed teeth, there was an adaptive mechanism to maintain adequate oral function. On the other hand, an impairment of masticatory ability is thought to occur when fewer than 20 teeth are present [27–29]. Similar conclusions were also drawn in Japan. It is stated that maintaining more than 20 teeth was necessary for mastication [30] and people with 20 or more teeth could eat most types of Japanese foods [31–33]. People who have 20 or more remaining teeth also show better oral condition and health status than those who have less than 20 teeth [34, 35]. According to the Japanese dental survey [36] conducted in 2005, the mean number of retained teeth in the Japanese elderly (65 years and older) was less than 20. Thus, there is much room for improvement in dental status of the Japanese elderly.

There are researches that examine the total number of FTUs [11, 12, 37], but no study investigates the categories of the FTUs or FTUs at the opposing tooth pair level. Comparison of the number of FTUs in subjects with and without 20 or more natural teeth indicated that the mean number of FTUs did not differ, although those with 20 natural teeth had fewer numbers of FTUs than those with more than 20 natural teeth by approximately two.

The categories of the FTUs were extremely different depending on the number of natural teeth. Not only did subjects with 20 or more natural teeth have natural to natural teeth as the dominant category of FTUs, but they had fewer FTUs with removable prosthetic teeth compared to those with 19 or fewer natural teeth. The latter had very few FTUs with natural to natural teeth and many FTUs with removable prosthetic teeth. Subjects with 20 or more natural teeth had more than 9.1 FTUs based on natural or fixed prosthetic teeth out of 10.1 total FTUs. On the other hand, those with 19 or fewer natural teeth had more than 8.7 FTUs based on removable prosthetic teeth out of 10.1 total FTUs. Even among subjects with 20 or more natural teeth, those with 20 natural teeth had fewer number of FTUs with natural to natural teeth and higher number of FTUs with removable prosthetic to natural teeth compared to those with more than 20 natural teeth. In other words, people with fewer natural teeth tended to have their missing teeth restored with dentures. Consequently, they had a higher number of FTUs with removable prosthetic teeth.

An analysis of FTU categories at the opposing tooth pair level revealed that the overall distribution of total FTUs was similar, whether or not subjects had 20 or more natural teeth. The percentage of FTUs was higher in the premolars than in the molars. The proportion of FTUs with natural to natural teeth was also higher in the premolars than in the molars in subjects with 20 or more natural teeth, while FTUs with natural to natural teeth had been replaced with removable prosthetic to natural teeth or removable to removable prosthetic teeth in those with 19 or fewer natural teeth. The investigation of subjects with 20 or more natural teeth also showed that those with 20 natural teeth had very low percentages of FTUs with natural to natural teeth, particularly in molars, compared to those with more than 20 natural teeth.

Subjective masticatory function, as determined from Yamamoto's chewing ability test suggested that ease of eating was clearly influenced by the number of natural teeth, with chewing becoming easier with a greater number of natural teeth. More than 70% of subjects with 20 or more natural teeth reported they could chew all 15 foods, thus having many natural teeth was considered important for people to eat and enjoy meals with a wide range of foods. In contrast, less than 20% of subjects with 19 or fewer natural teeth could chew all foods. Therefore, people are more likely to experience chewing difficulty if they lose their natural teeth. Those results suggested that the shortened dental arch (SDA) [29, 38], which was defined as having an intact anterior region but a reduced number of posterior teeth, was not sufficient for appropriate mastication.

The masticatory ability also depends on the number of FTUs, and a loss of FTUs is reported to be a key variable in the decrease of masticatory performance [13–16]. In this study, however, the findings from FTUs category imply that even if the total number of FTUs increases as a result of removable prosthodontic treatment, it may not yield a significantly improved masticatory function. Thus, when FTUs are recovered with dentures, they appear to be poor substitutes for natural teeth in chewing foods, possibly due

to various factors, including a lack of retention, poor adaptation, poor stability, and reduced bite force as suggested in previous studies [39–41]. Maintaining as many occluding pairs of natural teeth as possible is essential in reducing the likelihood of chewing difficulty [9, 11, 17] and masticatory function is not improved with removable dentures [42–44]. Hence, we suggest that not only the number of FTUs but also the category of the FTUs are relevant factors affecting masticatory function.

As shown in this study, the number of retained natural teeth and categories of the FTUs are key factors of chewing ability. These results add evidence that maintenance of these factors may be of primary importance for promoting a healthy oral condition. It is reported that the SDA influences not only on mastication, oral function, and temporomandibular joint but on the oral health-related quality of life [23, 45]. Therefore, it is important to maintain as many natural teeth as possible and to avoid replacing lost posterior teeth with removable prostheses. Keeping the FTUs with natural to natural teeth better maintains good oral function.

Acknowledgments This study was partly supported by the Ministry of Health, Labour and Welfare Grants-in-Aid for Scientific Research and the 8020 Promotion Foundation.

Conflict of interest statement We have no conflict of interest.

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Community Dental Health (2011) **28,** 297–300
Received 28 December 2008; Accepted 25 February 2010

doi:10.1922/CDH_2499Zaitsu04

Association of clinical oral health status with self-rated oral health and GOHAI in Japanese adults

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Objective: The objective of this study was to investigate clinical oral health status relationships that affect quality of life (using the 12-item General Oral Health Assessment Index (GOHAI)) and self-rated oral health in a community of Japanese residents. ***Methods:*** 459 residents of Yokote City, Japan aged 40-55 years had oral health examinations and completed self-administered questionnaires collecting data on age, gender, GOHAI items and self-rated oral health. Linear regression analysis was performed with GOHAI or self-rated oral health as a dependent variable and gender, age and indicators of oral health status as independent variables. ***Results:*** The GOHAI indicated 42.7% of subjects were concerned about the appearance of their teeth, 30.1% were worried about teeth problems and 27.5% concerned about sensitive teeth. Analyses showed that gender, decayed teeth, oral dryness and missing teeth were significantly associated with variation in GOHAI scores, and that gender, decayed teeth, oral dryness and oral hygiene were significantly associated with variation in self-rated oral health. ***Conclusion:*** This study revealed that in this sample of Japanese adults aged 40-55 years, decayed teeth and oral dryness affected both GOHAI and self-rated oral health, whereas missing teeth affected GOHAI and oral hygiene affected self-rated oral health. Subjects did not recognise periodontal disease as a quality of life impacting condition or as a health problem.

Key words: *Quality of life, self-rated oral health, dental health status, Japanese adults, GOHAI*

Introduction

Many studies show that the quality of life (QOL) is an important element of health (Locker and Allen, 2007; Locker *et al.,* 2001; Tabira *et al*, 2002). QOL, as the overall goal of health, was suggested by Wilson and Cleary in a model applicable to oral health (Locker, 2005). Many studies have investigated the relationship between oral health status and QOL (Locker *et al.,* 2001). The General Oral Health Assessment Index (GOHAI, Atchison and Dolan, 1990) is a self-administered questionnaire popularly used to assess the Oral Health Related Quality of Life (OHRQoL). GOHAI has been translated, validated and used in many countries (Daradkeh and Khader, 2008; Tubert-Jeannin *et al.*, 2003) including Japan (Naito *et al*., 2006). GOHAI is mainly used with elderly people and there are few OHRQoL studies conducted with groups other than elderly in Japan (Ikebe *et al*, 2007; Locker, 2003; Wong and McMillan, 2005). Particularly there are limited OHRQoL data on the mid-aged groups which could prompt earlier preventive intervention. At this age (40-55 years) it is possible to investigate the relationship between GOHAI and several oral diseases like dental caries and periodontal disease as this age-group tends to have more natural teeth. OHRQoL studies which examine oral health status have mainly focused on tooth loss or xerostomia (Wong and McMillan, 2005) so impacts of dental caries, periodontal disease and oral hygiene have not yet been assessed.

It may be important to investigate the relationship between oral health status and self-rated oral health as Wilson and Cleary have suggested that negative oral health perceptions could be a predictor of oral health related quality of life (Locker, 2005).

Thus, the main aim of this study was to investigate clinical oral health status relationships that affect quality of life using both GOHAI, and self-rated oral health in community of Japanese residents aged 40-55 years.

Methods

All 10,771 residents in Yokote city, Akita Prefecture, Japan aged 40-55 years on the municipal electorate register were sent invitation letters to participate in this study. They were given information about the purpose of this research, the design of the study and response letters to participate. Some 504 agreed to join the study and signed informed consent forms. The investigation was carried out from August 1st to September 30th 2007. Only the 459 subjects with complete data were included in the analysis. The study protocol was approved by the Tokyo Medical and Dental University Ethics Committee (#278).

A self-administered questionnaire covered demographic information (gender and age), the Japanese version of GOHAI and a self-rated oral health question. GOHAI is a 12-item instrument comprising questions related to oral function, anxiety and pain/discomfort during the last three months. Response categories for each question were: 1 all the time, 2 often, 3 sometimes, 4 seldom and 5 never.

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Summing the 12 scores gave the mean GOHAI score in the possible range 12-60 with higher scores indicating better perceived OHRQoL. The question to elicit self-rated oral health was: "How do you consider your present oral health condition?" with response options: 1 very bad, 2 bad, 3 fair, 4 good and 5 very good.

Self-administered questionnaires and dental examinations were conducted at local dental clinics by 50 dentists of the Yokote and Hiraka Dental Associations. The required reporting standards, based on WHO (1997) recommendations, were circulated to these dentists in a detailed manual which was then explained and discussed at an information session. The examinations were conducted with subjects in a dental chair under an operator light. The dentists examined and recorded decayed, missing and filled teeth (third molars excluded), periodontal status (gingival bleeding, calculus and pocket depth), oral hygiene and oral dryness. Decay was coded according to the extent of lesion development: D0, sound surface; D1, initial caries; D2, enamel caries; D3, caries of dentin; and, D4, pulpal involvement. Periodontal status was examined using a dental mirror and a periodontal probe. The deepest pocket depth was recorded by probing all sites around each natural tooth. Pocket depths of 4mm or more on any one tooth site were judged to indicate periodontitis. Existence of calculus and gingival bleeding on probing were checked on each tooth while measuring the probing depth.

Oral hygiene was examined and reported as: *good* - plaque hardly existing, *poor* - plaque existing on more than two-thirds of surfaces of the cervical region of one or more teeth; or *fair* - a mid-range score between *good* and *poor*. Oral dryness was visually examined and reported in this analysis as: *yes* - dry or *no* - moist.

Functional Tooth Units (FTUs) were defined as pairs of opposing teeth, and FTU scores were used to evaluate masticatory function (Hatch *et al*., 2001; Kwok *et al.*, 2004; Ueno *et al*., 2008). The total number of FTUs was defined as pairs of opposing natural teeth (i.e. sound, restored and minimal score carious teeth), artificial teeth which may be on implant, fixed or removable prostheses. D4 score carious teeth, with extensive coronal destruction, and missing teeth, were regarded as non-functional units. FTUs from posterior teeth, in which there were two opposing molars, were scored as two, while FTUs with two opposing premolars, scored as one FTU. Therefore, a person with a complete dentition had 12 FTUs (third molars excluded).

Descriptive statistics were calculated for each examined item. The t-test was used to investigate the bivariate association of GOHAI and self-rated oral health with clinical oral health status (number of decayed teeth, missing teeth, filled teeth, teeth with gingival bleeding on probing, teeth with calculus, teeth with 4mm and deeper periodontal pockets and FTUs). GOHAI was categorised from the mean score into *<54* or *54+*. Self-rated oral health was categorised into "*very good/good/fair*" and "*bad/very bad*". The χ^2 test was used to investigate the bivariate association of grouped GOHAI and self-rated oral health data with clinical oral health status (oral hygiene and oral dryness). Oral hygiene was divided into *good/fair* and *poor* response options. Oral dryness were divided into *yes* and *no* response options. Linear regression analysis was performed with GOHAI scores or self-rated oral health as dependent variables. Gender, age and clinical oral health status indicators were used as independent variables. Two-sided p-values less than 0.05 were considered to be statistically significant. Statistical analyses were performed with the SPSS 15.0 J software.

Results

The mean age of the subjects was 48.8 years (s.d. 4.3) with a third, 154, being male, 305 female. The mean numbers of decayed, missing and filled teeth were 1.6, 2.7 and 13.8 respectively, mean DMFT 18.0. The mean number of teeth with gingival bleeding was 5.9, calculus 8.6 and pocket depth 4mm or more 4.7. The proportion of subjects with oral hygiene rated *good/fair* was 87.4% and 12.6% were rated *poor*. Some 3.7% had oral dryness. The mean FTU score was 10.3 units (s.d. 2.5).

Table 1 summarises the responses to of the GOHAI items and the self-rated assessments of oral health. The mean GOHAI score was 53.6 (s.d. 6.1). Table 1 shows only the proportion of subjects who answered negatively on the GOHAI, that is, *all the time*, *often* or *sometimes*.

Bivariate analyses using both mean and grouped GOHAI scores had significant relationships with missing teeth and FTUs (Table 2). Decayed teeth, FTUs, periodontal status (gingival bleeding, calculus and pocket depth), oral hygiene and oral dryness also showed significant relationships with poor (*bad/very bad*) self-rated oral health (Table 3). Linear regression analysis showed that GOHAI score was significantly associated with gender, number of decayed teeth, number of missing teeth and oral dryness while poor self-rated oral health was significantly, associated with gender, number of decayed teeth, poor oral hygiene and oral dryness (Table 4).

Table 1. General Oral Health Assessment Index (GOHAI) and self-rated oral health

Characteristics	*% (n=459)*	
*GOHAI 12 items**		
Have to limit food intake/choice of food	14.6	
Trouble biting/chewing	19.4	
Unable to swallow comfortably	2.8	
Unable to speak clearly	6.5	
Discomfort during eating	12.0	
Limited contact with people	5.9	
Not pleased with the look of teeth	42.7	
Use medication to relieve pain	8.9	
Worried about teeth problems	30.1	
Self-conscious of teeth problems	12.6	
Uncomfortable eating in front of people	4.6	
Sensitive to hot/cold/sweet/sour food	27.5	
Self-rated oral health		
Very good	7.2	
Good	16.6	76.7%
Fair	52.9	
Bad	20.5	
Very bad	2.8	23.3%

* Percentage reporting 'All the time', 'Often' or 'Sometimes'

Table 2. Bivariate association of GOHAI with oral health status

Oral health status	*Below GOHAI mean, <54 n=175*	*Above GOHAI mean, 54+ n=284*	*p-value*
Decayed Teeth [a]	1.8	1.4	0.112
Missing Teeth [a]	3.4	2.2	<0.001
Filling Teeth [a]	13.6	14.0	0.476
FTU [a]	9.6	10.7	<0.001
Gingival bleeding [a]	5.8	5.9	0.863
Existence of calculus [a]	9.0	8.3	0.337
Deep pockets [a]	5.4	4.2	0.053
Oral hygiene (poor) [b] %	14.9	11.3	0.261
Oral dryness [b] %	5.7	2.5	0.073

[a] T-test [b] χ^2 test

Table 3. Bivariate association of self-rated oral health with oral health status

	Self-Rated Oral Health Group		
Oral health status	*Bad n=352*	*Good/Fair n=107*	*p-value*
Decayed Teeth [a]	1.4	2.2	0.010
Missing Teeth [a]	2.5	3.3	0.053
Filling Teeth [a]	14.0	13.4	0.340
FTU [a]	10.5	9.7	0.007
Gingival bleeding [a]	5.5	7.2	0.022
Existence of calculus [a]	7.9	10.8	0.002
Deep pockets [a]	4.1	6.4	0.004
Oral hygiene (poor) [b] %	9.4	23.4	<0.001
Oral dryness [b] %	2.3	8.4	0.003

[a] t-test [b] χ^2 test

Table 4. Linear regression analysis with GOHAI (G) and self-rated oral health (SR) as the dependent variables

	B		*S.E.*		*Beta*		*t*		*p*	
	G	*SR*	*G*	*SR*	*G*	*SR*	*G*	*SR*	*G*	*SR*
Gender	-1.37	0.26	0.60	0.09	-0.11	0.14	-2.27	3.00	0.023	0.003
Age	0.02	-0.02	0.07	0.01	0.02	-0.07	0.35	-1.51	0.729	0.133
Decayed teeth	-0.25	0.05	0.11	0.02	-0.11	0.15	-2.29	3.14	0.023	0.002
Missing teeth	-0.36	0.02	0.11	0.02	-0.19	0.08	-3.35	1.43	0.001	0.154
Filled teeth	-0.09	0.01	0.05	0.01	-0.08	0.06	-1.53	1.27	0.126	0.206
FTUs	0.22	-0.03	0.14	0.02	0.09	-0.07	1.65	-1.28	0.099	0.200
Gingival bleeding	0.07	0.00	0.05	0.01	0.07	0.02	1.23	0.34	0.218	0.735
Dental calculus	-0.05	0.01	0.04	0.01	-0.06	0.10	-1.05	1.79	0.295	0.074
Pocket depth ≥4mm	-0.07	0.01	0.06	0.01	-0.07	0.06	-1.20	1.00	0.232	0.317
Oral hygiene	-0.58	0.21	0.58	0.08	-0.05	0.12	-0.99	2.45	0.322	0.015
Oral dryness	3.71	-0.50	1.45	0.21	0.12	-0.11	2.55	-2.36	0.011	0.019

F=5.09, p<0.001 for GOHAI . F=5.95, p<0.001 for self-rated oral health

Discussion

The response rate of participation was 4.3% in this study. Participants had to visit a local dental clinic for examination and complete a consent form and questionnaires: a considerable demand on their time and effort. In Japan, it is uncommon for people to go to a clinic for regular examinations, instead they tend to go only when some symptoms like toothache or biting difficulty occurs. This may partly explain the low response rate. However, our sample's mean GOHAI score was almost the same as that of Japanese aged 40-59 years (Naito, 2007) and their mean DMFT was almost the same that was found in the 2005 national oral health survey of 40-54 year-olds (SACSDD, 2007) suggesting our sample is close to the Japanese population for this age group. Male response rates may be lower than females because many middle-aged males were at work in the daytime. However analysis by linear regression adjusted for any impacts of gender. This research was a community-based study involving and engaging local dentists. One of the epidemiological limitations of the study therefore is that clinical measurements lack rigorous calibration and standardization.

It should be noted that oral health service delivery and the National Health Service in Japan is different from many other nations. In Japan, all residents benefit from a public health insurance system covering the main dental treatment needs, such as dental caries, periodontal diseases and prosthetic treatment. This benefit may impact substantially on QOL measures such as GOHAI. Compared with other countries, the Japanese have fewer decayed and missing teeth but many filled teeth (WHO, 2008) and high levels of conservative and prosthetic treatments.

The main oral health complaints of Japanese adults aged 40-55 years, in this study, were the appearance and pain associated with their teeth. On the other hand, the main complaints reported by older people (mean 83 years) were discomfort when eating, and not biting well (Locker *et al*, 2001). In general, it appears from these findings that this mid-aged group of Japanese people is more concerned with the impact of psychological well-being and pain, than the older groups who tend to report higher levels of oral function problems and discomfort as their main concerns.

The linear regression analysis suggests that oral health status elements which appeared to impact strongly on GOHAI and self-rated oral health were somewhat different. Gender, decayed teeth and oral dryness affected both GOHAI and self-rated oral health, whereas missing teeth affected GOHAI and oral hygiene affected self-rated oral health.

Gender affected GOHAI and self-rated oral health. These findings are similar to research showing female GOHAI scores to be lower than male scores (Tsakos *et al.*, 2009). Missing teeth affected only the GOHAI score and not self-rated oral health. Oral hygiene affected only self-rated oral health. But the signs of periodontal disease such as gingival bleeding, calculus and pocket depth which may cause tooth loss were not related to either GOHAI or self-rated oral health.

These findings strongly suggest that there is little linkage between periodontal health, and either quality of life (GOHAI) or self-perception of periodontal diseases in this population. It would seem appropriate therefore to provide health education programs to help this age group to recognise their periodontal status so that they can prevent periodontal diseases and associated loss of teeth.

In conclusion, this study revealed that the main complaints of Japanese adults aged 40-55 years are appearance of their teeth or pain from teeth. Gender, decayed teeth and oral dryness were related to both GOHAI and self-rated oral health, whereas missing teeth were only related to GOHAI, and oral hygiene was only related to self-rated oral health. Further research is required on more representative samples of the Japanese mid-aged population, with more refined methods to observe whether the trends found in this study can be generalized.

Acknowledgements

This study was supported by a grant from the 8020 Promotion Foundation and the Grant-in-Aid for Scientific Research by Ministry of Health, Labour and Welfare, Japan (H18-Iryou-Ippan-037). We also thank the Yokote and Hiraka Dental Associations for their cooperation with this study and both their members and the participants for their great help.

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Journal of Investigative and Clinical Dentistry (2010), **1**, 79–84

ORIGINAL ARTICLE

Community Dentistry

Validity of the self-reported number of natural teeth in Japanese adults

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Keywords
dental examination, natural teeth, oral health status, self-reporting, validity.

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Received 21 December 2009; accepted 13 June 2010.

doi: 10.1111/j.2041-1626.2010.00016.x

Abstract

Aim: The aims of this research were to assess the validity of self-reporting of the number of teeth by comparing the number with that obtained through clinical dental examinations, and to investigate factors affecting the discordance between the two measures.

Methods: Self-administered questionnaires and dental examinations were conducted among 1152 dentate community residents in Japan. The validity of the patients' reports of the number of teeth was assessed by comparing the self-reported number with that determined at the clinical examination. Factors affecting the absolute value of the difference between the self-reported number of teeth and the number at clinical examination were investigated using a multivariate analysis.

Results: Overall, 47.5% of participants had perfect agreement in their self-report with the clinical examination. There was a slight tendency toward underestimation of the number of natural teeth by self-reporting. Pearson's correlation coefficient was 0.80, and the intraclass correlation coefficient was 0.78 for all patients. Decayed, filled, sound teeth, and fixed prosthetic pontics were significantly associated with the absolute value of the difference between self-reports and clinical examinations.

Conclusions: Patients' reported number of remaining teeth, the data for which were collected via the questionnaire, provided reasonably valid data on the actual number of teeth within a population group.

Introduction

Data on population dental health status have been predominantly obtained through standardized clinical examinations by calibrated dentists in controlled epidemiological surveys. Clinical dental examinations are regarded as the diagnostic "gold standard" for accurate and reliable information on population oral health status. However, they are very resource intensive in terms of personnel, facilities, time, and cost. Information gained through questionnaire and interview methods are alternative sources of data on oral health status. If the subjective (self-reported) oral health measurement is valid, it would provide a more convenient process for measuring oral health conditions in populations and groups at lower cost, less resource involvement, and within shorter timeframes. Thus, the availability of valid, self-reported measures of dental status could supplement large-scale epidemiological studies in periodic surveillance, as large-study populations could be reached by, for example, computer-assisted telephone interview surveys rather than by clinical examination.[1] The data obtained would be used for monitoring the oral health status of populations, planning dental public health goals and policies, and evaluating the impact of changes in external environments on dental conditions and the treatment needs of populations.

Many studies investigating the relationship between self-reported oral health and actual oral health by means of clinical examinations have been conducted.[2–8] A key outcome variable in population studies is the mean number of

natural teeth in a population group. Prior research has documented various degrees of validity of patients' self-reported number of remaining natural teeth, in comparison to the true number, using different survey methods.[9–11]

Overall, the number of natural teeth estimated by questionnaires is in good agreement with clinical examinations,[12–14] but in their study, Palmqvist *et al.*[15] suggested that self-reporting of missing teeth and the prevalence of prosthetic restorations is not reliable. Most studies on the validity of self-reported number of teeth have been conducted in Western Europe and North America, and many reports have suggested that replication among populations with different sociocultural backgrounds is needed. There are some studies examining the validity of the self-reported number of teeth in Japan that indicate that the self-reporting of Japanese people is valid and reliable.[16,17] Factors influencing the validity of the self-identification of natural teeth, however, have not been investigated in Japan.

The hypotheses of this research are: (a) the self-reported number of teeth in a Japanese population could be used as a surrogate to accurately estimate the actual number of teeth and (b) the dental status of the individual is related to the degree of validity of the accurate measurement of the number of natural teeth. Therefore, the aims of this research were to assess the validity of self-reporting of the number of teeth (using a self-reporting questionnaire) by comparing the number to that obtained through clinical dental examinations, and to investigate factors affecting the discordance between the two measures.

Materials and methods

Patients

Patients were drawn from a population of 21 961 community residents aged 40–56 years who dwelt in Yokote city, Akita prefecture, Japan. Letters informing the community in general terms about the study and seeking their individual participation in the research were mailed to all eligible patients. Responses were received from 1163 residents (participation rate: 5.3%) who agreed to join the study and signed the informed consent form. The investigation was carried out from November 2006 to December 2007. Self-administered questionnaires and dental examinations were conducted at local dental offices with the cooperation of the Yokote and Hiraka Dental Associations. A total of 1152 dentate people (386 men: mean age = 48.7, standard deviation [SD] = 4.6; 766 women: mean age = 49.5, SD = 4.5) was used for the analysis, after excluding patients who had incomplete data on the study variables ($n = 11$). Therefore, this report presents data only on the dentate proportion of the population sampled. This study protocol was approved by the Tokyo Medical and Dental University Ethical Committee (no. 278).

Questionnaire

The self-administered questionnaire was made available to participants when they presented at the dentist's office prior to the dental examination. Among other items collected, demographic information (sex and age) and participants' self-reported estimate of the number of natural teeth they had were recorded. The question they were specifically asked to respond to was: how many natural teeth do you have in your mouth? No specific instructions on how to conduct the self-assessment were given to participants.

Dental examination

Clinical examinations of dental status were performed by local general dentists; each patient was in the dental chair, and a standard operatory light, a dental mirror, and an explorer were used. A training and calibration session was held before the study commenced, and a handbook that described standardized clinical criteria based on the World Health Organization (WHO) format[18] was distributed to all participating dentists. The dentists examined dental status as well as types of prosthetic restoration. The inter- or intra-reliability statistic in clinical examinations was not calculated because many dentists ($n = 43$) participated in the research.

Statistical analysis

The validity of patients' reports of the number of teeth was assessed by comparing the self-reported number with that determined at the clinical examination. The overall association between the self-reported number of teeth and actual number was analyzed using scatter plots. Pearson's correlation coefficient and intraclass correlation coefficient (ICC) were calculated to quantitatively evaluate the validity.

The association was further analyzed by creating two categories of remaining teeth (1–19 and 20–32 teeth), because these criteria for the number of teeth is widely used in Japan as the 8020 campaign,[19] as well as by the WHO and Federation Dentaire Internationale.[20,21]

Factors affecting the absolute value of the difference between the self-reported number of teeth and the number at clinical examination were investigated using a multivariate analysis. The generalized linear model (GLM) of the negative binominal distribution with a logit built-in link function analysis was used to investigate associations between potential influencing variables. Age and sex, which were considered to confound the association between variables, were used as covariates, while the number of sound (0–8 and ≥9), decayed (0 and ≥1), filled (0–9 and ≥10) and fixed prosthetic pontics (0 and ≥1), removable prosthetic teeth (0 and ≥1), and implanted

teeth (0 and ≥1) were used as dichotomous factors in the model. Dichotomous values were chosen based on the median values of the variable concerned. Analyses were performed using SPSS software, version 17.0 (SPSS Japan, Tokyo, Japan).

Results

A scatter plot of the self-reported number of teeth against clinical counts is presented in Figure 1. The points on the diagonal line drawn in the graph indicate that there are absolute agreements and no systematic tendencies toward overestimation or underestimation. The points appearing above the line suggest overreporting, while the points below the line indicate underreporting. Since more points of difference present below the diagonal line than above the line, and points below the line vary more widely than points above the line, the scatter gram results indicate a slight tendency toward underestimation of the number of natural teeth by self-reporting. As shown in Table 1, 47.5% of participants had perfect agreement in their self-report with the clinical examination. The percentages of perfect agreements were 35.2% for patients with 1–19 teeth, and 48.3% for those with 20–32 teeth. For each category, those who showed a difference of within one tooth were 53.6% and 70%, respectively.

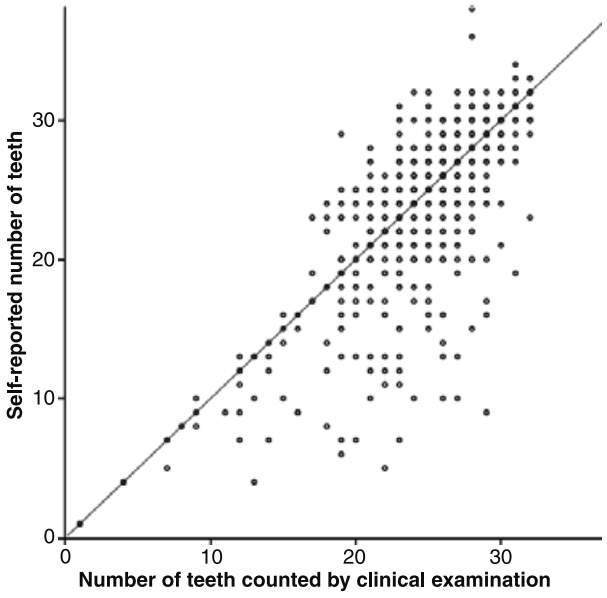

Figure 1. Scatter gram of the number of teeth by clinical examination and that by self-reporting.

The dental status measures of patients are presented in Table 2. The values for males and females were combined in these analyses. The mean age was higher in patients with 1–19 teeth (52.2 ± 3.0 years) than in those with 20–32 teeth (49.0 ± 4.6 years). For all patients, the mean number (SD) of teeth reported by clinical examination was 25.84 (3.93), and the mean number by self-reporting was 25.52 (4.96). In patients with 1–19 teeth, the clinical mean was 14.90 (4.67), and that reported by individuals was 14.15 (6.33); in the 20–32 teeth group, the clinical mean was 26.56 (2.58), and self-reported mean was 26.27 (3.82). Therefore, all mean differences between clinical and self-reporting were less than one tooth.

Table 3 presents the two types of correlations calculated between the number of teeth by self-reporting and by clinical examination, together with their confidence intervals. Both types of correlation analyses resulted in coefficients that were slightly lower in patients with 20–32 teeth than those with 1–19 teeth. Pearson's correlation coefficients were 0.76 for patients with 1–19 teeth, and 0.66 for those with 20–2 teeth. The ICC were 0.72 for patients with 1–19 teeth, and 0.61 for those with 20–32 teeth, respectively. For all patients, Pearson's correlation coefficient was 0.80, and the ICC was 0.78.

Since the absolute value of the difference between the self-reported number of teeth and the number at clinical examination was positively skewed due to a high proportion of zero values, and found not to be normally distributed by the Shapiro–Wilk test, the GLM was used for the multivariate analysis. The GLM were carried out for each subgroup (1–19, 20–32) of remaining natural teeth. Age and sex were controlled as covariates. The χ^2-tests of GLM were significant in each subgroup: $\chi^2 = 29.4$ in the group with 1–19 teeth ($P < 0.001$), and $\chi^2 = 109.8$ in the

Table 1. Distribution of differences in the number of teeth between self-reporting and clinical examination with means and standard deviations (SD)

		Difference between self-reporting and clinical examination (self-reporting minus clinical examination)																
No. teeth		≤−7	−6	−5	−4	−3	−2	−1	0	1	2	3	4	5	6	≥7	Mean	SD
1–19 (*n* = 71)	*n*	7	2	2	3	3	4	6	25	7	1	0	4	2	4	1	−0.75	4.12
	%	9.8	2.8	2.8	4.2	4.2	5.6	8.5	35.2	9.9	1.4	0	5.6	2.8	5.6	1.4		
20–32 (*n* = 1081)	*n*	42	12	13	24	31	42	98	522	136	73	42	23	10	5	8	−0.29	2.88
	%	4.1	1.1	1.2	2.2	2.9	3.9	9.1	48.3	12.6	6.8	3.9	2.1	0.9	0.5	0.8		
Total (*n* = 1152)	*n*	49	14	15	27	34	46	104	547	143	74	42	27	12	9	8	−0.32	2.97
	%	4.3	1.2	1.3	2.3	3.0	4.0	9.0	47.5	12.4	6.4	3.6	2.3	1.0	0.8	0.8		

Table 2. Dental status measures of patients by the number of teeth (self-reporting versus clinical examination)

	No. teeth					
	1–19 teeth (n = 71)		20–32 teeth (n = 1081)		Total (n = 1152)	
Dental status measures	Mean	SD	Mean	SD	Mean	SD
Self-reported number of teeth	14.15	6.33	26.27	3.82	25.52	4.96
Clinical dental examination						
No. remaining teeth	14.90	4.67	26.56	2.58	25.84	3.93
No. sound teeth	3.69	2.94	10.76	5.72	10.33	5.84
No. decayed teeth	0.97	1.78	1.49	2.71	1.46	2.66
No. filled teeth	10.24	4.37	14.31	5.24	14.06	5.28
No. fixed prosthetic pontics	1.97	2.54	0.82	1.25	0.89	1.39
No. removable prosthetic teeth	6.42	7.67	0.21	0.97	0.59	2.59
No. implanted teeth	0.11	0.75	0.01	0.13	0.01	0.22

SD, standard deviation.

Table 3. Pearson's and intraclass correlation coefficients by the number of teeth

		Correlation coefficients	
No. teeth	n	Pearson's (95% CI)	Intraclass (95% CI)
1–19	71	0.76 (0.65, 0.85)	0.72 (0.59, 0.82)
20–32	1081	0.66 (0.63, 0.70)	0.61 (0.57, 0.65)
Total	1152	0.80 (0.78, 0.83)	0.78 (0.75, 0.80)

CI, confidence interval.

group with 20–32 teeth ($P < 0.001$), respectively. Among the patients with 1–19 teeth, those with one and more decayed teeth ($P < 0.001$) and with 10 and more filled teeth ($P < 0.01$) were more likely to inaccurately report the number of teeth present than their counterparts (Table 4). Two variables (sound teeth and fixed prosthetic pontics) were significantly associated with the absolute value of the difference in patients with 20–32 teeth. Patients with nine or more sound teeth ($P < 0.001$) were more likely to have valid self-reports than their counterparts, while those with one and more fixed prosthetic pontics ($P < 0.001$) were more likely to incorrectly report their number of natural teeth than their counterparts.

Discussion

The results of this study suggest that patients' reported number of teeth collected via the questionnaire can provide reasonably valid data on the actual number of teeth within a population group. The magnitude of discordance of tooth counts was less than one tooth, and patients tended to slightly underestimate the actual number of remaining teeth. Correlations between self-reports and clinical examinations were high both in Pearson's and intraclass procedures, which were approximately 0.8 for the total sample of patients.

Self-reporting of the number of teeth has been shown to be valid in research from several different age groups and in different countries. Therefore, this research supports work conducted elsewhere in Japan[16,17] and internationally,[10–12,14] that the self-report, in population terms, is a valid procedure to estimate the number of teeth in an adult's dentition.

The variability in the number of teeth is reported to affect the validity of self-reports, with a tendency for less accuracy when the actual number of teeth increases.[11] In this study, the analysis was performed by dichotomizing the sample into two categories, depending on the number of remaining teeth, and a similar trend in relationship was evident. A lower validity of the self-reported estimate among patients with 20–32 teeth was indicated by the smaller correlation coefficient, in particular, the ICC.

We could not compute a Kappa statistic because two variables, self-reported teeth number and actual number of teeth, had different range of values. Instead, we used the ICC. The ICC is preferable to Pearson's correlation coefficient in estimating validity.[22] Pearson's correlation coefficient can be high, even if two variables do not show perfect agreement, while the ICC reflects the overall magnitude of absolute agreement. The maximum number of differences between the two measures (self-reporting and clinical examination) was 20 teeth in the 20–32 teeth group, and a maximum of 13 teeth in the 1–19 teeth group. This large difference is why lower correlation coefficients were observed in patients with 20–32 teeth. Therefore, our hypothesis of less-valid reports among individuals with many teeth was verified.

The proposition that certain dental characteristics (decayed and filled teeth, fixed prosthetic pontics, and removable prosthetic teeth) would be associated with the validity of self-reports was also confirmed. The rationale was that prosthetic or cavitated teeth might have confused some patients as to whether these teeth should be

Table 4. Generalized linear model of the absolute value of the difference between self-reporting and clinical examination

	No. teeth							
	1–19				20–32			
Independent variable	*n*	*β*	SE	*P*-value	*n*	*β*	SE	*P*-value
Sound teeth								
≥9	5	0.96	0.70	0.17	662	−0.38	0.09	0.00
0–8	66	(reference)			419	(reference)		
Decayed teeth								
≥1	26	0.95	0.33	0.00	503	0.14	0.08	0.09
0	45	(reference)			578	(reference)		
Filled teeth								
≥10	41	1.10	0.35	0.00	903	0.02	0.12	0.87
0–9	30	(reference)			178	(reference)		
Fixed prosthetic pontics								
≥1	35	0.52	0.32	0.10	444	0.59	0.08	0.00
0	36	(reference)			637	(reference)		
Removable prosthetic teeth								
≥1	37	−0.60	0.33	0.07	61	0.31	0.16	0.06
0	34	(reference)			1020	(reference)		
Implanted teeth								
≥1	2	0.76	0.84	0.36	3	0.30	0.74	0.69
0	69	(reference)			1078	(reference)		

Adjusted for age and sex. SE, standard error.

included as "natural teeth." Patients with 1–19 teeth seemed to have trouble counting natural teeth, as they were uncertain of whether dental caries or fillings were their own teeth. Pitiphat *et al.*[12] also reported that patients tended to underestimate the number of filled and decayed teeth, and the correlation between the self-reported and actual means was low for decayed teeth.

However, patients with 20–32 teeth appeared to not be able to recognize their fixed prosthetic appliances well. The deviations from the concordance could partly be due to the possible miscounting of the fixed prostheses with pontics. This result is in agreement with previous studies reporting that self-assessment is more subjective to error, where missing teeth are replaced with fixed prosthodontics.[23] A higher number of sound teeth appeared to help patients more accurately count their teeth, especially among patients with 20–32 teeth. These findings suggest that the difficulty of accurately counting the correct number of teeth by self-assessment is largely due to the complexity of the individual's dental condition. Use of the absolute value of the difference would cause a bias because it could not distinguish the effect of underestimation of the number of teeth from that of overestimation. However, a separate analysis for underestimation and overestimation was not performed due to the small number of subjects, especially in those with 1 to 19 teeth.

This study population was not a representative sample of the general population. Patients were volunteers taking part in the study, and the participation rate was very low. To improve the response rate, the reinforcement of public education about the importance of oral health would be necessary. However, in terms of dental status, the mean number of teeth present (25.8) and sound (10.3), decayed (1.5), and filled (14.0) teeth in the current age group of patients in this study were similar to those of the Japanese dental survey data on patients in the same age group:[24] mean number of teeth present (25.8) and sound (12.6), decayed (1.0), and filled teeth (12.2). Therefore, this sample provides a proximate dental health status profile to the adult Japanese population in this age group.

Oral health data collected by clinical dental examinations have been considered as the only valid source of information.[25] However, based on the present findings and previous studies of an aggregate population level, and acknowledging certain limitations, it is feasible to assume that lay people's self-reports can be considered as alternative instruments for estimating the number of natural teeth present in adult dentitions. The use of self-reported information collected in this way would allow for not only an easy and inexpensive method for collecting data of large-scale research and surveillance but also provide a helpful tool for planning oral health programs. However, the validity of conclusions drawn from such data should be qualified. For example, the validity is slightly less in patients with many teeth, and the counting of decayed and filled teeth and fixed prosthetic pontics was prone to increased errors in reporting. The validity of self-reported tooth counts might be

improved if the wording of the questionnaire explicitly explained restorative and prosthodontic characteristics so that respondents could understand the status of restorations correctly. Further research would also be needed to confirm current results in other age-group populations. This study confirms the benefits of pursuing self-reporting methods of determining oral health status and refining such approaches through further research.

Patients' reported number of remaining teeth collected by the questionnaire provided reasonably valid data on the actual number of teeth within a population group.

Acknowledgments

This study was partly supported by the Ministry of Health, Labour and Welfare Grants-in-Aid for Scientific Research and the 8020 Promotion Foundation.

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J Med Dent Sci 2007; 54: 159−165

Original Article

Prevalence of oral malodor and related factors among adults in Akita Prefecture

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The national survey on health and welfare conducted in 1999 reported approximately 15% of people, who had some dental problem, suffered from oral malodor. Oral malodor was ranked the fourth highest dental complaints in Japanese. However, there is a scarcity of epidemiological studies assessing the prevalence of oral malodor in the general population. Thus the aims of this study were to assess the prevalence of oral malodor and its relationship with oral health indicators among general adults aged 40 to 75 years in Akita Prefecture, Japan. The prevalence of oral malodor, diagnosed using the organoleptic method, revealed that approximately 37% of subjects had oral malodor. Logistic regression analysis suggested that oral hygiene, periodontal disease and oral dryness were influential factors which could cause oral malodor. Hence oral malodor related health education, preventive interventions such as tooth and tongue brushing instruction, and treatment regimens targeting periodontal disease should be incorporated into community oral health programs. Such an approach would bring about not only a reduction in the complaint of oral malodor condition, but also the promotion of overall oral health.

Key words: Oral malodor, Halitosis, Bad breath, Epidemiology, Periodontal disease

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Received March 20; Accepted June 8, 2007

Introduction

Oral malodor (halitosis or bad breath) is an offensive odor of oral cavity and may disturb interpersonal communication and social activities. The oral region is the most frequent origin of halitosis[1], which is caused by Volatile Sulfur Compounds (VSCs), especially, hydrogen sulfide, methyl mercaptan and dimethyl sulfide[2]. VSCs are produced by putrefaction of gram-negative anaerobic bacteria[3]. It is reported that around 90% of oral malodor originates in the oral cavity, although several non-oral causes are attributed to oral malodor[4,5]. Among oral related causes, tongue coating[6], periodontal disease[7] and poor oral hygiene[8] can generate oral malodor. Therefore, treatments corresponding to the causes of oral malodor include mechanical or chemical tongue cleaning[9], periodontal disease treatment[10], oral hygiene instruction[11] and mouthrinses or mouthwashes[12,13].

The national survey on health and welfare conducted in 1999[14] reported approximately 15% of people, who had some dental problem, suffered from oral malodor. Oral malodor was ranked the fourth highest dental complaints in Japanese. The percentage of people who suffered from oral malodor increased with age and the trend continued until the age-group of 45-54 years. That is, from 7.6% of 15-24 year-olds, 10.1% of 25-34 year-olds, 17.7% of 35-44 year-olds, and 20.7% of 45-54 year-olds. From the age-group of 55-64 year-olds and older, the percentage presenting with oral malodor decreased gradually. In the survey conducted in general Japanese, Miyazaki et al.[15] stated that 6 to 23% of people complained about oral malodor. The concern about oral malodor is therefore relatively high in Japan. In the United States, 10 to 30% of the popula-

tion was reported to suffer from bad breath[16]. Liu et al.[17] investigated the prevalence of oral malodor in the Chinese general population and found that 27.5% of the population had oral malodor when the organoleptic test was employed. On the other hand, 20.3 to 35.4% of the subjects exhibited on oral malodor with the Halimeter® (Inerscan Corp., Chatworth, CA, USA).

Many studies have been reported on the mechanisms of oral malodor causation, diagnosis and measurement devices. However there is a scarcity of epidemiological studies assessing the prevalence and intensity of oral malodor in the general population. Thus the aims of this study were to assess the prevalence of oral malodor and its relationship with the oral health indicators in a general population of adults in Japan.

Subjects and Methods

Subjects

Invitation letters that informed subjects about the purpose and the design of the study and sought their participation in the research, were mailed to about 25,000 residents ages 40 to 75 years who dwelt in Yokote health center jurisdiction, Akita Prefecture, Japan. Some 2,141 people (910 men: aged 61.8±8.8 years old, 1,231 women: aged 59.9±9.2 years old) agreed to participate in the study and signed the informed consent form. Investigation was carried out in April, 2005 for persons aged 55 to 75 years, and in November and December, 2006 for those aged 40 to 55 years. A self-administered questionnaire and dental examination were conducted at local dental offices with the cooperation of the Yokote and Hiraka Dental Associations.

This study protocol has been approved by the Tokyo Medical and Dental University Ethical Committee.

Questionnaire

Self-administered questionnaire items consisted of demographic (age and sex) information, subjective symptoms of oral malodor (presence/absence) and smoking habits (current smoker/past smoker/non-smoker).

Clinical dental examination

All clinical dental examinations included tooth status (third molars were included), oral dryness, oral hygiene, pocket depth, existence of calculus, gingival bleeding on probing, and the organoleptic test for oral malodor. The clinical assessments were performed by participating dentists with subjects in a dental chair with an operatory light, a dental mirror, an explorer and a periodontal probe. Standardized clinical criteria for each measurement were described in detail in a handbook distributed to all participated dentists.

Oral dryness was diagnosed dichotomously by visually observing the whole mouth and recorded either dry or moist. Oral hygiene of teeth, dentures and tongue was visually evaluated on a subjective category scale of 1 to 3: 1 (good) no apparent plaque or tongue coating; 2 (pair) two-third or less of the whole mouth or tongue dorsum covered; 3 (poor) more than two-third of whole mouth or tongue dorsum covered with plaque or coating. Pocket depth measurement was assessed on each tooth surface circumferentially, and the deepest measure was scored in millimeters for each tooth, including third molars. Existence of calculus (presence/absence) and bleeding on probing (presence/absence), were evaluated following the pocket depth measurement. All measurements were recorded per tooth for all present teeth including third molars. Oral malodor was diagnosed by the dentists using the organoleptic test and scored on a subjective scale from 1 to 3 as follows; 1=strong malodor, 2= moderate malodor, 3=no odor.

Statistical analysis

Prevalence of oral malodor was investigated by age-group (49 or younger, 50-54, 55-59, 60-64, 65-69, 70 or older), sex, subjective symptoms of oral malodor, smoking habit, number of decayed teeth (0, 1-2, 3 or more), oral dryness, oral hygiene of teeth, oral hygiene of dentures, oral hygiene of tongue, number of teeth with gingival bleeding on probing (0, 1-5, 6 or more), number of teeth with calculus (0, 1-5, 6 or more), and number of teeth with 5 mm and deeper periodontal pockets (0, 1-5, 6 or more). Number of decayed teeth, oral hygiene of teeth, number of teeth with gingival bleeding on probing, number of teeth with calculus, and number of teeth with 5 mm and deeper periodontal pockets were analyzed only in dentate people, and oral hygiene of dentures was analyzed only in denture wearing subjects.

Two logistic regressions analyses were performed. Firstly, on dentate subjects (N=2,039), regression of dentists' diagnosis of oral malodor (0: no odor, 1: moderate or strong oral malodor) on age-group, sex, smoking habit, number of existing teeth, number of decayed teeth, oral dryness, oral hygiene of teeth, oral hygiene of tongue, number of gingival bleeding on prob-

ing, number of existence of calculus, and number of 5 mm and deeper periodontal pockets. Secondly, on dentate subjects with dentures (N=770), regression of dentists' diagnosis of oral malodor (0: no odor, 1: moderate or strong oral malodor) on age-group, sex, smoking habit, number of existing teeth, number of decayed teeth, oral dryness, oral hygiene of teeth, oral hygiene of dentures, oral hygiene of tongue, number of gingival bleeding on probing, number of existence of calculus, and number of 5 mm and deeper periodontal pockets. The statistical analysis was performed with the SPSS15.0J software.

Results

Among the total 2,141 subjects, 785 (36.7%) people had moderate or strong oral malodor. Oral malodor prevalence was lower in younger age-groups (49 or younger and 50-54) compared to older age-groups, and males had a higher prevalence than females. Subjects who reported the subjective symptoms of oral malodor had a higher prevalence of oral malodor diagnosed by the dentists than those who had not. Current smokers had a higher prevalence of oral malodor compared with past or non smokers. The prevalence of oral malodor increased with the number of decayed teeth, and people with oral dryness had a higher prevalence of oral malodor in comparison to those without oral dryness. In dentate people, those with poorer oral hygiene of teeth had the higher prevalence of oral malodor. Similarly, subjects with dentures, who had poorer oral hygiene, had the higher prevalence of oral malodor. Subjects who had a greater amount of tongue coating, higher levels of gingival bleeding on probing, higher levels of calculus, and higher numbers of 5mm and deeper periodontal pockets had the higher prevalence of oral malodor.

Logistic regression analysis in dentate people is presented in Table 1. Oral hygiene of teeth, coating on the

Table 1. Logistic regression analysis in dentate people (N=2,039)

Explanatory variable		N	p-value	Odds ratio	95% Confidence Interval	
					Lower	Upper
Age-group	–49 (reference)	286				
	50–54	220	.176	1.379	.866	2.196
	55–59	410	.003	1.813	1.220	2.694
	60–64	375	.003	1.828	1.220	2.739
	65–69	349	.015	1.668	1.103	2.522
	70+	399	.023	1.623	1.068	2.466
Sex	Male (reference)	877				
	Female	1162	.019	.710	.533	.944
Smoking habit	Non smoker (reference)	1379				
	Past smoker	378	.590	1.104	.769	1.585
	Current smoker	282	.621	.917	.651	1.292
Number of existing teeth	1–10 (reference)	194				
	11–20	358	.982	1.005	.663	1.523
	21+	1487	.452	.861	.582	1.273
Number of decayed teeth	0 (reference)	1155				
	1–2	553	.752	1.041	.813	1.332
	3+	331	.314	1.165	.865	1.568
Oral dryness	No (reference)	1894				
	Yes	145	.000	2.607	1.749	3.886
Oral hygiene of teeth	Good (reference)	370				
	Fair	1264	.000	5.348	3.246	8.811
	Poor	405	.000	14.265	8.243	24.687
Oral hygiene of tongue	Good (reference)	507				
	Fair	1379	.000	2.302	1.706	3.105
	Poor	153	.000	4.284	2.692	6.818
Gingival bleeding on probing	0 (reference)	529				
	1–5	763	.048	1.355	1.002	1.832
	6+	747	.000	1.865	1.356	2.563
Existence of calculus	0 (reference)	561				
	1–5	553	.478	.895	.659	1.216
	6+	925	.002	1.592	1.186	2.138
5mm and deeper periodontal pockets	0 (reference)	1221				
	1–5	628	.432	1.098	.870	1.387
	6+	190	.000	2.780	1.879	4.113

tongue, number of 5mm and deeper periodontal pockets, oral dryness, levels of gingival bleeding on probing, levels of calculus, sex and age-group were all associated with oral malodor occurrence. Those with fair oral hygiene of teeth (OR=5.3, p<0.001), poor oral hygiene of teeth (OR=14.3, p<0.001); fair oral hygiene of the tongue (OR=2.3, p<0.001), poor oral hygiene of the tongue (OR=4.3, p<0.001); 6 or more teeth with 5mm and deeper periodontal pockets (OR=2.8, P<0.001); oral dryness (OR=2.6, P<0.001); 1-5 teeth with gingival bleeding on probing (OR=1.4, P=0.048), 6 or more teeth with gingival bleeding on probing (OR=1.9, P<0.001); 6 or more teeth with calculus (OR=1.6, P=0.002) and older age-groups (55 years old and older) were more likely to have oral malodor compared with their respective reference categories. Female subjects (OR=0.7, p=0.019) were less likely to have oral malodor compared with males.

On the other hand, in the logistic regression analysis of dentate subjects with dentures - oral hygiene of teeth, number of 5 mm and deeper periodontal pockets, oral hygiene of the tongue, oral dryness, oral hygiene of dentures, levels of gingival bleeding on probing, and levels of calculus - were contributors to oral malodor prevalence. Those with fair oral hygiene of teeth (OR=5.3, p=0.001), poor oral hygiene of teeth (OR=13.1, P<0.001); 6 or more teeth with 5 mm and deeper periodontal pockets (OR=4.3, p<0.001); fair oral hygiene of the tongue (OR=1.7, p=0.026), poor oral hygiene of the tongue (OR=4.0, p<0.001); oral dryness (OR=2.4, p=0.001); poor oral hygiene of dentures (OR=2.4, P=0.013); 6 or more teeth with gingival bleeding on probing (OR=1.9, p=0.023) and 6 or more teeth with calculus (OR=1.6, P=0.034) were more likely to have oral malodor compared with their respective reference categories (Table 2).

Table 2. Logistic regression analysis in dentate people with dentures (N=770)

Explanatory variable		N	p-value	Odds ratio	95% Confidence Interval	
					Lower	Upper
Age-group	–49 (reference)	23				
	50–54	39	.456	1.709	.417	7.004
	55–59	126	.348	1.801	.527	6.161
	60–64	140	.366	1.760	.517	5.991
	65–69	185	.416	1.654	.493	5.552
	70+	257	.607	1.371	.411	4.573
Sex	Male (reference)	328				
	Female	442	.062	.635	.394	1.023
Smoking habit	Non smoker (reference)	530	.			
	Past smoker	139	.932	1.027	.559	1.886
	Current smoker	101	.295	.733	.410	1.311
Number of existing teeth	1–10 (reference)	192				
	11–20	321	.921	.977	.622	1.536
	21+	257	.263	.750	.453	1.241
Number of decayed teeth	0 (reference)	488	.			
	1–2	184	.807	.950	.631	1.432
	3+	98	.522	.843	.499	1.424
Oral dryness	No (reference)	690				
	Yes	80	.001	2.412	1.402	4.149
Oral hygiene of teeth	Good (reference)	92				
	Fair	499	.001	5.257	1.967	14.048
	Poor	179	.000	13.095	4.632	37.024
Oral hygiene of dentures	Good (reference)	192				
	Fair	496	.452	1.199	.747	1.925
	Poor	82	.013	2.395	1.199	4.784
Oral hygiene of tongue	Good (reference)	168				
	Fair	531	.026	1.742	1.068	2.842
	Poor	71	.000	4.014	1.969	8.183
Gingival bleeding on probing	0 (reference)	195				
	1–5	356	.141	1.418	.891	2.258
	6+	219	.023	1.875	1.089	3.229
Existence of calculus	0 (reference)	278				
	1–5	229	.861	1.039	.675	1.601
	6+	263	.034	1.633	1.037	2.571
5mm and deeper periodontal pockets	0 (reference)	448	.			
	1–5	250	.815	1.046	.719	1.522
	6+	72	.000	4.288	2.147	8.564

Discussion

Humans have a sense of smell that can detect the differences of the strength or concentration of odor molecules[18]. An organoleptic test scale with 0-5 intensity was introduced by Allison and Katz[19], and by Rosenberg et al.[20]. This has been widely used in clinical malodor studies. In this study, a modified organoleptic test scale with 1 to 3 was used. The current prevalence of oral malodor diagnosed with this organoleptic method revealed that approximately 37% of subjects had oral malodor. The rate was higher than that of reported in previous research: 6 to 23% by Miyazaki et al.[15], 10 to 30% by Meskin[16], and 20.3 to 35.4% by Liu et al.[17]. It is not feasible however to compare too closely the current malodor rate with previous studies since each researcher employed slightly different malodor measurement methods. Nonetheless, it might be that regional differences of malodor prevalence may exist.

Similar to a previous report[14], the present results showed that the percentage of people who had oral malodor tended to increase with age up to age of 55-59 years, but a decreasing trend in older age-groups, was not observed. Subjects who self-reported oral malodor had a higher probability of being diagnosed with the condition by the examining dentists. Further, there was a significant difference between males and females in the degree of oral malodor. Males had higher prevalence of oral malodor compared to females, and gender was still a significant variable in the logistic regression analysis after adjusting for other variables. These results are contrary to the study by Miyazaki et al.[15] that failed to demonstrate a relationship between self report and gender with malodor prevalence. Further investigations will be needed to evaluate these relationships.

The logistic regression analysis demonstrated that oral hygiene of teeth and tongue, periodontal condition, and oral dryness were significant factors associated with oral malodor. Among these variables, oral hygiene of teeth was the most influential. It seems many dental clinicians are prone to think that dental plaque is the direct cause of oral malodor, but the evidence of such a relationship is reported to be low[21]. Since VSCs production from dental plaque is very small, dental plaque could not be a direct cause of oral malodor unless an abundance of plaque is accumulated on tooth surfaces. The current results could be interpreted from two standpoints: firstly, oral hygiene of this sample was very poor, consequently oral malodor may actually has been caused by abundantly accumulated dental plaque. Secondly, the dentists examined regarded a subject with very poor oral hygiene person as presenting oral malodor because of an intuitive prejudice.

Oral hygiene of the tongue also had a strong influence on oral malodor. The tongue dorsum is a favorite place for growth of anaerobic bacteria responsible for the condition[22]. It has been reported that 60-70% of oral malodor originates from bacterial activities on the dorsal surface of the tongue[23]. In addition, there are studies demonstrating that tongue coating is strongly related to VSCs production[15,24,25] and around 40% of VSCs have an origin on the dorsum of the tongue[4]. Pedrazzi et al.[26] showed substantial reducing of oral malodor after removing the tongue coating with adequate appliances. Other research, likewise, demonstrated that cleaning of the tongue decreases the level of VSCs, the amount of tongue coating and the number of microorganisms[6,27,28]. Thus it was understandable that oral hygiene of the tongue was one of the important factors in oral malodor in this population.

Periodontal diseases are regarded as common cause of oral malodor[6,15]. Oral malodor has been reported to be caused by the same bacteria that cause gingivitis and periodontitis[29]. There are reports that VSCs concentrations are higher in individuals with periodontal diseases than in those without periodontal diseases[6,27,30]. There is also evidence that the concentration of VSCs increases with the severity of periodontal disease[9]. However research by Yaegaki and Sanada[6] showed the presence of oral malodor without any periodontal diseases. Pocket depth has been used as one of the indices of periodontal disease progression. Therefore the result that people who had many 5mm and more pockets had higher risk for oral malodor was comparable to former findings that demonstrated the relation between periodontal disease severity and oral malodor. Gingival bleeding is also another indicator for periodontal diseases. In the current study, as similar to the previous research, gingival bleeding on probing was a significant factor for oral malodor. It is reported that a strong correlation between the volume of gingival crevicular fluid (GCF), which is a serum transudate or an inflammatory exudate, and hydrogen sulfide produced by the GCF exists[7,31]. In addition, there is research that shows VSCs are positively correlated with the bleeding index, since hemoglobin is an essential component for the growth of causal bacteria of oral malodor such as *Porphyromonas gingivalis*[6]. Blood decomposition

products themselves also can produce sulfur-containing peptides and amino acids that are the source of VSCs.

Dry mouth is generally thought to be a potential contributory factor in the production of oral malodor because the reduction of salivary flow rate weakens the cleansing mechanism of the oral cavity and predisposes the oral micro-flora toward the gram-negative bacteria responsible for the oral malodor[32,33]. Previous studies have not verified any relationships between the reduction of salivary flow rate and increase of oral malodor or concentration of VSCs in mouth air, although an extreme reduction in resting saliva influences the generation of methylmercaptan and hydrogen sulfide[15,34,35]. Even though oral dryness was evaluated only dichotomously as presence/absence in this study, different from earlier research, oral dryness was indicated to be an important predictor for oral malodor. This relationship persisted after controlling for confounding variables in the study, which strongly suggests that salivary flow does have an association with oral malodor occurrence.

In summary, the results of this epidemiological survey demonstrated that the prevalence of oral malodor in this specific community was very high. Factors associated with oral malodor were oral hygiene, periodontal disease and oral dryness. Hence health education and preventive intervention; such as tooth brushing instruction, and treatment regimens targeting periodontal disease as well as tongue cleaning should be incorporated within community oral health programs. The inclusion of such elements within a community based program would bring about not only a reduction in the prevalence of oral malodor, but also the promotion of overall oral health.

Acknowledgements

This work was supported by the 8020 Promotion Foundation.

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Asia-Pacific Journal of Public Health
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Factors Influencing Perceived Oral Health of Japanese Middle- Aged Adults

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Asia Pac J Public Health published online 20 December 2011
DOI: 10.1177/1010539511428352

The online version of this article can be found at:
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Asia-Pacific Journal of Public Health
XX(X) 1–9

DOI: 10.1177/1010539511428352
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Factors Influencing Perceived Oral Health of Japanese Middle-Aged Adults

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Abstract

The objective of this study was to analyze the relationships between subjective oral health symptoms and clinical oral health conditions on the perceived oral health of 1799 Japanese middle-aged adults. A self-administered questionnaire together with dental examinations was administered. A structural equation modeling analysis with Bayesian estimation was used to examine the factors influencing perceived oral health as a latent variable with 4 other latent variables: subjective oral health symptoms, clinical tooth conditions, clinical periodontal conditions, and other clinical oral conditions. For perceived oral health as the endogenous variable, only subjective oral health symptoms and clinical tooth conditions showed significant relationship. Clinical periodontal conditions and other clinical oral conditions did not show significant effects on the perceived oral health.

Keywords

clinical oral health, perceived oral health, periodontal conditions, structural equation modeling, Bayesian estimation

Introduction

Perceived health is a key factor that has an impact on well-being and quality of life.[1,2] Perceptions of oral health are associated with oral health care services utilization as well as actual clinical oral health status.[3] If people perceive their oral health is poor, or that they have a problem, this may trigger a health behavior change (visiting a dentist, brushing their teeth) and bring about a change in their oral health status (receiving a dental restoration, reducing gingival bleeding) as a result. Hence, understanding a person's perception of oral health could provide important information that will lead to the improvements not only in oral health promotion interventions but also in oral health care utilization.

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Furthermore, it has been demonstrated that factors associated with the perception of oral health differ by ethnicity because of different lifestyles, diet, and health behaviors.[4] Until now, very few studies concerning perceived oral health have been done in Japan.[5] Thus, it is valuable to investigate the determinants of perceived oral health in Japanese people, which may be different from those in other ethnic groups.

In addition, most studies on perceptions of oral health have been conducted in elderly populations or special groups of people such as patients or military personnel,[6,7] and few studies targeting free-living Japanese middle-aged adults are available. Middle-aged people are likely to be influenced by a diverse array of psychological, socioeconomic, and oral health factors such as untreated dental caries, missing teeth, and risk of periodontal disease. Since oral health conditions in this age-group will greatly influence the conditions in old age, it is important to provide appropriate strategies for maintaining or ameliorating oral health in the middle-aged group.

Many types of statistical analysis have been used to examine the relationships among multiple variables that have an impact on perception of oral health need. A structural equation modeling (SEM) analysis is a powerful statistical technique that allows simultaneous testing of complex associations among variables specified within models.[8] The SEM analysis incorporates multiple independent and dependent variables as well as conceptual latent constructs that "clusters of measured variables" may represent.

In the field of dental research, however, very few studies have used SEM as a statistical technique. Konishi et al[9] analyzed the relationship between oral health status, oral motor function, daily-life situations, and self-assessed oral health in independently living elderly Japanese using the SEM. By applying SEM, Baker et al[10] examined a conceptual model of the direct and mediated pathways between clinical and nonclinical variables in relation to oral health–related quality of life of outpatients with xerostomia.

The SEM analysis is currently considered the most appropriate technique for exploring and assessing multivariable theoretical models. Therefore, the principal objective of this study was to analyze the relationship of subjective oral health symptoms and clinical oral health conditions on the perceived oral health of independently living Japanese middle-aged adults by using the SEM analysis.

Methods

Subjects

Invitation letters were mailed to approximately 17 500 residents (40-64 years old) who lived in the area under the jurisdiction of Yokote Health Center, Akita Prefecture, Japan. The letters informed them about the purpose and the procedure of the research and sought their participation in the study. The study was carried out from July 2005 through September 2007. Self-administered questionnaires and dental examinations were conducted at local dental offices with the cooperation of the Yokote and Hiraka Dental Associations. The final sample consisted of 1835 participants who agreed to join the study and signed the informed consent form. Data from a total of 1799 subjects (690 men, mean age = 53.9 years, SD = 6.8; 1109 women, mean age = 52.7 years, SD = 6.3) were used for the final analysis, after excluding subjects who were edentate (n = 7) or had incomplete data on the study variables (n = 29). The study protocol was approved by the Tokyo Medical and Dental University Ethical Committee.

Questionnaire

The questionnaire written in Japanese consisted of three parts. The first part collected demographic information (gender and age). The second part inquired about the existence of subjective oral

health symptoms such as "tooth sensitive to cold," "tooth sensitive to heat," "gingival bleeding," "oral malodor," "loose teeth," and "dry mouth." The responses were coded as "yes" or "no."

The third part contained two questions. The first question—"How do you rate your oral condition?"—was intended to measure the generic perception of the subject's oral condition. Subjects' responses were recorded on a 5-point Likert-type scale: *excellent*, *good*, *fair*, *poor*, and *very poor*. The second question—"Do you have any difficulty in eating and enjoying food?"—probed an important oral function. Subjects' responses were recorded on a 5-point Likert-type scale: *never*, *sometimes*, *fairly often*, *very often*, and *all the time*.

Dental Examination

Prior to the research, a handbook describing detailed standardized clinical criteria based on the World Health Organization format[11] was distributed to 43 participating dentists. Clinical examinations of oral health status were performed by the dentists with subjects in a dental chair with an operatory light, a dental mirror, an explorer, and a periodontal probe. Third molars were excluded from all the examinations.

The dentists examined dental status such as the number of teeth present and carious teeth (both enamel and dentine) as well as periodontal conditions such as the number of teeth with gingival bleeding on probing, calculus deposits and 4-mm or deeper periodontal pockets. The total number of functional tooth units (total-FTUs) was defined as the number of pairs of opposing natural teeth (i.e., sound, restored, and carious teeth) and artificial teeth on implant-supported, fixed (bridge pontics), and removable prostheses.[12,13] Carious teeth with extensive coronal destruction and missing teeth were regarded as nonfunctional. Only FTUs from posterior teeth were investigated, in which two opposing premolars were defined as one FTU and two opposing molars were defined as two FTUs.

Statistical Analysis

To assess a structural model of direct and indirect relationships among multiple variables, the SEM analysis was performed. The SEM analysis is used to test relationships between measured and latent variables. In comparison with multiple-regression techniques, SEM has some advantages for analyzing complex relationships within a conceptual model by allowing the inclusion of latent variables. Latent variables are those that cannot be measured directly but are estimated from measured variables in the model. Latent and measured variables used in the SEM analysis are shown in Table 1. Since we used many dichotomous and categorical variables, Bayesian estimation based on Markov chain Monte Carlo simulation technique was used as suggested by Lee and Song.[14]

"Perceived oral health" was defined by two measured variables: self-assessed oral condition and perceived oral function. Measured variables used for "subjective oral health symptoms" were tooth sensitive to cold, tooth sensitive to heat, gingival bleeding, oral malodor, loose teeth, and dry mouth. "Clinical tooth conditions" were composed of three measured variables: number of teeth present, number of untreated dental caries, and total-FTUs. "Periodontal conditions" were made of three measured variables: number of teeth with gingival bleeding on probing, number of teeth with calculus deposits, and number of teeth with 4-mm or deeper periodontal pockets. "Other clinical oral conditions" were derived from three measured variables: degree of oral malodor by organoleptic method (strong, moderate, and none), existence of dry mouth (yes or no) and existence of oral mucosal lesions (yes or no).

Variables were recoded so that the severity of subjective oral health symptoms and bad clinical oral conditions were indicative of poor perceived oral health. The effects are presented as

Table 1. Characteristics of the Study Latent and Measured Variables (N = 1799)

Variable	Response/Range	n/Mean	%/SD
Perceived oral health			
Self-assessed oral condition	Excellent	180	10.0
	Good	258	14.3
	Fair	910	50.6
	Poor	375	20.9
	Very poor	76	4.2
Perceived oral function	Never	462	25.7
	Sometimes	789	43.8
	Fairly often	534	29.7
	Very often	10	0.6
	All the time	4	0.2
Subjective oral health symptoms			
Tooth sensitive to cold	Yes	466	25.9
	No	1333	74.1
Tooth sensitive to heat	Yes	106	5.9
	No	1693	94.1
Gingival bleeding	Yes	471	26.2
	No	1328	73.8
Oral malodor	Yes	646	35.9
	No	1153	64.1
Loose teeth	Yes	192	10.7
	No	1607	89.3
Dry mouth	Yes	312	17.3
	No	1487	82.7
Clinical tooth conditions			
Teeth present	1-28	23.9	5.0
Untreated dental caries	0-26	1.3	2.5
Total no. of functional tooth units	0-12	10.1	2.6
Clinical periodontal conditions			
Gingival bleeding	0-28	5.4	6.0
Calculus deposits	0-28	7.3	7.6
Periodontal pockets	0-28	3.8	5.6
Other clinical oral conditions			
Oral malodor	Strong	46	2.6
	Moderate	571	31.7
	None	1182	65.7
Dry mouth	Yes	84	4.7
	No	1715	95.3
Oral mucosal lesions	Yes	33	1.8
	No	1766	98.2

standardized parameter estimates (SPEs), with mean = 0 and variance = 1. In this standardized unit, the magnitudes can be compared directly for relative importance. All SPEs were computed based on the structure of current theoretical path diagram using all variables. AMOS 18 software was used for the analysis.

Table 2. Standardized Parameter Estimates on Measured Variables

Variable	Standardized Parameter Estimates	Significance, *P*
Perceived oral health		
Self-assessed oral condition	0.74	.01
Perceived oral function	0.27	.01
Subjective oral health symptoms		
Tooth sensitive to cold	0.33	.01
Tooth sensitive to heat	0.30	.01
Gingival bleeding	0.38	.01
Oral malodor	0.33	.01
Loose teeth	0.31	.01
Dry mouth	0.22	.01
Clinical tooth conditions		
Teeth present	0.37	.01
Untreated dental caries	0.22	.01
Total no. of functional tooth units	0.48	.01
Clinical periodontal conditions		
Gingival bleeding	0.75	.01
Calculus deposits	0.61	.01
Periodontal pockets	0.66	.01
Other clinical oral conditions		
Oral malodor	0.35	.01
Dry mouth	0.30	.01
Oral mucosal lesions	0.07	Not significant

Results

The response rate in this study was 10.5%. Table 2 shows SPEs on the measured variables of the five latent variables. All SPEs except for oral mucosal lesions were significant. In "perceived oral health," self-assessed oral health condition had a higher SPE (0.74) than perceived oral function (0.27). Poor self-assessed oral condition and oral function were associated with poor "perceived oral health."

Gingival bleeding had the highest SPE (0.38) in the "subjective oral health symptoms," followed by oral malodor (0.33), tooth sensitive to cold (0.33), loose teeth (0.31), tooth sensitive to heat (0.30), and dry mouth (0.22). Having symptoms of any those measured variables was linked to perceiving more oral health symptoms.

Lower number of teeth present, higher number of teeth with untreated dental caries, and lower total-FTUs were related with worse "clinical tooth conditions." The SPEs on the total-FTUs (0.48) and numbers of teeth present (0.37) were higher than that on the number of teeth with untreated dental caries (0.22).

Gingival bleeding (0.75) had higher SPEs than calculus deposits (0.61) or periodontal pockets (0.66) in "clinical periodontal conditions." Higher numbers of teeth with gingival bleeding, calculus deposits, and periodontal pockets were associated with worse "clinical periodontal conditions."

Among "other clinical oral conditions," the highest SPE was observed on oral malodor (0.35), followed by dry mouth (0.30) and oral mucosal conditions (0.07). Having more these lesions was associated with worse "other clinical oral conditions."

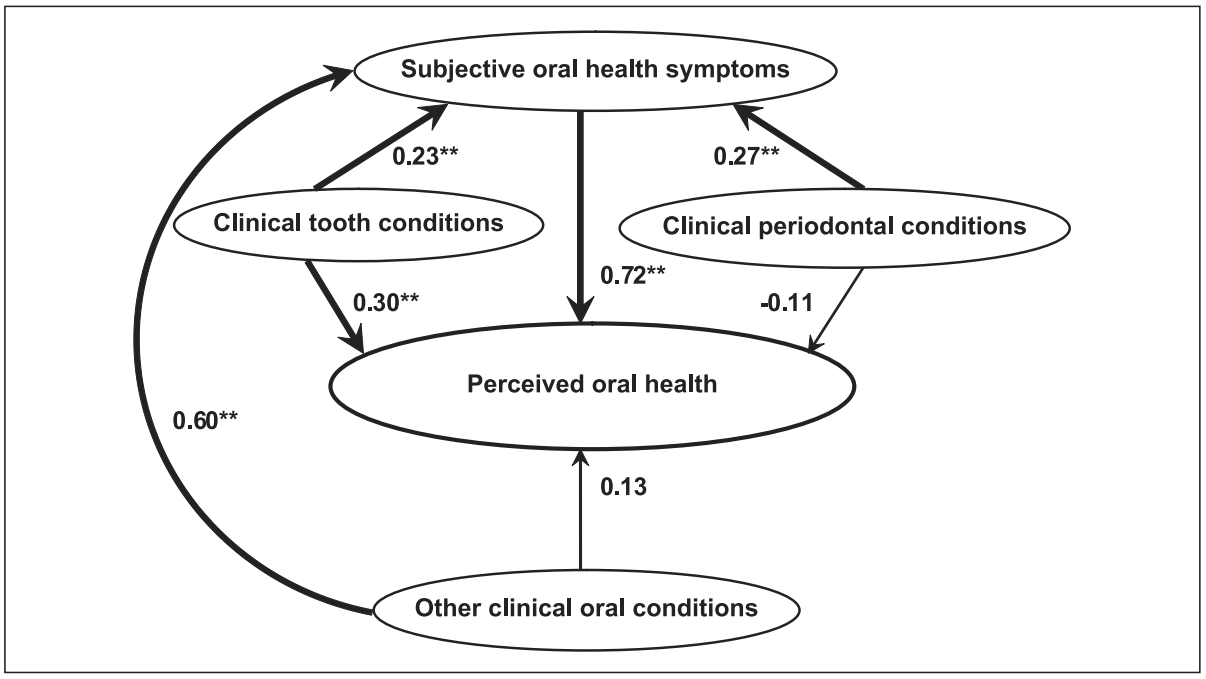

Figure 1. Path diagram of variables influencing perceived oral health (numerical values indicate standardized parameter estimates)
**$P < .01$.

As displayed in Figure 1, 5 out of 7 SPEs on paths between 5 latent variables were significant. Among SPEs on paths directing toward the "perceived oral health," "subjective oral health symptoms" showed the highest value (SPE = 0.72), followed by "clinical tooth conditions" (SPE = 0.30). However, SPEs on paths from "clinical periodontal conditions" to "perceived oral health" (SPE = −0.11) and from "other clinical oral conditions" to "perceived oral health" (SPE = 0.13) were not significant. More "subjective oral health symptoms" or worse "clinical tooth conditions" were linked to poorer "perceived oral health."

Paths from "clinical tooth conditions," "clinical periodontal conditions," and "other clinical conditions" to subjective oral health symptoms" were all significant. Worse "clinical tooth conditions," "clinical periodontal conditions," and "other clinical oral conditions" were linked to more "subjective oral health symptoms." "Other clinical oral conditions" had a higher value (SPE = 0.60) compared with "clinical periodontal conditions" (SPE = 0.27) or "clinical tooth conditions" (SPE = 0.23).

Discussion

In this study, a SEM analysis with Bayesian estimate was carried out to understand and explain the complicated relationships of subjective oral health symptoms and clinical oral health status to perception of oral health. The present findings indicated that subjective oral health symptoms were the most powerful factor in explaining how people perceived their oral health. A previous study also suggested that perceptions of oral health depended on the specific symptoms the person might experience.[15] These findings provide a valuable insight into the oral health care needs and services of middle-aged community residents. There is a possibility that Japanese people do not perceive their oral health compromised unless they experience certain symptoms or clinical signs. Therefore, middle-aged Japanese people may not be likely to seek dental treatment until some

apparent symptoms or signs occur. A poor recognition of symptoms of oral ill health may result in delay in accessing necessary health care service.

There was a huge gap between a layperson's standpoint of health and dental professional's one. Therefore, it appears important to create favorable health behavior changes for people to access health services appropriately. Previous studies have also shown that there is a large discordance between subjectively perceived oral health and professionally measured oral health.[6]

Among the clinical oral conditions, only latent variable "tooth conditions," in which numbers of teeth present and FTUs were the dominant indicators, had a significant influence on the perceived oral health. Clinical periodontal conditions did not show a significant effect on perceived oral health in this study. This finding is similar to reports in other countries.[6] It is an important finding for improving community oral health, because people who cannot recognize and acknowledge their deteriorating periodontal condition accurately are at increasing risk of delaying access to dental care or instituting preventive actions to reduce periodontal disease morbidity with increasing age. Prevention of advanced periodontal conditions in older adults requires earlier recognition of the importance of signs and symptoms of these diseases.

The SEM analysis procedures can examine both direct and indirect effects of variables. The impact of clinical periodontal conditions or other clinical oral conditions on perceived oral health was thought to be indirect rather than direct, because SPE values for the direct paths from these variables to perceived oral health were very low: −0.11 and 0.13, respectively. However, the SPE values for paths from these variables through subjective oral health symptoms were significantly large. That is, the effects of the clinical variables on perceived oral health were mediated by subjective oral health symptoms. A modified and simplified version of the model by Wilson and Cleary[16] applied to oral health also shows that clinical conditions such as oral diseases and disorders do not directly affect the quality of life but are mediated by oral symptoms.

There are many perspectives on perceived oral health. Davis[17] describes that perceptions of oral health depend on the understanding by the individual of what "normal" oral health is. According to Locker and Gibson,[18] self-rating of oral health is an assessment of the functional, psychological, and social impact of oral disease and disorder on overall well-being. Several multi-item indices have been developed to evaluate perceived oral health, because these are considered more valid and reliable than a single-item measure.[19]

In this study, we used two single-item measures to represent perceived oral health. They are a simple, easy way of summarizing the state of a person's oral health. Many studies demonstrated that a single-item global self-rating was a valid, reliable measure of health and could be used as a substitute for multi-item scales and instruments to summarize a person's oral health status and as an oral health outcome measure.[18]

One limitation in the study is that intra- or interexaminer variability assessments were not carried out. In addition, there are a certain limitations to generalizations from this study. First, since our main objective was to assess the relationship of subjective and clinical oral conditions with perception of one's oral health, other factors not included in the analysis may increase its explanatory power—for example, factors such as socioeconomic status, use of dental services, oral health behaviors, and oral health attitudes or beliefs.[20]

Second, we evaluated a sample that was derived from a certain community population; therefore, the present report could not be generalized to the overall Japanese population. However, the study subjects were free-living residents, not a special group of people such as dental patients; and the oral health status of subjects was similar to that of subjects in the Japanese national survey.[21] Therefore, we consider this sample as having a proximate profile of the middle-aged adult Japanese population even if it is not representative of all Japanese in this age-group. In future studies, we will include other potential factors influencing perceived oral health and test whether these results can be generalized to other populations.

This study targeted subjects aged 40 to 64 years, largely because there is a paucity of research on people living independently in this age-group. As very few people were edentulous, it was possible to assess the effect of tooth and periodontal conditions on perceived oral health after excluding edentulous subjects. There was no major difference in the parameters for 40 to 50 years and older than 50 years age-groups.

Conclusion

This study suggested the powerful role of subjective oral symptoms on perceptions of oral health. Therefore, it appears necessary for dental professionals to be more proactive in informing the general population of the importance of regular dental checkups and the oral health symptoms to monitor and maintain their oral health conditions. This knowledge could also be used to improve oral health services utilization at an individual level and as information for planning and conducting appropriate intervention programs for oral health promotion at a population level.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interests with respect to the research, authorship, and/or publication of this article.

Funding

This research was partly supported by the 8020 Promotion Foundation.

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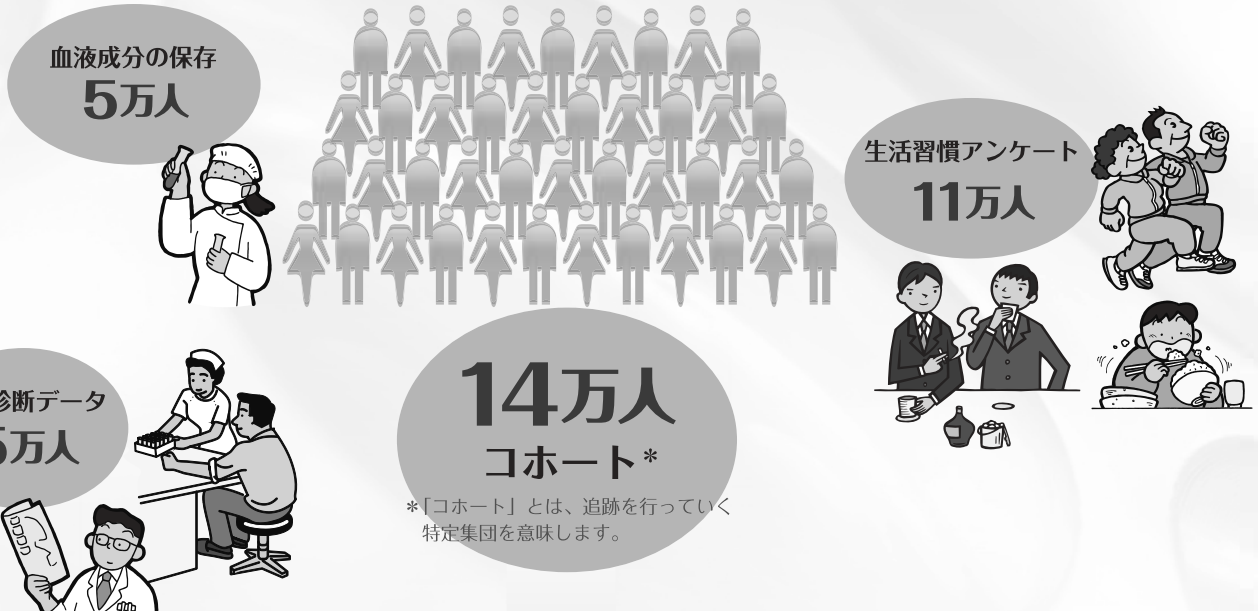
多目的コホート研究

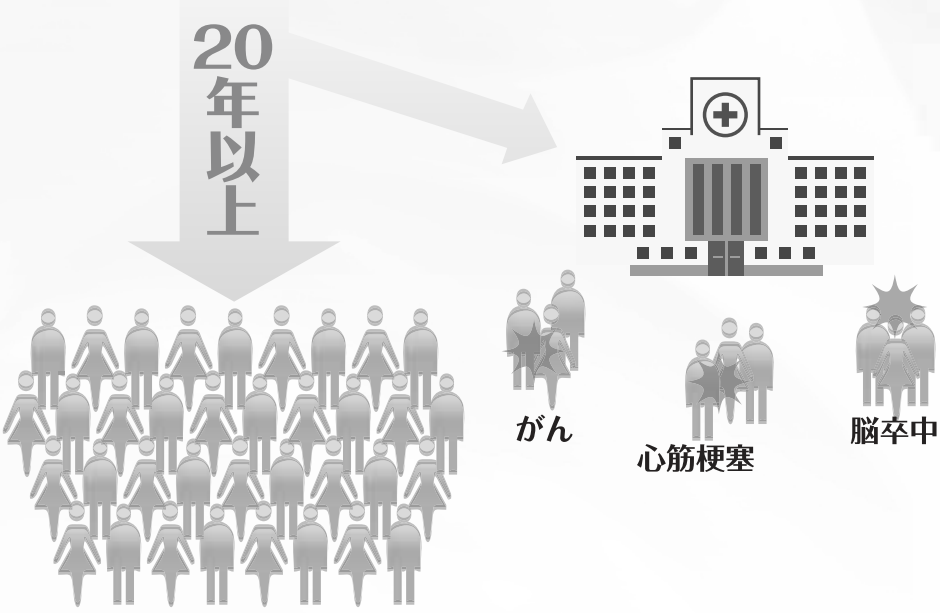
JPHC STUDY

Japan Public Health Center-based Prospective Study

研究の概要 Outline

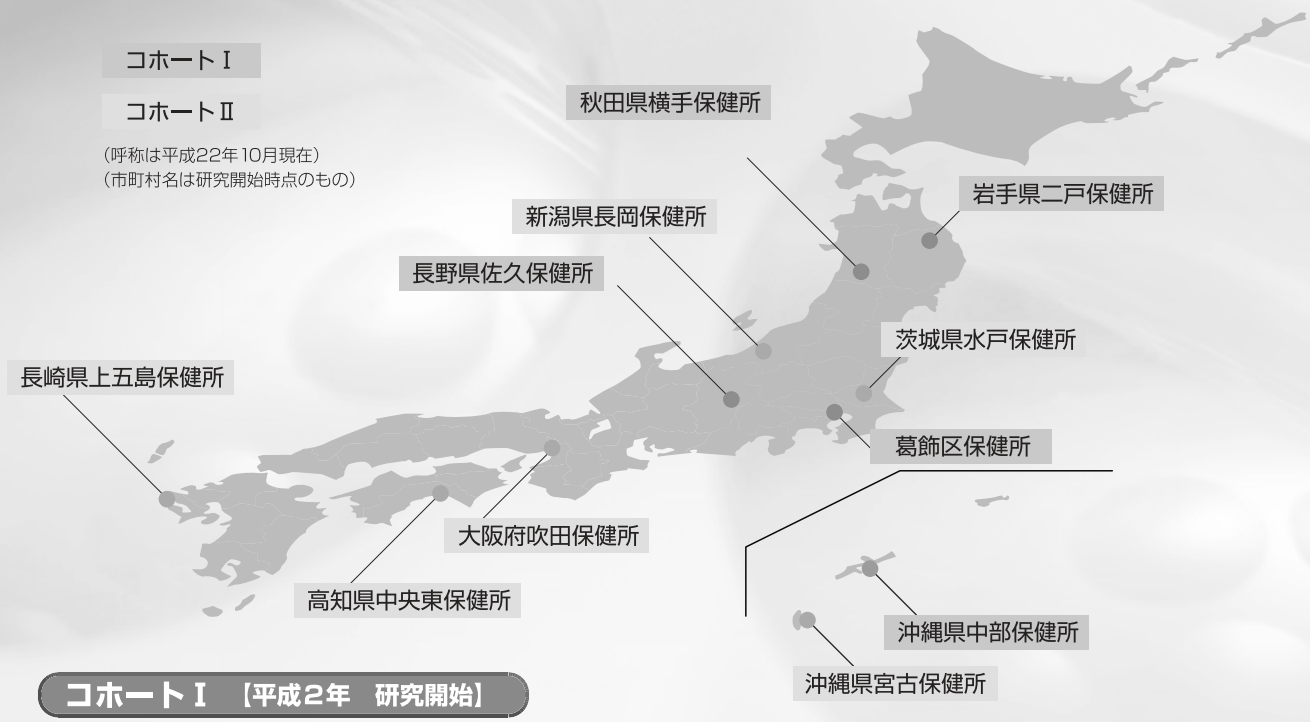
日本人をその平均寿命（平成20年：男性79歳、女性86歳）以前に死に至らしめたり、生活の質を低下させる重要な原因になっている、がん・心筋梗塞・脳卒中・糖尿病などの病気の発生には、食習慣・運動・喫煙・飲酒などの生活習慣が深く関わっており、生活習慣の改善によって、これら疾病の発生をある程度未然に防ぐことが可能であるものと考えられています。しかしながら、どのような食事をどの程度とればよいのか、飲酒はどの程度が適量であるか、などについて、日本人についてのデータは十分とは言えないのが現状です。そこで、約10万人の地域住民の方から生活習慣や健康に関する情報と血液を提供していただき、どのような生活習慣を持つ人が、がん・脳卒中・心筋梗塞・糖尿病などになりやすいのか、あるいはなりにくいのかを明らかにするために、多目的コホート研究を立ち上げ、10年以上にわたる長期追跡により、結果を積み上げてきました。さらに期間を延長することにより、長期にわたる予防やリスク要因について、新たな実証的データを得て、日本人の健康のためにはどのような生活が望ましいのかを追求します。





この研究は、国立がん研究センターがん研究開発費（平成21年度までは厚生労働省がん研究助成金）による「多目的コホート研究に基づくがん予防など健康の維持・増進に役立つエビデンスの構築に関する研究」班（班主任　津金昌一郎　国立がん研究センターがん予防・検診研究センター予防研究部長）において全国11保健所と国立がん研究センター、国立循環器病研究センター、大学、研究機関、医療機関などとの共同研究として行われています。

研究の対象者 Study Population



コホートⅠ 【平成2年 研究開始】

地域住民コホートとして

●岩手県二戸保健所地域……二戸市および軽米町
●秋田県横手保健所地域……横手市および雄物川町
●長野県佐久保健所地域……南佐久郡８町村（臼田町、佐久町、小海町、川上村、南牧村、南相木村、北相木村、八千穂村）
●沖縄県中部保健所地域……具志川市および恩納村

に在住する、平成元年12月31日現在で40歳以上60歳未満の方（昭和５年１月１日から昭和24年12月31日に生まれた方）全員を、市町村の住民基本台帳より抽出して対象者としました。

大都市住民コホートとして

●葛飾区保健所地域……葛飾区

に在住する、平成２年より６年までの５年間に、区が実施する40歳および50歳の節目健診を受診された方を対象者としました。

コホートⅡ 【平成5年 研究開始】

地域住民コホートとして

●茨城県水戸保健所地域……友部町および岩瀬町
●新潟県長岡保健所地域……小国町
●高知県中央東保健所地域……野市町および香我美町
●長崎県上五島保健所地域……宇久町、小値賀町、新魚目町、有川町、上五島町および奈良尾町
●沖縄県宮古保健所地域……平良町および城辺町

に在住する、平成４年12月31日現在で40歳以上70歳未満の方（大正12年１月１日から昭和27年12月31日に生まれた方）全員を、市町村の住民基本台帳より抽出して対象者としました。

大都市住民コホートとして

●大阪府吹田保健所地域……吹田市

■平成５年度吹田市総合健康診査（40歳と50歳の節目健診）対象者（平成５年４月から平成６年３月までに40歳または50歳の誕生日を迎える方）のうち、それぞれの誕生日の時点で吹田市に住民票があることが確認できた方を対象者としました。

■国立循環器病センター計画健診対象者で、平成元年４月１日から平成４年４月１日にわたって、吹田市住民基本台帳から性、及び10歳階級の年齢で層別化して無作為に抽出した者のうち、平成５年４月１日時点で40歳以上70歳未満であり、吹田市に住民票があることが確認できた方を対象者としました。

ベースライン調査 Baseline Survey

対象者に対して、生活習慣などに関するアンケート調査を行いました。また、地域や職域で行われる健康診断の機会を利用して血液や検査データの提供をお願いしました。

アンケート調査

対象者全員に対して、共通自記式アンケート質問票「健康づくりアンケート」を配布・回収し、健康状態、喫煙・飲酒、食生活、身体活動などの生活習慣についての情報を提供して頂きました。

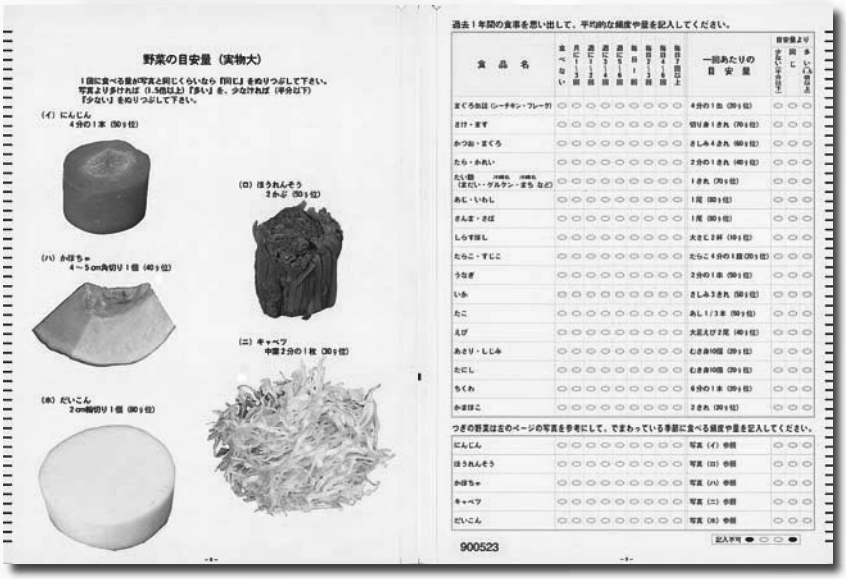
血液試料および健康診断データの収集

市町村で実施する老人保健法による基本健康診査や職場で実施する労働安全衛生法による定期健康診断などの機会を利用して、受診し、同意を得られた対象者の血液試料と健診データを提供して頂きました。

5年後調査・10年後調査・15年後調査 Additional Surveys

コホート研究の開始より５年後の時点において、コホート対象者に対して、２回目のアンケート調査を行いました。目的は、ベースライン時のアンケート調査では定性的にしか把握出来なかった、対象者の食物摂取状況について半定量的にとらえること、生活習慣の変化をとらえること、そして、疾病罹患情報を得ることです。また、血液試料および健康診断データの収集を、ベースライン調査時に準じ実施しました。

コホート研究の開始より10年後に、コホート対象者に対して、ほぼ同様の内容で３回目のアンケート調査を行いました。さらに、15年後に、健康状況に関する簡単なアンケート調査を行いました。



フォーローアップ調査 Follow-up Cohort Participants

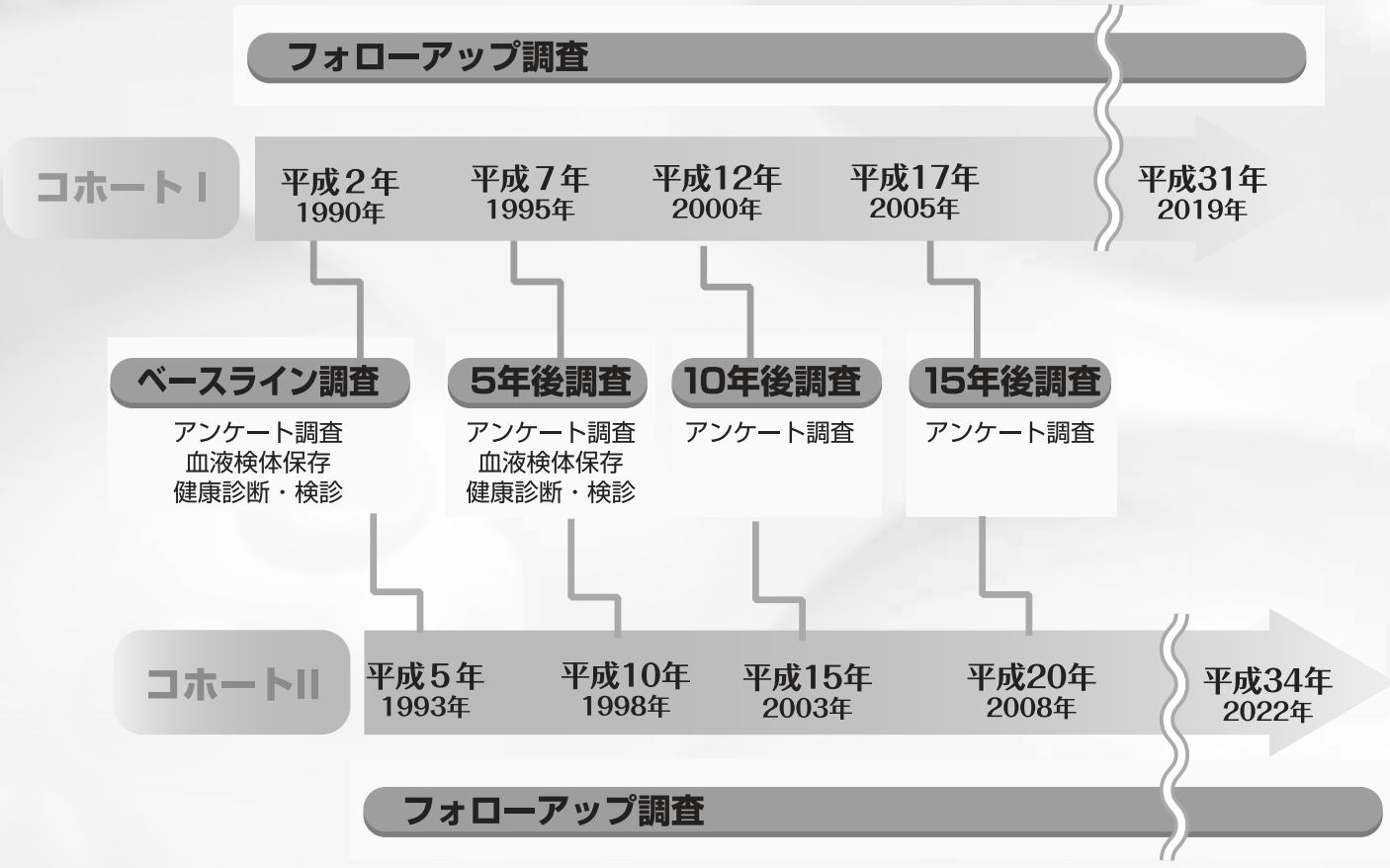
コホート対象者全員の、①死亡、②転出および再転入、③がん、循環器疾患（脳卒中、心筋梗塞）、糖尿病などの病気の罹患についての把握を行っています。

研究成果の還元 Public Relations

参加者へのコホート研究の成果に関する情報の還元などを目的に、成果の概要をまとめた冊子等をお送りしています。また、研究班のホームページで最新の情報を入手できるようにし、希望者へe-mailでリサーチニュースの配信を行っています。

研究スケジュール Schedule

コホートⅠの平成２年からの予定とコホートⅡの平成５年からの流れを以下に示します。



問い合わせ先 （平成22年10月現在）

Japan Public Health Center-based prospective Study

多目的コホート研究事務局

〒104-0045　東京都中央区築地5-1-1　独立行政法人国立がん研究センター
がん予防・検診研究センター　予防研究部内
TEL：03（3542）2511（内線3392）　FAX：03（3547）8580
E-mail：jphcadmin@ml.res.ncc.go.jp　ホームページ：http://epi.ncc.go.jp/jphc/

多目的コホート研究（JPHC Study）

現在までの成果

条件で検索する

疾患（エンドポイント）を選択する（複数選択可）

罹患（がん）	☐ 全がん ☐ 咽頭がん ☐ 食道がん ☐ 胃がん ☐ 大腸がん ☐ 肝がん ☐ 胆道がん ☐ 膵がん ☐ 喉頭がん ☐ 肺がん ☐ 乳がん ☐ 子宮がん ☐ 卵巣がん ☐ 前立腺がん ☐ 腎がん ☐ 膀胱がん ☐ 血液・リンパのがん ☐ 甲状腺がん
罹患（循環器系疾患）	☐ 全循環器系疾患 ☐ 脳卒中 ☐ 虚血性心疾患・心筋梗塞
罹患（その他）	☐ 2型糖尿病 ☐ 白内障 ☑ 歯の喪失・健康 ☐ 骨折 ☐ メタボリックシンドローム ☐ 肥満 ☐ 身体機能障害 ☐ 体重増加 ☐ 禁煙
死亡	☐ 全死亡 ☐ がん死亡 ☐ 胃がん死亡 ☐ 循環器疾患死亡 ☐ 自殺
研究方法等について	☐ 自己申告データ ☐ 健康参加者効果 ☐ 妥当性 ☐ 予測モデルの作成

要因（キーワード）で絞り込む（複数選択可）

喫煙習慣と飲酒習慣のグループ	☐ 喫煙 ☐ 受動喫煙 ☐ 酒
食品、飲料、栄養素グループ	☐ 食パターン ☐ 野菜・果物 ☐ 大豆・みそ・豆腐 ☐ 食塩・塩蔵食品 ☐ 乳製品 ☐ 卵 ☐ コレステロール・脂肪酸 ☐ 緑茶・コーヒー ☐ ビタミン・ミネラル類 ☐ イソフラボン ☐ 食物繊維 ☐ 魚 ☐ 肉 ☐ n-3系多価不飽和脂肪酸 ☐ 飽和脂肪酸 ☐ 米飯 ☐ 海藻 ☐ 清涼飲料
体格と身体活動などのグループ	☐ 体格（身長・体重・肥満指数） ☐ 身体活動・運動
現象と既往歴・がん検診のグループ	☐ 家族歴 ☐ 既往歴 ☐ 便通 ☐ 女性関連要因 ☐ 検診・がん検診受診歴 ☐ 味の好み ☐ 飲酒で顔が赤くなる ☐ 年齢 ☐ 睡眠時間
社会心理要因のグループ	☐ 学歴・教育歴 ☐ 社会的な支え ☐ 家族構成 ☐ ストレス ☐ 性格・意識・行動パターンなど ☐ 就業状況
検診データ・血液分析関連	検診データ ☐ 脂質 ☐ 血圧 ☐ 血糖・HbA1c ☐ メタボリックシンドローム ☐ 身体指標 保存血液分析 ☐ ウイルス・細菌感染マーカー ☐ 炎症マーカー ☐ 肝機能マーカー ☐ 食品・栄養成分 ☐ 化学物質 ☐ インスリン関連マーカー ☐ 萎縮性胃炎マーカー ☐ 性ホルモン
その他	☐ その他 ☐ 飲料 ☐ 重金属

多目的コホート研究（JPHC Study）

現在までの成果：記事一覧

検索条件

罹患（循環器系疾患）	虚血性心疾患・心筋梗塞

検索結果【 該当タイトル：25件 】

no	記事	投稿日
180	緑茶・コーヒー摂取と脳卒中発症との関連について	2013/03/15
179	飽和脂肪酸摂取と循環器疾患発症の関連について	2013/03/11
177	清涼飲料水（ソフトドリンク）と循環器疾患発症との関連について	2012/12/26
176	長期的な粒子状物質への曝露と循環器疾患の発生および死亡との関連について	2012/12/05
174	血清CRP値と脳卒中、虚血性心疾患との関連について	2012/11/09
171	歯周病原細菌感染と冠動脈性心疾患(CHD)	2012/10/17
142	身長と循環器疾患発症リスクとの関連	2011/07/06
138	糖尿病と虚血性心疾患との関連について	2011/04/08
108	生活を楽しんでいる意識と循環器疾患	2009/09/30
106	脳卒中・心筋梗塞の自己申告データの正確さについて	2009/07/08
102	飲酒と循環器疾患発症との関連への社会的な支えの影響	2009/05/22
99	血圧区分と循環器疾患発症リスクおよび死亡リスクとの関連	2009/04/16
97	メタボリックシンドローム関連要因（メタボ関連要因）と循環器疾患発症との関連	2009/04/16
90	家族構成と虚血性心疾患発症リスクとの関連	2009/01/06
76	教育歴、社会的役割と循環器疾患発症リスクとの関連	2008/08/12
75	カルシウム摂取と循環器疾患の関連について	2008/07/29
74	タイプA行動パターンと虚血性心疾患発症リスクとの関連	2008/07/18
68	葉酸、ビタミンB6、ビタミンB12摂取と虚血性心疾患発症との関連について	2008/05/28
63	社会的な支えと循環器疾患の発症・死亡リスクとの関連	2008/02/07
58	イソフラボンと脳梗塞・心筋梗塞発症との関連について	2007/12/04
54	肥満指数（BMI）、体重の変化と虚血性心疾患発症について	2007/08/23
50	飲酒習慣と心筋梗塞の関連について	2007/04/07
40	卵と心筋梗塞発症の関連について	2006/11/18
33	喫煙と虚血性心疾患発症との関連について	2006/04/11
29	魚・n-3脂肪酸摂取と虚血性心疾患発症との関連について	2006/01/17

◀ 検索条件設定に戻る

多目的コホート研究（JPHC Study）

歯周病原細菌感染と冠動脈性心疾患（CHD）

ー「多目的コホート研究（JPHC研究）」からの成果報告ー

私たちは、いろいろな生活習慣と、がん、脳卒中、心筋梗塞、糖尿病などの病気との関係を明らかにし、日本人の生活習慣病予防に役立てるための研究を行っています。
平成2年（1990年）と平成5年（1993年）に、岩手県二戸、秋田県横手、長野県佐久、沖縄県中部、茨城県水戸、新潟県長岡、高知県中央東、長崎県上五島、沖縄県宮古、大阪府吹田の10保健所（呼称は2011年現在）管内にお住まいの方々にご協力いただき、生活習慣などについてのアンケート結果、血液試料などをご提供いただきました。その後、2007年まで冠動脈性心疾患（CHD）の発生についての追跡調査を行いました。これらのデータを活用して行った歯周病原細菌とCHDの関係についての研究の成果を専門誌で論文発表しましたので、ご紹介します(International Heart Journal 2012年 53巻 209-214ページ)。

保存血液を用いた、コホート内症例対照研究

喫煙、飲酒、肥満などがCHDのリスク要因として知られていますが、これらに加えて、歯周病がCHDの発症と進行に関係していることが多くの疫学研究で示されています。
多目的コホート研究開始時に、一部の方から健康診査の機会を利用して、研究目的で血液を提供していただきました。そのうち2007年までの追跡期間中に、191人がCHDと診断されました。CHD発症者1人に対し、CHDにならなかった方から年齢・性別・居住地域・採血時の条件をマッチングさせた2人を無作為に選んで対照者に設定し、合計573人を分析対象としました。研究では、保存された血液を用いて、歯周病の原因菌として注目されている3種類の細菌、すなわち「アグリゲイティバクター・アクチノミセテムコミタンス（*A. actinomycetemcomitans*）」、「ポルフィロモナス・ジンジバリス（*P. gingivalis*）」、「プレボテラ・インターメディア（*P. intermedia*）」の血漿抗体レベルを調べました。抗体レベルが高いと歯周病原細菌に感染していることを示します。今回、歯周病原細菌の血漿抗体レベルとCHDの発生の関係を調べるためにコホート内症例対照研究を行いました。

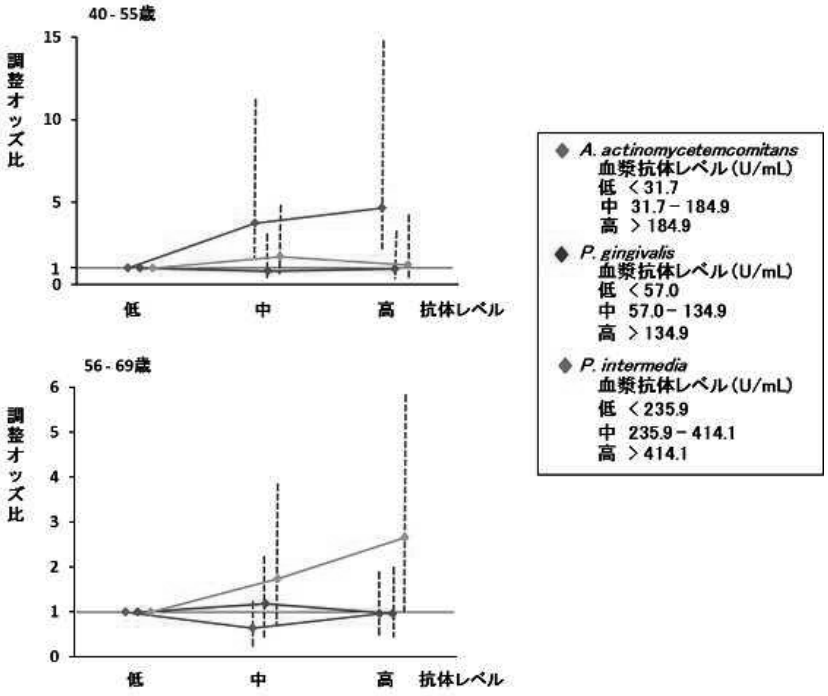
歯周病原細菌の感染でCHDリスク上昇

3種類の歯周病原細菌に対する血漿中のIgG抗体レベルによって全対象者を3つに区分（高・中・低）し、抗体レベルが低いグループを基準とする各グループのCHDの発症リスクを算出しました。その際、交絡要因からの影響がないよう統計学的に調整しました。

年齢階級別に分析を行ったところ、ベースライン時の年齢が40-55歳のグループでは、*A. actinomycetemcomitans*に対する血漿抗体レベルが低いグループに比べ、中程度のグループでは約3.7倍、高いグループでは約4.6倍と有意にCHD発症リスクが高く、量反応関係がみられました（トレンドP値=0.007）。

また、ベースライン時の年齢が56-69歳のグループでは、*P. intermedia*に対する血漿抗体レベルの低いグループに比べ、高いグループでは約2.7倍と有意にCHD発症リスクが高く、量反応関係がみられました（トレンドP値=0.007）。

歯周病原細菌に対する血漿抗体レベルごとのCHD発症のリスク



この研究について

この研究の特徴は、血漿抗体レベルによって歯周病原細菌の感染、すなわち歯周病の状態を評価したことです。歯周病の臨床指標と比較して、抗体レベルによる評価は歯周病による全身の健康への影響をより的確に把握できると考えられます。さらに、喫煙、飲酒、肥満などのCHDの重要な交絡要因の影響を考慮して分析を行っています。

ただし、限界もあります。高い血漿抗体レベルがそのとき進行中の歯周病を反映しているのか、それ以前の歯周病原細菌の感染の結果なのかを区別することは困難です。また、本研究では歯周病の代表的な3種類の細菌を分析対象としましたが、歯周病原細菌は他にもたくさんあります。

今回、日本人を対象とした疫学研究で、CHD発症前の保存血液を分析することで、歯周病原細菌の感染とその後のCHD発症との関係を前向き研究によって確認することができました。歯周病は予防したり治療したりすることが可能であり、歯周病対策を行うことがCHD発症予防に貢献する可能性が示されました。

教育歴と歯の健康

-「多目的コホート研究（JPHC研究）」からの成果-

私たちは、いろいろな生活習慣と、がん・脳卒中・虚血性心疾患・糖尿病、歯の疾患などとの関係を明らかにし、日本人の生活習慣病予防に役立てるための研究を行っています。多目的コホート対象地域のうち秋田県横手保健所管内にお住まいであった、1990年に40-59歳で、生活習慣などについてのアンケート調査にお答えいただいた男女約1万2,000人に対し、2005年に歯科健診を受けていただくよう、書面でお願いしました（歯科研究）。

アンケートの回答から、対象者の最終学歴が中学校の場合を教育歴の低いグループ、高等学校の場合を中程度のグループ、短大以上の場合を高いグループとしました。また、2005年に歯科アンケート調査を行った際に、甘い菓子や飲料の摂取頻度、前年の歯科健診受診の有無、喫煙状況をお答えいただき、歯科健診への参加を呼びかけました。

2006年1月までに男性706人、女性812人、合計1,518人が歯科健診に参加し、第三大臼歯（いわゆる親知らず）を除いて全部で28本の永久歯のうち何本残っているかなど、歯の健康状態について歯科医師による調査を受けました。その結果にもとづいて、教育歴と歯の健康との関連を調べ、専門誌で論文発表しましたので紹介します。
（Community Dentistry and Oral Epidemiology 2012年6月WEB先行公開）

教育歴は歯の健康に影響する

対象者の人数は、教育歴の低いグループ402人（33.5%）、中程度のグループ602人（50.6%）、高いグループ191人（15.9%）でした。歯科アンケートの結果の中で、男性では、教育歴が低いほど甘い飲料の摂取頻度が高いという差がみられましたが、その他の項目については差がみられませんでした。

歯科健診の結果、教育歴の高いグループほど、永久歯が20本以上残っている割合が高くなりました。また、残っている永久歯の本数、処置歯（FT）の数が多くなりました。上下で噛みあう歯のペア数（機能歯ユニット：FTU）では、自分の歯による機能歯ユニット（n-FTU）、自分の歯とインプラントやブリッジなどの人工歯による機能歯ユニット（nif-FTU）について、ともに教育歴の高いグループほど多くなりました。しかし、入れ歯を含むすべての歯による機能歯ユニット（総FTU）数は統計学的に有意な差はみられませんでした（表）。

表　教育歴と歯の健康

教育歴	低い		中程度		高い		傾向P値
	平均値	標準偏差	平均値	標準偏差	平均値	標準偏差	
歯の数	16.97	17.80	18.46	19.09	20.72	21.35	0.037
DT数	0.82	1.26	0.93	1.38	0.95	1.38	0.248
FT数	9.03	9.72	9.76	10.33	11.46	12.07	0.016
n-FTU数	3.76	4.33	4.68	5.20	5.78	6.29	<0.001
nif-FTU数	4.58	5.15	5.40	5.94	6.79	7.31	<0.001
総FTU数	10.05	10.75	10.14	10.70	10.53	11.13	0.623

年齢、性別、甘い菓子の摂取、甘い飲料の摂取、歯の健診受診、喫煙、
歯や入れ歯の清掃状態が結果に影響しないように調整。ハイライトした項目で統計学的な有意差がみられた。

研究結果について

厚生労働省や日本歯科医師会によって推進されている8020運動は、「80歳で20本以上の永久歯を残す」ことを目標にしています。今回の研究では、教育歴の高いグループほど20本以上の永久歯が残っている割合は高いことが示されました。社会経済状況による歯の健康の違いについて、同様の研究結果は他にもあります。
また、今回の研究では、教育歴の高いグループほど処置歯（FT）の数が多かったのですが、このことは歯科医院の受診状況を反映していると考えられます。反対に、未処置歯（DT）の本数には教育歴による違いがみられませんでしたが、もともと未処置歯が少ない（平均1本未満）ために、違いが検出できなかったものと考えられます。FTUのペア数は総数では変わらず、n-FTUとnif-FTUでは教育歴の高いグループが高いことから、教育歴の低いグループでは、永久歯をより多く失っていますが、入れ歯を入れて噛み合わせを維持していることが推測されます。わが国には国民皆保険制度があって入れ歯を比較的安価で作ることができるので、社会経済状況による影響は少ないと考えられます。しかし、自分の歯と比べると入れ歯では噛む力は弱くなってしまいます。

歯科健康教育を実施することで教育歴による歯の健康格差の解消を

今回の研究結果は、日本の成人において教育歴が歯の健康に影響していることを初めて示したものです。今後、より多くの日本人を対象に社会経済状況を表わす複数の指標と歯の健康の関連について検討する必要があります。
研究結果からは、個人的な健康習慣の改善とともに、歯の健康を向上させるための社会的な環境づくりの大切さが示唆されます。また、義務教育期間に歯科健康教育を行うことによって子供たちに適切な情報を伝え、教育歴による歯の健康格差の解消を図ることの必要性が示されました。

多目的コホート研究（JPHC Study）

喫煙、禁煙年数と歯の喪失との関連について

−「多目的コホート研究（JPHC研究）」からの成果−

私たちは、いろいろな生活習慣と、がん・脳卒中・虚血性心疾患・糖尿病、歯の疾患などとの関係を明らかにし、日本人の生活習慣病予防に役立てるための研究を行っています。多目的コホート対象地域のうち秋田県横手保健所管内にお住まいであった、平成元年（1989年）に40−59歳で、生活習慣についてのアンケート調査にお応えいただいた男女約1万2000人に対し、平成17年（2005年）に歯科健診を受けていただくよう、書面でお願いしました（歯科研究）。

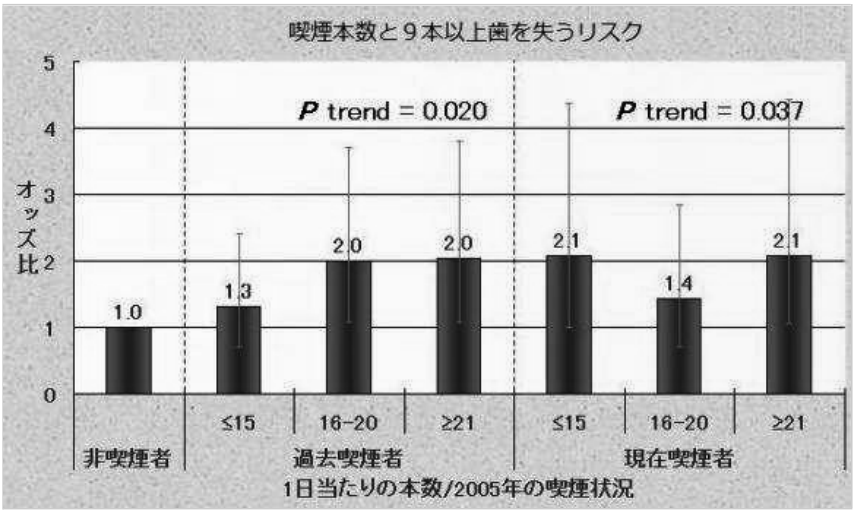
平成18年（2006年）1月までに男性706人、女性812人、合計1518人が受診し、第三大臼歯（いわゆる親知らず）を除いて全部で28本の永久歯のうち何本残っているか、歯科医院において検査が行われました。その結果にもとづいて、喫煙、禁煙年数と歯の喪失との関連を調べました。その結果を、専門誌で論文発表しましたので紹介します。
（Oral Diseases 2009年15巻69−75ページ）

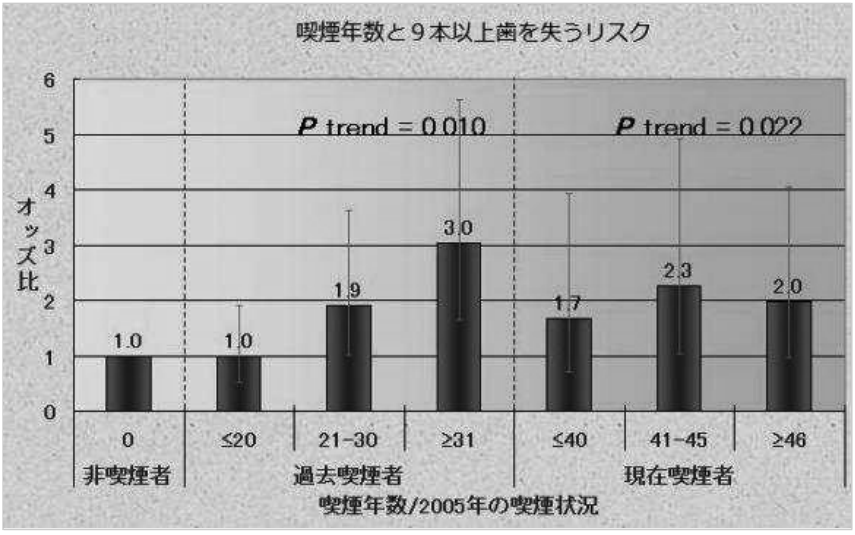
喫煙状況に関する調査は、1990年（平成2年）、1995年、2000年と2005年に行われました。それらの回答から、男性を現在喫煙グループ(135人)、過去喫煙グループ（251人）、非喫煙グループ（161人）に分け、喫煙経験のある方についてはそれ以前の調査から喫煙年数と1日当たりの本数、過去喫煙者についてはさらに禁煙してからの年数を算出しました。

厚生労働省や日本歯科医師会により推進されている8020運動では、80歳で20本以上の歯を残すことを目標にしています。そこで、男性の喫煙状況と、28本の永久歯のうち9本以上を失う（歯が20本より少なくなってしまう）リスクとの関連を調べてみました。歯科健診の結果、残っている永久歯が少ないグループ（0本から19本）が197人、20本から28本の多いグループが350人でした。また、年齢が高くなるほど、残っている歯が少ないグループになるリスクが高くなりました。

喫煙者と非喫煙者で、喫煙本数と年数が9本以上歯を失うリスクと関連

現在または過去喫煙者で1日21本以上吸うグループの9本以上歯を失うリスクは、非喫煙者グループの約2倍でした。また喫煙年数が最長のグループのリスクは、現在喫煙者（46年以上）では非喫煙者グループの約2倍、過去喫煙者（31年以上）では約3倍でした。



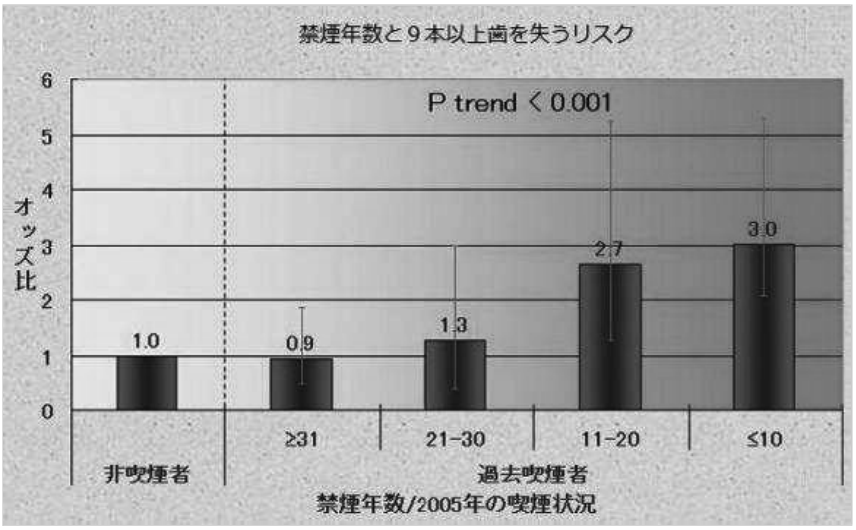


現在喫煙者でも過去喫煙者でも、9本以上の歯を失うリスクを喫煙本数別、または年数別に比べると、いずれも喫煙本数が多くなるほど、また喫煙年数が長くなるほど、リスクが高くなるという傾向が確認されました。

禁煙してからの年数と9本以上歯を失うリスクとの関連

次に、過去喫煙者について、禁煙してからの年数別にグループ分けして、9本以上歯を失うリスクを比べました。

禁煙してから21年以上たっていると、非喫煙グループとリスクが変わりませんでした。禁煙してからの年数が短くなるにつれてリスクが高くなる傾向があり、11年から20年では2.7倍、10年以内の最も短いグループでは3倍でした。



この研究について

今回の研究では、たばこを吸っている人は吸わない人に比べて自分の歯を失うリスクが高いことがわかりました。そのリスクは、喫煙本数が多いほど、また喫煙年数が長いほど高いことがわかりました。これまでの国内外の研究でも、同様の結果が確認されています。

過去喫煙者については、これまで日本の研究では歯を失うリスクがほとんど示されていませんが、今回の研究で、禁煙後20年以内の場合に、9本以上歯を失うリスクが明らかに高くなることが示されました。ただし、禁煙年数が21年以上のグループでは、たばこを吸わない人と同様でした。

禁煙後の年数と歯の本数についての研究はあまり行われていませんが、欧米から、13年の禁煙年数で歯を失うリスクがたばこを吸わない人と同じになるという報告があります。歯の本数に対する喫煙の影響がなくなるには、禁煙後相当の年月が必要なのかもしれません。

たばこに含まれるニコチンなどの毒素は歯周組織を破壊し、間接的にも免疫力を弱め、歯周ポケットに菌の繁殖しやすい環境を作るなど、歯周病が進行して歯が抜けてしまうリスクを高めます。また、喫煙と歯の根面にできるむし歯のリスクの関連を示す結果もあります。禁煙により、そうした喫煙によるダメージが減り、年数がたつごとに歯を失うリスクが低くなるということが考えられます。女性は今回の研究では喫煙者の割合が低く、分析することができませんでしたが、男性と同様のメカニズムと考えられます。

たばこ関連の疾病のうち、歯や歯肉の症状は直接本人の目で確認できます。歯科医や歯科衛生士は、喫煙の害を伝え、禁煙への動機付けを促すことができます。医科の専門家と協力して歯科の専門家が積極的に禁煙政策に関わり、早い段階で禁煙を成功させることができれば、歯に限らず他の病気による負担を低減することができるでしょう。