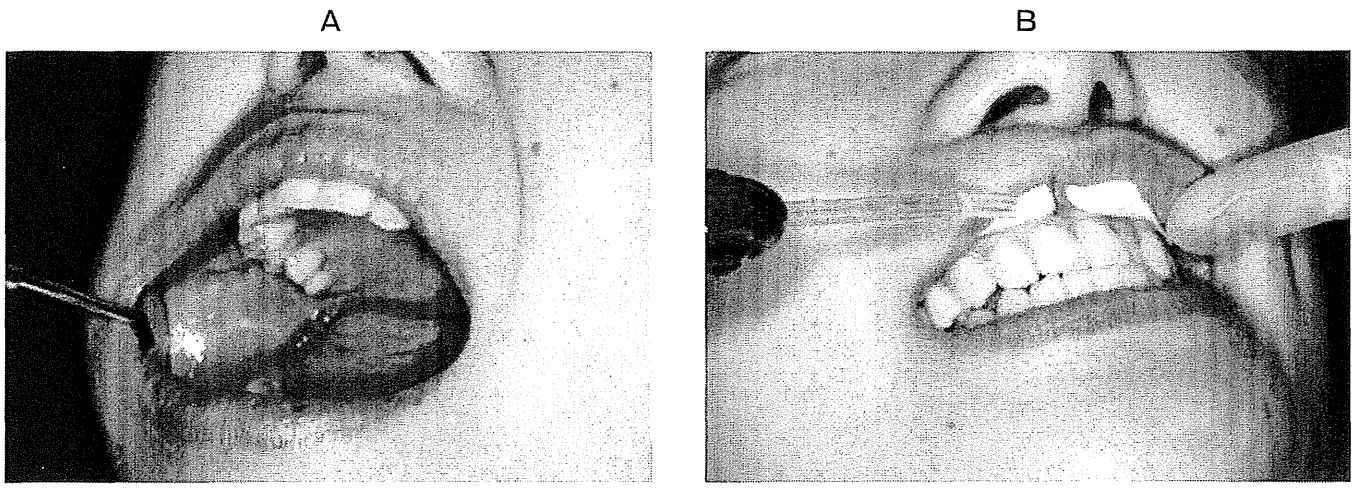

Fig. 1 Illustration of the two procedures
A : Exclusion of buccal mucosa using a dental mirror
B : Removal of cotton rolls from the gingivobuccal fold.

discomfort is reduced by these techniques or not. It is also unclear whether implementation of these techniques also makes dental treatment easier for the dentist or dental hygienist. Techniques that improve patient comfort are undesirable if they cause the operator significant distress. Therefore, good techniques would improve the comfort of both patients and operators.

Saliva plays important roles in digestion, antibacterial and buffering actions, lubrication, and protection of the oral mucosa(1, 2). In hyposalivation patients, the oral mucosa is easily damaged(3), and discomfort or pain may occur. It is possible that the degree of discomfort and salivary volume are correlated. If moistening techniques are effective to even normal salivation patients, it should be implemented for hyposalivation patients as well.

The purpose of this study was to evaluate the effects of moistening techniques on the process of dental treatment. This study was carried out to clarify three points: (i) whether the salivary volume affects the level of discomfort in two dental procedures; (ii) whether a moistened/dry dental mirror or dental cotton roll affects the level of subjects' discomfort; (iii) whether these two techniques are useful for both patients and dentists or dental hygienists during dental treatment.

Materials and Methods

Subjects

The subjects were 38 students (one man, 37 women, 20.9 ± 0.2 years old) whose salivary volume was more than 2g in a Saxon test. They were third year students of the Department of Oral Health and Welfare, Faculty of Dentistry Niigata University. This study was approved by the Ethics Committee of the Faculty of Dentistry of Niigata University (21-R26-10-02).

Methods

Measurement was accomplished between 14:00 and 15:00 hours in the middle of December, to standardize for the effects of the circadian rhythm (1) and climate (2). The students were divided into small groups consisting of two or three subjects. Each of them played the role of both subject and operator by rotation. First, the Saxon test was performed to measure the volume of stimulated saliva(3).

Next, an instructor (K.I.) demonstrated the methods for the two procedures. After the students had watched the demonstration, the subjects were in the supine on the dental chair and the two procedures were implemented under both dry and moistened conditions. First, the buccal mucosa was excluded with a dry surface dental mirror for 5 seconds (Fig. 1-A), after which the mirror was removed. Next, the same procedure was performed using a moistened mirror (mirror removal procedure). The other procedure was removal of a dental cotton roll from the gingivobuccal fold (cotton roll removal procedure). Two cotton rolls were placed in the upper anterior gingivobuccal fold bilaterally for 30 seconds. One cotton roll was removed as it was with forceps and the other was moistened before removal with a three way syringe(Fig. 1-B). The subject's comfort was evaluated on a

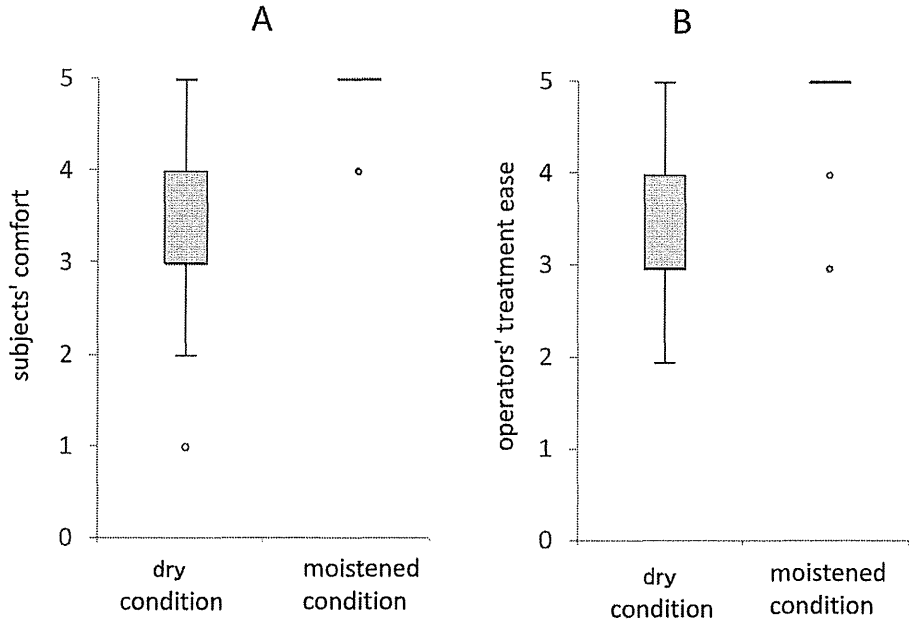

Fig. 2 Comparison of the moistened or dry conditions in the mirror removal procedure
A : The subjects' comfort
B : The operators' treatment ease
Circles show outliers.

five point scale (1, uncomfortable; 2, slightly uncomfortable; 3, average, 4: somewhat comfortable, 5: comfortable). The ease of treatment for the operator was also evaluated on a five point scale (1, difficult; 2, slightly difficult; 3, of average difficulty; 4, somewhat easy; 5, easy).

Data Analysis

As all variables were not normally distributed, non-parametric analyses were used. To examine the relationship between the salivary volume and the subjects' comfort or the operators' treatment ease during the two procedures, Spearman coefficients were used. To compare the moistened with the dry condition, the Wilcoxon signed ranks test was used. In addition, to examine the relationship between the subjects' comfort and the operators' ease of treatment, Spearman coefficients were used. The statistical software used was SPSS16.0, and statistically significance was set at $P < 0.05$.

Results

Salivary volume and the subjects' comfort and operators' ease of treatment

The mean weight of the Saxon tests was 4.64 ± 1.30 g. There was no significant correlation between stimulated salivary volume and either the subjects' comfort or the operators' treatment ease in the mirror removal procedure under dry conditions ($r = 0.04$, $r = 0.02$, respectively). Moreover, there was no significant correlation between stimulated salivary volume and either the subjects' comfort or the operators' treatment ease in the cotton roll removal procedure without moistening ($r = 0.15$, $r = 0.07$, respectively).

Comparison of the moistened and dry conditions in the two procedures

The mean rating for the subjects' comfort in the mirror removal procedure was 3.3 ± 1.0 for the dry condition and 4.7 ± 0.4 for the moistened condition, with the mean rating being significantly greater for the moistened condition ($P < 0.01$, Fig. 2-A). The operators' treatment ease was rated 3.3 ± 0.9 for the dry condition and 4.7 ± 0.6 for the moistened condition, with the mean rating being significantly greater for the moistened condition ($P < 0.01$, Fig. 2-B).

The mean rating for the subjects' comfort for the cotton roll removal procedure was 4.5 ± 0.9 for the moistened condition and 2.1 ± 0.7 for the dry condition, with the mean rating being significantly greater for the moistened condition ($P < 0.01$, Fig. 3-A). The mean rating for operators' treatment ease was 4.8 ± 0.4 for the moistened condition

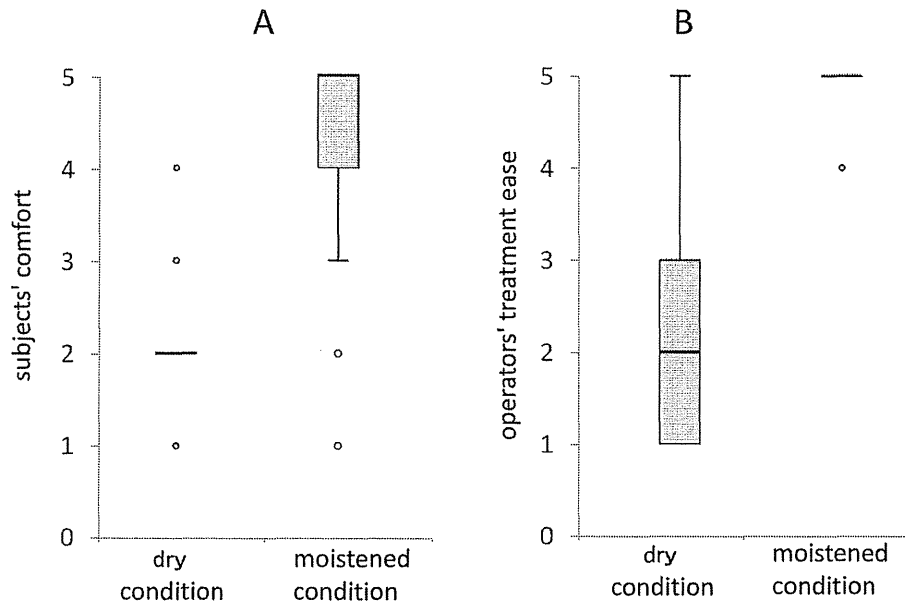

Fig. 3 Comparison of the moistened and dry conditions in the cotton roll removal procedure
A : The subjects' comfort
B : The operators' treatment ease
Circles show outliers.

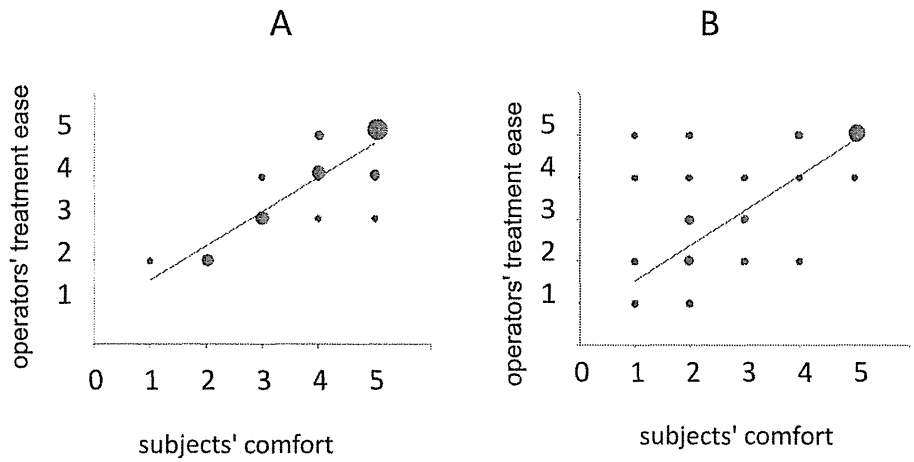

Fig.4 Comparison of the subjects' comfort and the operators' treatment ease
A : The mirror removal procedure
B : The cotton ball removal procedure

and 2.2±1.2 for the dry condition, with the mean rating being significantly greater for the moistened condition ($P<0.01$, Fig. 3-B).

Correlation between the subjects' comfort and the operators' ease

There was a significant strongly positive correlation between the subjects' comfort and the operators' ease for both the mirror removal ($r=0.79$, $P<0.01$, Fig. 4-A) and the cotton roll removal procedures ($r=0.77$, $P<0.01$, Fig. 4-B).

Discussion

Although all participants in this study had normal salivation, comfort was significantly increased by moistening in both the mirror and cotton roll removal procedures. It

is known that discomfort and pain are easily produced due to hyposalivation. Therefore, using moistening techniques in these procedures may make them more comfortable for hyposalivation patients.

Special consideration is necessary in dental treatment of hyposalivation patients. There is empirical evidence that amalgam is the most successful restorative material for these patients because bonded materials appear to fail at a higher rate and self-curing glass ionomers fail in a dehydrated environment(4). However, there have been no articles concerning treatment techniques except a sentence that the buccal mucosa will stick to a mirror(4).

Before this study, we expected to find a positive correlation between the salivary volume and the subjects' comfort in the two procedures. However, there was no statistically significant difference. It has been reported that saliva moves like a film in the mouth (5). Dawes et al. revealed that the speed of movement of this salivary film is 0.8mm/min in the upper-anterior buccal region and 8.0 mm/min in the lower -anterior lingual region, the velocity differing between these regions(6). In the present research, the subject was in the supine position in the dental chair and the buccal mucosa was excluded near the angle of the mouth. Therefore, under the influence of gravity, most of the parotid saliva might have flowed towards the posterior portion and away from the mirror, resulting in little saliva being in the region of the mirror. In addition, the cotton rolls were inserted into the upper anterior gingivobuccal fold. The velocity of the salivary film in this region might be slower in the upright position than in the dorsal position. These factors may account for the lack of correlation between the subjects' comfort and the salivary volume during the two procedures.

During dental treatment, exclusion of the buccal mucosa with a dental mirror and insertion of dental cotton rolls into the gingivobuccal fold to absorb moisture are frequently performed. Therefore, if the techniques described here need additional steps and have no merit, they would be stressful for the operator. However, this study revealed that not only moistening techniques brought the subjects' comfort and operators' ease but, also they exhibited a positive correlation. In other words, the techniques that are gentler for the subjects are also gentler for the operator. These results suggest that these techniques are useful not only in those with normal salivation, but also in patients with hyposalivation.

However, the present study did have two limitations. First, the subjects were all healthy students. Future studies that include patients with hyposalivation are necessary. Second, the study procedure was neither randomized nor blinded. We chose a simple design because this was a student project and its main purpose was for the participating students to experience the degree of comfort/discomfort that patients might feel. In future studies, a randomized and blinded design should be used.

It is strongly recommended that dentists and dental hygienists use these techniques for all patients to the benefit of both patient and operator.

Conclusion

When using dental instruments and removing cotton rolls and gauze, moistening of the materials used increases both subjects' comfort and operators' treatment ease in healthy subjects.

Acknowledgments

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Lecture

解説

誤嚥性肺炎と口腔ケア*

山下喜久**

Key Words : aspiration pneumonia, oral health care, elderly

はじめに

多くの先進国では平均寿命が顕著に延伸する一方で出生率が低下しており，その結果として社会の少子高齢化が急速に進行している．特に日本の高齢化率は諸外国に比較して群を抜いた速さで上昇しており，2055年には65歳以上の高齢者の割合が全人口の40％を超えた「超高齢者社会」を迎えるという．このような高齢化率の上昇の問題に加えて，団塊世代が生産年齢人口から高齢者群に移行することで，単に高齢化率が上昇するだけではなく，高齢者人口の実数が現在よりも1,400万人近く増加することが予測されている．このような少子高齢化社会の到来は，現行の年金制度や医療制度ではほとんど想定されておらず，従来の社会保障制度では高齢者の生活や健康を今後支えきれなくなることがわが国の重要な政治問題となっており，増税に対する賛否両論の意見が日々新聞の紙面を賑わしている．2003年から施行されている健康増進法では，国民自身に自らの健康の維持増進の責務を課しているが，このような時代背景の中，今後高齢者といえども健康維持についての自己責任が少なからず求められることになると思われる．一方，平成21年度の厚生労働省の統計データをみると，65～84歳までの死亡原因は第1位悪性新生物，第2位心疾患，第3位脳血管疾患，第4位肺炎であるが，85歳を超えると肺炎は脳血管疾患を抜いて第3位，さらに90歳を超えると第2位となり，年齢が進むごとに肺炎による死亡の割合が増加している．このような肺炎による死亡者の88％は75歳以上の高齢者であり，高齢者の健康管理に感染症，特に肺炎への対策が急務となっている．近年，高齢者の肺炎に関しては口腔のケアによってそのリスクが低減できることが多くの研究で示されており[1)2)]，わが国のこれからの健康問題を考える上で口腔ケアが重要な意味を持つ．

誤嚥性肺炎と口腔細菌

1．高齢者の肺炎

高齢者では，脳卒中，全身麻痺などによって咳反射や嚥下反射が低下し，本人が自覚しない状態で咽頭部および口腔内の細菌が唾液や食塊とともに肺に流れ込む不顕性誤嚥を起こすリスクが高くなる[1)]．特に身体活動性が低下した寝たきりの高齢者ではそのリスクがより一層高まる．口腔・咽頭細菌叢を構成する細菌種が気管支や肺胞を不顕性誤嚥によって持続的に汚染することで発症するのが誤嚥性肺炎であり，高齢者の肺炎の多くは誤嚥性肺炎といわれている．市中肺炎の起炎菌が口咽頭部に定着している場合には肺炎をひき起こすリスクが当然高いが，歯周病の患者では歯周病菌が誤嚥によって肺に到達し肺炎をひき起こすことが考えられている．事実，697名の80歳の被験者の5年間の追跡調査の

* Aspiration pneumonia and oral health care.

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結果，10歯以上に4 mm以上の歯周ポケットがある者では，歯周ポケットが9歯以下の者に比べて肺炎による死亡率が3.9倍高いという報告がある[3]．さらに，通常は病原性を示さない口腔・咽頭部の常在細菌でも体力や免疫能の低下した高齢者に対して日和見病原体となって肺炎をひき起こすこともある．誤嚥には胃液などの消化液が食べ物とともに食道を逆流して肺に到達する場合もあり，胃瘻などの経管栄養摂取を受けていて口から食べ物を摂取していない場合でも誤嚥による肺炎が起こる可能性がある点にも注意を要する．

2．高齢者の肺炎と口腔細菌

これまでに，口腔細菌が誤嚥性肺炎に関与していることは多くの研究者が報告しており[4)~6)]，口腔細菌の中でも歯周病原性菌などいくつかの特徴的な細菌種が誤嚥性肺炎の起炎菌として注目されてきた．しかし，これらの細菌種の病原性は多様であり，また，その菌量や宿主の健康状態によってもその病原性が大きく左右されることが考えられるため，誤嚥性肺炎の明らかな原因菌として特定されるに至っていない．口腔細菌が誤嚥によって肺に到達することで誤嚥性肺炎が発症することは，誰しもが考えつくことであるが，全身状態が不安定な高齢者における誤嚥性肺炎の起炎菌を単一菌種に特定することはそれほど容易ではない．また，全身や口腔の健康状態が多様な高齢者では，誤嚥性肺炎と口腔細菌との関連性を調べるにあたって，全身疾患や口腔状態などの細菌種以外の複数の交絡因子を加味した多変量解析が必要であると考えられる．

Terpenningら[7)]は唾液中の*Staphylococcus aureus*，*Porphyromonas gingivalis*および*Streptococcus sobrinus*の存在が誤嚥性肺炎に関係していることを報告している．この研究では外来患者，入院患者ならびに高齢者施設入居者358人の生活習慣，全身疾患，口腔状態および口腔細菌を調べ，これらのパラメーターを加えた多変量ロジスティック回帰分析を行っている．しかしながら，その際に調べられた細菌種の数はごく限られており，しかもこれらの細菌種選択の根拠も明らかではないことから，口腔細菌叢の全体像と肺炎の関連性を同様の研究で調べる必要がある．

われわれは口腔細菌叢の全体像を把握することが口腔の健康を評価する上で有用であることを報告してきた．歯科の2大疾患である齲蝕や歯周炎は特定の細菌種を起因菌として発症すると考えられてきたが，その病因論は必ずしも明確にされていない．口腔内には齲蝕や歯周病の原因菌と想定される細菌種のほかにも莫大な種類と量の細菌種が存在しており，それらの細菌種間の相互関係が各個人の口腔疾患に対する感受性に影響を与えていると考えられる．これまでは口腔細菌叢を網羅的に検索する手法が確立されておらず，口腔細菌叢の全体像と口腔の健康の関連性を調べることは容易ではなかった．しかし近年，細菌の16S ribosomal RNA遺伝子の塩基配列の解析をベースにして培養によらない分子生物学的手法が用いられるようになって，ヒト口腔からは700種を超える細菌種が同定されている[8)]．

分子生物学的手法の中には簡便に環境中の複雑な細菌群集を比較することができるterminal restriction fragment length polymorphism（T-RFLP）法があるが，従来のT-RFLP法ではDNA断片のサイズの計測精度が低いため，T-RFLP法単独で細菌種を正確に同定することは難しかった．そこで，われわれはT-RFLP法のサイズ定義を改良して，DNA断片の測定精度を向上させた[9)]．この改良T-RFLP法を用いて唾液中の細菌種構成を解析した結果，歯周炎患者や口臭の強い患者の唾液中には*Prevotella*属および*Veillonella*属が有意に優勢であり，本法が臨床評価に有用であることを明らかにしている[10)11)]．また，われわれの改良T-RFLP法の精度が高いことはパイロシーケンス法による口臭患者の唾液中の細菌種構成の再解析を行った結果でも確認されている[12)]．

われわれはこの改良T-RFLP法を用いて65歳以上の病院あるいは高齢者施設の入所者343人（平均年齢85.8±7.4，男性85人，女性258人）を対象として舌苔細菌叢と肺炎および発熱との関連性の解明を試みた[13)]．肺炎の発症については口腔診査後の6か月間の追跡を行ったところ追跡期間中に35人が肺炎を発症し，その中の11人が死亡した．6か月の追跡期間中に21人が施設を出所し，23人が肺炎を含むなんらかの原因で死亡したた

表1　診査項目と肺炎および発熱日数との関連性

診査項目	肺炎	発熱日数
	ハザード比 (95%信頼区間)	オッズ比 (95%信頼区間)
クラスター		
A	1	1
B	2.7(0.6～12.6)	10.5(2.0～55.5)**
C	4.0(1.1～15.1)*	4.4(1.1～17.8)*
D	4.9(1.2～21.1)*	11.6(2.3～57.8)**
舌苔		
なし・少量	1	1
中等量・多量	3.2(1.4～7.3)**	3.7(1.4～9.6)**
舌の湿潤度		
5.0mm以上	1	1
1.0～4.9mm	2.9(1.1～8.0)*	2.7(1.0～7.3)*
1.0mm未満	7.9(2.8～22.4)**	10.3(2.9～36.4)**
身体活動レベル		
歩行可	1	1
車椅子使用	2.6(0.7～10.1)	4.6(0.8～25.3)
寝たきり	1.3(0.3～6.4)	6.7(1.1～39.4)*
嚥下障害		
なし	1	1
軽度	1.4(0.5～3.9)	1.5(0.5～4.1)
重度	7.0(1.7～28.9)**	9.5(2.1～42.9)**
抗菌薬の使用		
0	1	1
1～4日	2.7(0.9～8.2)	4.0(1.1～15.1)
5日以上	2.8(1.0～7.5)*	3.6(0.8～15.6)

ハザード比はCox比例ハザード回帰分析を用いて算出した．オッズ比は多重ロジスティック回帰分析を用いて算出した．* $P<0.05$, ** $P<0.01$

め，残る299人について，口腔診査の前後6か月の計1年間の発熱日数(37.5℃以上が9日以下，あるいは10日以上)を調査した．その結果16項目の口腔および全身に関する診査項目の中で，舌苔の細菌叢，舌の乾燥，義歯の使用，身体的活動の低下，認知症，嚥下困難，抗生物質の使用が肺炎発症および発熱日数に有意な関連性を示した．改良T-RFLP法で解析した舌苔の細菌叢は表1に示すようにクラスターA, B, C, Dの4つに分類された．Cox比例ハザード回帰分析で追跡期間中の6か月間の肺炎頻度のハザード比を比較したところ，クラスターAに対し，クラスターC, Dが他の交絡因子(舌の乾燥，嚥下困難，身体的活動レベルおよび義歯の使用など)と独立して有意に高値を示した．クラスターBはクラスターAに比べて肺炎の発症頻度は高い傾向にあったが，統計的な有意差は認められなかった．また，クラスターA, B, C, D群の肺炎による死亡率は，それぞれ，17%，60%，50%および100%であり，全死亡数が少ないため，統計的有意差を示すことはできなかったが，他のクラスターに比べてクラスターAの肺炎発症頻度が低いという結果と一致していた．さらに，発熱日数についても多重ロジスティック回帰分析を用いてオッズ比を比較したところ，クラスターAに比べてクラスターB, C, Dの3つのクラスターはいずれも有意に高い値を示した．

そこで，各クラスターの特徴となるTRFsに割り振られる細菌種の特徴を調べたところ，クラスターAでは*Streptococcus*属と*Rothia*属が，クラスターC, Dでは*Prevotella*属，*Veillonella*属，*Treponema*属が他のクラスターに比較して優位であった．さらに，クラスターC, Dに限ってこの2つのクラスターの相違をみると，クラスターDでは*Neisseria*属，*Haemophilus*属，*Aggregatibacter*属の存在がクラスターCに比べてより優位であったが，2つのクラスター間では高齢者の肺炎関連疾患に大きな差が認められなかったことから，肺炎関連疾患についてこれらのクラスターを分類する意味は今のところ不明である．また，クラスターC, Dのいずれにも肺炎の起因菌として通常あげられている細菌種の偏在を検出することはできなかった．*Prevotella*属，*Veillonella*属および*Treponema*属が高齢者の肺炎発症や発熱にどのような役割を果たしているのかについては今のところ明らかではないが，これらの細菌が優位な舌苔では，肺炎を発症しやすく，反対に，*Streptococcus*属と*Rothia*属が優位な舌苔では肺炎を発症し難いことが本研究の結果で示された．すなわち，高齢者の健康管理を行う上で，口腔細菌叢の分析が有益な情報をもたらし，健康な口腔細菌叢を維持する上で有用なガイドラインとなることが期待される．

高齢者の肺炎に対する口腔ケアの予防効果

1．口腔ケア

前述のように口腔細菌が誤嚥性肺炎に強く関連するのであれば，口腔ケアによって口腔細菌の量をコントロールすることで，誤嚥性肺炎が

予防できると考えるのが必然である．実際，米国CDC(Centers for Disease Control and Prevention)の医療ケア関連肺炎防止のガイドラインでも口腔ケアに関連する口腔咽頭部の機械的清掃や消毒剤による清掃が推奨されている[14]．しかし，その一方で口腔ケアには統一された定義がなく，医療現場のそれぞれの立場でそのとらえられ方もまちまちである．さらに，この「口腔ケア」という用語が商標登録(出頭/登録番号：登録4568672)されるに至っては，「口腔ケア」に学術的な意味づけを行うことすら躊躇される．しかし，患者の治療を中心とした疾病思考のキュアに対するケアの理念を口腔保健に持ち込んだ意義はきわめて重要であり，口腔ケアには特定の個人の思惑を超えた多くの医療関係者の心が託された用語であることから，この小論ではあえて口腔ケアの用語を用いて高齢者の肺炎と口腔ケアの関連性を考察したい．

口腔ケアは大別すると口腔清掃を中心とした狭義の意味で用いられる場合と摂食，嚥下，構音などの口腔機能の維持や回復をも含めた，より広い意味で用いられる場合がある．単純に考えれば肺炎には前者に関連する口腔衛生状態が主に関係しており，後者を構成する口腔機能が肺炎の発症に大きく影響することは考え難いが，高齢者の肺炎では主に誤嚥性肺炎が中心であることを考えると嚥下機能などの口腔機能が無視できないことが容易に理解できる．

2. 口腔清掃と高齢者の肺炎の予防

まず，始めに口腔衛生状態の改善が肺炎の発症に及ぼす影響について考えてみたい．一口に口腔清掃といってもこれの意味するところは単純ではない．歯科医療で齲蝕と歯周疾患を防ぐために実施する口腔ケアでは，歯面に付着するバイオフィルムとしてのデンタルプラークを除去することが第一義的な目標となる．齲蝕を予防する意味で歯面から酸産生菌を含めてバイオフィルムを除去することは現場に犯人を近づけないことにほかならず，まったく理に適った齲蝕予防方法である．歯ブラシが到達できない歯と歯の隙間の清掃にはデンタルフロスや歯間ブラシを適宜用いることで補完することができるが，本人だけのセルフケアではどうしても限界があるため，近年では歯科医療従事者による定期的なプロフェッショナルケアが推奨されている．また，フッ化物配合の歯磨き剤による歯質の再石灰化強化も齲蝕予防の口腔ケアに重要な役割を演じている．歯周病に関しても歯と歯茎の境目のデンタルプラークの除去が重要となる．近年，原因除去を主な目的として毛先を使った方法(主としてスクラッビング法)が趨勢となっているが，かつては歯茎のマッサージも兼ねて毛の脇腹を使ったローリング法が主流であり，テレビのコマーシャルなどで紹介されていたことを年配の方はご記憶されているのではないだろうか．著者は歯面の清掃だけに注目する現代の歯周予防のためのブラッシング法の考え方に若干の疑問を抱いているが，現在は齲蝕，歯周病の予防はいずれも基本的に歯面のデンタルプラークの除去を目標として実施されている．全身状態に特に問題を抱えていない患者を扱う歯科医院での口腔ケアの概念は正にこのような考え方に基づいている．

一方で，口腔ケアが高齢者の肺炎の発症頻度を減少させることを示す多くの報告では口腔清掃は単に歯面のデンタルプラークの除去だけでなく，歯茎や舌背あるいは咽頭頬粘膜などの機械的清掃に加えて，グルコン酸クロールヘキシジンやイソジンなどの消毒剤による化学的清掃による広範な口腔清掃による口腔ケアが実施されており[1]，歯面の清掃だけでは肺炎の予防には十分ではないと思われる．唾液中の細菌種の構成は歯面に生息する細菌種よりむしろ舌背などの軟組織の粘膜の細菌種を反映していることが報告されており[15][16]，誤嚥性肺炎を考える上では歯科医療で主に対処してきた歯面のプラークよりもむしろ軟組織に定着する細菌叢の状態(量と質)を改善することがより大切である可能性が高い．しかし，軟組織の機械的清掃については歯ブラシを用いた例や清掃用のスポンジを用いた例が報告されているが，軟組織の損傷の回避と清掃効果の向上という背反する要求を満たす必要があり，科学的な根拠に立脚した確実な方法は確立されていない．今後はより安全で，効果的な軟組織の効果的な清掃方法の確立が待たれる．

表2 嚥下訓練方法の分類

訓練の分類	嚥下訓練方法	備考
間接的訓練	口すぼめ呼吸・ストロー呼吸	口の前20～30cmの位置にあるロウソクの炎を消すような気持ちで口をすぼめて息を吐き出させる．肺機能，鼻咽腔の閉鎖機能の強化に役立ち口唇の訓練にもなる．ストローを使って吸ったり吐いたりするストロー呼吸も効果がある
	咳をする練習	食物が咽頭や気管に誤嚥したときに有効に咳をして異物を吐き出すための訓練．腹部に手を置き腹筋を使い勢いよく一気に咳をする．腹筋の強化，声門，軟口蓋の強化に役立つ．食事をする前にいつも数回咳をする習慣をつける
	押し出し運動	上肢に力を入れると胸郭が固定され声門が閉鎖され呼吸が停止し，力を抜くと声門が開いて一気に呼気が出る．椅子に腰掛けて両手で椅子を「押し」ながら体を持ち上げるようにする．声門の閉鎖機能，軟口蓋の筋力強化に役立つ．力を抜くときに勢いよく呼気が出るので，咽頭に食物が残留しているときに行うとその排泄に有効である
	口唇，頬，舌の運動・マッサージ・ブラッシング・リラクゼーション	口に空気をためて頬を膨らませたり引っ込めたりする．できるだけ長く口の中に空気を保つ．口腔内に空気を保つことは鼻咽腔の閉鎖機能の強化に役立つ．マッサージや歯ブラシによるブラッシングも筋肉のリラクゼーションや知覚刺激になり嚥下に好影響を与える
	嚥下体操	嚥下体操は誤嚥の予防につながる．全身や前頸筋群，舌に関与する首を中心とした筋肉をリラックスさせる目的で行う．食事の前に2,3分行うだけで効果がある
直接的訓練	嚥下パターン訓練(supraglottic swallow)	吸気し，呼吸を止め，胸腔内を陽圧にすることで，気管内への侵入を予防したうえで，唾液または空気を飲み込む．この際，反射が障害されていれば少量の(2 ml程度)水を口腔前庭に滴下してから嚥下する．嚥下後，間を置かず，咳嗽させる．このパターンを繰り返す．これにより，嚥下と呼吸の協調性を増すことができる
	のどのアイスマッサージ	凍った綿棒に少量の水をつけて，軟口蓋や舌根部を軽く2,3回刺激した後，すぐに空嚥下をさせる．嚥下反射は，綿棒による機械的(物理的)刺激，水の化学的刺激，氷による温度刺激の相乗作用で誘発されやすくなる．摂食訓練の前や，食間に空嚥下の練習をするときに併用する．空嚥下と併用すると効果的である
	氷なめ	氷をなめると，少量の冷たい水が刺激となって嚥下反射が誘発されやすい．嚥下反射を誘発させるのが目的であり，誤嚥が多いときは避けるべきである

3．嚥下機能の回復による高齢者の肺炎予防の可能性

嚥下機能が誤嚥性肺炎に強く関連することに関しては，昨年優れたメタアナリシスが報告されている[17]．このメタアナリシスでは，始めに2000年1月～2009年4月までに脆弱高齢者の誤嚥性肺炎のリスク因子に関して英文で報告された論文の中から嚥下障害が誤嚥性肺炎に関連すると報告している9つの研究を選び，この中から未調整のオッズ比が入手できる6つについてサマリーオッズ比を計算している．これらの研究には均質性があると認められなかったためDerSimonian-Laired法でサマリーオッズ比を計算したところ，9.84(95%信頼区間：4.15～23.33)であった．一方で，研究に有意な均質性が認められる4つの研究結果に絞ってMantel-Haenszel法でサマリーオッズ比を計算すると12.93(95%信頼区間：8.61～19.44)とより高いオッズ比が得られている．これらの結果から嚥下障害が誤嚥性肺炎のリスクであることには疑いの余地はない．

これらの文献で扱われている嚥下障害の多くの原因が脳卒中であることから，脳卒中以外の原因で生じる嚥下障害も誤嚥性肺炎のリスクといえるか否かについては研究の余地が残されていることが指摘されている．しかし，嚥下機能の回復が誤嚥性肺炎の予防として有効であることには衆目の一致するところであろう．とは言っても嚥下機能の回復はさほど簡単なことではなく，十分な科学的根拠に基づく嚥下機能の回復法が現時点ではそれほど多くない．現状で嚥下障害のある患者，特に寝たきりの状態にある者に最も効果的と思われる事項は摂食時の姿勢に

注意することである．寝たきりの高齢者が誤嚥しにくい体位として垂直座位で頸部前屈の姿勢が奨められている[18][19]．垂直座位にすることで食塊を積極的に嚥下しなければ不意に咽頭に落ちることはなく，嚥下できない食塊は口腔外に落ちるため，誤嚥のリスクが低下する．さらに，頸部前屈位を取ることで食塊の通路が広がるのに対し咽頭と気管の通路が狭くなることで誤嚥を予防できる．また，嚥下障害に対する嚥下訓練開始時の体位として30度仰臥位における頸部前屈姿勢が推奨されている[20]．理由としては，嚥下障害がある場合には垂直座位ではほとんど食塊を送り込めないこと，咽頭期が障害されている場合は嚥下反射遅延のため垂直座位では嚥下反射前の誤嚥が起こりやすいことに加えて垂直座位では顔が下を向いて食事介助が困難なことがあげられる．

嚥下機能の回復を目指す訓練方法は表2に示すように間接的訓練と直接的訓練に大別される[19]．間接的訓練では嚥下に必要な基礎機能の向上が安全に得られるが，これだけでは嚥下機能は望めない．実際の嚥下機能の向上を図るためには直接的訓練が必要であるが，誤嚥のリスクがあることに留意する必要がある．また，機能回復という点では嚥下機能に直接関係はしないが口腔ケアの機械的刺激が咳嗽反射に影響するという興味深い報告がある[21]．この報告では施設に入居した高齢者59名(30名が介入群，-29名が対照群)を対象として介入群に毎食後介助者による機械的口腔清掃を1か月間行ったところ，介入群ではクエン酸に対する咳嗽反射がベースラインに比較して有意に上昇しており，口腔ケアの機械的刺激がさまざまな口腔機能の回復に影響を与えることで誤嚥性肺炎の予防につながっていることが考えられる．

また，在宅療養高齢者(288名：男性76名，女性212名，平均年齢84.2歳)について口腔の健康状態と生活機能との関係をパス解析で評価した最近のわれわれの研究(未発表データ)では，歯の数が20本以下で義歯を使用していない者では嚥下機能を直接低下させることで栄養摂取障害を起こし，ひいては日常生活能力の低下につながる可能性が示唆されている．また，施設入居高齢者を対象とした研究では，経管栄養者の口腔細菌叢が経口栄養摂取者と比べ著しく破綻して日和見感染の原因菌が極端な比率で増殖していることを認めており，口から食事をする日常の何気ない生活行動そのものが健康の維持にいかに大きな意味を持っているかを明らかにした[22]．すなわち，誤嚥性肺炎の主要な要因である嚥下障害を予防するためには，日常の口腔ケアで歯を健康に保ち，高齢者になっても自分の歯で食事をすることが大切であるといえる．しっかりと自分の歯で食事をすることが健康の第一歩であることを肝に銘じたい．

おわりに

本稿ではまず始めに高齢者の健康に大きく影響を与える誤嚥性肺炎と口腔細菌との関連性を考察した．従来，肺炎の発症については特定の病原細菌の有無に焦点を当てた議論が盛んに行われ，原因菌の探究が大きな研究の目標とされてきた．しかし，健康状態が必ずしも良好でない高齢者では，病原性の低い細菌が健康障害に与える影響も加味する必要がある．このような意味から，従来口腔疾患の予防を目的として行われてきた口腔ケアが高齢者の肺炎の予防に有効であるとの考えが確立されつつある．しかし，口腔ケアの考え方には場所や人によってとらえ方がかなり異なっており，肺炎を予防するために必要な口腔ケアが何かというコンセンサスは十分には確立されていない．本小論では，口腔のケアを狭義と広義の意味からとらえ，高齢者の肺炎の予防に必要な口腔ケアとは何かを基本に立ち返って考察し，口腔粘膜の清掃や嚥下機能の維持・回復が高齢者の肺炎予防に重要であることを示した．しかし，その一方で口腔ケアの効果を評価できる手法は十分ではなく，せっかくの予防処置も肺炎あるいは発熱の発症をエンドポイントとして評価せざるを得ない．誤嚥性肺炎予防に必要な口腔ケアのシステムを体系的に構築するためには，適切なサロゲートエンドポイントを設定し，口腔ケアの効果を迅速かつ客観的に評価する必要があり，その確立は今後の重要な課題である．

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Community Dent Oral Epidemiol

COMMUNITY DENTISTRY AND ORAL EPIDEMIOLOGY

Interrelationship of oral health status, swallowing function, nutritional status, and cognitive ability with activities of daily living in Japanese elderly people receiving home care services due to physical disabilities

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Abstract – *Objectives:* Malnutrition and cognitive impairment lead to declines in activities of daily living (ADL). Nutritional status and cognitive ability have been shown to correlate with oral health status and swallowing function. However, the complex relationship among the factors that affect decline in ADL is not understood. We examined direct and indirect relationships among oral health status, swallowing function, nutritional status, cognitive ability, and ADL in Japanese elderly people living at home and receiving home care services because of physical disabilities. *Methods:* Participants were 286 subjects aged 60 years and older (mean age, 84.5 ± 7.9 years) living at home and receiving home care services. Oral health status (the number of teeth and wearing dentures) was assessed, and swallowing function was examined using cervical auscultation. Additionally, ADL, cognitive ability, and nutritional status were assessed using the Barthel Index, the Clinical Dementia Rating Scale, and the Mini Nutritional Assessment-Short Form, respectively. Path analysis was used to test pathways from these factors to ADL. *Results:* The mean number of teeth present in the participants was 8.6 ± 9.9 (edentates, 40.6%). Dysphagia, malnutrition, and severe cognitive impairment were found in 31.1%, 14.0%, and 21.3% of the participants, respectively. Path analysis indicated that poor oral health status and cognitive impairment had a direct effect on denture wearing, and the consequent dysphagia, in addition to cognitive impairment, was positively associated with malnutrition. Malnutrition as well as dysphagia and cognitive impairment directly limited ADL. *Conclusions:* A lower number of teeth are positively related to swallowing dysfunction, whereas denture wearing contributes to recovery of swallowing function. Dysphagia, cognitive

Key words: activities of daily living; cognitive ability; elderly people with physical disabilities; nutritional status; oral health status

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impairment, and malnutrition directly and indirectly decreased ADL in elderly people living at home and receiving home nursing care. The findings suggest that preventing tooth loss and encouraging denture wearing when teeth are lost may indirectly contribute to maintaining or improving ADL, mediated by recovery of swallowing function and nutritional status.

In almost every country, the proportion of older people is increasing relative to younger age groups (1). Especially in Japan, the population is aging rapidly because of dramatic reductions in early mortality and declines in fertility. Indeed, the population aged 65 years old and older in Japan accounts for 23% of the total population in 2011 (2), and this percentage is the highest in the world. As the number of elderly people increases, so does the number of those requiring long-term nursing care, such as those who are bedridden and suffering from dementia (3).

Since 2000, nursing services supporting the daily lives of elderly individuals who require long-term care because of physical disability have been provided through the social insurance system enacted in Long-term Care Insurance Act in Japan (4). In this system, applicants for services are classified into five grades according to the severity of their physical disability, and the amount of nursing care service provided is determined by grade (5). The number of elderly receiving long-term care based on this act was about 4 million in 2010 according to a report by Japanese Ministry of Health, Labour and Welfare (6). Another report showed that 29% of elderly Japanese requiring long-term care deteriorated as measured by the grade of care service needed, and 23% of them died within 2 years (7). For elderly people receiving nursing care, further deterioration in their ability to conduct activities of daily living (ADL) such as bathing, dressing, and walking is an important concern.

Previous studies have suggested that malnutrition and cognitive impairment can lead to deterioration in ADL (8, 9), and malnutrition has been associated with cognitive impairment in elderly people (8). Moreover, nutrition and cognitive function have also been shown to correlate with oral health status (10, 11) and swallowing function (12, 13). However, these studies focused on direct relationships between bivariates. We need to also take into account that decline in ADL is affected by complex direct and indirect interactions among multiple factors. That is, it is not enough to analyze an association incorporating multiple factors as independent variables to show comprehensively how these risk factors affect deterioration in ADL.

Furthermore, most studies about the effects of oral condition on malnutrition and decline in ADL have been limited to elderly people in nursing homes and hospitals (11–13); few studies have examined these associations in elderly people living at home. In Japan, about 3 million people received home care services, and about 1 million people received facility services, such as at a nursing home, via long-term care insurance in 2010 (5, 14). In the United States, because of social trends toward reduced nursing home use, the number of disabled elderly people needing home care support has increased (15). Considering the growing number of aged people and the inevitable subsequent increase in the number who will require long-term nursing care in most developed countries, an increase in the number of elderly people requiring home care is expected to be a major issue in modern societies worldwide. Therefore, it is useful to investigate the many factors leading to a decline in ADL among elderly people living at home.

In the present study, we examined the direct and indirect effects of oral health status, including number of teeth and denture wearing, swallowing function, nutritional status, and cognitive ability, on ADL in Japanese elderly people living at home and receiving home care services because of physical disabilities. We hypothesized the following: (i) cognitive impairment leads to eating difficulties (e.g., difficulty chewing food, difficulty swallowing food), and these difficulties impair nutritional status (16); (ii) oral health status affects eating difficulties (17); (iii) cognitive impairment affects oral health status (18), or, conversely, oral health status affects cognitive impairment (19); (iv) cognitive impairment and malnutrition lead to a decline in ADL (9) (Fig. 1). The conceptual model was proposed, based on empirical evidence.

Materials and methods

Study setting and study population

This cross-sectional study was undertaken in two midsized municipalities in Fukuoka prefecture (western Japan) between November 2010 and

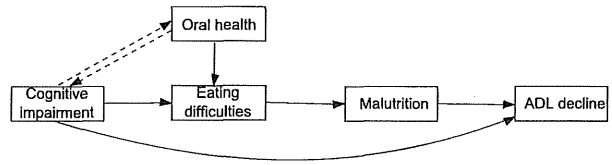

Fig. 1. The conceptual model. Dotted lines indicate paths explored the direction in this study.

February 2011. The study population comprised 337 participants aged 60 years or older who were living at home and using an in-home long-term care support center that coordinates home care services such as home nursing care, visiting rehabilitation, visiting bathing service, day service, and day care (rehabilitation) by service providers. Of these, 51 participants with missing data were excluded. Finally, 286 participants (75 men, 211 women) were included.

The study was approved by Kyushu University Institutional Review Board for Clinical Research. We obtained participants' or their family members' consent, as required for approval by the review board.

Assessment of oral health status and swallowing function

Oral health status and swallowing function were assessed by qualified dental hygienists. Oral health status was assessed by recording the number of teeth and denture wearing.

Swallowing function was examined by cervical auscultation, a non-invasive method of listening with a stethoscope to the sounds of swallowing 3 ml of water during the pharyngeal phase, following the method of Zenner et al. (20) with minor modifications. When breath sounds after swallowing material were clear, we evaluated swallowing function as normal. When stridor, coughing, or throat clearing was heard after swallowing material or when swallowing was repeated, we evaluated this as impaired swallowing function (i.e., dysphagia).

Measurement of ADL, cognitive ability, and nutritional status

Participant's ADL, cognitive ability, and nutritional status were recorded by a nurse or a care worker at the in-home long-term care support center. ADL was assessed using the Barthel Index, which covers all aspects of self-care independence in daily living activities such as transfer, walking stairs, toilet use, dressing, feeding, and bathing (21). A total score of 100 points indicates complete self-sufficiency, whereas a score of zero indicates that the person is completely dependent (21).

Cognitive ability was assessed using the Clinical Dementia Rating (CDR). CDR status was assigned according to the presence or absence of dementia and, if present, its severity (none, questionable or very mild, mild, moderate, or severe cognitive impairment), as described previously (22).

Nutritional status was evaluated using the Mini Nutritional Assessment-Short Form (MNA-SF) (23). The MNA-SF has the option of using calf circumference when body mass index is not available because of a bedridden and immobile state. Nutritional status was defined in three classifications by the MNA-SF: 0–7 points = malnourished; 8–11 points = at risk of malnutrition, and 12–14 points = well nourished.

Comorbid conditions

We assessed comorbidity with the Charlson comorbidity index (24, 25), which provides a weighted score for a participant's comorbidities taking into account how many of 19 predefined comorbid conditions an individual has, because elderly people generally live with multiple diseases, and the presence of comorbidities has a negative effect on both physical and cognitive function (26).

Statistical analysis

Bivariate associations between oral health status and swallowing function, nutritional status, cognitive ability, ADL, or confounding variables such as age, gender, and comorbid conditions were tested with the chi-square or ANOVA test. Oral health status was categorized as 20 or more teeth with dentures; 20 or more teeth without dentures; 10 to 19 teeth with dentures; 10 to 19 teeth without dentures; 0 to 9 teeth with dentures; or 0 to 9 teeth without dentures. A P value < 0.05 was considered to indicate statistical significance. The SPSS software (ver. 19.0 for Windows; IBM SPSS Japan, Tokyo, Japan) was used for data analyses.

To test the hypothesis, we conducted path analysis using the M-plus statistical package (27). Path analysis can be used instead of several separate regressions to examine mediating effects within a single model (28). Additionally, path analysis allows testing of causal relationships among a set

of observed variables (29). We tested the hypothesized model using path analysis (Fig. 2). The model examined the interactive effects of nine constructs. We hypothesized that cognitive ability and nutrition status directly affect ADL. We also hypothesized that the number of teeth, denture wearing, and cognitive ability precede swallowing function. Additionally, the number of teeth, denture wearing, and swallowing function precede nutrition status. Considering the association between cognitive ability and oral health status, it is possible that cognitive impairment affects oral health status (18) or, conversely, that oral health status affects cognitive impairment (19). We tested alternative path models each with different directionalities among the number of teeth, denture wearing, and cognitive ability. We adjusted for age, gender, and comorbid condition.

Data used in this study included both continuous and dichotomous variables. Thus, the path model was analyzed using weighted least-squares mean and variance adjustment estimation (WLSMV). WLSMV uses a diagonal weight matrix with robust standard errors and mean- and variance-adjusted chi-square test statistics (27). We used a significance level of $P < 0.05$ for the regression coefficients. The degree of correspondence between the hypothesized models and the actual data was assessed with a goodness-of-fit test. Criteria for the goodness-of-fit test include a comparative fit index (CFI), a Tucker-Lewis index (TLI), a root-mean-square error of approximation (RMSEA), and the weighted root-mean-square residual (WRMR). Values of >0.95 for the CFI, >0.95 for the TLI, <0.06 for the RMSEA, and <0.90 for the WRMR are considered to indicate a good fit of the data to the model (27) (30).

Statistical power was considered for this analysis. In path analysis, sample sizes of around 150 to 200 are more desirable (31). With an alpha level of 0.05 and 286 subjects, it is estimated that the statistical power for this study reached 0.95.

Results

The participants were 75 men and 211 women. The age of the study population ranged from 61 to 104, and the mean age ± SD was 84.5 ± 7.9 years (79.1 ± 7.9 years for men and 86.4 ± 6.9 years for women). The mean number of teeth present was 8.6 ± 9.9, and 40.6% of participants were edentulous, while the mean number of teeth present was 14.4 ± 8.9 in 170 dentate subjects. The proportion of participants who did not visit a dental clinic was 75.9%.

Activities of daily living, cognitive ability, and nutritional status according to different categories of oral health status (including number of teeth, denture wearing), and swallowing function are presented in Tables 1 and 2. Subjects having 0 to 19 teeth and no dentures showed lower levels of ADL, cognitive function, and nutritional status than did those who had more than 20 teeth or who wore dentures. Subjects with dysphagia had lower ADL, more severe cognitive impairment, and more malnutrition than those with normal swallowing (Table 3).

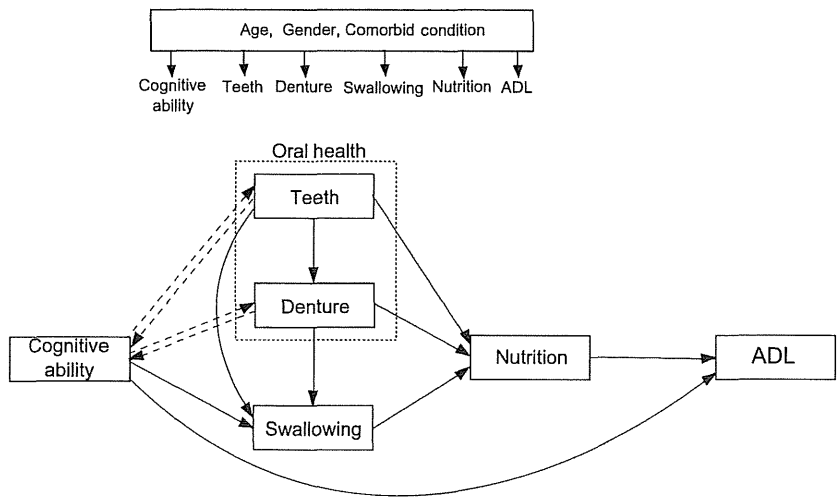

Fig. 2. The hypothesized model. The model consists of nine observed variables including confounding variables such as age, gender and comorbid conditions. Dotted lines indicate paths explored the direction in this study.

Table 1. Functional ability, cognitive function, and nutritional status according to the number of teeth [*n* (%)]

Variable	0–9 teeth (n = 179)	11–19 teeth (n = 48)	≥20 teeth (n = 59)	Total	*P* value
Age, mean ± SD	86.4 ± 7.1	82.8 ± 7.2	80.0 ± 8.5	84.5 ± 7.9	<0.001
Female	144 (80.4)	33 (68.8)	34 (57.6)	211 (71.3)	0.002
Dysphagia	57 (31.8)	16 (33.3)	16 (27.1)	89 (31.1)	0.743
Functional ability (Barthel Index), mean ± SD	57.2 ± 26.7	59.8 ± 28.4	62.1 ± 30.2	58.6 ± 27.7	0.467
Nutritional status (MNA-SF), mean ± SD	10.2 ± 2.1	9.7 ± 2.4	10.3 ± 2.6	10.1 ± 2.2	0.361
Nutrition status category					0.311
Normal (12–14)	52 (29.1)	13 (27.1)	23 (39.0)	88 (30.8)	
Risk of malnutrition (8–11)	105 (58.7)	25 (52.1)	28 (47.5)	158 (55.2)	
Malnutrition (0–7)	22 (12.3)	10 (20.8)	8 (13.6)	40 (14.0)	
Cognitive function (CDR)					0.262
None/Questionable	48 (26.8)	11 (22.9)	23 (39.0)	82 (28.6)	
Mild/Moderate	90 (50.3)	25 (52.1)	28 (47.5)	143 (50.0)	
Severe	41 (22.9)	12 (25.0)	8 (13.6)	61 (21.3)	
Comorbid condition (Charlson Comorbidity Index), mean ± SD	1.3 ± 1.1	1.5 ± 1.2	1.7 ± 1.3	1.4 ± 1.2	0.100

SD, standard deviation.

Table 2. Functional ability, cognitive function, and nutritional status according to oral health status [*n* (%)]

Variable	0–9 teeth, no denture (n = 26)	0–9 teeth with denture (n = 153)	10–19 teeth, no denture (n = 18)	10–19 teeth with denture (n = 30)	≥20 teeth, no denture (n = 49)	≥20 teeth with denture (n = 10)	*P* value
Age, mean ± SD	88.5 ± 6.6	86.1 ± 7.2	81.8 ± 7.5	83.3 ± 7.1	78.4 ± 8.2	87.6 ± 5.4	<0.001
Female	19 (73.1)	125 (81.7)	12 (66.7)	21 (70.0)	26 (53.1)	8 (80.0)	0.005
Dysphagia	15 (57.7)	42 (27.5)	7 (38.9)	9 (30.0)	13 (26.5)	2 (20.0)	0.061
Functional ability (Barthel Index), mean ± SD	38.1 ± 29.6	60.4 ± 24.8	53.9 ± 28.6	63.3 ± 28.2	59.8 ± 30.3	73.5 ± 28.0	0.001
Nutritional status (MNA-SF), mean ± SD	9.2 ± 2.1	10.4 ± 2.0	9.3 ± 2.4	10.0 ± 2.4	10.1 ± 2.8	11.4 ± 1.2	0.041
Nutritional status category							0.313
Normal (12–14)	4 (15.4)	48 (31.4)	4 (22.2)	9 (30.0)	18 (36.7)	5 (50.0)	
Risk of malnutrition (8–11)	16 (61.5)	89 (58.2)	10 (55.6)	15 (50.0)	23 (46.9)	5 (50.0)	
Malnutrition (0–7)	6 (23.1)	16 (10.5)	4 (22.2)	6 (20.0)	8 (16.3)	0 (0.0)	
Cognitive function (CDR)							0.038
None/Questionable	4 (15.4)	44 (28.8)	3 (16.7)	8 (26.7)	17 (34.7)	6 (60.0)	
Mild/Moderate	10 (38.5)	80 (52.3)	9 (50.0)	16 (53.3)	25 (51.0)	3 (30.0)	
Severe	12 (46.2)	29 (19.0)	6 (33.3)	6 (20.0)	7 (14.3)	1 (10.0)	
Comorbid condition (Charlson Comorbidity Index), mean ± SD	1.3 ± 0.9	1.3 ± 1.2	1.1 ± 0.5	1.7 ± 1.4	1.7 ± 1.4	1.6 ± 1.3	0.151

SD, standard deviation.

Path analysis

First, we estimated an initial model with all hypothesized pathways corresponding to the estimated variables directly or indirectly affecting ADL. Then, some insignificant paths were eliminated, and others who showed significant bivariate correlations were added while confirming the model-fit indices. A final model was then estimated with only statistically significant paths retained. The final model was a fairly good fit [χ^2 (14) = 19.805; P = 0.136; CFI = 0.972; TLI = 0.945; WRWR = 0.571; RMSEA = 0.038 (0.001 to 0.074)]. Figure 3 shows parameter estimates for the final path model. The model showed the following

Table 3. Activities of daily living, cognitive ability, and nutrition status with or without dysphagia [*n* (%)]

Variable	Dysphagia (*n* = 89)	Normal (*n* = 197)	*P* value
Age, mean ± SD	84.5 ± 8.6	84.5 ± 7.5	0.991
Female	55 (61.8)	156 (79.2)	0.002
ADL (Barthel Index), mean ± SD	42.8 ± 28.3	65.8 ± 24.3	<0.001
Nutritional status (MNA-SF), mean ± SD	9.3 ± 2.3	10.5 ± 2.1	<0.001
Nutritional status category			<0.001
Normal (12–14)	16 (18.0)	72 (36.5)	
Risk of malnutrition (8–11)	52 (58.4)	106 (53.8)	
Malnutrition (0–7)	21 (23.6)	19 (9.6)	
Cognitive impairment (CDR)			<0.001
None/Questionable	32 (36.0)	60 (30.5)	
Mild/Moderate	35 (39.3)	108 (54.8)	
Severe	22 (24.7)	29 (14.7)	
Comorbid condition (Charlson Comorbidity Index), mean ± SD	1.4 ± 1.1	1.4 ± 1.2	0.976

SD, standard deviation.

significant direct paths: (i) ones from 'Age' and 'Gender' to 'Teeth'; that is, increasing age decreased the number of remaining teeth [β (standardized coefficient) = −0.36] and females had fewer teeth than males (β = −0.14); (ii) one from 'Teeth' to 'Denture'; fewer teeth led to wearing denture (β = −0.79); (iii) one from 'Teeth' and 'Denture' to 'Swallowing'; having many teeth and wearing dentures promoted normal swallowing function (β = 0.78, 0.81, respectively); (iv) one from 'Gender' to 'Swallowing'; female tended to have normal swallowing function (β = 0.22); (v) one from 'Cognitive Ability' to 'Denture' and 'Nutrition'; a high level of cognitive ability led directly to wearing dentures and better nutritional status (β = 0.23 and 0.34, respectively); (vi) one from 'Swallowing' to 'Nutrition'; normal swallowing function promoted normal nutritional status (β = 0.25); (vii) ones from 'Swallowing', 'Cognitive Ability', and 'Nutrition' to 'ADL'; normal swallowing function, a high level of cognitive ability, and normal nutritional status resulted in a higher level of ADL (β = 0.33, 0.26, and 0.35, respectively); (viii) one from 'Comorbid Condition' to 'ADL'; severer comorbid condition caused a lower level of ADL (β = −0.10); and (ix) double-headed arrows among 'Age', 'Gender', 'Comorbid Condition', and 'Cognitive Ability'; age was correlated with cognitive ability, gender, and comorbid conditions. On the other hand, the number of teeth and denture wearing were not directly associated with either nutritional status or ADL.

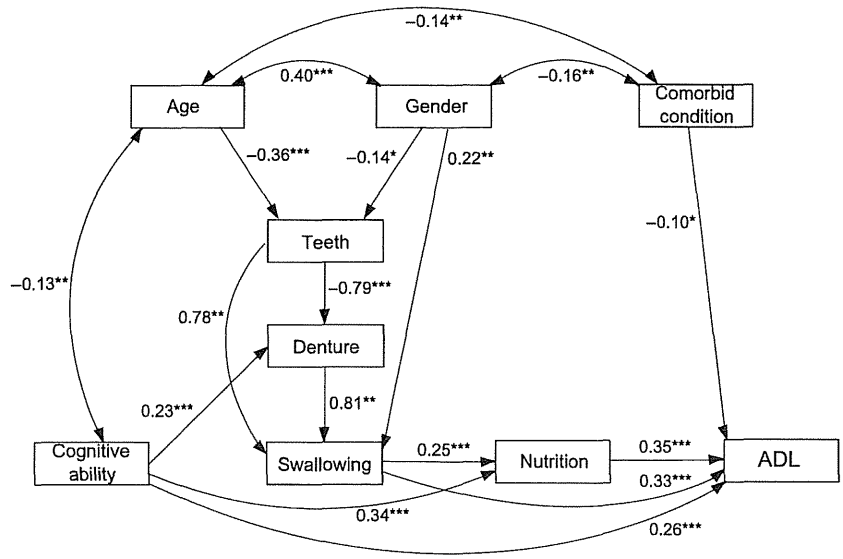

Fig. 3. The final model. Double-headed arrows indicate covariance. All significant values (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$) indicate standardized coefficients. Continuous variables are 'Age', 'Comorbid Conditions' (Charlson Comorbidity Index), 'Nutrition' (MNA-SF), 'Teeth', and 'ADL' (Barthel Index). Categorical or ordered variables are 'Gender' (1 = male, 2 = female), 'Dentures' (0 = not wearing, 1 = wearing), 'Swallowing' (0 = dysphagia, 1 = normal swallowing function) and 'Cognitive Ability' (1 = severe cognitive impairment, 2 = moderate, 3 = mild, 4 = questionable, 5 = none).

Discussion

This study showed the complex pathway from cognitive ability and oral health status via swallowing function and nutritional status to ADL in aged Japanese people living at home and receiving home care, using path analysis. To the best of the authors' knowledge, this is first study to show the interaction between multiple factors leading to a decline in ADL. Path analysis is an analytical technique that allows the testing of causal models using cross-sectional data. Possible pathways leading to ADL decline, based on our findings and those of previous studies, are as follows. Having fewer teeth leads to wearing dentures, but severe cognitive impairment disrupts denture wearing because of problems in accessing dental care; chewing difficulties resulting from having fewer teeth and no dentures can lead to dysphagia; dysphagia impairs the ability of elderly people to consume adequate amounts of food to meet their nutritional needs, leading to malnutrition (16); cognitive impairment, in turn, causes potential problems related to the inability to eat or to lack of access to food (32), hence leading to malnutrition. Swallowing function, cognitive ability, and nutritional status had direct effects on ADL. This finding agrees with previous studies in elderly people (9, 13). Malnutrition and cognitive impairment are associated with poor muscle strength and reduced physical performance (33), leading to disability, which reduces the ability to perform the basic activities of daily living. Although the effect of oral health status on ADL was indirect in this study, we cannot ignore it because of the moderate association between oral health status and swallowing function. Understanding various factors related to deterioration in ADL among these subjects would contribute to considering a multilateral approach for maintaining ADL in elderly people who are living at home.

The results of the present study suggested that oral health status, as measured by indicators such as the number of teeth and denture wearing, had a direct effect on swallowing function. A previous study reported that laryngeal penetration, usually because of neuromuscular disorder, occurs with much greater frequency in edentulous elderly people who are not wearing dentures than in those who dentulous (34). In our study, when the effect of denture wearing on swallowing function in edentulous persons was examined, 10 of 15 edentates (66.7%) without dentures showed dysphagia, whereas 29 of 101 edentates (28.7%) wearing dentures did. Tamura et al. described that wearing dentures and keeping the appropriate mandible position and proper occlusion were important for smooth swallowing in elderly individuals (35). Additionally, loss of occlusal support and loss of mandibular stopping by occlusion may disturb the coordination of swallowing function (34).

In this study, we did not find a statistically significant association between oral health status and nutritional status in the path analysis. This finding conflicts with those of previous studies (11, 12). There may be at least two reasons that oral health status was not associated with nutritional status in the present study. First, our path model included some factors related to nutritional status, such as oral health status, swallowing function, cognitive ability, and ADL. However, previous studies (11, 12) that demonstrated an association between oral health status and nutritional status failed to incorporate these factors into their analyses. Probably, because factors other than oral health status more strongly affect nutritional status, the relationship would be less obvious in our study. Second, even when elderly people do not have enough teeth, do not wear dentures, and do not chew satisfactorily, food preparation by a caregiver may make food easy to chew and thereby prevent nutritional deterioration. Nutritional status was related to swallowing function, but not to oral health status, in this study, suggesting that swallowing function may have a greater direct effect than chewing ability on malnutrition. However, there was an association between swallowing function and oral health status in our study, and oral health status may still indirectly influence nutritional status.

Our results suggest that maintaining or improving oral health status and swallowing function indirectly or directly contribute to preventing a decline in ADL in elderly people who require home care. Yoneyama et al. (36) reported that oral care reduced febrile days and the risk of pneumonia in older patients receiving nursing care. These findings indicate that dental interventions, such as provision of dentures, treatment for dental caries or periodontal disease, professional oral care, swallowing training, and oral care training for caregivers, have a beneficial indirect effect on general health in those requiring long-term nursing care. However, our results also showed that 75.9% of participants had not received dental treatment; many elderly people requiring home care have difficulty in gaining access to professional dental care. Further efforts are needed to develop a long-term

care system or community system that provides ready access to dental services.

Our study had some limitations. Using path analysis, our study made causal inferences about the relationships among various factors related to ADL; however, the cross-sectional design means that we cannot rule out reverse causation. Further longitudinal study is needed to examine a temporal relationship. Second, we did not incorporate sociological factors, such as socioeconomic status and education level, into this study. Several studies have reported a relationship between sociological factors and oral health status, ADL, cognitive ability, and nutritional status (9, 37–39). ADLs are associated with psychosocial factors (9). Because sociological factors and psychosocial factors were considered to have more indirect effects on ADL than oral health status, cognitive ability, and nutritional status, we did not gather this information in this survey. Third, we did not assess the prevalence of specific oral diseases such as dental caries and periodontal disease. Finally, we recruited the subjects using an in-home long-term care support center in two midsized municipalities in Japan. Our sample may limit the ability to extrapolate our findings to all Japanese elderly people. Caution is warranted in generalizing our findings to the rest of the Japanese population.

In conclusion, based on the present study, we propose a potential causal pathway by which oral health status directly affects swallowing function, and dysphagia, cognitive impairment, and malnutrition directly or indirectly affect ADL in elderly people living at home and receiving home nursing care. These findings suggest that maintaining the number of teeth from a younger age and wearing dentures when teeth are lost may indirectly reduce malnutrition and subsequent ADL decline in these people.

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