表1　対象者の各年代における属性および摂食・嚥下機能に関する状態

		n（人）	30歳未満（%）	30～50歳未満（%）	50～60歳未満（%）	60～70歳未満（%）	70～80歳未満（%）	80～90歳未満（%）	90歳以上（%）	無回答（%）	平均（歳）
	全体	106	9.4	11.3	17.0	17.9	25.5	15.1	0.9	2.8	61.4
性別	男性	62	6.5	8.1	19.4	24.2	27.4	11.3	—	1.9	61.9
	女性	42	14.3	16.7	14.3	9.5	23.8	19.0	2.4	—	60.2
原疾患	脳血管障害	57	5.3	3.5	26.3	19.3	24.6	17.5	—	3.5	64.5
	口腔咽頭腫瘍術後	3	—	—	—	66.7	33.3	—	—	—	67.0
	頭部外傷	7	42.9	42.9	14.3	—	—	—	—	—	31.9
	認知症	9	—	—	—	22.2	11.1	55.6	11.1	—	80.9
	パーキンソン病	9	—	—	—	11.1	55.6	33.3	—	—	76.0
	重症筋無力症	7	42.9	42.9	—	—	14.3	—	—	—	41.9
	筋萎縮性側索硬化症	5	—	40.0	20.0	20.0	20.0	—	—	—	55.8
	脳性麻痺	3	—	—	33.3	66.7	—	—	—	—	59.0
	その他	24	12.5	12.5	4.2	25.0	29.2	12.5	4.2	—	59.9
病態① 舌挙上状態	挙上なし	45	6.7	13.3	17.8	17.8	24.4	15.6	2.2	2.2	61.8
	やや挙上	51	11.8	11.8	13.7	19.6	25.5	15.7	—	2.0	61.2
	挙上あり	8	12.5	—	37.5	12.5	25.0	12.5	—	—	58.5
病態② 軟口蓋 挙上状態	挙上なし	8	—	—	—	25.0	25.0	50.0	—	—	77.0
	やや挙上	72	5.6	9.7	19.4	19.4	27.8	15.3	1.4	1.4	63.4
	挙上あり	25	24.0	20.0	16.0	12.0	20.0	4.0	—	4.0	50.4
病態③ 絞扼反射	消失	37	13.5	13.5	8.1	13.5	37.8	8.1	—	5.4	59.9
	減弱	33	3.0	12.1	24.2	12.1	18.2	27.3	3.0	—	65.7
	正常	34	11.8	8.8	20.6	29.4	17.6	11.6	—	—	58.5
摂食・嚥下 障害の時期	先行期	16	—	12.5	—	18.8	25.0	37.5	—		
	咀嚼期	50	12.0	10.0	12.0	16.0	30.0	18.0	—		
	口腔期	90	7.8	12.2	16.7	20.0	24.4	15.6	1.1		
	咽頭期	86	81.4	12.8	16.3	17.4	27.9	14.0	1.2		
	食道期	1	—	—	—	—	—	100.0	—		

「原疾患」「摂食・嚥下障害の時期」は複数回答あり．無回答の項目については，表中に未記入とした．

結　果

1. 対象者の属性および摂食・嚥下機能関連の状態

対象者106名の年齢分布は，70歳以上80歳未満が最も多く27名（25.5%），次いで60歳以上70歳未満19名（17.9%），50歳以上60歳未満18名（17.0%）の順で，最高齢92歳，最小齢6歳と年齢幅は広かった．性別においては，特記すべきことはなかった．

原疾患は，複数回答ありで「脳血管障害」が最も多く57名（53.8%），次いで「認知症」「パーキンソン病」ともに9名（8.5%），「頭部外傷」「重症筋無力症」ともに7名（6.6%）の順であった．その他は，筋萎縮性側索硬化症等，27疾患と多岐にわたった．

摂食・嚥下障害の病態としては，舌挙上状態において回答のあった104例中，「やや挙上」が51例（49.0%），「挙上不可」が45例（43.3%）であり，両者で92.3%を占めた．軟口蓋挙上状態においては，回答のあった105例中，「やや挙上」が72例（68.6%），「挙上不可」が8例（7.6%）であり，両者で76.2%を占めた．また，絞扼反射に関しては，回答のあった104名中「減弱」が33例（31.7%），消失が37例（35.6%），正常が34例（32.7%）であった．

摂食・嚥下の5期のうち，障害の時期として，複数回答ありで最も多かったのは口腔期（口腔から咽頭への食塊移送）の90名（84.9%），次いで咽頭期の86名（81.1%），咀嚼期50名（47.2%），先行期16名（15.1%），食道期1名（0.9%）の順であった（表1）．

会話明瞭度について，①氏名～⑤職業では，「時々わからない語がある」25名（23.6%）～30名（28.3%）と最も多く，次いで「聞き手が話題を知っていればわかる」19名（17.9%）～26名（24.5%），「まったく了解不能」15名（14.2%）～20名（18.9%）の順で，いずれも同様の傾向であった（図2）．

鼻咽腔閉鎖機能に関して，開鼻声（鼻漏れ声）は，①「あー」②「いー」③「あおい」すべてにおいて「やや鼻にかかる（開鼻声軽度）」が34名（32.1%）～37名（34.9%），次いで「ほとんど『んー』に近い音に聞こえる（開鼻声重度）」26名（24.5%）～29名（27.4%），「かなり鼻にかかる（開鼻声中等度）」21名（19.8%）～25名（23.6%）となり，異常なしは13名（12.3%）～18名（17.0%）に過ぎなかった（図3）．閉鼻声（鼻づまり）は，①「ま」②「な」ともに異常なしが80名（75.5%），「ま」が「ば」，「な」が「だ」に聞こえるといった異常は23名（21.7%）であった．

原疾患発症後の装置使用までの期間は，回答のあった59例中1年以上3年未満が18名と最も多く，次いで2年以上6カ月未満と6カ月以上12カ月未満がともに10名，3年以上6年未満が7名の順であり，1カ月未満は1名，中央値は18カ月であった（図4）．

栄養摂取状況は，初回評価時に「経口摂取のみ」が71名（68.3 %）と最も多く，「経管栄養のみ」が20名（19.2%），「経口と経管の併用」13名（12.5%）の順であった．

2. PLP装着による介入群とコントロール群の比較検証

会話明瞭度は，①氏名（図5）～⑤職業すべての項目において，介入群の「初回評価の装着なしと装着あり」「初回評価の装着なしと再評価の装着なし」「初回評価の装着なしと再評価の装着あり」「初回評価の装着なしと再評価のコントロール群」，および「再評価の介入群装着なしと再評価の介入群装着あり」「再評価の介入群装着なしと再評価のコントロール群」に有意な差がみられ

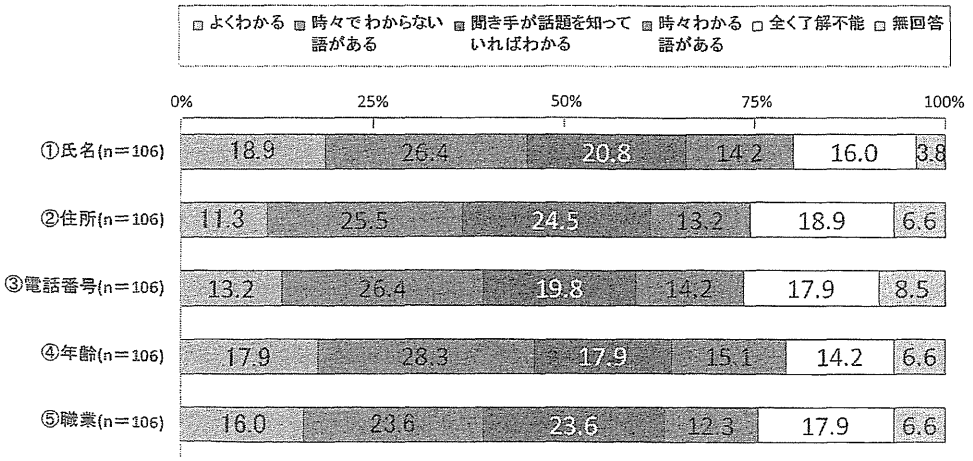

図2　会話による発話明瞭度の評価

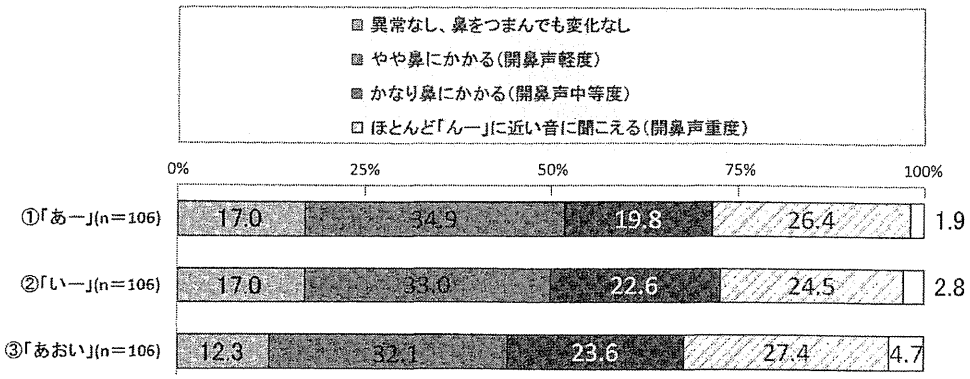

図3　開鼻声の検査

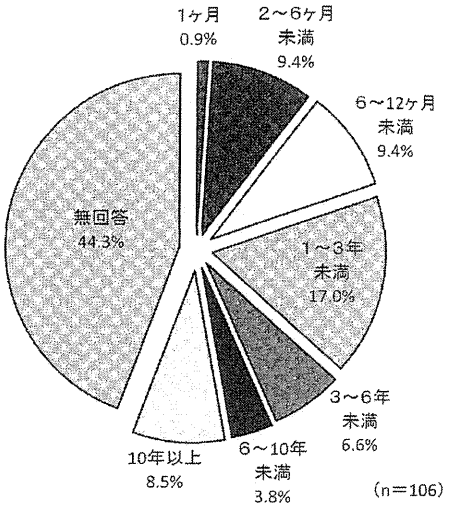

図4　原疾患発症後の装置使用までの期間

た（$p<0.05$）．このことは，鼻咽腔閉鎖機能における開鼻声，発話の評価においても同様であったが，閉鼻声ならびにMPTにおいては，いずれとの比較にても有意差は認められなかった．

改訂水飲みテスト（図6）とフードテストにおいては，介入群の「初回評価と再評価」および「介入群の再評価とコントロール群の再評価」に有意な差がみられた．

VF所見の①鼻咽腔閉鎖において，介入群初回評価時29名中，「不可」10名（34.5%），「不十分」17名（58.6%），「良好」2名（6.9%）であったのが，再評価30名中「不可」6名（20.6%），「不十分」16名（53.3%），「良好」8名（26.7%）となり，「介入群における初回評価と再評価」および「介入群における再評価とコントロール群における再評価」に有意な差がみられた（図7）．他の評価

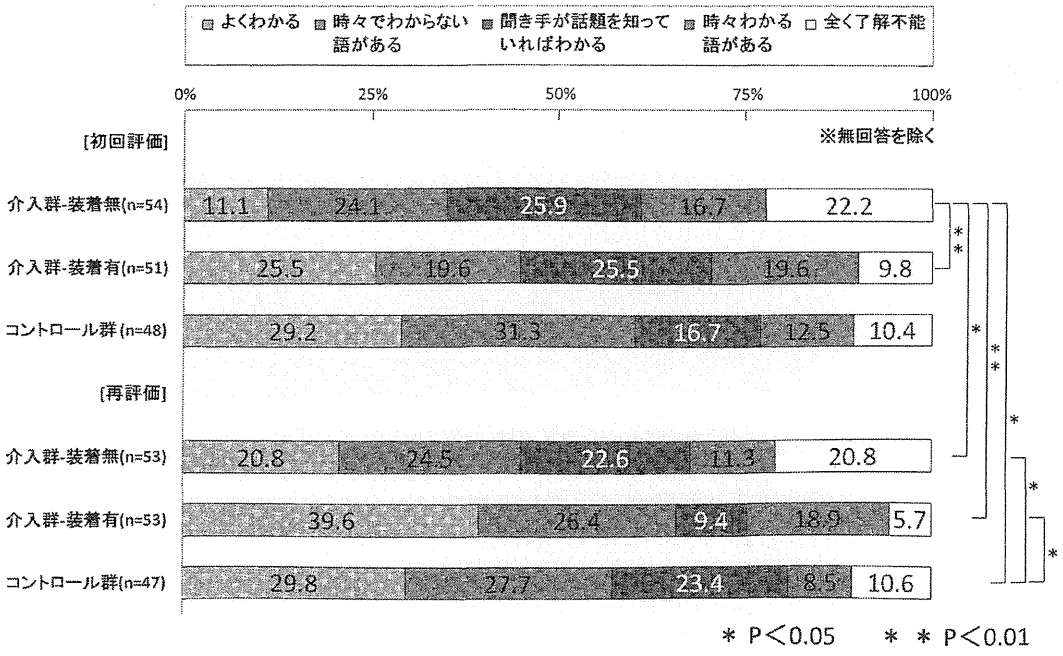

図5　会話による発話明瞭度の評価　「氏名」の発話状態

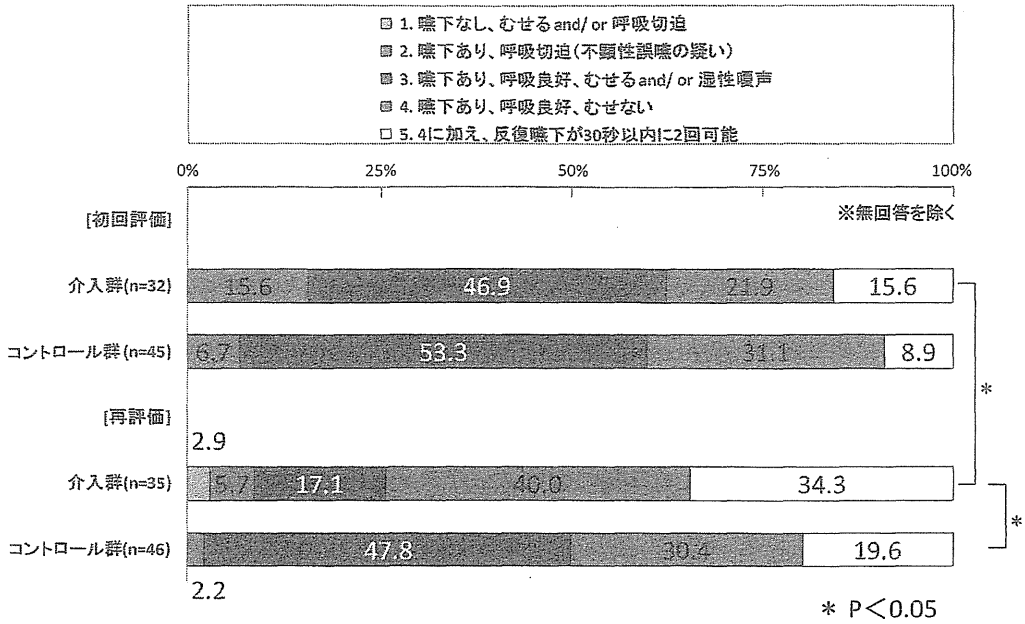

図6　改訂水飲みテスト

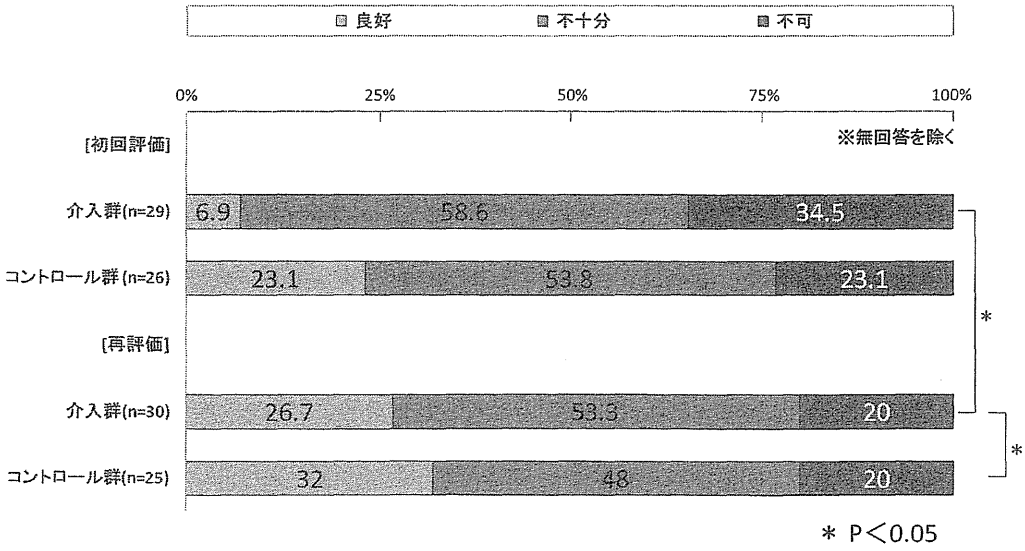

図7　VFによる鼻咽腔閉鎖機能

項目②鼻咽腔逆流において介入群初回評価時に「多量逆流」3名（10.3%），「少量逆流」18名（62.1%），「逆流なし」8名（27.6%）であったのが，再評価時に「多量逆流」1名（3.3%），「少量逆流」9名（30.0%），「逆流なし」20名（66.7%），③口腔内残留において介入群初回評価時に「多量残留」5名（17.2%），「少量残留」15名（51.7%），「残留なし」9名（31.0%）であったのが，再評価時に「多量残留」1名（3.3%），「少量残留」14名（46.7%），「残留なし」15名（50.0%），④喉頭蓋谷あるいは梨状窩の残留において介入群初回評価時に「多量残留」11名（37.9%），「少量残留」14名（48.3%），「残留なし」4名（13.8%）であったのが，再評価時に「多量残留」4名（13.3%），「少量残留」18名（60.0%），「残留なし」8名（26.7%），⑤喉頭内侵入において介入群初回評価時に「侵入あり排出されず」8名（27.6%），「侵入あり排出される」13名（44.8%），「喉頭侵入なし」8名（27.6%），再評価時に「侵入あり排出されず」7名（23.3%），「侵入あり排出される」9名（30.0%），「喉頭侵入なし」14名（46.7%），⑥誤嚥において介入群初回評価時に「多量誤嚥」1名（3.4%），「少量誤嚥」14名

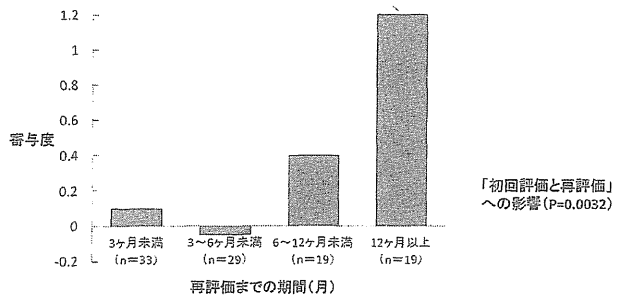

図8　VFによる喉頭蓋谷あるいは梨状窩の残留検査

初回評価から再評価までの期間での検証.

(48.3%)，「誤嚥なし」14名 (48.3%)，再評価時に「多量誤嚥」0名，「少量誤嚥」10名 (33.3%)，「誤嚥なし」20名 (66.7%)，⑦食道入口部開大において介入群初回評価時に「ほとんど開大せず」0名，「開大不十分」15名 (51.7%)，「食塊の量に対して十分開く」14名 (48.3%)，再評価時に「ほとんど開大せず」0名，「開大不十分」9名 (30.0%)，「食塊の量に対して十分開く」21名 (70.0%) であった．いずれも鼻咽腔閉鎖の評価同様に，「介入群における初回評価と再評価」および「介入群における再評価とコントロール群における再評価」に有意な差がみられた．

VE所見の③咀嚼状態において，介入群初回評価にて「大部分が粉砕されていない」4名 (26.7%)，「一部粉砕されていない」5名 (33.3%)，「全部が粉砕されている」6名 (40.0%) であったのが，再評価にて「大部分が粉砕されていない」3名 (18.8%)，「一部粉砕されていない」7名 (43.8%)，全部が粉砕されている6名 (37.5%) であり，「介入群における初回評価と再評価」に有意な差はみられなかった．他の項目 (①②④⑤⑥) においては，「介入群における初回評価と再評価」および「介入群における再評価とコントロール群における再評価」に有意な差がみられた．

VFによる初回評価から再評価までの期間別効果について，図8に示すように，喉頭蓋谷あるいは梨状窩の残留は「12カ月以上」「6カ月以上12カ月未満」の順で改善に寄与していた．他の診査項目 (⑤⑥) についても，同様の傾向であった．

栄養摂取状況は，介入群55名中，初回評価にて「経管栄養のみ」5名 (9.1%)，「経口経管併用」7名 (12.7%)，「経口摂取のみ」43名 (78.2%) であったのが，再評価にて0名 (0%)，5名 (9.8%)，46名 (90.2%) となり，有意な差が認められた．一方，コントロール群においても，初回評価と再評価の間に有意差がみられたが，「再評価の介入群」と「再評価のコントロール群」との間にも有意差を認めた (図9)．

聞き取りによる「主観的健康感」については，介入群57名中の37名 (64.9%)，コントロール群49名中の4名 (8.2%) に変化を認め，「食事の疲労感が減った」「鼻漏れ声が軽減したため社会活動の参加意識が向上し，介護予防教室に通うようになった」「鼻から水，食品が抜けないので，家族と同じメニューが食べられるようになった」「外食する機会が増えた」「表情が豊かになった」などの声が聞かれた．

考　察

PLPは本来，発話障害に対する補助装置として臨床応用されており，その治療効果については，Gibbons ら[16]

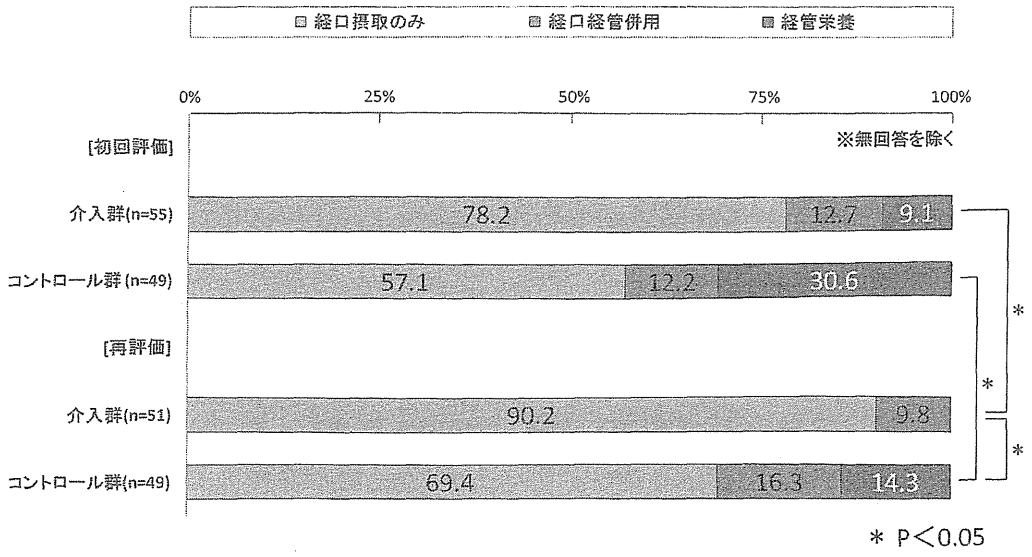

図9　栄養摂取状況

以降，多数報告されている[17-22]．発話障害におけるPLP適応者は，摂食・嚥下障害を併発している場合が少なからずあり，PLP装着を継続する中で，摂食・嚥下障害も改善傾向を示すといった臨床的印象をもつことがある．そこで，今回は摂食・嚥下障害の視点から，PLPの適応基準と効果について検討した．

1. PLPの適応基準について

調査対象機関は，前述した植田らの調査結果より[5]，あらかじめPLPの応用を日常的に取り入れている医療機関としたが，PLPの普及自体がもともと高いものではなく，全国的にみてもこれら医療機関での被検者を母数とすることで，現在実施されているPLP適応の原疾患や病態分布を把握することは妥当であると思われる．

PLPの適応基準を明確にするにあたり，年齢については小児から高齢者まで幅があり，性別に偏りはなかった．原疾患は脳血管疾患が過半数を占めていたものの，他に30疾患以上あり，適応疾患を特定することは困難であった．一方で，「挙上不可」「やや挙上」といった舌挙上状態不良が92.3%，軟口蓋挙上状態不良が76.2%，絞扼反射の評価から軟口蓋の感覚低下が疑われる者67.3%を占めた．舌挙上状態について，嚥下反射時の咽頭収縮の際，奥舌が軟口蓋を押すことにより軟口蓋と咽頭後壁が接触し鼻咽腔閉鎖が可能となることから，舌挙上状態不良が高率であったことは，軟口蓋の機能に強く影響している結果だと思われる．

発話関連について，会話明瞭度は「よくわかる」「時々わからない語がある」といった正常およびほぼ正常である者が40%以上であったが，鼻咽腔閉鎖機能における開鼻声の異常が83%，呼気鼻漏出による子音の歪みが87.7%であった．また，摂食・嚥下の5期のうち，口腔期と咽頭期障害が80%以上を占めていた．

以上より，PLPの適応を判断するためには，疾患よりも病態のほうが把握しやすいと思われた．すなわち，「軟口蓋挙上不良，軟口蓋の感覚低下，開鼻声，呼気鼻漏出による子音の歪み，口腔期・咽頭期障害，舌挙上不良」を，摂食・嚥下障害に対するPLPの適応基準とすべきであるといえよう．

2. PLPの効果について

対象患者の疾患発症後PLP装着までの期間は，1カ月未満が1名（0.9%），2カ月～6カ月未満が10名（9.4%），中央値は18カ月であった．急性期，回復期，あるいは慢性期といった病態時期別の結果を得るのは今回の調査の限界であり，対象者の9割が6カ月以上の慢性期であることから，自然治癒における影響は考慮しなかった．

会話明瞭度，開鼻声，発話の評価については，装着直後の効果（即時的効果）が得られたが，これは従来からのPLPの効果[16-22]を踏襲した結果となった．今回，さらに介入群再評価時のPLP未装着での効果（持続的効果）も得られた．一方，閉鼻声に効果が認められなかったのは，軟口蓋挙上とは直接関連のないところでの運動であるためと推察される．生理学的にMPTは鼻咽腔閉鎖には関連がないといわれている．臨床的には影響を受けている印象があるので，今回の調査項目としたが，本研究においても，結果として差は認められず，従来の見解を確認するにとどまった．

本研究では，PLPが摂食・嚥下機能の動態の何に効果をもたらしているのか，スクリーニング検査と装置診断（VF，VE）により検討した．フードテストと改訂水飲みテストにおいては，図6に示したように，3点（嚥下あり，むせるand/or湿性嗄声，and/or口腔内残留中等度）の誤嚥が疑われる者が再評価時に顕著に減少し，「誤嚥なし」あるいは「正常」を示した．この結果をさらに嚥下動態として詳細に検討するために，VF，VEによる装置診断の結果を確認した．VFにおいて，初回評価時に鼻咽腔閉鎖が不可，鼻咽腔逆流あり，喉頭蓋谷や梨状窩の残留，および誤嚥を認めた者が再評価時に減少した．軟口蓋の挙上状態を最も表出している「鼻咽腔閉鎖」「鼻咽腔逆流」の改善は，嚥下時の口腔内圧を高めるにあたって有利な環境となり，結果的に食塊の口腔および咽頭部の残留量減少に貢献したと思われる．今後は，その点を検証するために，鼻咽腔閉鎖機能と嚥下圧の関連についても検討していく所存である．

その一方で，VEにて米飯や軟菜食における咀嚼状態を評価したところ，初回評価と再評価時に明確な差が認められなかった．このことから，PLPは咀嚼機能への影響はないものの，嚥下機能の改善に貢献することが認められた．

初回評価から再評価までの期間別効果については，「12カ月以上」が最も改善に寄与していた．W. G. Selleyら[3]は，10週間という短期間で効果が認められたと報告しているが，それは，彼らがリハビリテーション目的の回復期の入院患者を対象としており，今回の調査は疾患慢性期の患者が主な対象であったこととの違いによるものと思われる．対象が口蓋裂関連の状態において西尾[17]は，6カ月程度で軟口蓋の賦活化が認められたとしているが，本研究は一部を除き，対象は異なるものの，同様に6カ月以上の装着にて賦活化が認められた．以上より，PLPは，発話障害に対する補助具であると同時

に，6カ月以上の中期・長期的な期間をおけば摂食・嚥下機能改善のための訓練用装置であるとの期待がもてた．PLPの装着は，その挙上子が軟口蓋に触覚刺激を発生している．そこで，たとえ軟口蓋不全麻痺であっても，発声，呼吸，唾液嚥下等の活動時に微妙に動態を示している軟口蓋には，触覚あるいは圧覚に対して繰り返し刺激を与えていることになる．アイスマッサージよりも微細ではあるが，それに準じる刺激が長期間，軟口蓋に作用しているものと考えられ，その結果，患部の賦活化が誘発されたと推察される．

栄養摂取状況において，初回評価時に経管栄養のみの者はすべて，「経管と経口の併用」あるいは「経口摂取のみ」に移行することができた．栄養摂取状況の変化に影響する要因は複数考えられると思われるが，PLPによる鼻咽腔閉鎖機能改善も，それらの要因のひとつとして貢献したと推察される．このことは，介入群とコントロール群における最も顕著な差として，「主観的な健康感」に認められた．摂食機能の改善に伴う栄養摂取状況の変化は，単に食事機能や摂食行為にとどまらず，社会活動への参加，外出意欲の向上など，生活全般にわたって好影響を及ぼしていることが示唆された．

結　論

1. PLPの適応を判断するには，疾患よりも病態のほうが把握しやすいと思われた．
2. PLPは発話障害に対する補助具であると同時に，6カ月以上の中期・長期的な期間をおくことにより，摂食・嚥下機能改善のための訓練用装置であるとの期待がもてた．

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The Effectiveness of Palatal Lift Prosthesis for Dysphagia

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Abstract

Purpose: The purpose of this study was to create adaptational criteria for palatal lift prosthesis (PLP) and to examine the effects of PLP as a device for dysphagic patients.

Methods: A group in whom PLP was attached in addition to function training (PLP group, $N=57$) was compared with the group which underwent function training (non-PLP group, $N=49$). Analysis of the PLP group was performed based on the initial evaluation (articulation test, examination of velopharyngeal function, maximum phonation time (MPT), food test (FT), modified water swallowing test (MWST), videofluoroscopy (VF), video-endoscopy (VE), nutrition state, and subjective health investigation) after making the PLP. Both groups were examined every 3 months (about 3, 6, 12 months and more than 12 months) after the initial evaluation.

Results: We needed to define the clinical state of subjects rather than their disease itself because almost all subjects had cerebrovascular disease. Especially, more than 80% of subjects suffered from inability to elevate their tongue and soft palate, rhinolalia aperta, articulatory disorder, dysfunction of oral stage and pharyngeal stage.

In the PLP group, the subjects who were suspected of aspiration on FT and MWST when the initial evaluation was showed decreased aspiration after using the PLP. In addition, improvement of velopharyngeal function and nasal regurgitation was observed in VF. Our finding suggested that the PLP caused a build-up of pressure in the oral cavity during swallowing, and helped to reduce residues of materials in the oral cavity and pharynx. Moreover, there was no difference in the state of mastication for rice and soft solids in VE. Therefore, this finding suggested that the PLP helped to improve the swallowing function although it had an insignificant effect on the mastication. Regarding the period of service of the PLP, it was more effective to use the PLP for more than 6 months.

Conclusion: To identify adaptation to using the PLP, it is important to perceive not only the disease of patients but also the clinical state. Our findings suggest that the PLP is effective for inability to elevate the tongue and soft palate, rhinolalia aperta, articulatory disorder, dysfunction of oral stage and pharyngeal stage. In addition, regarding the period of service of the PLP, it was more effective to use the PLP for more than 6 months.

Key words : dysphagia, swallowing, palatal lift prosthesis (PLP), exercise for swallowing function

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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

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

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contributes to recovery of swallowing function. Dysphagia, cognitive 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

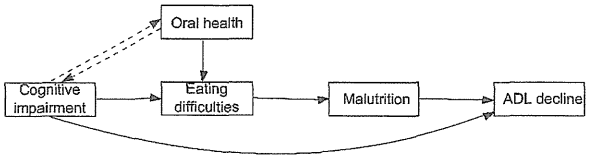

Fig. 1. The conceptual model. Dotted lines indicate paths explored the direction in this study.

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).

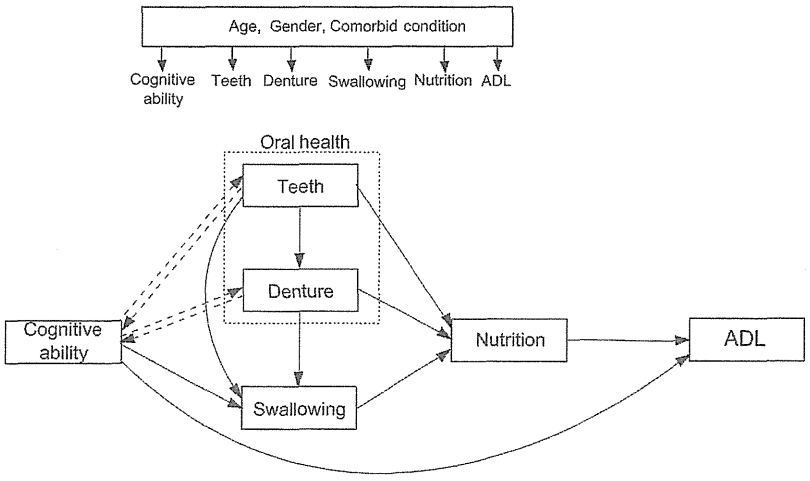

Fig. 2. The hypothesized model. The model consists of nine observed variables including confounding variables such as age, gender and comorbid conditions. Dotted lines indicate paths explored the direction in this study.

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.

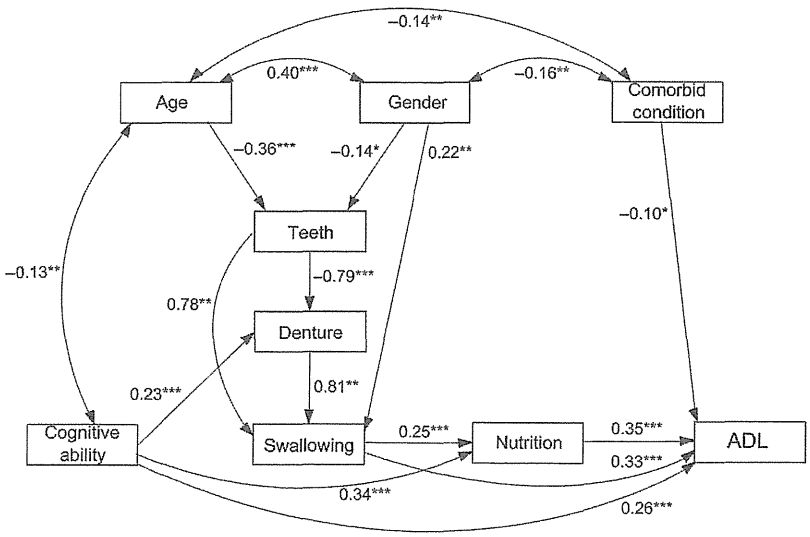

Fig. 3. The final model. Double-headed arrows indicate covariance. All significant values (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$) indicate standardized coefficients. Continuous variables are 'Age', 'Comorbid Conditions' (Charlson Comorbidity Index), 'Nutrition' (MNA-SF), 'Teeth', and 'ADL' (Barthel 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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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Effects of the reappearance of primitive reflexes on eating function and prognosis

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Aim: Primitive reflexes can reappear with diseases of the brain, particularly those affecting the frontal lobes. Most studies on primitive reflexes have reported an association between such reflexes and brain damage, and the clinical symptoms of dementia. These reflexes can also be present during eating; however, their effects on eating function are difficult to evaluate. The purpose of the present study was to identify the frequency at which primitive reflexes reappear in elderly people, and to determine the effects that such reflexes have on eating function, nutritional status and prognosis.

Methods: We followed 121 nursing home residents for 6 months. All patients required long-term care and were examined for the presence of a sucking reflex, snout reflex and phasic bite reflex for baseline measures. Demographic characteristics, physical and cognitive function, and nutritional status were obtained from chart reviews, interviews with nurses, and a brief physical examination at baseline and incidence of aspiration pneumonia during the study period.

Results: The sucking reflex was confirmed in 31 patients (25.6%), snout reflex in 15 patients (12.3%) and phasic bite reflex in 28 patients (23.1%). One or more of these reflexes was identified in 38 patients (31.4%). A relationship between the presence of a primitive reflex and nutritional status was shown. An association with the presence of these reflexes and the development of aspiration pneumonia during 6 months was also confirmed.

Conclusions: The appearance of primitive reflexes appears to be associated with the risk of malnutrition and developing aspiration pneumonia. **Geriatr Gerontol Int 2013; ••: ••–••.**

Keywords: dementia, dysphagia, elderly people, nutrition, primitive reflexes.

Introduction

Primitive reflexes are observed during the neonatal and infant periods, but later they recede as a result of cerebral cortex inhibition and brain stem activity.[1] However, they reappear in healthy elderly people and in patients with diseases of the nervous system.[2,3] It is also known that the incidence at which these reflexes reappear increases with age.[4,5] They can also reappear as a result of trauma to the brain.[6] Although any combination of these reflexes is considered to be indicative of damage to cognitive function, it is believed that this relationship is a result of age and is not in itself specific for brain disease.[7] It has been reported that in cases of Alzheimer's disease or cerebrovascular dementia, a relationship can be identified between the appearance of primitive reflexes and the severity of damage to cognitive function.[8] In contrast, no association with a decline in cognitive function has been recognized.[4]

The major primitive reflexes in the oral cavity are the sucking reflex, snout reflex and phasic bite reflex. Most studies on primitive reflexes to date have reported an association between such reflexes and brain damage, and the clinical symptoms of dementia. As these reflexes can also be recognized during eating, their effects on eating function cannot be ignored. Nevertheless, the association between these reflexes and eating function

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or nutritional status is unknown. In the many studies of elderly patients in long-term care, there is a high incidence of malnutrition.[9] Problems associated with malnutrition include reduced immunity and increased susceptibility to infection.[10] Malnutrition is also a risk factor for respiratory tract infections, including aspiration pneumonia[11] and in-hospital infections.[12] Furthermore, it has been found that malnutrition can result from masticatory disorders due to tooth loss,[13,14] but there have been no reports of malnutrition resulting from masticatory disorders due to motor impairment.[15] The purpose of the present study was to determine the incidence of primitive reflexes in older adults living in nursing homes, and to identify the effects of such reflexes on eating function, nutritional status and prognosis.

Methods

The participants were 121 of 127 elderly patients who lived in two nursing homes in Tokyo, Japan, and who required care (mean age 86.1 ± 7.9 years; 33 males [81.6 ± 8.3 years]; 94 females [87.7 ± 7.2 years]). Individuals under nutritional management by feeding tube were excluded.

The criterion for patient selection was that physical symptoms and cognitive impairment must have been stable for the preceding 3 months. During this 3-month period, no patient had acute disorders (e.g. severe infection, heart failure, or stroke requiring special treatment or intensive care).

In addition, the association between primitive reflexes and nutritional status was examined in 110 participants (mean age 86.2 ± 7.6 years; 30 males [82.4 ± 7.6 years]; 80 females [87.7 ± 7.2 years]) whose serum albumin could be measured. Under the approval of the Ethics Committee in the School of Life Dentistry, Nippon Dental University, the present study was carried out after obtaining informed consent from the participants or their families. The Clinical Dementia Rating (CDR)[16] was used for evaluating cognitive functions, and the Barthel Index[17] was used for evaluating activities of daily living (ADL). The basic survey was conducted in May 2009 and the subjects were then observed over the course of the next 6 months.

The protocol for this study was approved by the Ethics Committee of the Nippon Dental University School of Life Dentistry at Tokyo (#09–11).

Primitive reflex evaluation methods

The presence of primitive reflex was evaluated at the beginning of the present study.

Using the methods of Paulson,[18] participants were examined in the mornings in a quiet room of the nursing home for the presence or absence of a sucking reflex, snout reflex or phasic bite reflex.

Primitive reflexes were evaluated as follows by the same dentist:

Sucking. Incomplete sucking, with only weak contraction of the orbicularis oris muscle, or full sucking, with sucking movements of the tongue and pharynx, after the tip of the patient's index finger is firmly placed between his closed lips.

Snout. Weak puckering or protrusion of the lips, with elevation of the lower lip, after the examiner taps lightly on the midline of the subject's upper lip with his index finger.

Phasic bite. Vertical movement of the lower jaw, as in mastication, after the examiner presses downward with one finger on the molar region of the lower jaw.

Physical and oral examinations

ADL and cognitive functions

In the results of evaluation using the Barthel Index,[17] ADL was considered stable at 45 points or more, but as having declined at 40 points or less. In the present study, based on the results of evaluation by CDR, cognitive function was considered normal at code 1 or lower, and decreased at code 2 or higher.

Nutrition indicators

Nutritional status was evaluated at baseline.

Bodyweight and height were measured and body mass index (BMI) was calculated. In addition, blood samples were taken for the measurement of serum albumin. Values less than 3.5 mg/dL were considered to indicate malnutrition. The texture of the food served at each of the nursing homes was also recorded. Participants who could not ingest an adequate amount of calories as a result of dysphagia were supplemented with high-calorie foods; the participants supplemented with ≥200 kcal per day were assigned to a dietary supplementation group.

Swallowing function

Participants were asked to swallow 3 cc of water and underwent auscultation of the cervical area after swallowing. If choking was produced in conjunction with swallowing or if a wet or gargling sound was detected by auscultation, the participant was considered to have dysphagia.

Other

Medical information at the nursing facilities was examined in order to determine whether the participants had