but more often than NC whites, while they were generally similar to elders in Adelaide and Toronto in terms of both ranking and yearly occurrence.

The differences compared with previous OHIP studies may be explained in a number of ways: they may be differences in the conceptual and linguistic equivalence of translated items (delicate shades of meaning of the question), or differences in the social security system, the health insurance system, national character (optimistic or pessimistic), or true differences in the perceived severity of oral health across cultures[7]. However, physical pain and psychological discomfort tended to be reported more frequently than social disability and handicap, which is similar to the other studies[8]. Our results provide additional support for Locker's theoretical model of oral health indicating that social disability and handicap are less frequent and measure the most comprehensive impact on quality of life[10].

In conclusion, the Japanese version OHIP-14 had a high internal reliability overall ($\alpha = 0.95$) and comparable ranking for items when compared with studies from other countries. Poor self-assessed general health, using a removable denture, and reporting a need for dental treatment were all independent variables, which were related to having a higher level of oral problems or impacts. The strong association of these dental health variables with the sum OHIP 14 precluded financial status and education level as independent variables. Neither age, gender, marital status, nor living companion status had an association with the OHIP measurement. However, generalisation of the specific variables, which had an association in this study should be viewed with caution and not considered representative for the general elderly Japanese as our study population was a convenience non-randomly-selected sample. The findings of this study do suggest that the culturally adapted OHIP-14 version may be a good research instrument to consider for use in measuring the impact of oral problems on the quality of life in a Japanese population.

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ELSEVIER

Association of bite force with ageing and occlusal support in older adults

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Summary *Objectives.* The purpose of this study was to investigate the effect of ageing, occlusal support and TMJ condition and general health status on bite force in older adults.

Methods. The study sample consisted of 850 independently-living people over the age of 60 years. Bilateral maximal bite force in the intercuspal position was measured with pressure sensitive sheets. TMJ noise by palpation and limitation of mouth opening (less than 40 mm) were assessed. Subjects were grouped into three categories by occlusal support according to the Eichner Index.

Results. A multiple logistic regression analysis showed that whether participants had low bite force or not was significantly associated with gender, age, self-rated general health and occlusal support, but not TMJ noise or mouth opening limitation. Overall bite force showed a statistically significant but weak negative Spearman's correlation with age ($r = -0.24$, $p < 0.001$). However, there was no significant correlation between age and bite force in the Eichner C group for males or in any of the Eichner classification for females.

Conclusions. Decline of occlusal support and general health might translate into reduction of bite force with ageing in older adults. Since tooth loss is not physiological ageing but pathological ageing, it cannot be shown that reduction of bite force is a natural effect of ageing.
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Introduction

A primary reason for dental treatment is to restore oral function, especially mastication. Bite force shows a positive relationship with masticatory performance and dietary selection,[1-4] which is closely related to quality of life. Therefore, bite force has often been used as a variable for objectively evaluating masticatory function.

Factors reported to affect masticatory performance include age,[5] dental status,[6,7] salivary flow,[5] temporomandibular joint (TMJ) disorder[8] and/or orofacial pain.[9]

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Skeletal muscle atrophy, declining strength, and physical frailty are generally accepted as inevitable concomitants of ageing.[10] The muscle mass of old animals, as compared with young ones, is reported to have decreased by 30-40%, and strength to an even greater extent.[11] Bite force for individuals of 75 years and over was reported to be 40% lower than that for those of 35-44 years.[5] The main reason for the reduced bite force is thought to be atrophy of the jaw-closing muscles. The cross-sectional areas of the masseter and medial pterygoid muscle showed a significant reduction with age, with those in edentulous subjects showing a greater decrease than in dentate subjects.[12] In addition, masticatory ability is reported to relate to general health.[13] Indeed, elderly people are likely to have more compromised dentition and individually diverse health status than any other generation, although some people maintain good dental status and masticatory performance. There has previously been no investigation of potential explanatory variables (e.g. loss of occlusal support, ageing masticatory muscles, TMJ disorder, or decline of general health) associated with bite force in a large population of older adults.

The purpose of this study was to investigate the effects of ageing, occlusal support, TMJ condition and general health on bite force in independently-living older adults. We hypothesised that healthy older adults could maintain their bite force if the occlusion was also maintained, in spite of the ageing process.

Methods

Subjects

The subjects in this study were 1,738 students of the Senior Citizens' College of Osaka prefecture who attended the program from 1999 to 2001. The study sample consisted of community-dwelling, independently-living people over the age of 60 years who attended lectures once a week. This college is one of the adult education systems supported by the government of Osaka prefecture which enrolls volunteers for a period of one year. This course focused not only on health topics but also on other topics of interest to elderly people, such as finances or culture.

At the end of a lecture on oral health issues, the purpose and procedures of this study were explained to the audience, and volunteers were solicited to participate in filling out a questionnaire and volunteering to return for a dental examination on another day. After informed consent was obtained, subjects were given the opportunity to ask questions while completing the questionnaires; subjects could refuse to participate in the oral examination portion of the study. The final study population which voluntarily participated in the dental as well as the oral examination included 850 persons (460 men and 390 women). The participation rate was 48.9% of the total subjects, and their mean age was 66.6 ± 4.3 years. The mean age and the proportion of each gender were quite similar to those who did not volunteer for the dental examination ($n=888$).

Procedures

Informed consent was obtained from each participant, and the protocol was approved by the Institutional Review Board of Osaka University Graduate School of Dentistry. Comprehensive dental examinations were conducted by six calibrated dentists. Self-rated general health condition was estimated by the answer to the question: 'How do you rate your general health at the present time?' The volunteers were asked to respond with 'good', 'fair', or 'poor'.

Maximal bite force

Bilateral maximal bite force was measured with pressure sensitive sheets, the thickness of which was 97 micrometers (Dental Prescale 50 H R type, Fuji Film Co., Tokyo, Japan). The subjects performed maximal clenching in the intercuspal position with a pressure-sensitive sheet placed between the maxilla and the mandibular dental arch. Removable denture wearers bit the sheets with their dentures. Thirty subjects who had a partially edentulous arch without a replacement or who complained of a toothache or irritation of the denture-bearing tissues were excluded from the study population.

The occlusal force was measured by colour development in a pressure-sensitive film with special analytical equipment (Occluzer FPD703, Fuji Film Co.). The uses, limitations, validity, and reliability of this method have been discussed and reported previously.[14,15] Shiga et al. have shown that the bite force with this system has a significant positive correlation to real pressure values ($r=0.990$, $p<0.01$) and displayed 98-100% of the true values for pressures between 20 and 80 N on 1 mm^2.[16]

Temporomandibular joint dysfunction (TMD)

Signs and symptoms of TMD, which included TMJ pain, noise by palpation and limitation of mouth opening (less than 40 mm), were assessed.

Because only 10 subjects had TMJ pain, it was excluded as an explanatory variable in the analyses.

Occlusal support

Because the edentulous population was very small ($n=32$, 3.9%), and dentate status was strongly confounded with occlusal support, we used occlusal support, that is, the Eichner Index, to indicate dental status in this study.

Occlusal supports were recorded according to the Eichner Index.[17] The molar and premolar contacts of the residual teeth define the classification: class A contacts four support zones, class B one to three zones or contact in the anterior area only, and class C has no support zone at all, although a few teeth can still remain.

Statistical analysis

The data analyses were done using SPSS Version 11.0 for Windows (SPSS Inc., Chicago, IL, USA). Since the bite force was not normally distributed, non-parametric tests of both the Mann-Whitney U test and the Kruskal-Wallis test were used to examine differences in bite force with regard to each of the individual explanatory variables.

The Kruskal-Wallis test was used for age, self-assessed general health and Eichner classification, and the Mann-Whitney U test otherwise. P-values ≤ 0.05 were considered to be statistically significant. Pairwise comparisons were made by means of the Mann-Whitney U tests with Bonferroni correction only following significant results of Kruskal-Wallis tests. Results were considered significant at $\alpha=0.017$ for three categories.[18]

A stepwise multiple logistic regression analysis was carried out to test each explanatory variable's relationship with the outcome variable after controlling for the other factors. The dichotomised outcome variable was whether participants had low bite force or not. There is no established cut-off value for the definition of low bite force. Yeh et al. divided their study participants into four groups[5] and identified low bite force as less than the 25th percentile, medium low bite force as the 25-50th percentile, medium high bite force as the 50-75th percentile, and high bite force as more than the 75th percentile.[5] We adopted this classification to decide whether participants had low bite force or not using the lowest 25th percentile as the cut-off value.

For this analysis, explanatory variables were scored as dichotomies as follows: males=0, females=1; self-rated general health: good=0, fair/bad=1; TMJ noise: without=0, with=1; mouth open limitation: 40 mm and over=0, less than 40 mm=1. For occlusal support, class A was set equal to 0 and Classes B and C equal to 1. Age was left as a continuous explanatory variable. Explanatory variables were entered into the model by the forward stepwise method with the significance level set at 0.05.

Spearman correlation coefficients were used to evaluate the relationship between age and bite force for all subjects and also for subjects stratified by gender, and by gender and Eichner classification.

Results

Bite force was not normally distributed (Fig. 1). The median value was 426 N, and the 25th and 75th percentiles were 238 and 669 N, respectively.

The bite force was significantly associated with gender, age, self-rated general health, and occlusal
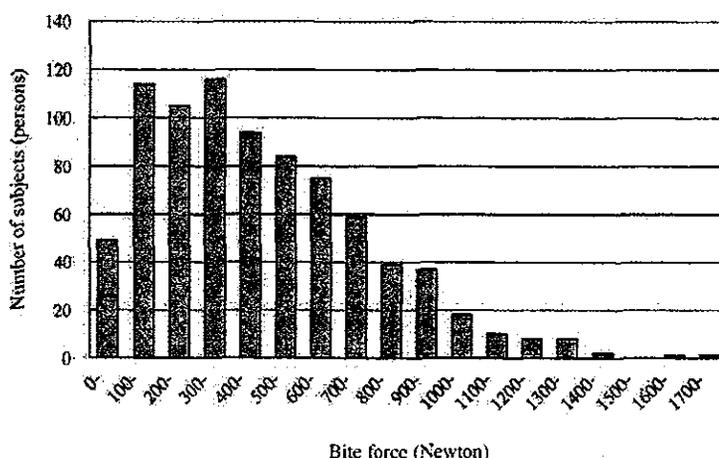

Bite force (Newton)

Fig. 1 Distribution of bite force ($n=820$).

Table 1 Frequency of demographic and oral variables and mean, standard error (SE), median, interquartile range of the bite force.

	n	Mean (N)	SE (N)	Median (N)	Interquartile range (N)		P-value
Gender							
Male	444	511.7	15.1	468.5	447.8		0.003
Female	376	442.4	14.2	382.0	397.8		
Age							
60-64	295	549.1	18.2	515.0	413.0	A	<0.001
65-69	326	470.9	16.6	418.5	442.6	B	
70+	199	392.2	18.7	333.0	395.5	C	
Self-assessed general health							
Good	451	525.0	14.9	470.0	430.2	A	<0.001
Fair	297	428.3	15.8	382.9	413.8	B	
Poor	72	410.9	31.9	345.3	471.5	B	
Eichner classification							
A	389	617.6	15.2	591.3	417.4	A	<0.001
B	297	417.8	14.4	369.0	329.5	B	
C	134	218.0	14.3	180.5	168.1	C	
TMJ noise							
no	591	478.0	12.5	423.0	434.2		0.631
yes	229	484.9	19.5	439.4	420.1		
Mouth open limitation							
40 mm and over	766	485.3	11.0	428.1	428.1		0.065
less than 40 mm	54	403.4	36.0	326.5	404.0		
Total	820	479.9	10.5	425.7	431.3		

The Kruskal-Wallis test was used for age, self-assessed general health and Eichner classification, the Mann-Whitney U test for others. Pairwise comparisons were made using Mann-Whitney U tests with Bonferroni correction ($\alpha = 0.017$), where results were significant in Kruskal-Wallis tests. Pairs of values with different letters (A,B,C) are significantly different.

support, but not with TMJ noise or mouth opening limitation (Table 1). Males, younger persons, and subjects in good health had significantly stronger bite force than their counterparts. Participants in the Eichner A group had the highest median bite force among three groups ($p<0.01$).

A stepwise multiple logistic regression analysis showed that whether participants had low bite force or not, it was significantly associated with gender, age, self-rated general health and occlusal support (Table 2). The Nagelkerke R^2 of the model was 0.313, showing about 31% of the variation in the outcome variable could be statistically explained by this model. The overall accuracy of the model in predicting subjects having low bite force was 80.7%. Sensitivity was 93.5% and specificity was 43.5%.

The odds ratio was the highest for occlusal support. The Eichner B group compared to the A group was 3.6 times more likely to have low bite force, and the Eichner C group compared to the A group was 19.4 times more likely to have low bite force.

Overall bite force showed a statistically significant but weak negative correlation with age ($r=-0.24$, $p<0.001$)(Table 3). In the groups made up of the same gender and Eichner class, Spearman correlation coefficients between age and bite force in males, where significant, were very weak in the Eichner A group ($r=-0.15$, $p<0.05$) and in the Eichner B group ($r=-0.22$, $p<0.01$). There was no significant correlation in the Eichner C group for males or in any of the Eichner groups for females.

Table 2	Stepwise logistic regression analysis for the bite force.					
	B	SE	P-value	Odds ratio	95% CI	95% CI
Gender	0.550	0.194	0.006	1.70	1.16	2.49
Age	0.036	0.022	0.038	1.05	1.00	1.09
General health	0.403	0.186	0.016	1.56	1.09	2.25
Eichner classification			<0.001			
B	1.673	0.223	<0.001	3.63	2.35	5.63
C	3.209	0.268	<0.001	19.44	11.50	32.86

Age: continuous variable; Gender: males=0, females=1; Self-rated general health: good=0; fair/bad=1; Eichner classification: class A was set equal to 0 and classes B and C equal to 1.

Discussion

This cross-sectional study evaluated a sample of functionally independent older urban adults who had volunteered for an education program. Most previous studies had evaluated a wider age range of patients from dental schools, hospitals or nursing homes. However, this study focused only on older adults and covered a larger number of subjects than former studies. How representative these individuals are of elderly Japanese is not precisely known. However, in Japan, most elderly people (95.5% of those 75-79 years, 90.8% of those 80-84 years, and 79.1% of those 85 years and over) are functionally independent and have no limitations in their daily activities.[19] The disability-adjusted life expectancy, the so-called 'healthy life expectancy' of the Japanese, is 74.5 years, which is the highest in the world. Therefore, it is important to know about the oral health of these independent elderly people who appear to represent a majority of the elderly Japanese population.

Table 3	Spearman correlations between bite force and age.		
	Nimber of subjects	rs	P-value
Overall	820	−0.238	<0.001
Male	444	−0.324	<0.001
Eichner A	208	−0.150	0.030
Eichner B	164	−0.219	0.005
Eichner C	72	−0.217	0.067
Female	376	−0.210	<0.001
Eichner A	181	−0.105	0.160
Eichner B	133	−0.105	0.230
Eichner C	62	−0.071	0.585

In the present study, we evaluated the bilateral bite force in the intercuspal position, which is involved in several critical stages of food breakdown. We also examined gender, age, self-rated general health, occlusal support, and TMJ condition, as was done in previous studies. Factors investigated previously, which were associated with bite force, were income or educational level.[7] It has been reported that edentulous rates were negatively related to levels of education and income.[20-22] But in Japan, asking questions about educational or income level, especially of older people, is impolite and may result in a refusal to participate in the study. Therefore, we did not use these questions in our questionnaire.

The average of bite force is quite similar to what was found in previous studies using the same measuring device.[14,23] We found the bite force stronger in men (512 N) than in women (443 N), echoing the findings from previous studies.[23,24] This might be a result of difference in muscle strength.

Individuals with various TMD were reported to show a decrease in bite force,[8,9,25-27] although this has not been found by others.[28] We did not find an association of TMD with bite force. One possible reason is that a major contributing factor to TMD in our older subjects was not pain but TMJ noise or mouth opening limitation. In addition, our sample population was older than those of the other studies and seemed to be functionally adapted to the internal derangement of TMJ.

Self-rated general health was significantly associated with bite force independently of the other variables. It is well known that self-assessed health status well describes the objective health condition in geriatric persons. Subjective health conditions have been reported as important health status indicators, synthesizing objective health states and predicting physical condition and mortality.[29-31] The direction of cause and

effect is not clarified by this analysis; however, this suggests that elderly persons with impaired general health experienced more impact on oral function.

The bite forces of the Eichner class B and C groups were 68 and 35% of the class A group, respectively. As predicted, occlusal support of the residual teeth was suggested to be the most important variable for determining the bite force. The previous studies with varied measuring methods indicated that maximal bite force was 5-6 times greater in the dentate subjects than in the denture wearers.[32] It suggested directly that stronger occlusal force needs natural teeth supported with periodontal tissue, and artificial teeth over mucous membrane of residual ridge is not sufficient for the recovery of bite force. In addition, it suggested indirectly that occlusal contacts between maxillary and mandibular teeth activate oral function by masticatory muscles and temporomandibular joints, and so on. The cross-sectional area of both masseter and medial pterygoid muscles in edentulous subjects showed a greater decrease than in dentate subjects throughout the age range.[12] Significant correlation was found between masseter and medial pterygoid cross-sectional size and bite force.[33] Apart from the effects of tooth loss and muscle atrophy, the bite force in removable denture wearers might be limited because denture-bearing tissue is more subject to discomfort, compression, and denture shifting.[8,34]

Bite force was reported to decrease with increasing age after 25 years in women and after 45 years in men.[35] It also was reported that the direct effect of age on bite force was statistically significant but relatively small between 37 and 80 years (mean 58.5), excluding removable denture wearers.[36] In this study, overall age had a significant correlation with the bite force after controlling for other variables; however, in the groups of the same gender and occlusal support, correlation coefficients were very weak or not significant. Therefore tooth loss is supposed to be the most significant factor on reduction of bite force rather than ageing itself. In other words, oral function might be well preserved with advancing age if dentition is maintained in good condition.

Conclusions

Decline of occlusal support and general health might translate into reduction of bite force with ageing in older adults. Since tooth loss is not physiological ageing but pathological ageing, we cannot show that reduction of bite force is a natural effect of ageing. Maintaining a reasonable number of healthy natural teeth and occlusal support is the best guarantee for good masticatory ability with increasing age.

Acknowledgements

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原 著 論 文

実験用口蓋床の厚さと材質が味覚閾値に及ぼす影響

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Influence of Thickness and Material of Experimental Palatal Plate on Gustatory Response

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歯科補綴学的意義

義歯の装着後に，味覚に対する不満を訴えられることがときどきある．硬口蓋を被覆することが味覚閾値に対して影響を及ぼすことについては，これまで報告してきた．本研究では，義歯床の材質や厚さが味覚閾値に与える影響について検討した結果，材質による差は認められなかったが，厚さ 0.5 mm の金属床では，厚さ 1.5 mm の床と比較して，味覚は改善されることが示された．すなわち，床の厚さを薄くすることが可能な金属床の選択は，味覚の面からも有効であることが示唆された．

抄　録

目的：本研究の目的は，硬口蓋を被覆する義歯床の材質や厚さが味覚に及ぼす影響について検討することである．

方法：習慣的な喫煙経験がなく，歯の欠損が認められない 20 名（男性 11 名，女性 9 名，平均年齢 25.1±2.8 歳）を被験者とした．まず，全口腔法と咀嚼法による味覚検査を塩味と苦味について行った．3 種類の実験用口蓋床として，硬口蓋を被覆する厚さ 1.5 mm のレジン床（1.5 R 床）および金属床（1.5 M 床）と厚さ 0.5 mm の金属床（0.5 M 床）をそれぞれ製作し，非装着時と各床装着時において認知閾値を測定した．次に，同じ測定条件においてグミゼリーを用いた咀嚼能率検査を行った．

結果：全口腔法による味覚検査では，塩味は床装着による変化は認められなかった．一方，苦味は 1.5 R 床装着時と 1.5 M 床装着時では，有意な差は認められなかったが，0.5 M 床装着時は，1.5 R 床および 1.5 M 床装着時と比較すると有意に小さい認知閾値となった．咀嚼法による味覚検査では，塩味および苦味いずれにおいても，全口腔法の苦味と同様の結果であった．単位時間あたりの咀嚼能率では，0.5 M 床は，1.5 R 床および 1.5 M 床と比較すると有意に高い値を示した．

結論：厚さを薄くすることが可能である金属床の選択は，味覚の点から有用であること，さらにより短時間に食物の細分化を行うことができることが示唆された．

和文キーワード

味覚，咀嚼能率，実験用口蓋床

I. 緒　　言

　味覚は，口腔特有の感覚の1つであり，食物中から溶出した味物質が，主として舌や軟口蓋に分布する味蕾を刺激することによって認識される[1]．また，一般に基本的な味の種類は，甘味，塩味，酸味，苦味の4種類と考えられており[2]，多くの味はこの4種類のいずれか，あるいはその組合せで表現されるが，その食物がもつ匂い（嗅覚），温度（冷温覚），形状や色彩（視覚），歯ごたえ（触覚），スパイス（痛覚），咀嚼音（聴覚）などが総合され，広義の味覚として認識される[3]．一方，硬口蓋においても，酸味と苦味が感知されること[4]，感覚点の分布が多いこと[5]などが報告されており，味覚を認識するうえで重要な役割をはたす部位であると考えられる．

　これまで著者らは，義歯装着後に生じる味覚の変化の原因には，味蕾が床に直接被覆されることだけではなく，咀嚼運動に変化が生じ味蕾に味物質が到達しにくくなることや心理的な要因が関与していることを報告してきた[6~10]．

　一方，臨床において金属床を装着した場合，レジン床と比較して，違和感などが軽減され患者の満足が得られることがある．これについては，金属床は厚さを薄くすることが可能なため，口腔感覚への影響が少ないこと[11]から，味覚も阻害しにくいことが考えられる．しかし，硬口蓋を被覆する義歯床の厚さを薄くすることが，味覚に対してどのように影響を及ぼすかについては，いまだ明らかではない．

　そこで本研究では，レジン床と比較して厚さの薄い金属床を用いて口蓋粘膜を被覆することが，味覚に対してどのように影響を及ぼすかを知る目的として，有歯顎者を対象に硬口蓋部を被覆する実験用口蓋床（以下，実験床とする）を製作し，味覚検査および咀嚼能率について比較検討を行った．

　なお，本研究については，大阪大学大学院歯学研究科倫理委員会の承認を得ており，各被験者には本実験の要旨について説明を行い，了解を得て実施したものである．

II. 方　　法

1.　被験者

　被験者には，大阪大学大学院歯学研究科職員のなかから第三大臼歯以外に欠損を認めず，習慣的な喫煙経験のない24から28歳の20名（男性11名，女性9名，平均年齢25.1±2.8歳）を選択した．

2.　実験床の製作

　各被験者の上顎に対し，シリコーン印象材を用いて印象採得を行ったのち，超硬質石膏（サンロック®，デンツプライ三金）にて石膏模型を製作した．複模型用シリコーン印象材（デュプリコーン®，松風）と高温鋳造用耐火模型材（CDインベストメント®，松風）を用いて耐火模型を製作し，周縁を口蓋側歯頸部，後縁をアーラインに設定し，Co-Cr合金（コバルタン®，松風）を用いて，厚さ1.5mmの金属床（以下，1.5M床とする）と厚さ0.5mmの金属床（以下，0.5M床とする）を製作した．さらに，石膏模型にパラフィンワックス（厚さ：1.5mm）を用いて，金属床と同じ形態のワックスパターン製作後，注入型レジン（ポアレジン®，松風）を用いて，厚さ1.5mmのレジン床（以下，1.5R床とする）を製作した．いずれの実験床も研磨後，ホワイトシリコーン（フィットチェッカー®，ジーシー）にて適合状態を確認したのち，咬合干渉が生じないよう修正し実験床を完成した．さらに，各実験床の厚さは，図1に示した通り，松田[12]の報告に従い，第一小臼歯，第一大臼歯および
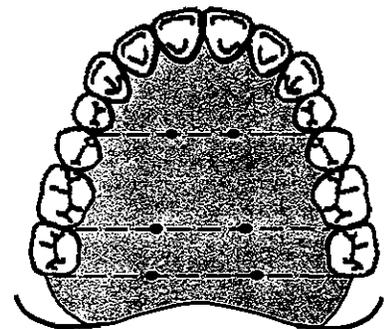

図1　The simulated figure of the experimental palatal plates and the measuring point（●）of thickness
各実験床の模式図と厚さの測定点（図中の●印）

表 1 The concentration of testing solutions for each taste on the whole mouth method
全口腔法に用いた各味質における被験溶液の濃度

(g%)

Solutions	1	2	3	4	5	6	7	8
Salt (Sodium chloride)	4.0×2^{-7}	4.0×2^{-6}	4.0×2^{-5}	4.0×2^{-4}	4.0×2^{-3}	4.0×2^{-2}	4.0×2^{-1}	4.0
Bitter (Quinine)	0.004×2^{-7}	0.004×2^{-6}	0.004×2^{-5}	0.004×2^{-4}	0.004×2^{-3}	0.004×2^{-2}	0.004×2^{-1}	0.004

表 2 The concentration of testing solutions for each taste on the chewing mouth method
咀嚼法に用いた各味質における被験溶液の濃度

(g%)

Solutions	1	2	3	4	5	6	7	8
Salt (Sodium chloride)	4.0×2^{-7}	4.0×2^{-6}	4.0×2^{-5}	4.0×2^{-4}	4.0×2^{-3}	4.0×2^{-2}	4.0×2^{-1}	4.0
Bitter (Quinine)	0.016×2^{-7}	0.016×2^{-6}	0.016×2^{-5}	0.016×2^{-4}	0.016×2^{-3}	0.016×2^{-2}	0.016×2^{-1}	0.016

第二大臼歯遠心を結ぶ線分をそれぞれ3等分した2点の計6点の測定点において，それぞれ規定の厚さ（誤差が1%以内）であることを確認した．

3．分析項目および分析方法

非装着時，1.5R床，1.5M床および0.5M床の3種類の各床装着時における味覚検査と咀嚼能率検査を行い，実験床による差について分析した．異なる実験条件における測定は3〜5日の間隔をあけて行い，その順序はランダムとした．味覚検査については，各被験者において得られた認知閾値より，非装着時において認知閾値に達した濃度を基準値1として，それに対する実験床装着時の相対閾値を求めて比較検討を行った．なお，各実験床装着による差の検定には，Friedman test にて有意差の認められた場合に対して，Bonferroni の修正による多重比較を行った．

1）全口腔法による味覚検査

四基本味のうち塩味と苦味について認知閾値の測定を行った．すなわち，各被験溶液は，温度を26〜30℃とし，表1に示した通り8段階に調整し，濃度の低いものから順に最長10秒間口に含ませ，認知閾値を求めた．味質の測定順序は，塩味，苦味の順とし，異なる味質に移るときには前の味が残らないように含嗽を十分に行い，10分間の間隔を設けた．

2）咀嚼法による味覚検査[6]

全口腔法と同様に，四基本味のうち塩味と苦味について認知閾値の測定を行った．すなわち，各被験溶液は，温度を26〜30℃とし，表2に示した通り8段階

に調整した．また，被験試料として，直径10mm，長さ10mmのロール綿に各被験溶液を300μl注入したものを用い，濃度の低いものから順に被験者に対し通常の咀嚼運動を行うように指示した．味質の測定順序は，塩味，苦味の順とし，異なる味質に移るときには前の味が残らないように含嗽を十分に行い，10分間の間隔を設けた．

3）グミゼリーを用いた咀嚼能率検査

当教室が開発した試験用グミゼリーNo.3（以下，グミゼリーとする）による咀嚼能率検査法[9]を用いた．被験者に歯ブラシのみによる口腔清掃を十分に行わせたのち，グミゼリー1個を習慣性咀嚼側にて通常の食事と同様に10秒間咀嚼するように指示し，グルコースの溶出量より表面積増加量を算出した．

III．結　果

1．全口腔法による味覚検査

図2に示した通り，塩味では各床装着時の間に有意差は認められなかった．一方，苦味では，各床装着時の間に有意差が認められ，0.5M床装着時は，1.5R床および1.5M床装着時と比較して有意に認知閾値が低くなった．

2．咀嚼法による味覚検査

図3に示した通り，塩味と苦味いずれにおいても，各床装着時の間に有意差が認められ，0.5M床装着時は，1.5R床および1.5M床装着時と比較して有意に
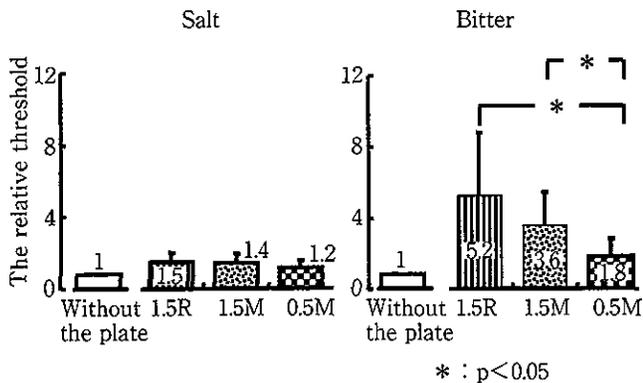
Salt　　　　　　　　　Bitter

＊：p＜0.05

図2　The relative thresholds for each taste on the whole mouth method, when the thresholds of judgment without the plate was standardized
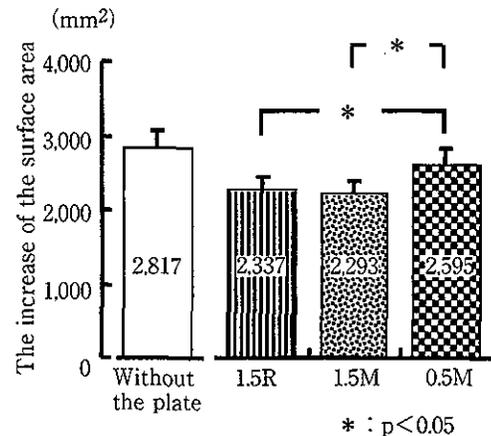全口腔法において，各味質の非装着時おける認知閾値を基準値1としたときの各測定条件の相対閾値

(mm²)

＊：p＜0.05

図4　Masticatory performance on each condition of measurement
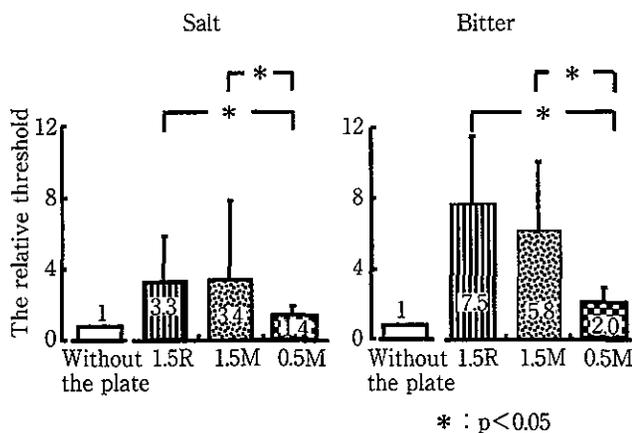各測定条件における咀嚼能率診査

Salt　　　　　　　　　Bitter

＊：p＜0.05

図3　The relative thresholds for each taste on the chewing method, when the thresholds of judgment without the plate was standardized
咀嚼法において，各味質の非装着時おける認知閾値を基準値1としたときの各測定条件の相対閾値

認知閾値が低くなった．すなわち，厚さの薄い0.5M床装着時では味がわかりやすくなることが示された．

3．グミゼリーを用いた咀嚼能率検査

図4に示した通り，各床装着時の間に有意差が認められ，0.5M床装着時は，1.5R床および1.5M床装着時と比較して有意に表面積増加量が大きい値を示した．すなわち，厚さの薄い0.5M床装着時では咀嚼が行いやすく，効率よく食物の細分化が行われていることが示された．

IV．考　　察

一般に味覚は，舌と軟口蓋で主に認識され，硬口蓋部ではほとんど認識しない[1]といわれているが，感覚点は多く存在しており，食物の認識，食塊の形成，嚥下にいたる一連の咀嚼運動を行ううえで重要な部位である．また，関塚[13]は口蓋部を被覆するような義歯床，連結装置あるいは支台装置などを装着することによって口腔内の感覚が変化することを，榎村[14]は口蓋部の被覆によって咀嚼能率は低下し，舌と口蓋との運動や感覚機能の協調作用がうまく行われなくなることを報告している．一方，著者らもこれまで実験床が厚くなると，単位時間当たりの咀嚼能率が下がり，味覚の認知閾値も高くなることを報告しているが[10]，逆に実験床を薄くすることが味覚の改善につながるかどうかについては明らかではなく，また，床の材質による影響についての報告もみられない．このことから，本研究では硬口蓋を被覆する床の厚さや材質の違いによって，味覚がどのように影響されるかについて検討し，その結果について考察を行う．

1．実験方法について

1）実験床

実験床の形態は，咀嚼および発音機能などに影響を及ぼす[12]といわれていることから，床縁の設定位置や厚さを規定する必要がある．これまで著者らが用いてきた床，すなわち，厚さは1.5 mm，周縁は咬合接触

に影響を与えないように歯頸部に対し移行的に接し，後縁は全部床義歯の床後縁として多く利用されているアーラインに設定した．床の厚さを薄くする場合，レジンを用いて実験床を製作すると研磨後の床の適合が悪くなるため，歯科用 Co-Cr 合金を用いて，厚さ 0.5 mm の実験床を製作することとした．さらに，材質の違いを検討するために厚さ 1.5 mm 金属床も製作し，厚さ 1.5 mm のレジン床と金属床および厚さ 0.5 mm の金属床の 3 種類で比較検討を行った．

　2)　味覚検査

　味覚検査には，一定温度の被験溶液を口に含ませる全口腔法[15]，ピペット，綿棒やろ紙で一定量を舌に滴下したり塗布したりする塗布法[16,17]などがある．本実験では，実験床を装着することによって口腔内全体の味覚の感じ方が変化することと，咀嚼運動の変化によって味覚が変化することが考えられることから，両者を検討するために，著者らがこれまで用いてきた全口腔法と咀嚼法を採用した．また，味質は四基本味のうち，実験床の装着の影響を受けやすい塩味，酸味および苦味のなかから，軟口蓋の閾値が低い苦味と高い塩味[1]の認知閾値について検討を行った．

　認知閾値は，被験者の年齢，性および肉体的条件によって異なるばかりでなく，味物質の種類，被験溶液の量や温度，刺激時間ならびにその間隔，検査を行う時間帯などによっても異なる[18]といわれており，味覚検査を行う場合，被験者や被験溶液の条件を統一する必要があると考えられる．そこで，本研究の実験条件は奥田[19]の報告に従った．

　被験者に関して，一般に生体は，発育，成長，老化という一連の過程を経ており，その間さまざまな形態的および機能的な変化が起こっている[20,21]．口腔感覚も例外ではなく，舌の振動や触覚の閾値は高齢者のほうが高くなり[22]，また喫煙についても味覚閾値が高くなるとの報告[23]もある．そのため，本研究の被験者は，喫煙習慣が過去においても認められず，比較的口腔感覚の安定している 20 歳代の男女[23,24]を選択した．

2.　実験結果について

1)　全口腔法による味覚検査について

　塩味については，各床装着時で有意な差が認められなかった．これは，全口腔法による味覚検査では，厚さ 1.5 mm のレジン床装着時における塩味の認知閾値は，非装着時と比較して有意差が認められなかった[6]ことから，実験床の装着の影響を受けにくい味質であることによるものと考えられる．一方，苦味については，同じ厚さ 1.5 mm のレジン床と金属床との間では有意な差が認められなかったが，厚さ 0.5 mm の金属床装着時は，厚さ 1.5 mm のレジン床および金属床と比較して味覚閾値が下がり，味がわかりやすくなった．これは，実験床に対する違和感が大きい厚さ 1.5 mm の実験床装着時では，厚さ 0.5 mm の実験床装着時と比較して，心理的な味の対比効果の影響が大きく[8]，さらに被験溶液が比較的口腔の前方部に留まりやすかった[6]ために，軟口蓋の味蕾が刺激されにくかったことが考えられる．

2)　咀嚼法による味覚検査について

　塩味および苦味のいずれにおいても，同じ厚さ 1.5 mm のレジン床と金属床との間では有意な差が認められなかったが，厚さ 0.5 mm の金属床装着時は，厚さ 1.5 mm のレジン床および金属床と比較して味覚閾値が下がり，味がわかりやすくなった．これは，実験床を装着することによって，舌の運動や感覚機能の協調作用がうまく行われなくなるが[25]，実験床が薄くなることによって，これらの協調作用がある程度回復されることによるものと考えられる．

3)　咀嚼能率について

　咀嚼能率については，同じ厚さ 1.5 mm のレジン床と金属床との間では有意な差が認められなかったが，厚さ 0.5 mm の金属床装着時は，厚さ 1.5 mm のレジン床および金属床と比較して単位時間あたりの咀嚼能率は高い値を示した．厚さ 0.5 mm の金属床では，実験床が薄くなり舌房が広くなったために，咀嚼運動が容易となり，咀嚼能率が向上したものと考えられる．

　一方，グミゼリー咀嚼時の咀嚼能率と咀嚼法による味覚検査との関連性については，単位時間あたりの咀嚼能率が低く，細分化する速度が遅くなることにより，認知閾値も高くなり味がわかりにくくなるものと考えられ，食品に対する効率の良い細分化と味覚は密接に関係することが示された．

V.　結　　論

　本研究は，硬口蓋を被覆する床の厚さや材質が異なることによって，味覚や咀嚼にどのように影響を及ぼ

すかを検討するため，厚さと材質の異なる3種類の実験床を用いて味覚検査と咀嚼能率測定を行った結果，以下のような結論を得た．

1．厚さ1.5mmの金属床と厚さ1.5mmのレジン床との間には，味覚検査および咀嚼能率測定のいずれにおいても有意な差は認められなかった．

2．厚さ1.5mmの実験床を装着することによって認知閾値が上昇した味質は，厚さ0.5mmの金属床を装着することによって認知閾値は低くなった．

3．厚さ1.5mmの実験床装着時と比較して，厚さ0.5mmの金属床装着時では，単位時間あたりの咀嚼能率が高くなった．

以上の結果，義歯床によって硬口蓋を被覆すると，味覚の認知閾値は高くなり，咀嚼能率も低下するが，床の厚さを薄くすることが可能である金属床を選択することによって，味覚の認知閾値は低くなり，さらに，より短時間に食物の細分化を行うことができることが示唆された．

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Influence of Thickness and Material of Experimental Palatal Plate on Gustatory Response

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ABSTRACT

Purpose : This study examined influences of thickness and materials of experimental palatal plates on gustatory response.

Materials and Methods : In this study, the subjects were twenty non-smoking adults (11 males and 9 females) with intact dentition. Three kinds of experimental palatal plate covering their whole hard palates were made : 1.5 R plate (a resin plate with 1.5 mm thickness), 1.5 M plate (a metal plate with 1.5 mm thickness), and 0.5 M plate (a metal plate with 0.5 mm thickness). First, responses to salt or bitter taste were investigated in the gustatory test by the whole mouth method and the chewing method, with and without each plate. Then, the masticatory performance per minute was investigated with and without each plate.

Results : 1. There was no significant difference in the gustatory tests and the masticatory performance between the 1.5 R plate and 1.5 M plate. 2. In the whole mouth method, only for bitter taste, the threshold of judgment of the 0.5 M plate was significantly different from that of the 1.5 R plate or 1.5 M plate. 3. In the chewing method, for both salt and bitter tastes, the threshold of judgment of the 0.5 M plate was significantly different from that of the 1.5 R plate or 1.5 M plate. 4. The masticatory performance of the 0.5 M plate was significantly different from that of the 1.5 R plate or 1.5 M plate.

Conclusions : It is suggested that thinner metal palatal plates are effective for gustatory response.

Key words

taste, masticatory performance, palatal plate