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# Masticatory Function and Physical/Mental Activity in the Elderly

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## Abstract

Eighty elderly persons residing in a nursing home and a geriatric hospital were surveyed with the Dementia Rating Scale, fingertip skills, grip strength, and masticatory function by a food intake questionnaire. The correlation coefficient between dementia and masticatory scores, finger skills, and masticatory score, were statistically, significant ($p<0.01$). Grip strength and finger skill scores were all lower in persons not wearing dentures ($p<0.01$) suggesting that these tests may have some use as a measure for predicting the ability elderly persons to function with complete dentures. The results of this study suggest a close relationship between masticatory function and some measures of physical-and-mental activity in this group of elderly subjects.

Key words: Masticatory Function, Elderly person, Removable denture, Dementia, Physical activity

In recent years the number of aged persons in the population of developed countries has been steadily increasing. Tooth loss is a typical age-associated stomatognathic change, and edentulism rates among the elderly have been reported as 35.7 percent in Japan[1] and 33.8 percent in the United States in persons aged 65-74 years[2]. A number of European countries and Australia have reported higher rates of edentulism, 57 to 85 percent[3]. Dentures are

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generally made to restore oral functions after the natural teeth have been lost. However, there are also other stomatognathic changes associated with aging as well as oral manifestations of systemic diseasses which can make the wearing of dentures difficult for elderly persons. Some of the more significant changes occur in the structure of the mucosa, the function of oral musculature, taste perceptions, salivary function, and in the nervous system[4,5,6].

Dementia has become a serious problem in health care for elderly persons. It is caused by neuronal degeneration and loss of brain cells in the cortex (Alzheimere's disease, senile dementia) or by cerebrovascular accidents (multi-infarct dementia)[7]. Masticatory movements are controlled by the various proprioceptors and masticatory functions may be affected if the upper central nervous system is compromised by dementia.

This paper investigates the relationship between masticatory function and dementia, grip-strength, and finger skills in an elderly population.

## Materials and methods.

### 1. Subjects

The test group was 80 elderly persons (34 males, 46 females) residing in a nursing home and a geriatric hospital. The age and sex distribution of the subjects is shown in Figure 1, the average age was 80.4 years. Forty-four patients wore complete dentures, 16 removable partial dentures, twenty had no dentures or had never used dentures. Of the 20 who had no dentures, 16 were edentulous and 4 had $6.0 \pm 4.6$ teeth.

### 2. Physical and Mental Activity Measures

(1) Dementia scale: The degree of dementia was examined by the Hasegawa Dementia Rating Scale (Table 1). The subjects were classified into 4 groups according to the scores suggested by Hasegawa[8].

(2) Finger skills: Small disks, balls, and pins were used as a simple test for evaluating hand function by way of a pegboard[9] to evaluate fine motor funciton. The finger skill score was the time for patients to complete the test.

(3) Grip strength: Grip strength was measured with Smedlay's dynamometer for children. Grip scores were expressed as the ratio of grip strength to body weight.

(4) Masticatory score: A food list for complete denture wearers (Table 2) was used for evaluating masticatory functions. This evaluation list had been developed by our group in two pilot investigations which are surmmarized below. Initially, 170 different foods were chosen from "The 4th Food Component Book"[2]. Then 30 complete

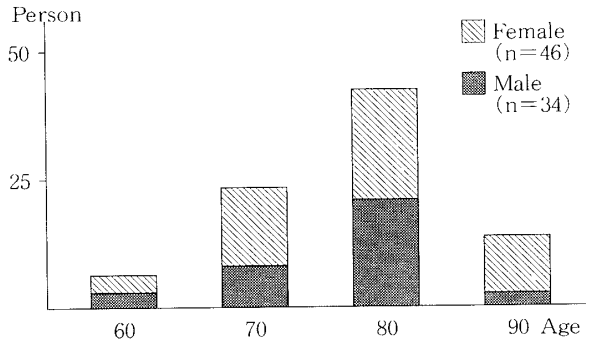


Fig 1. Age & Sex of Subjects

**Table 1** Hasegawa's dementia test

Hasegawa's scale of dementia

| Question | Allotting of marks |
|---|---|
| 1. Please tell me your name? (First & second name) | 0, 0 |
| 2. What day is it today? (Month, day, day of the week) | 0, 3 |
| 3. Where are you now? | 0, 2.5 |
| 4. How old are you? (correct within 3～4 years) | 0, 2 |
| 5. When did it happen? (recent occurrance) | 0, 2.5 |
| 6. Where ara you from? (birth place) | 0, 2 |
| 7. When did World War II come to an end? (correct within 3～4 years) | 0, 3.5 |
| 8. How many days in a year? | 0, 2.5 |
| 9. Who is the prime minister of Japan? | 0, 3 |
| 10. What is 100 minus 7? And, please take 7 from the answer. 100−7=93, 93−7=86 | 0, 2, 4 |
| 11. Please repeat the next numbers coversely. (6−8−2, 3−5−2−9) | 0, 2, 4 |
| 12. Please name these 5 articles. (After telling, put 5 articles out of sight.) Please repeat the name of these 5 articles name. | 0.5, 1.5 2.5, 3.5 |

Time required: within 15 minutes
Full marks: 32.5

| Total points | Evaluation |
|---|---|
| >31 | normal |
| 30.5～22 | subnormal |
| 21.5～10.5 | predementia |
| 10> | dementia |

denture wearers whose general health and oral tissue were without pathosis and where residual ridge resorption was moderate, were asked to assign each type of food to one of four categories (○ -- can eat, × -- cannot eat, △ -- do not eat because I dislike it, □ -- have not eaten since starting to wear dentures) with both old and new dentures. Next, a list of 35 foods was developed from the results of this investigation. The new list considered food texture (hardness, viscocity, elasticity, adhesiveness)[10], cooking methods, and likes and dislikes. This second questionnaire was given to 39 other patients who had been wearing newly made complete dentures for 6 months and whose general health and oral tissue were similar to the previous denture patients. In the second survey the 39 patients were asked to select from 5 answers (2--can be eaten easily, 1--can be eaten with difficulty, 0--cannot be eaten, △--I do not eat because I dislike it, □ -- I have not eaten it since starting to wear dentures). The answers were scored (2, 1, 0) and the 35 foods were classified into 5 grades of difficulty (Table 3). The "Standard masicatory ability of complete denture wearers" as a diagnostic criteria were developed from these studies by calculating the rate of the ability to eat for each grade (Fig. 2). The masticatory ability of each individual was shown as a "masticatory score" (Table 4). The mean masticatory score for complete denture wearers was 60.2 point. In this study when a patient could not answer the questionnaire, help was sought from caretakers or

Table 2 Qustionnaraire with 35 Foods Listings

Questionnaire on Masticatory Function

Please fill the blanks as follows
[2] ……easily eaten
[1] ……eaten with difficulty
[0] ……cannot be eaten
[△] ……do not eat because of dislike
[□] ……have not eaten since starting to wear dentures

| | | | |
|---|---|---|---|
| 1 | [ ] fried rice cracker | 2 | [ ] rice cake |
| 3 | [ ] raw abalone | 4 | [ ] sliced raw cuttlefish |
| 5 | [ ] strawberries | 6 | [ ] boiled fish paste patty |
| 7 | [ ] raw cabbage | 8 | [ ] boiled beef |
| 9 | [ ] boiled cabbage | 10 | [ ] raw cucumbers |
| 11 | [ ] jellyfish | 12 | [ ] konjaku |
| 13 | [ ] boiled taro | 14 | [ ] dried cuttlefish |
| 15 | [ ] vinegared octopus | 16 | [ ] pickled radish |
| 17 | [ ] boild onions | 18 | [ ] takuwan (pickled radish) |
| 19 | [ ] boiled kombu (tukudani kombu) | 20 | [ ] fried chicken |
| 21 | [ ] boiled chicken | 22 | [ ] roast chicken |
| 23 | [ ] pickled eggplant | 24 | [ ] raw trepang |
| 25 | [ ] raw carrots | 26 | [ ] boiled carrots |
| 27 | [ ] banana | 28 | [ ] ham |
| 29 | [ ] peanuts | 30 | [ ] roast pork |
| 31 | [ ] pork cutlets | 32 | [ ] pudding |
| 33 | [ ] sliced raw tuna | 34 | [ ] pickled scallion |
| 35 | [ ] apples | | |

Thank you very much for your cooperation,

Table 3 The 35 foods classified into 5 grades of difficulty by taking-difficulty

| | Grades of 35 Foods (By degree of eating difficuly) |
|---|---|
| I | pudding, bananas, boiled cabbage, boiled carrots, boiled taro, sliced raw tuna, boiled onions |
| II | strawberries, ham, boiled chicken, boiled fish paste patty, konjaku, boiled kombu (tsukudani kombu), raw cucumber, |
| III | fried chicken, fried rice crackers, roast chicken, apples, pickled eggplants, boiled beef, raw cabbage, |
| IV | roast pork, pickled scallion, pickled radish, rice cakes, peanuts, sliced raw cuttlefish, pork cutlet |
| V | raw carrots, takuwan, jellyfish, vinegared octopus, raw trepang, raw abalone, dried cuttlefish, |

family members.

## Results.

The subjects were divided into two groups. Those with masticatory scores above 60 points and those below. The masticatory score of 60 was chosen because the mean score in "normal" complete denture wearers, has been recorded as 60.2.

**Table 4** Expression of chewing score

| Food group | Standard rate of the performance to eat | Difficulty rate | (Full mark points) | | Individual points |
|---|---|---|---|---|---|
| I | 97.4% | 1 | (7 foods×2=14) | ····· | A |
| II | 85.7% | 1.14 | (7 foods×2=14) | ····· | B |
| III | 74.9% | 1.30 | (7 foods×2=14) | ····· | C |
| IV | 64.1% | 1.52 | (7 foods×2=14) | ····· | D |
| V | 32.6% | 3.00 | (7 foods×2=14) | ····· | E |
| Total | | 7.96×14=111.4 | | | |

Chewing score=(A+1.14B+1.30C+1.52D+3.00E)×100/111.4

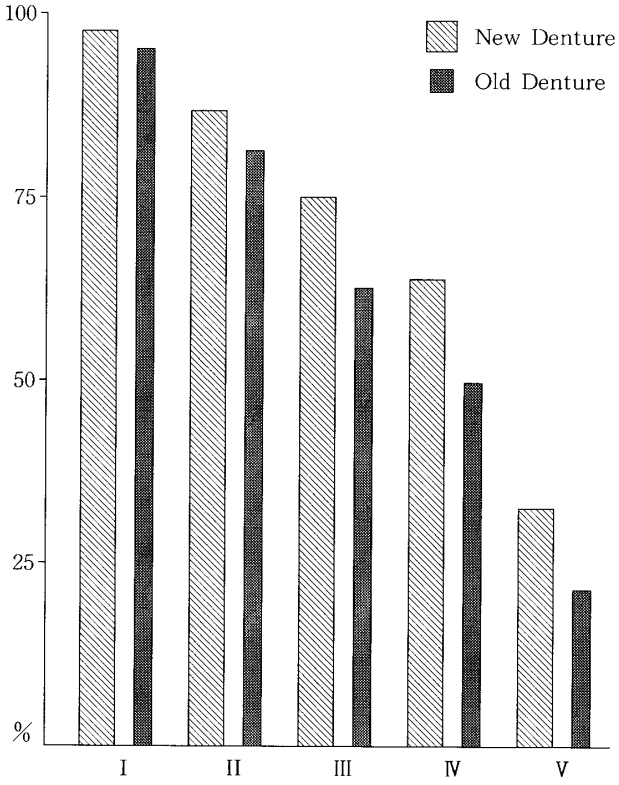


Fig. 2. Standard masicatory ability of Complete Denture Wearers

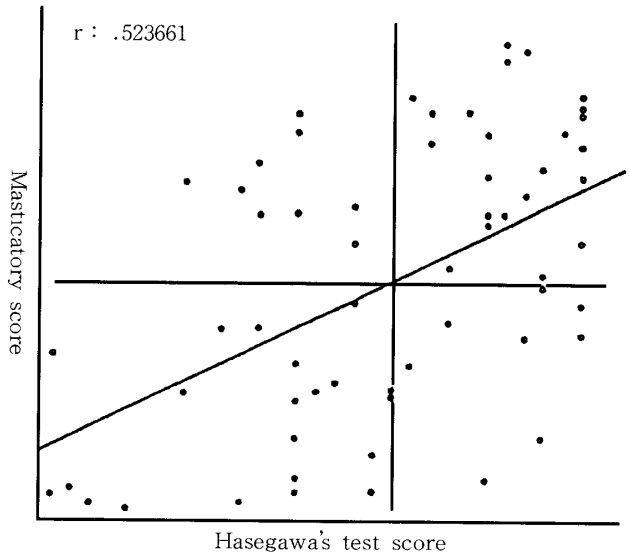


Fig. 3. Hasegawa test scores and Masticatory score, Correlation coefficient 0.52, statistically significant ($p<0.01$)

The patients in each group were categorized according to Hasegawa's test scores for dementia (Fig. 3). The correlation coefficient between the dementia and masticatory scores was 0.52 and this was statistically significant ($p<0.01$) (Fig. 4).

The two groups of subjects with masticatory scores above and below 60 were further divided into three groups according to finger skill scores: good (+), fair (±), and poor (−). Sixty-eight percent in the 60+ group displayed good finger skill scores, while less than half of the 60− group recorded good finger skill scores (Fig. 5). The correlation coefficient between finger skills scores and masticatory scores was 0.39, also statistically significant ($p<0.01$) (Fig. 6).

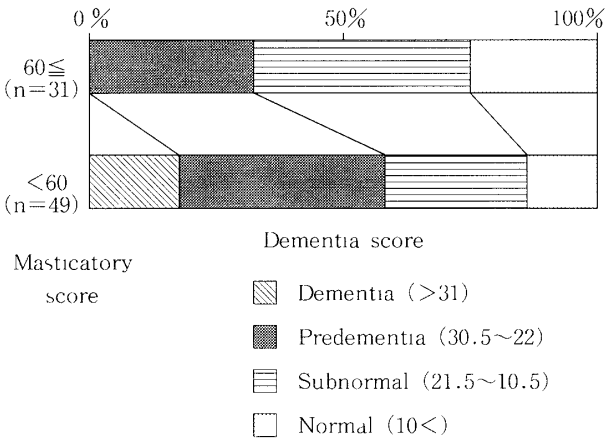


Fig. 4. Hasegawa test scores and masticatory score Seventy percent of the 60+ Masticatory score group displayed normal or subnormal scores, while less than forty percent of the 60− group showed normal or subnormal scores.

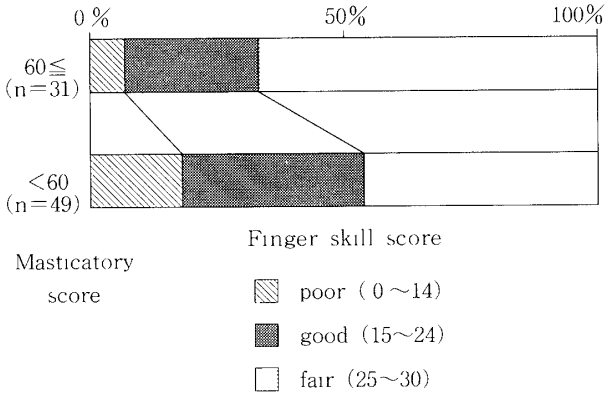


Fig. 6. Finger skill score and Masticatory score Sixty-eight percent of the 60+ group displayed good finger skill scores, while less than half of the 60− group showed good finger skill scores.

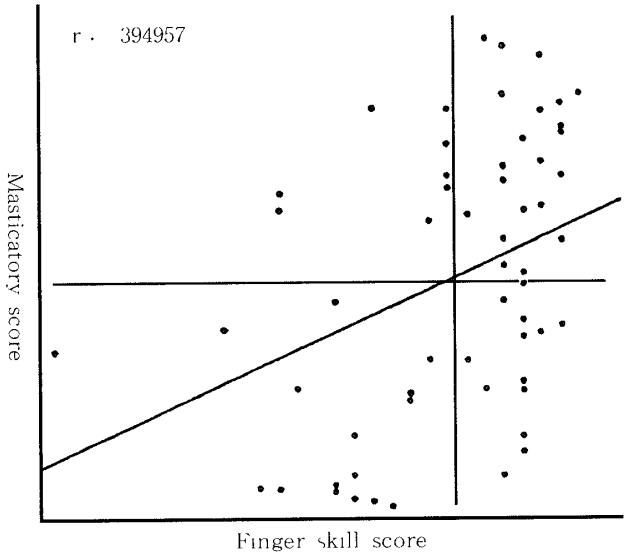


Fig. 5. Finger skill score and Masticatory score Correlation coefficient 0.39, statistically significant ($p<0.01$)

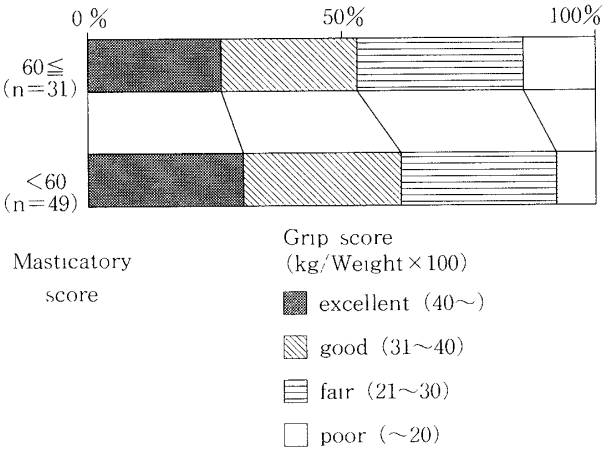


Fig. 7 Grip score and Masticatory score The 60+ Masticatory score group generally showed higher Grip scores

The subjects of the 60+ and 60− groups were further divided into four groups according to their average grip scores which were recorded as excellent (++), good (+), fair (±), and poor (−). There were no statistically significant correlations, but the 60+ masticatory score group tended to have higher grip scores.

## Discussion.

Brain cells in the central nervous system are activated by various stimuli, such as gustation and masticatory pressure through the sensory network in the periodontal membrane[11]. Due to this, mastication seems important in the physical and mental activities of elderly persons after

teeth loss.

Objective evaluation methods of masticatory functions have been investigated in denture wearers by measuring the masticatory performance and efficiency[12,13], by the use of electromyograph recordings of muscle activity[14,15], and masticatory force analysis[16,17]. The masticatory function in denture wearers is affected by denture fit and stability and by the characteristics and volume of saliva, artificial tooth form, shape of residual alveolar ridge, denture experience, and also some mental factors. As a consequence, a comprehensive evaluation of patients is necessary to be able to successfully predict denture wearer performance. It was interesting, but not surprising that for persons wearing complete dentures, difficulties with eating corresponded to the hardness of food as measured by the texturo-meter[18] (Table 5).

When using a questionnaire for epidemiological studies appropriate diagnostic criteria must be established and validated. The questionnaire with 35 foods items in this study was developed and tested in our department and we have found it a valid test. To ascertain the validity of the questionnaire method the following test was performed: Interviews with the denture wearers established which subjects were satisfied with their dentures. The clinician then evaluated denture retention, support and stability, denture base form, and occlusion. In this study, denture conditions were evaluated by two specialists in removable prosthodontics who examined retention, stability, and occlusion. In addition to this evaluation, patients were asked about the degree of satisfaction with their dentures. Denture evaluations were made as follows: points were awarded for retention, stability, and occlusion (30: good; 20: fair; 10: poor), and totals were averaged. Persons without dentures or who had not used dentures were given 0 points. Points for satisfaction were assigned in the same manner. The mean of the

**Table 5** Food-taking difficulty and hardness by texturometer

| | 0～1kg | 1～2kg | 2～3kg | 3～5kg | 5～7kg | 7～9kg | 9～20kg |
|---|---|---|---|---|---|---|---|
| I | pudding | bananas<br>carrots<br>(boiled) | taro<br>(boiled)<br>tuna<br>(raw) | | | | |
| II | | | ham<br>fish paste<br>(boiled) | konnyaku<br>cuccumber<br>(raw) | | | |
| III | | | | apple | cabbage<br>(raw) | eggplant<br>(pickled) | |
| IV | | | | pork (roast)<br>rice cake | scallion<br>(pickled) | cuttlefish<br>(raw sliced)<br>peanuts | |
| V | | | | | | | abalone<br>(raw)<br>trepang<br>(raw)<br>cuttlefish<br>(dried)<br>takuwan |

denture evaluation and degree of satisfaction was used as the denture score.

The relationship between the masticatory score and the denture score was statistically analyzed and the correlation coefficient was found to be 0.73 which was statistically significant ($p<0.01$) (Fig. 8). This result was interpreted to indicate that the masticatory score obtained by the questionnaire was valid for an evaluation of masticatory functions in complete denture wearers. The questionnaire has also been used to compare newly made complete dentures to old dentures. The difference between the ability to eat with new complete and old complete dentures are shown in Fig. 2[18]. This evaluation method has also been used to evaluate removable partial denture wearers after mandibular segmental resection[19]. The dementia test score and the masticatory score were found to correlate statistically. The degree of dementia was evaluated by Hasegawa's method which is a modification of the mental status questionnaire (MSQ) by Kahn et al.[20] and similar to the Mattis scale by Coblentz et al.[21] It is a very reliable scale which has been used for both clinically and epidemiological study. It is interesting that the divided-bar chart (Fig. 4) data suggests that many of the dementia and pre-dementia patients had measures below the average masticatory score. Baum and Bodner[22] reported age-related changes in oral motor function as evidence of altered performance among older persons. Masticatory rhythms and tongue motor skills are controlled by the various proprioceptors. The upper central nervous system has been investigated by electromyography, mandibular kinesiograph[23], and ultrasound[24]. Results of these studies suggest that the oral motor behavior in the eldenly may be different from that of younger adults. Hand functions are dependent upon anatomic integrity, mobility, muscle strength, sensation, and coordination. It is also influenced by age and mental state[25]. Hand dexterity, especially fingertip dexterity, in the elderly

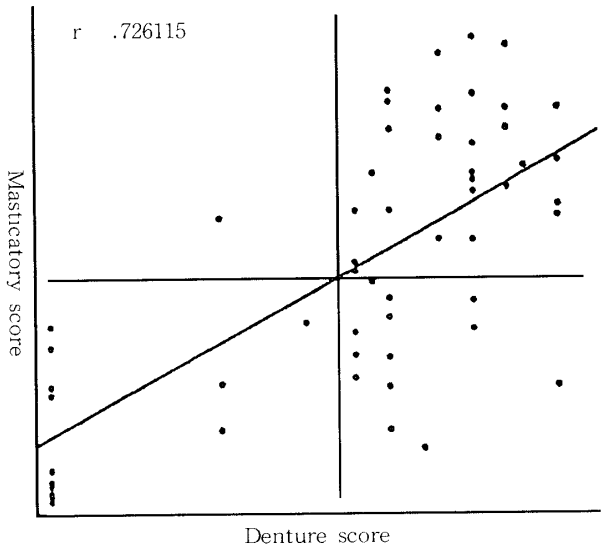


Fig. 8. Denture score and Masticatory score

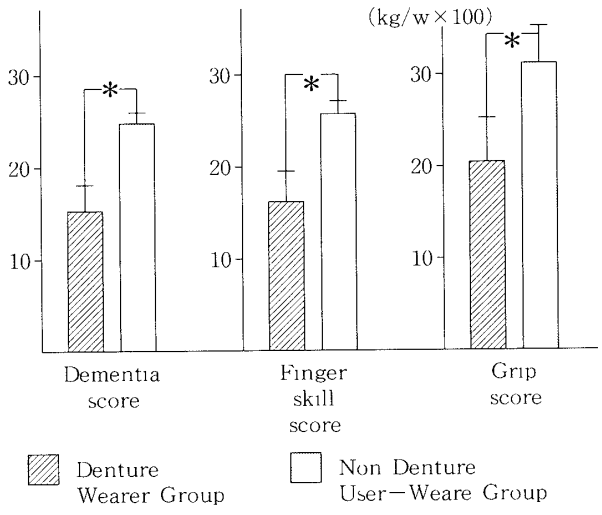


Fig. 9. Dementia score, Finger skill score, and Grip strength in the Denture Wearer Group and Non Denture User-Wearer Group Asterisks indicate statistically significant ($p<0.01$) differences between values

has also been reported to decrease[26]. Fingertip functions have been studied in brain-damaged patients such as persons with Acute Cerebellar Ataxia[27]. Successful complete denture wearing requires intact oral neuromuscular skills. In this study, the relationship between masticatory function and finger skill scores showed a significant correlation. Fingertip dexterity may be a simple and effective method for evaluating the ability of older patients to function with complete dentures.

This hypothesis is strengthened by the fact that the dementia scores, the grip strength, and the finger skill scores, were all lower in non-denture wearers ($p<0.01$) (Fig. 9) than in persons able to wear dentures successfully. The results of this study suggest a close relationship between masticatory functions and physical/mental activities. However, further investigation would be necessary to develop and test the appropriate skills for clinical applications.

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## 抄　　録

特別養護老人ホームおよび老人病院に入所・入院中の80名に対して，痴呆の程度（長谷川式簡易痴呆スケール），手指巧緻性スコア(簡易上肢機能検査)，比握力，および咀嚼能力(摂取可能食品アンケート法を用いた咀嚼スコアによる評価）を調査した。

痴呆スケールと咀嚼スコアおよび手指巧緻性スコアと咀嚼スコアとの間には有意な相関が認められた(P＜0.01)。義歯未使用者における比握力および手指巧緻性スコアは，義歯使用者に比して，有意に低い値を示した（P＜0.01)。

比握力および手指巧緻性スコアは高齢全部床義歯装着者の咀嚼能力を評価するための一助になる可能性が示唆された。また，今回の調査から，高齢者における咀嚼機能が身体活動および精神活動と密度に関連していることが示唆された。