# The effect of new complete dentures on mastication and dietary intake

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Masticatory efficiency, the subjective experience of masticatory performance, and dietary intake were measured for 43 subjects who were provided with new complete dentures. The subjects were tested on three occasions: with the old complete dentures, with the new complete dentures when free from symptoms, and with the new dentures about 4 months after insertion. Masticatory efficiency and the subjective experience of masticatory performance increased significantly when the subjects were provided with new dentures, but no changes were found in the dietary intake. With the new dentures the masticatory efficiency and the subjective experience of masticatory performance were correlated to each other. □ *Masticatory and chewing efficiency; masticatory physiology; nutrition; prosthetics*

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Eating is a complex activity. Our knowledge of the interrelationship of masticatory efficiency (the capacity to comminute food), nutritional intake, and the psychological experience derived from eating is far from complete. Furthermore, the possibility cannot be excluded that reduced masticatory efficiency may affect the gastrointestinal system.

Patients with new complete dentures have reduced masticatory efficiency compared with those with intact dentition (1–3), a fact that may influence dietary intake (4–7). The intake of iron and vitamins A and C has been reported to be insufficient in individuals with complete dentures (8). However, low masticatory efficiency does not necessarily mean that the dietary intake is not within recommended values (9). Apart from the physiological and biological effects of dietary intake, the choice of food also is of social importance and may influence the quality of life.

The correlation between masticatory efficiency as determined by different objective methods and the subjective experience of masticatory performance has been found to be weak (10, 11). Many authors have studied the ways in which variations in the design of complete dentures can influence masticatory efficiency. For example, masticatory efficiency was found to be related to the extension of denture base (12), occlusal patterns (13, 14), and cusp form (15). However, relining complete dentures (16) or replacing them with new ones (11) did not seem to improve masticatory efficiency.

The aims of this study were to investigate how the transition from old to new complete dentures affects masticatory efficiency, the subjective experience of masticatory performance, and the dietary intake and to analyze the relationships between these variables.

## Materials and methods

### *Subjects and dentures*

The material consisted of all patients in good general health who during the autumn of 1982 attended the Department of Prosthetic Dentistry, University of Umeå, to be fitted with new complete dentures by students. Forty-six patients attended; two patients were excluded because of poor general health and one because of difficulties in participating. Thus 43 patients remained: 24 women and 19 men. The average age was 63.7 years, the median age 65 years, the SD

13.2 years, and the range 39–82 years; three patients were less than 50 years old. Only two of the subjects had severe anamnestic dysfunction (index II), and none had severe clinical dysfunction (index III) of the stomatognathic system in accordance with Helkimo's index (17).

The stability, retention, occlusion, and protrusive and lateral occlusion of the old dentures were subjectively assessed by one of the authors (H-S. J. Gunne) in accordance with criteria described previously (18). The stability was poor in about a quarter of the upper and about three quarters of the lower dentures. The corresponding figures for retention were about 30% for the upper and about 80% for the lower dentures. Acrylic teeth were used in 61% of the old dentures and porcelain in the others. The occlusion and protrusive and lateral occlusion were estimated in accordance with criteria described previously (18), and the protrusive and lateral occlusion was found to be incorrect in approximately 90% of the cases and the occlusion in 40%. Consequently, the quality of the old dentures was on the whole comparatively poor, and the patients were in need of new dentures.

The subjects reported that they had on average used complete dentures for 29.5 years (range, 5–52 years). Half of the subjects said they had problems with chewing. Ninety per cent said that some foodstuffs were very difficult to chew, and a quarter had to avoid certain foodstuffs because they could not chew them at all. Nineteen subjects (44%) did not think that their food was well chewed before it was swallowed.

All subjects were provided with new complete dentures aimed at obtaining the best possible stability and retention and as correct occlusion and protrusive and lateral occlusion as possible (18). Acrylic 20° teeth were used.

### *Masticatory efficiency*

The subjects were investigated on three testing occasions in accordance with the schedule in Fig. 1.

Masticatory efficiency was calculated by two methods, both described elsewhere (2, 3, 19). In the first method gelatin (hardened with Formalin) was used as test material and the breakdown measured by calculating the summarized area of the masticated material. Almond was used as test material in the second method and the breakdown measured by fractionating the almond particles in a sieve system. In this study we used gelatin cubes with sides of 20 mm, not 22 mm as described earlier (2). Test pieces 1–4 were chewed with 20 strokes and test pieces 5 and 6 until the subjects felt ready to swallow. For pieces 5 and 6 the chewing time and number of chewing strokes were also recorded.

The areas of the gelatin particles in test

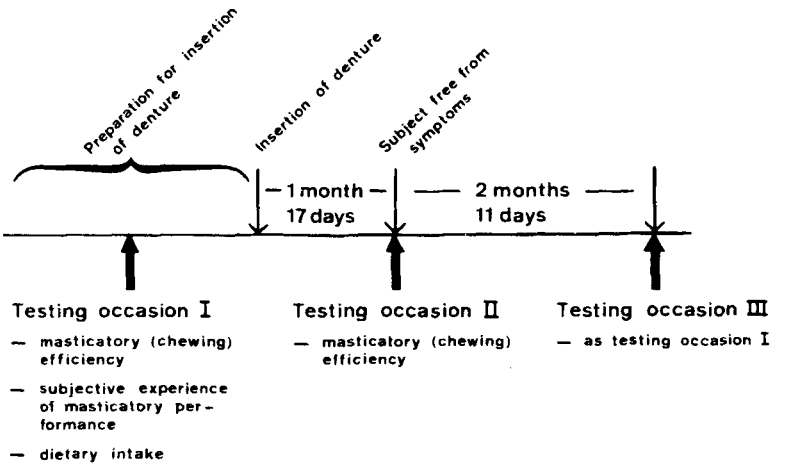


Fig. 1. Experimental design and time schedule for the three testing occasions.

pieces 3–6 were calculated after the chewing was finished. Then the test subjects were subjected to the second method and chewed four almonds (3). To enable the subject to adapt to the material, the first almond was eaten and swallowed. The second, third, and fourth were chewed for 10, 20, and 40 sec, respectively. The masticated almonds were fractionated in a sieve system, and a chewing efficiency index (Ci) was calculated, ranging from I to V, with I representing the greatest chewing efficiency.

Both tests were repeated after 1 week. The calculated areas of the gelatin pieces chewed with 20 strokes and until the test subject felt ready to swallow were based on results pooled from the two tests. The number of strokes per second of chewing was calculated for all gelatin pieces.

### *Subjective experience of masticatory performance (SP)*

The subjective experience was assessed by two methods:

1. In the clinic the subjects chewed four foodstuffs (apple, carrot, hard bread, almond) and a piece of gelatin. The assessment of chewing was classified and scored by the subjects themselves as follows: very easy = 0; rather easy = 1; neither easy nor difficult = 2; rather difficult = 3; very difficult = 4; and impossible to chew = 5 (test: SP I).

2. The subjects were asked how they assessed the chewing of 45 listed foodstuffs in a questionnaire. Both hard and soft foodstuffs from the seven different food groups (20) were represented. The foodstuffs were scored as follows: no problem with chewing = 0; some problems with chewing = 1; very difficult = 2; and impossible to chew = 3 (test: SP II).

Furthermore, on testing occasion III the subjects were interviewed about their subjective experience of chewing. On testing occasions I and III the subjects were asked about symptoms from the gastrointestinal organs and the use of laxatives (Table 1).

Table 1. The experience of chewing, gastrointestinal symptoms, and use of laxatives as reflected in answers to the questionnaire on testing occasion III

| | Better | Worse | No difference |
|---|---|---|---|
| 1. How can you chew your food now compared with earlier (with the old dentures)? | 28 | 3 | 12 |
| | | Yes | No |
| 2. Is there any foodstuff that you can chew now but had to avoid earlier (with the old dentures)? | | 14 | 29 |
| 3. Is there any foodstuff that is easier to chew now than earlier (with the old dentures)? | | 29 | 14 |
| 4. Do you think the food is well chewed when you swallow it? | | 35 | 8 |
| 5. Have you changed your food habits since you got your new dentures? | | 8 | 35 |
| 6. Do you think that it takes less time to eat the food with the new dentures? | | 13 | 30 |
| 7. Have you gotten used to the dentures? | | 43 | 0 |
| 8. Are you satisfied with the dentures? | | 41 | 2 |
| | | As before | Less |
| 9. Are you taking fewer laxatives? (Answered by those who used laxatives on testing occasion I, $n = 9$) | | 3 | 6 |
| 10. How are your gastrointestinal symptoms? (Answered by those who had symptoms on testing occasion I, $n = 22$) | | 12 | 10 |

*Dietary intake (DI)*

A 4-day dietary record was kept by the subjects, who were carefully instructed to note all intake of food, using both verbal and written information. The dietary records were evaluated by a dietitian (A-K. Wall). When the nutritional content was calculated, certain standards for portions and their nutrient content were used (21). Special food composition tables were also used (22). The reference groups used to evaluate the dietary intake were the Swedish nutritional recommendations (20) for subjects aged 51 years or more, and for total intake of energy subjects aged 52–70 years were used. Recommended intakes for evaluated variables are given in Fig. 4. For those subjects whose age diverged from these reference groups the recommended intake for the relevant age was used.

The subjects also supplied the intake frequencies for the 45 listed foodstuffs for which they had assessed their chewing capacity. The following alternatives were used: never, once or twice a month, once a week, more than once a week, once a day, and more than once a day.

*Correlation analyses*

The correlation between the two methods for measuring masticatory efficiency and between the two methods in which the subjects assessed their masticatory performance was calculated. The correlation between masticatory efficiency and subjective experience of masticatory performance was calculated, as was that between masticatory efficiency and dietary intake.

*Statistics*

The statistical calculations were made with Student's paired and unpaired $t$ test for the continuous variables of the gelatin method and with Wilcoxon's matched-pairs signed rank test and the Mann–Whitney U test for the noncontinuous variables of the almond method and of the methods for the subjective estimation of chewing. The Spearman rank correlation test was used in the correlation analyses (23, 24).

A $p$ value $< 0.05$ has been used as the lowest significance level for tests of differences. The following characteristics and abbreviations (within parentheses) are used in the text: mean value ($\bar{x}$), standard deviation (SD), range, and coefficient of correlation.

## Results

*Masticatory efficiency*

The ability to comminute gelatin, measured as the areas of gelatin particles, improved gradually over the three testing occasions when the subjects chewed with 20 strokes (Table 2). The differences between testing occasions I and II and between I and III were statistically significant (paired $t$ test). When the subjects chewed until they felt ready to swallow, there was a statistically significant improvement between testing occasions I and II (paired $t$ test). Thereafter the masticatory efficiency did not improve.

The subjects' ability to comminute almonds also improved over the test period. The Ci for the three testing occasions is given in Fig. 2. If a subject had different index values at the two repeated tests on any of the three occasions, the indices were added and divided by two. The differences between testing occasions I and II but not between II and III were significant (Wilcoxon's rank test).

When the subjects got their new dentures and chewed gelatin, the number of strokes and the chewing time until they felt ready to swallow decreased (Table 3). The differences between testing occasions I and II were significant for both variables (paired $t$ test). During the adaptation period (from testing occasion II to III) there was an additional but not significant decrease in both the number of strokes and chewing time. The chewing speed, in strokes per second, was constant during the test period but showed an interindividual range of 1.1–2.2 strokes/sec.

*Subjective experience of masticatory performance*

When the subjects' assessments after

Table 2. Calculated areas in $cm^2$ ($\bar{x}$, SD, and range) of masticated gelatin particles after chewing with 20 strokes and until the subject felt ready to swallow

| | | Testing occasion | | |
|---|---|---|---|---|
| | | I | II | III |
| 20 strokes | $\bar{x}$ | 89.2 —*— 101.6 | | 106.7 |
| | SD | 19.7 | 21.0 | 20.9 |
| | Range | 64.0–140.6 | 59.2–139.2 | 74.3–172.3 |
| Until subjects felt ready to swallow | $\bar{x}$ | 119.3 —*— 133.1 | | 133.2 |
| | SD | 30.7 | 26.2 | 23.8 |
| | Range | 62.4–182.0 | 67.2–187.4 | 85.4–199.7 |

* Difference is statistically significant.

Table 3. Number of chewing strokes and chewing time until the subject felt ready to swallow (when using gelatin as the test material)

| | | Testing occasion | | |
|---|---|---|---|---|
| | | I | II | III |
| No. of chewing strokes | $\bar{x}$ | 103.5 —*— 91.7 | | 86.5 |
| | SD | 48.5 | 35.0 | 36.8 |
| | Range | 38.0–266.0 | 40.5–189.0 | 31.5–206.0 |
| Chewing time (sec) | $\bar{x}$ | 65.7 —*— 56.2 | | 55.7 |
| | SD | 26.9 | 19.2 | 20.2 |
| | Range | 25.0–155.0 | 29.0–112.5 | 27.0–113.0 |

* Difference is statistically significant.

chewing apple, carrot, hard bread, almond, and gelatin with the old and the new dentures were compared, the greatest improvement was found for carrot. Most subjects ($n = 29$) assessed hard bread as very easy to chew on both testing occasions.

With regard to the total sum of points from each subject's evaluation of chewing the 4 foodstuffs and gelatin, the subjective experience had improved for 26 subjects (out of 43) and had deteriorated for 10 subjects. The improvement for the group as a whole was statistically significant (Wilcoxon's rank test).

On testing occasions I and III the subjects gave their assessments for chewing the 45 listed foodstuffs, and the relationship of the

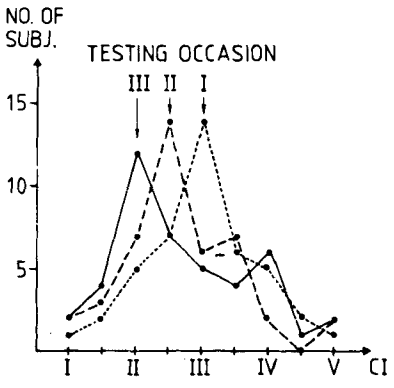


Fig. 2. Distribution of subjects in accordance with different chewing efficiency indices (Ci) on the three testing occasions (I means a very good, V a poor chewing efficiency).

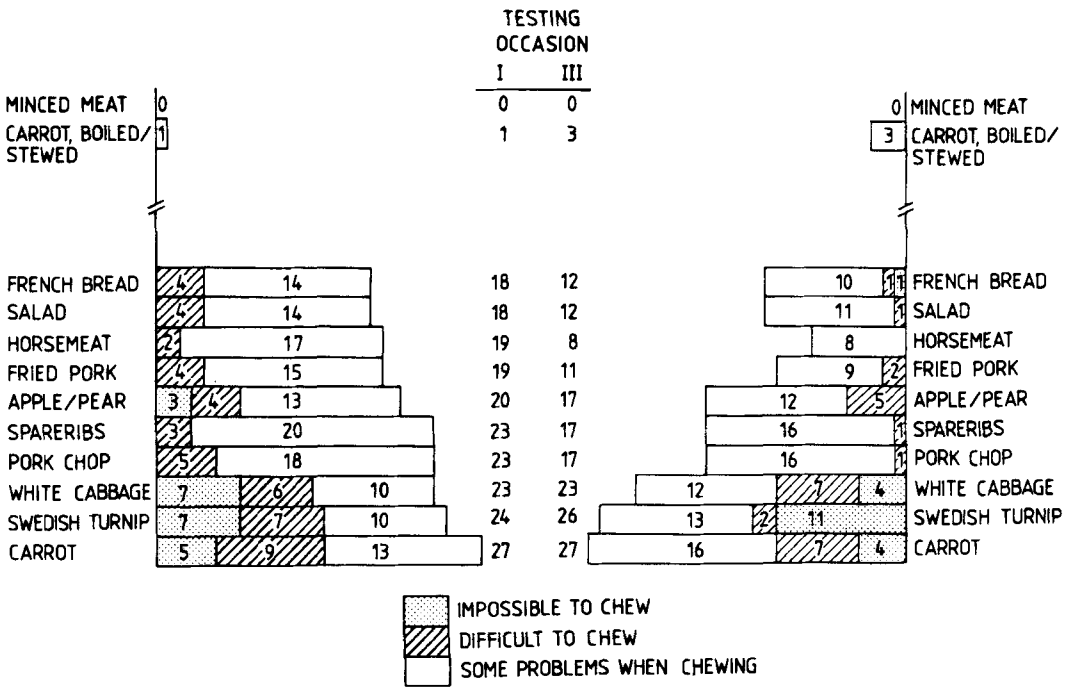


Fig. 3. A survey of the subjects' assessment of those foodstuffs most difficult to chew and the number of subjects with problems when chewing these foodstuffs on the two testing occasions.

total sum of points from the two occasions was compared. Twenty-six subjects got a lower score (that is, estimated that the foodstuffs were easier to chew) and 11 a higher score on occasion III than on occasion I. The improvement was statistically significant (Wilcoxon's rank test).

When the 45 listed foodstuffs were ranked in accordance with the problems they gave the subjects when chewing, there was no systematic difference between testing occasions I and III. Fig. 3 gives the 10 foodstuffs that were most difficult to chew on both testing occasions and the number of subjects who had problems chewing these foodstuffs. Carrot, Swedish turnip, white cabbage, pork chop, spareribs, and apple/pear with the peel on were the most difficult to chew and were ranked in the same order on both testing occasions.

Most of the subjects, 28 out of 43, said they could chew better with the new dentures (Table 1). New foodstuffs could be included by 14 subjects, and 29 thought that some foodstuffs were easier to chew after the treatment. Only a fifth of the subjects had changed their food habits. All had gotten used to the dentures, and all but two were satisfied with them. Almost half of those with gastrointestinal symptoms had experienced an improvement, and six of nine subjects had decreased their consumption of laxatives.

### *Dietary intake*

The results from the evaluation of the dietary record from testing occasions I and III are summarized in Figs. 4 and 5.

*Testing occasion I.* The mean intake of energy was below the recommendations for men and within the recommendations for women (Fig. 4). Intake of energy from fat exceeded the recommendations, was below for carbohydrates, and in agreement with recommendations for proteins. The intake

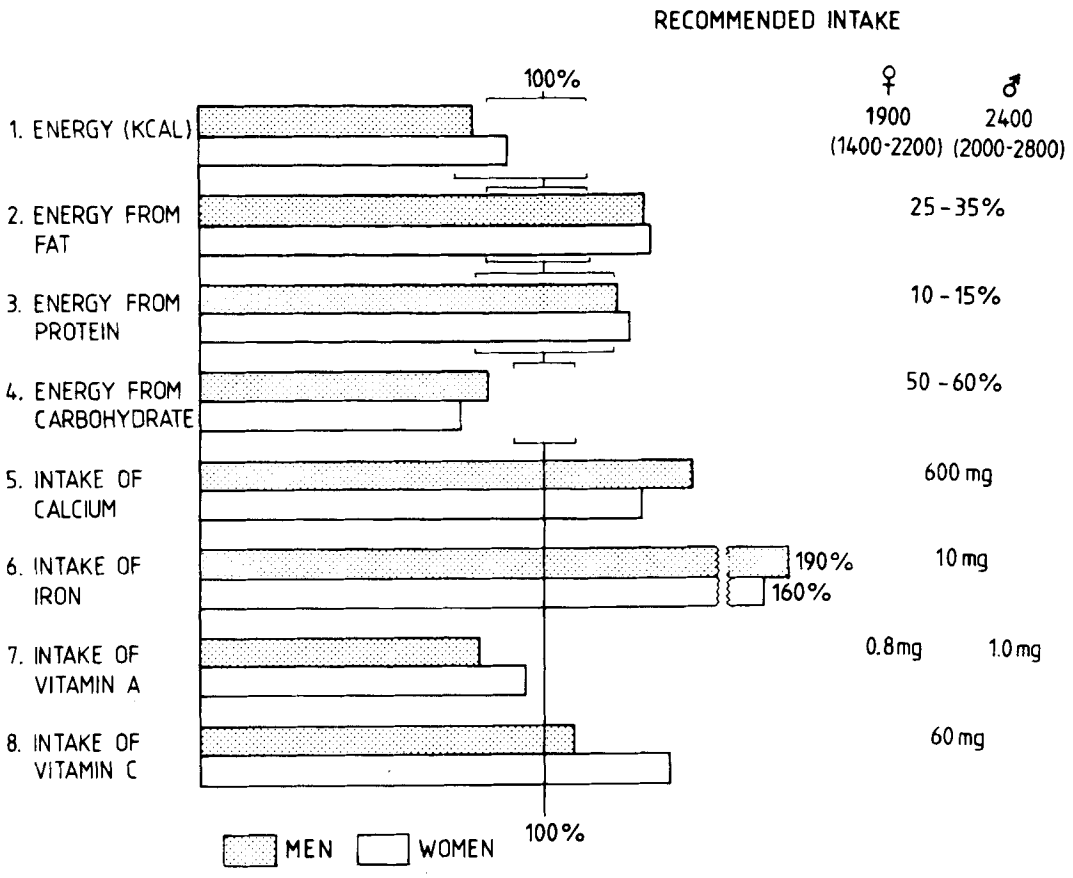


Fig. 4. Dietary intake (mean values) on testing occasion I in relation to recommendations (20).

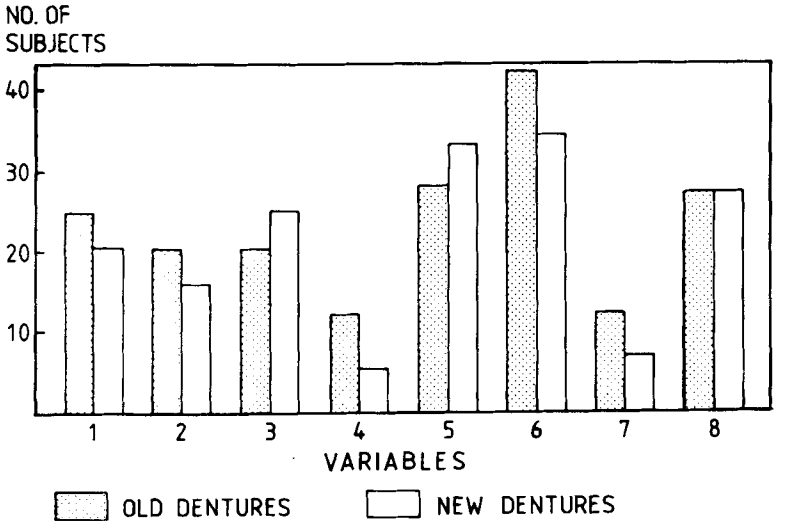


Fig. 5. Number of subjects with sufficient intake on testing occasions I and III. The variables are listed in Fig. 4.

of Ca, Fe, and vitamin C was adequate. The intake of vitamin A was just below that recommended.

*Testing occasion III compared with I.* Fig. 5 gives the number of subjects who fulfilled the recommendations for the eight variables. With the exception of intake of energy from carbohydrates (variable 4) and intake of vitamin A (variable 7) there were only small differences between the two testing occasions. For variables 4 and 7 there were fewer subjects who fulfilled the recommendations on testing occasion III than I. No statistically significant changes were found for any of the eight variables between testing occasions I and III.

For each of the eight variables in the dietary record the subjects were classified in two groups, those who fulfilled the recommendations and those who did not. The difference in masticatory efficiency between the two groups was tested with the results from the gelatin method (unpaired $t$ test) and the results from the almond method (Mann–Whitney U test). For none of the eight variables was there any significant difference in masticatory efficiency irrespective of the method used.

The frequencies of intake of the 45 listed foodstuffs did not change between testing occasion I and III in any systematic manner.

### *Correlation analyses*

On testing occasion I correlations were found only between Ci and masticatory efficiency when chewing gelatin with 20 strokes ($r = 0.58$; $p < 0.01$) and until the subjects felt ready to swallow ($r = 0.45$; $p < 0.01$) and between Ci and assessment of 45 listed foodstuffs ($r = 0.31$; $p < 0.05$).

Table 4 gives the correlation coefficients with $p$ values $< 0.05$ between the tested variables on testing occasion III. There was a low to moderate correlation between the masticatory efficiency and subjective experience of masticatory performance, except for Ci and assessment of chewing 45 listed foodstuffs. There was a low correlation between the two methods for measuring the masticatory efficiency and a moderate correlation between the two figures for the subjective experience of masticatory performance.

Table 4. Coefficient of correlation (with $p$ values <0.05) between the variables of masticatory efficiency and subjective experience of masticatory performance on testing occasion III ($n = 43$)

| | A | B | C | D |
|---|---|---|---|---|
| A | | | | |
| B | | | | |
| C | 0.36* | 0.46** | | |
| D | 0.53*** | 0.32* | 0.48** | |
| E | 0.49*** | 0.30* | | 0.63*** |

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
A = masticatory efficiency, 20 strokes (gelatin).
B = masticatory efficiency, until the subject felt ready to swallow (gelatin).
C = chewing efficiency index (almonds).
D = estimation of chewing 5 foodstuffs.
E = estimation of chewing 45 listed foodstuffs.

## Discussion

All but three patients who attended for treatment during the autumn of 1982 participated in the present study. Because there was no selection the material was representative of patients who were treated with complete dentures at that time.

Masticatory efficiency was measured by two methods. Two test materials with different textures were used, to obtain more complete information about the subjects' ability to comminute the food.

When the subjective experience of the capacity to chew is measured, there is a risk that the subject will overestimate his performance (11, 26, 27). In pilot studies subjects failed to express the assessment along a scale ranging from very poor to very good masticatory performance. We therefore used certain alternatives along an ordinal scale; a similar method has been reported previously (28). To decrease the risk of overestimating the masticatory performance for the four foodstuffs and the piece of gelatin, the assessment took place directly after chewing in the presence of the investigator. To gain a more complete understanding of the subjective assessment of chewing, the

subjects also scored their experience of chewing 45 ordinary foodstuffs, for which they gave the frequencies of intake.

If the subjects hesitated or expressed difficulties in choosing among the six alternatives when assessing the chewing of the four foodstuffs and the piece of gelatin, they were guided by the investigator. The chewing of the listed 45 foodstuffs was assessed at home, and, to make it easier for the subjects, only four alternatives were used.

The ordinal score points were summarized for each subject and foodstuff, and those figures were used in the statistical analyses. The differences between the points are not equivalent, and consequently the statistical procedure is not quite correct, but the statistically significant differences between testing occasions I and III could certainly not be ascribed to this.

The dietary intake was evaluated by means of a 4-day record because that method is the one used in the clinical routines of the Department. Many methods for evaluating dietary intake have been described (29). A longer period might make the record more reliable, but when 4- and 7-day records were compared, the differences were negligible (30). When a dietary record is used, the results are influenced by the willingness and ability of the subjects, and there is a risk of underregistration due to forgetfulness. The subjects might also be influenced by the expectations of the investigator. However, in this study we were solely interested in possible changes from one testing occasion to another and not in the dietary intake as such.

In the present study masticatory efficiency improved significantly 1 month after the new dentures were inserted. The subjects had used complete dentures for a long time (mean age, 29.5 years), which may have contributed to their speedy adaptation to the new dentures and improvement in masticatory efficiency, which is in agreement with results reported earlier (31).

When the effects of prosthetic or surgical treatment on masticatory efficiency were analyzed in previous studies, the results were contradictory. Thus optimizing complete dentures (16) or surgical correction of deformities of the jaws (27) did not improve masticatory efficiency. However, many prosthetic factors, such as denture base extension or occlusal patterns, have been reported to influence masticatory efficiency (12, 13). Furthermore, surgical reconstruction of the mandibular residual ridge and new complete dentures gave the same result (32). In a previous study (11) with a similar experimental design and using the same test material the transition from old to new complete dentures did not improve masticatory efficiency. The difference between the results from that study and the present one may be explained in two ways. First, in the previous study the breakdown of the test material was determined by fractionating in a sieve system, a method that makes interindividual comparisons difficult. Second, in the present study the results were based on four test pieces, whereas in the previous study there was only one test piece on each testing occasion. The improvement in masticatory efficiency presented in this study is emphasized by the significant decrease in the number of strokes until the subjects felt ready to swallow the gelatin pieces.

A statistically improved masticatory efficiency does not need to be of clinical significance. The clinical effect may be better expressed by the subjective experience of masticatory performance, which improved significantly when evaluated by means of two different tests. In test SP I the greatest improvement was found for carrot, and that foodstuff was also classified as the most difficult to chew in test SP II. Most of the 45 foodstuffs were regarded by a few subjects as being more difficult to chew with the new dentures than with the old ones. This was probably due to method error in recording subjective masticatory performance. Measuring the subjective experience of masticatory performance by scoring the assessment of different foodstuffs on a scale of whole integers from one to four has been shown to distinguish significantly between groups with different dentitions (10). A similar method was used and showed a significant improvement in the subjective experience after surgical reconstruction and new complete dentures (32).

The improvement of the subjective experience of masticatory performance was emphasized by the subjects' answers in the interview during testing occasion III. Sixty-five per cent thought they could chew better, and a third could chew new foodstuffs. A fifth of the subjects had changed their dietary habits (Table 1). The change could be a consequence of the treatment, but just participating in a study can increase the interest in diet and result in changed dietary habits. An improved assessment of chewing could also partly be explained by more comfortable dentures in general. Many studies have pointed out the difficulties complete denture wearers have in comminuting the food. Twenty per cent of those with removable dentures had problems in chewing hard bread and apple (33), and a quarter of the patients with complete dentures could not chew all kinds of foods (26).

The findings that 10 subjects out of 22 had fewer gastrointestinal symptoms and 6 out of 9 subjects decreased their consumption of laxatives after they had worn the new dentures for about 4 months (Table 1) are only indications that masticatory efficiency could affect the function of the gastrointestinal organs. Masticatory efficiency has been reported to have some influence on gastric distress (34), but the effect was not statistically significant. It is important to study these problems more thoroughly.

Many investigators have studied the relationship between dietary intake and dental state. Edentulous individuals without dentures are reported to have a lower intake of certain nutrients than denture wearers (35). Dental state was found to be related to intake of several food items and intake of nutrients (5). Impaired masticatory ability was also found to cause shifts in dietary selection (6).

In the present study no systematic differences in dietary intake between testing occasions I and II were detected. This is in agreement with results reported earlier (35). Nevertheless, a fifth of the subjects said they had changed their dietary habits. Deficiencies in dietary intake are not necessarily caused by impaired masticatory efficiency; economics also plays a part, and social and traditional factors may influence dietary habits. The method used in the present study to evaluate the dietary intake, in which the intake of energy and nutrients was derived from standard portions, is not exact enough to detect small changes. If an improvement in dietary habits had been noted, this might also be ascribed to an increased interest in diet as a result of participating in the study.

A previous study of complete denture wearers at our Department showed too low an intake of energy and vitamin A for both men and women, low intake of vitamin C for men, and low intake of iron for women (8). In our study deficiencies were found for the intake of energy for men and for vitamin A for both men and women. The intake of vitamin C and iron, on the other hand, was more than adequate. In both studies there were great interindividual variations in intake of energy and different nutrients. A mean intake above that recommended therefore does not mean that all subjects have an acceptable intake.

With one exception there was no correlation between masticatory efficiency and the subjective experience of masticatory performance on testing occasion I. Thus, there were subjects with poor masticatory efficiency who assessed their chewing ability as acceptable or vice versa. Patients could have adapted very well to their complete dentures and thus overestimated their chewing ability (26, 32, 36). On the other hand, the chewing of hard or tough foodstuffs is difficult even if the dentures function well. On testing occasion III there was a positive correlation between masticatory efficiency and the subjective experience of masticatory performance, with one exception (Table 4). Perhaps the subjects after the adaptation period were able to estimate more correctly their ability to chew different kinds of foodstuffs and were also more motivated. On the other hand, no correlation was found between masticatory efficiency and subjective experience when 31 patients who had received new complete dentures were tested (32).

The correlation between different methods for measuring masticatory efficiency has been found to be weak (25). The two

present methods for measuring masticatory efficiency were, in contrast to in a previous study (2), positively correlated on testing occasions I and III. The difference in the results could be ascribed to the increased number of test subjects in the present study and to the fact that the test pieces of gelatin were smaller and easier to handle in the mouth than in the previous study.

One explanation of the lack of correlation between the two methods for measuring the subjective experience of masticatory performance on testing occasion I (there was a moderate correlation on testing occasion III) could be an overestimation of or uncertainty about the capacity to chew the 45 listed foodstuffs. An overestimation could in its turn be a consequence of good adaptation to the old dentures.

The results from this study have shown that a transition from old complete dentures with poor qualities to new ones with good retention/stability and balanced occlusion/articulation increases the ability to comminute food. The subjects also estimated that their comminuting ability improved. However, no influence on dietary habits was found. Prosthetic treatment with new complete dentures implies better chewing comfort, but this does not seem to be enough to change the dietary habits of our patients, at least not in the short-term perspective studied in this investigation.

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