The effect of removable partial dentures on mastication and dietary intake

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Masticatory efficiency, the subjective experience of masticatory performance, and dietary intake were evaluated in 19 subjects who were treated with a removable partial denture in the lower jaw. The subjects were tested on three occasions: before treatment, with the dentures when free from symptoms, and about 4 months after the dentures were inserted. Masticatory efficiency and the subjective experience of masticatory performance increased significantly after the subjects were provided with the dentures, but no changes were found in the dietary intake. □ *Masticatory and chewing efficiency; masticatory physiology; nutrition; prosthetics*

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Masticatory efficiency is impaired in patients with partial dentition as compared with in those with a full dentition (1–5). This can influence the choice of food, which in turn may increase the risk of malnutrition (6–9). Furthermore, reduced masticatory efficiency or a tendency to avoid foods that are difficult to chew could possibly affect the functions of gastrointestinal organs (10, 11). Apart from these biological effects an apparently decreased masticatory efficiency may influence chewing comfort and social well-being.

Masticatory efficiency has been defined as the capacity to grind food or a test material and is consequently only one component of mastication. The correlation between masticatory efficiency and the subjective experience of masticatory performance has proved to be weak (5, 12–14). When 1106 patients were registered with regard to their own evaluation of their chewing efficiency and their general health, these variables were found to be correlated to each other (15). Chewing with a partially edentulous dentition—for example, chewing on only one side or only with the front teeth—may affect the stomatognathic system also by increasing the risk of the developing symptoms (16).

Restoration of a partially edentulous jaw may be made with fixed or removable dentures. The aims of this study were to investigate the effect of a bilateral mandibular free-end saddle denture on masticatory efficiency (ME), the subjective experience of masticatory performance (SP), and dietary intake (DI).

Materials and methods

The material consisted of all 19 patients (11 women and 8 men) who, during the autumn of 1982, underwent for the first time treatment with a mandibular removable partial denture (RPD). The treatment was carried out by students at the Department of Prosthetic Dentistry, University of Umeå. None of the subjects had ever worn an RPD previously. The average age was 58.4 years and the median age 61 years (range, 34–75 years). All cases were in the lower arch, classified as Kennedy class I. The subjects' dental status is shown in Fig. 1. The subjects reported that they had lost the posterior teeth in the lower jaw an average of 17.7 years (range, 1–40) ago. Three subjects had the teeth extracted 1 year ago, and one subject 4 years ago. The subjects were asked about their motives for the desire to get an RPD in the lower jaw. The most frequent motive was 'recommended by the dentist'

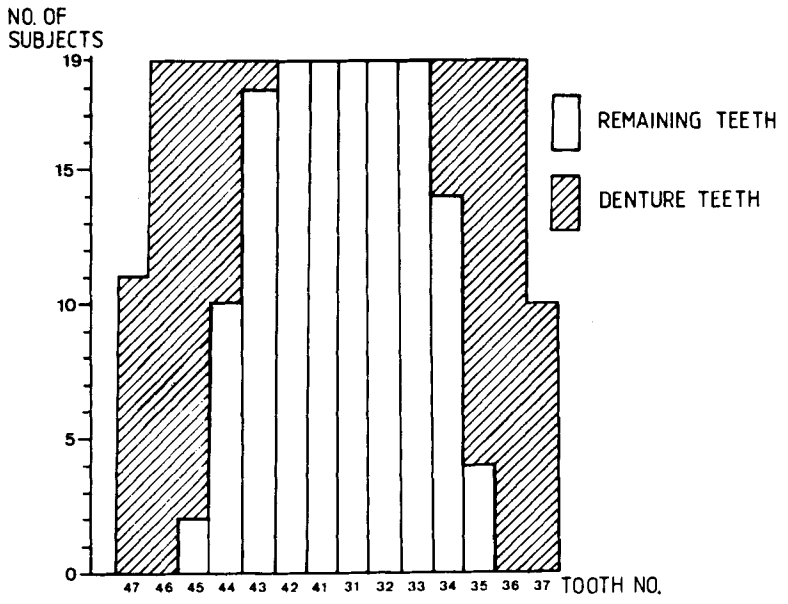

Fig. 1. The distribution of the subjects' remaining teeth in the lower jaw and the teeth replaced by the dentures.

(12 subjects) and 'want to improve the masticatory function' (9 subjects). Two subjects gave two motives. The RPDs had a cobalt–chromium alloy framework and double extension saddles. In the case of 11 patients an existing complete upper denture was replaced with a new one. The other eight patients had a dentate upper jaw, and all patients were provided with any necessary odontological treatment, which did not change the occlusal area in this jaw to any noticeable extent.

All the subjects were in good general health without severe clinical signs of disorders in the stomatognathic system (Table 1) (17).

Eight of the subjects had some problems with chewing. Five said that some foodstuffs were specially difficult to chew, and three had to avoid some foodstuffs because they were too difficult to chew. Ten subjects did not think the food was well chewed when they swallowed it, and one subject thought he had to swallow particles that were too large. None of them had problems with swallowing. When chewing, seven subjects used the right side, four the left side, two both sides, and six the front teeth.

Table 1. The distribution of the 19 patients in accordance with Helkimo's anamnestic (Ai) and clinical (Di) dysfunction index (17)

	0	I	II	III
Ai	12	3	4	—
Di	4	13	2	0

The subjects were tested in accordance with the schedule in Fig. 2. Masticatory efficiency was measured in two ways. The first method required the subject to chew six pieces of Formalin-hardened gelatin (18). Test pieces 1–4 were chewed with 20 strokes, and pieces 5 and 6 until the subject felt ready to swallow.

After the chewing was finished, the summarized area of the gelatin particles of test pieces 3–6 was calculated by diffusion of a water-soluble dye into the particles. Test pieces 1 and 2 were used only for training. The method has been described in detail earlier (19, 20). For the second method almonds were used as test material (2, 21). The first one was chewed and swallowed, and 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 1 to

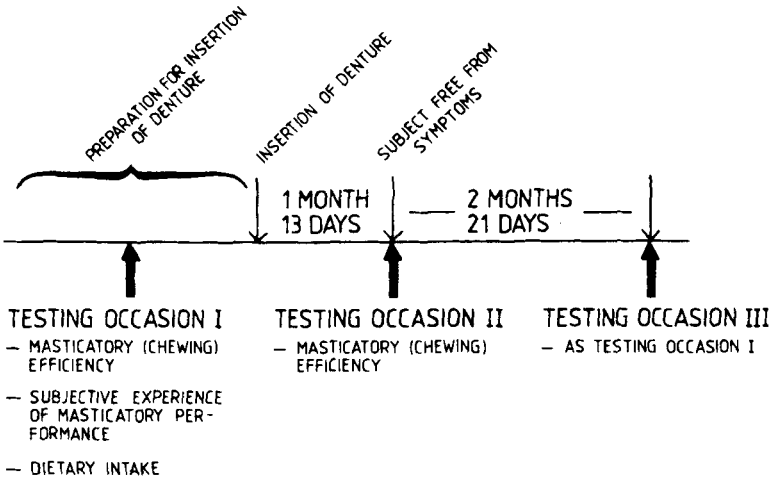

Fig. 2. Experimental design and time schedule for the three testing occasions.

5, with 1 representing the greatest chewing efficiency.

The SP was evaluated by two methods:

1. In the clinic the subjects chewed four foodstuffs (apple, carrot, hard bread, and almonds) and a piece of gelatin. The estimation of chewing was scored by the subjects themselves along an ordinal scale 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 also had to answer a questionnaire on how they scored the chewing of 45 listed foodstuffs. Both hard and soft foodstuffs from the seven different food groups (22) were represented. The foodstuffs were scored along an ordinal scale as follows: easy to chew = 0; a little difficult to chew = 1; very difficult = 2; and impossible to chew = 3 (test: SP II).

In addition, the subjects were interviewed about their subjective experience of chewing after they had worn their RPDs for about 4 months. The questions are listed in Table 5.

The dietary intake was registered by means of a 4-day dietary record, including 1 week-end day. The subjects were carefully instructed to register all their food intake daily. When the record was returned, any necessary corrections and completions were made by the investigator. The nutritive content in each subject's diet was calculated by using certain standards of portions (23), food composition tables (24), and a nutritional computer (NutriData). Ten variables were calculated (Fig. 5). The reference groups used to evaluate the dietary intake were the Swedish nutrition recommendations (22) for subjects aged 51 years or more, and for total intake of energy subjects aged 51–70 years were used. For those subjects whose age diverged from these reference groups the recommended intake for the relevant age was used.

The subjects also gave the intake frequencies for the 45 listed foodstuffs, for which they had also estimated chewing difficulties. 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.

Statistics

In the statistical analyses Student's paired t test for variables of the gelatin method and the dietary intake and Wilcoxon's matched-pairs signed rank test for variables of the almond method were used (25, 26). A p value < 0.05 was used as the lowest significance level of tests of differences. The following characteristics and abbreviations (within parentheses) are used: mean value ($\bar{x}$), median value (M), standard deviation (SD), and range.

Table 2. Calculated areas in cm^2 ($\bar{x}$, SD, and range) of masticated gelatin particles after being chewed with 20 strokes and until swallowing, and chewing efficiency index (median value and range)

		Testing occasion		
		I	II	III
20 strokes	$\bar{x}$	92.9 —*— 105.0		111.0
	SD	16.9	17.8	13.8
	Range	(74.3–144.2)	(71.8–137.8)	(87.2–149.2)
Until swallowing	$\bar{x}$	112.6 —*— 128.8		132.0
	SD	25.5	25.1	19.2
	Range	(87.0–191.4)	(85.4–186.0)	(96.6–162.1)
Chewing efficiency index	M	3	2	2
	Range	1–5	1–4	1–3

* Difference is statistically significant.

Results

Masticatory efficiency

The masticatory efficiency of the 11 subjects who had an old complete upper denture replaced by a new one did not differ from that of the other subjects. The results are therefore presented for the group as a whole.

The calculated areas of the gelatin pieces after being chewed with 20 strokes and until swallowing increased gradually over the test period (Table 2). The differences between testing occasions I and II and I and III, but not between II and III, were statistically significant both for chewing with 20 strokes and until the subjects felt ready to swallow. The mean values for the subjects who had lost their posterior teeth in the lower jaw only 1–4 years ago were for chewing with 20 strokes on the three testing occasions 79.1, 109.4, and 112.3 cm^2, respectively. The corresponding figures for chewing until the subjects felt ready to swallow were 94.6, 133.1, and 142.8 cm^2, respectively.

The median values of the Ci changed from three (testing occasion I) to two (testing occasions II and III), and the difference between testing occasion I and III, but not between I and II, was statistically significant (Table 2).

The mean number of chewing strokes needed until the subjects felt ready to swallow when chewing gelatin decreased from 51.7 (testing occasion I) to 43.3 (testing occasion II). For testing occasion III the corresponding figure was 38.4 (Table 3). The differences between testing occasions I and II and between I and III, but not between II and III, were statistically significant. The chewing time decreased correspondingly (Table 3).

The average chewing speed, which varied interindividually from 0.9 to 2.2 chewing strokes/sec, did not vary between the three testing occasions.

Subjective experience of masticatory performance

The results from test SP I—chewing each of the five food items without (testing occasion I) and with (testing occasion III) the RPD—showed that the greatest improvement was for almond and gelatin, whereas hard bread was estimated as very easy to chew on both testing occasions. For all five chewed foods some subjects experienced an impairment when chewing with the RPD. The total sums of points from the subjects' evaluation of chewing these foods

Table 3. Number of chewing strokes and chewing time in seconds ($\bar{x}$, SD, range) for chewing gelatin pieces until the subjects felt ready to swallow

		Testing occasion		
		I	II	III
No. of chewing strokes	$\bar{x}$	51.7 *	43.3 *	38.4
	SD	47.9	35.2	13.8
	Range	(23.0–236.3)	(20.5–183.6)	(21.0–77.5)
Chewing time	$\bar{x}$	31.9 *	26.5 *	23.6
	SD	29.8	21.6	8.1
	Range	(16.5–148.3)	(14.0–113.5)	(16.5–50.8)

* Difference is statistically significant.

are plotted in Fig. 3. The oblique lines in Figs. 3 and 4 are lines of values expected if there had been no change between the two testing occasions. When the results of testing occasion III were compared with those of testing occasion I, 11 subjects thought the chewing was easier, and 4 more difficult. The improvement was statistically significant.

The total sums of points from scoring the 45 foods listed in the questionnaire are given in Fig. 4. Fourteen subjects experienced an improvement when they chewed with RPD in place, and three an impairment. The differences between testing occasion I and III were statistically significant.

The intake frequencies of the 15 foodstuffs (Table 4) on the questionnaire which were most difficult to chew on testing occasion I did not differ from the frequencies on testing occasion III in any systematic manner. The 15 foodstuffs found most difficult to chew on testing occasions I and III were, with few exceptions, the same.

On testing occasion III the subjects answered some questions about changes that might have occurred after they were provided with the RPD (Table 5) and how they experienced the dentures. Fourteen subjects found it easier to chew with the denture. Only three subjects could now chew food

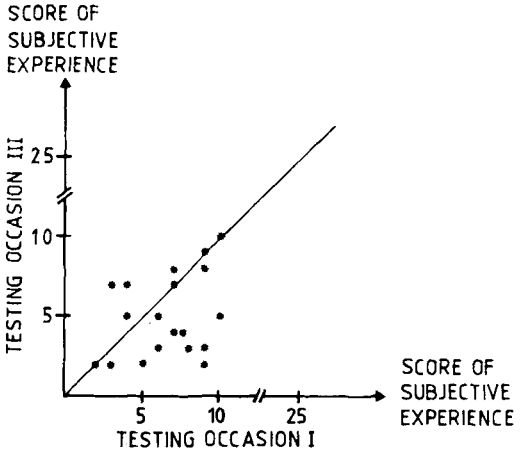

Fig. 3. The relation between the score from the subjects' estimation of chewing apple, carrot, hard bread, almond, and gelatin on testing occasions I and III.

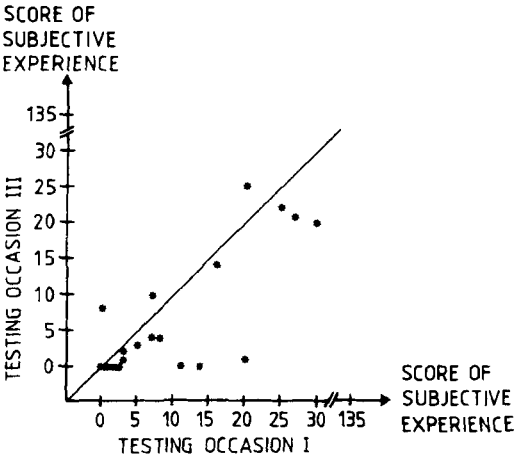

Fig. 4. The relation between the score from the subjects' estimation of chewing 45 listed foodstuffs on testing occasions I and III.

Table 4. The fifteen foodstuffs (of 45 listed) most difficult to chew on testing occasion I

Raw carrot	Bacon
Swedish turnip	Salad
Spareribs	White cabbage, piece
French bread	Hard bread
Apple with peel	Pork chop
Fried liver	Palt (potato dumpling)
Beef	Horsemeat
White cabbage, grated	

that they had had to avoid earlier, two had changed their food habits, and three thought the time needed for eating was shorter with the RPD in place. All but one were satisfied with their dentures; most of them had become used to the RPDs after 4 months, and none felt any pain under the dentures when chewing.

Dietary intake

The variables calculated from the dietary record are listed in Fig. 5.

Testing occasion I

The mean intake of total energy was lower than the recommendations for men and within for women (Fig. 5). For both men and women intake of energy from fat and protein was greater and for carbohydrates less than the recommendations. The mean intake for all subjects of vitamins A and C, thiamin, riboflavin, calcium, and iron was at the recommended levels. The intake of vitamins A and C was very high for women, as was the intake of iron for men.

Testing occasion I compared with III

Fig. 6 gives the number of subjects who fulfilled the recommendations for the 10 variables on the 2 occasions. With the exception of intake of energy from fat (variable 2) and intake of vitamin C (variable 6), there were only small differences between the two testing occasions. For variables 2 and 6 there were fewer subjects who fulfilled the recommendations on testing occasion III than

Table 5. The experience of chewing as reflected in answers to the questionnaire on testing occasion III (n = 19 subjects)

	Answers	
	Yes	No
Do you think it is easier to chew now with the RPD in place?	14	5
Is there any foodstuff that you can chew now but had to avoid earlier (without RPD)?	3	16
Is there any foodstuff that is easier to chew now compared with earlier (without RPD)?	11	8
Have you changed your diet habits since you got your RPD?	2	17
Do you think that it takes less time to eat the food with the RPD in place?	3	16
Do you feel any pain under the denture when chewing?	0	19
Are you satisfied with your RPD?	18	1
Have you become used to the denture?	18	1

	Right side	Left side	Both sides	Front teeth
Chewing habits	6	4	7	5*

* Three also used the sides.

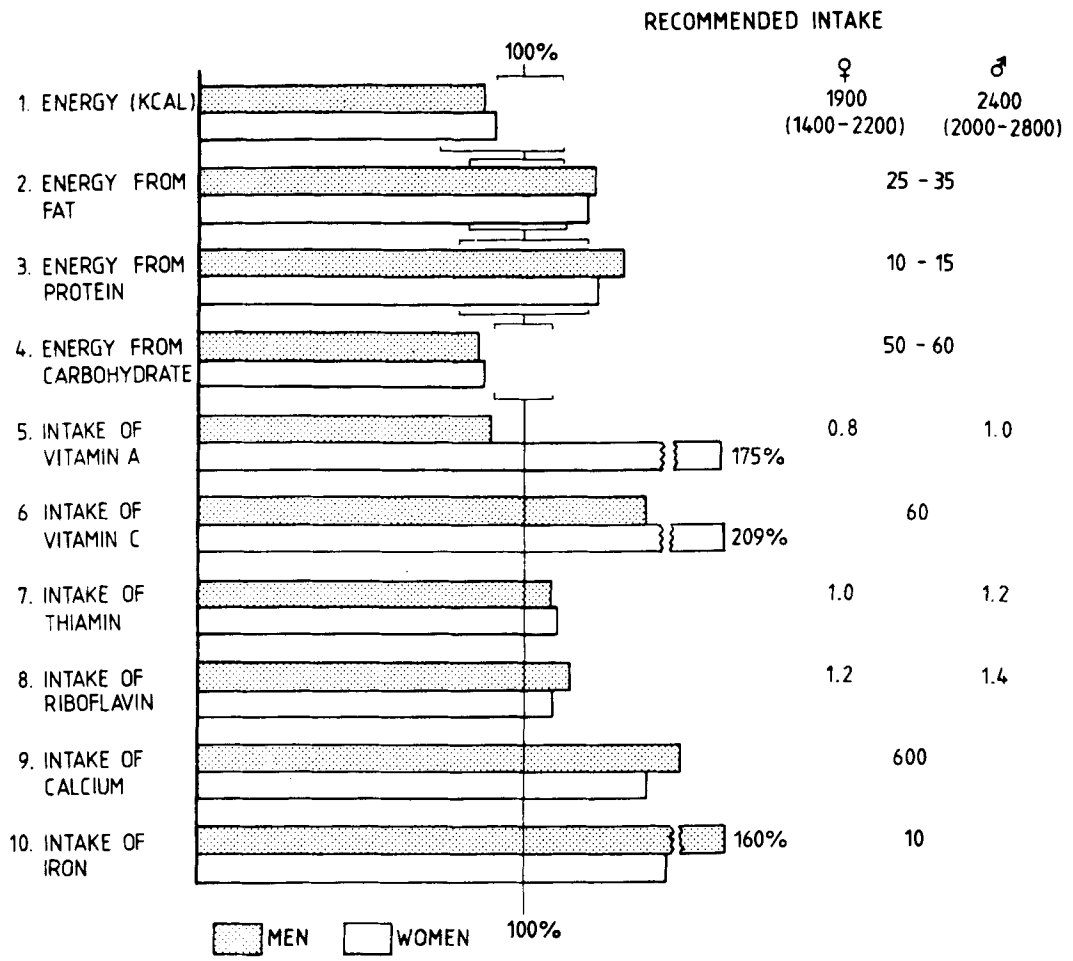

Fig. 5. Dietary intake (mean values) on testing occasion I in relation to recommendations (22).

on occasion I. No statistically significant changes were found for any of the 10 variables between testing occasions I and III. Thus the prosthetic treatment did not seem to have been any decisive effect on the dietary intake.

Discussion

All patients who, over a period of one term, attended our Department of Prosthetic Dentistry for prosthetic treatment with an RPD in the lower jaw and who had not previously worn that kind of denture participated in this study. Thus, the material was representative of this category of patients. The average age of the subjects fell within the interval 55–64 years. It has been shown that the prevalence of an RPD in either jaw in this group in Sweden is 7%, which is more than in any other age group (27).

In earlier studies no or only weak correlations between methods for estimating masticatory efficiency have been found (1, 28). However, three other methods were found to be correlated to each other (29). The lack of correlation is not surprising and could be explained by the fact that mastication, in the sense of comminuting the food, is a complex physiological process, and different methods may be influenced by various physiological factors. Apart from inter-individual variations in the number and

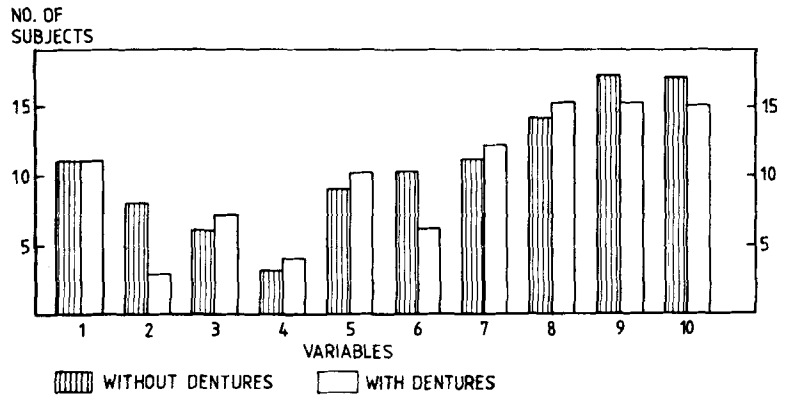

Fig. 6. Number of subjects with sufficient intake on testing occasions I and III. The variables are listed in Fig. 5.

localization of the teeth, there are also variations in, for example, mandibular mobility, exerted bite-force, and neuromuscular pattern. To broaden the concept of the estimation of the subjects' ability to comminute food, in the present study we used two methods and different test materials and different ways of analyzing the comminuting of the test materials.

Masticatory efficiency improved in a statistically significant manner after insertion of the RPD. The improvement was more obvious with the gelatin method, and with this method the improvement was already statistically significant on testing occasion II. The difference between testing occasions II and III was not statistically significant.

Masticatory efficiency, as measured by the almond method, also improved over the test period, but the improvement did not reach a statistically significant level until testing occasion III. The difference between the results with the two methods might be explained by a slower adaptation among patients in chewing almonds compared with gelatin. However, a more probable explanation may be the differences in data collected and methods used for statistical testings. The difference between the methods could also be explained by the different rheology of the test materials. Almonds are hard compared with gelatin, and in chewing almonds the subjects may have had greater problems with denture to denture or denture to natural teeth in the side regions than with the situation in the front region, with natural teeth opposing natural or denture teeth. Thus, the subjects may have preferred to chew almonds with the front teeth, which have a comparatively small area of occlusal table. Gelatin, on the other hand, is very difficult to chew with the front teeth, and the subjects are greatly helped by the replaced teeth on the sides. This fact emphasizes the problems encountered when trying to estimate masticatory efficiency.

The improvement of masticatory efficiency means that the subjects use their RPDs to a great extent. This is in agreement with the results of a cineradiographic investigation (30), in which patients were found to use premolar and molar teeth in free-end RPDs in the lower jaw more than the natural lower incisors.

Some of the improvement in masticatory efficiency from testing occasion I to III could be a training effect. Individuals with only natural teeth had significantly better masticatory efficiency on a second test, 1 week after the first test (1), but this was not the case with complete denture wearers (20). Few other studies of masticatory efficiency have dealt with the effect of an RPD. When masticatory efficiency was expressed as a percentage of that of a full natural dentition, the RPD improved the efficiency from less than 20% to 40–60%. The maximal efficiency was reached approximately 1 month after the subjects had received their RPDs

(31). When 20 subjects had the first molar replaced by a fixed or removable partial denture, there was a significant increase in masticatory efficiency (32), results later confirmed in a similar study (33).

The subjects who had had recent tooth extractions before prosthetic treatment had on testing occasion I a lower masticatory efficiency with the gelatin method than the group as a whole. The material is too small to draw a definite conclusion, but this may indicate that they had not adapted neurophysiologically or psychologically to partial edentulism. These subjects also profit more from the prosthetic treatment because the masticatory efficiency improved more than for the whole group.

The median value of Ci rose from 3 to 2 after the RPDs were inserted. In an earlier study subjects with the same dental state also achieved Ci 2 (1), and similar results have been reported elsewhere (2).

A statistically improved masticatory efficiency does not need to be of clinical relevance. However, the subjective experience of masticatory performance also improved in a statistically significant manner. The subjects' estimations were measured in two ways to express more completely possible changes after insertion of the RPD. Similar methods have been used in earlier studies (14, 34). For all foodstuffs in both tests there were some subjects, but not always the same ones, who experienced increased difficulties. This could be ascribed to poor validity or reliability of the tests or to the subjects having problems in making full use of the RPDs. Fourteen subjects thought it was easier to chew, and 15 had become used to the dentures. These findings were not reflected in changes in dietary habits, because only two subjects mentioned that they had changed their dietary habits.

A 4-day dietary record was used as the basis for the calculation of the nutritional content of the diet because this method is the one used in the clinical routines in our Department. Great effort was made to get the subjects to register their food intake very exactly. The use of a computer enabled the calculations to be made easily and yet accurately.

In the present study the purpose was to ascertain whether RPDs could affect the dietary intake. However, the mean intake of energy and nutrients before treatment was by and large in agreement with the recommendations. But great interindividual variations indicate that for some variables many subjects did not fulfill the recommendations. Despite an increased masticatory efficiency and a subjectively assessed improvement in chewing foodstuffs that earlier gave chewing difficulties, the number of subjects who fulfilled the recommendations after the prosthetic treatment did not increase. Thus, the improved masticatory ability did not motivate the subjects to change their dietary intake, which seems to be more influenced by other factors. Similar results were found in a study of complete denture wearers from our clinic (20). In some studies dietary intake has been reported to be related to dental state (8), but other studies have shown no such relation (35).

In conclusion, the present study has shown that a bilateral free-end RPD in the lower jaw influenced both masticatory efficiency and the subjective experience of masticatory performance in a positive manner but did not seem to have any decisive effect on dietary intake.

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