Changes in masticatory function after surgical treatment of mandibular prognathism

Cineradiographic study of bolus position

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The position of the bolus in persons with mandibular prognathism was examined using a cineradiographic method before and after surgical correction of the prognathism. The pre-operative study included 30 persons, 18 women and 12 men. The test foods were bread and toffee. The results showed that the upper incisal region participated more and the premolar and molar regions less frequently in the chewing act than in other patient groups examined earlier with the same method. This was especially the case in persons with pronounced mandibular prognathism. It was concluded that these patients may have a poor masticatory ability.
The post-operative registration was carried out on 23 of the patients. The results showed a more »normal» chewing pattern with a higher participation of the molar region. Due to this change the possibilities for a good masticatory function was considered increased after operation, but whether the chewing efficiency was improved could not be decided from the present study.

Key-words: Mastication; prognathism; radiography; surgery, oral

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An important indication for surgical correction of mandibular prognathism is the possibility of improving the patient's masticatory function. Masticatory function may be studied from several aspects; the mandibular movements during chewing, the bolus position during chewing or the efficiency of the chewing.

Only a few investigations regarding mandibular and masticatory function in patients with mandibular prognathism are to be found in the literature. *Lundberg* (1964) found that persons with mandibular prognathism did not spontaneously perform protrusive movements. After surgical correction, however, protrusive movements were observed in these patients. *Ahlgren* (1966) analyzed the masticatory movements of children in the frontal plane. He found that in cases with »normal» occlusion there was a simpler and more regular pattern than in cases of malocclusion. The individual variations were however great and no direct relationship between the type of occlusion and the pattern of masticatory movements

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Table I. *The age and sex distribution of the patients*

Years	11—15	16—20	21—25	26—30	31—35	36—	Total
Male	—	2	5	1	2	2	12
Female	1	8	5	3	1	—	18
Total	1	10	10	4	3	2	30

were found. *Bewersdorff* (1969), using an electronic three-dimensional method investigated the masticatory movements in several patients including five with mandibular prognathism. He found considerable differences between a control group and the prognathic group. After surgical correction the prognathic group was closer to the control group but there was still a larger difference between the prognathic group after operation and the control group than within the prognathic group before and after operation.

Hedegård, Lundberg & Wictorin (1967), *Lundberg, Wictorin & Hedegård* (1967) and *Wictorin, Hedegård & Lundberg* (1968) have studied bolus position during chewing in patients with different bite conditions. They used a cineradiographic method. Differences were found, for example between persons with a full complement of natural teeth and persons with full dentures. However cases of mandibular prognathism were not included in their investigations.

In an unpublished seminar investigation from the Department of Stomatognathic Physiology, University of Umeå (1967) a study of the masticatory function with the aid of a method described by *Loos* (1963) was presented. Among other patients, five persons with mandibular prognathism were tested and found to have a very low chewing rate and poor chewing efficiency.

After surgical treatment of mandibular prognathism, a dramatic change in the bite conditions is induced and an improvement of the masticatory function is intended. The aim of the present investigation was to evaluate this change in masticatory function with regard to the bolus position.

MATERIAL AND METHODS

The investigation included 30 patients treated with surgical correction of mandibular prognathism. In one of the patients the prognathism was unilateral (laterognathism). In seven cases the prognathism was combined with an anterior open bite. The sex and age distribution of the patients is shown in Table I. The average age was 24.4 years.

The indications for surgical treatment were functional disorders, aesthetic-psychological reasons or a combination of both (Table II). The vertical overbite varied from +5.7 mm to −3.7 mm and

Table. II. *The patients grouped according to sex and different indications for operation*

Indication	Male	Female	Total
1	4	—	4
2	1	4	5
3	7	14	21
Total	12	18	30

1 = Functional
2 = Aesthetic-psychological
3 = Combination of 1 and 2

Table III. *The patients' subjective opinions of their masticatory function before operation*

Opinion group	Male	Female	Total
1	3	4	7
2	6	11	17
3	3	3	6
Total	12	18	30

1 = Good
2 = Difficulty in biting
3 = Poor function and/or poor digestion.

the horizontal overbite from –0.4 — –11.4 mm. The mean number of teeth was 24.9, the mean number of teeth in occlusal contact 9.2 and the mean number of pairs of occluding teeth 4.1. The patients' own opinions of their masticatory function are presented in Table III.

The postoperative analyses were carried out on 23 of the patients only (in frontal projection 20 patients). One patient had moved from the area and one did not attend to the follow-up because of illness. In the other cases in which the analyses are missing, technical errors had caused underexposures of the cinefilms and the patients lived too far away to be recalled.

Surgical methods

In 29 cases the surgical correction was made by oblique sliding osteotomy of the mandibular rami (*Hinds* 1958, *Robinson* 1958, *Thoma* 1958) and in one patient by the sagittal splitting technique ad modum *Obwegeser-Dal Pont* (*Trauner & Obwegeser* 1955, *Dal Pont* 1961). In the patient with mandibular laterognathia, the operation was performed on one side only, in the other patients bilaterally. In one patient an anterior osteotomy of the lower alveolar process was made concomitantly with the ramus osteotomy. The preoperative planning and the surgical procedures (in cases of oblique sliding osteotomy) have been described earlier (*Åstrand, Bergljung & Nord* 1973). The mean surgical retroposition was 9.9 mm (range 3.0—15.5).

Registration method

The test foods used were soft wheat bread and a toffee both containing approximately 30 per cent barium sulphate. The bolus position was examined pre-operatively and six months post-operatively using a cineradiographic method described earlier by *Hedegård et al.* (1967). Exposures were made in both lateral and frontal (posterio-anterior) projections. The central ray, which was oriented horizontally, was incident on the midpoint of an electronic image intensifier and perpendicular to its plane. The distance from the focus to the primary screen of the image intensifier was 125 cm. The whole image field, 13 cm in diameter, was used. The exposure time was 20 seconds for each projection.

In the analyses, the dental arches were divided into three regions in both the frontal and lateral projections. The regions were related to the upper jaw. In the frontal projection the regions were: that posterior to 13 (region R), that from 13 to 23 (region F) and the region posterior to 23 (region L). In the lateral projection (Fig. 1) the regions were: the anterior teeth including the canine (region I), the premolar region (region P) and the molar region (region M).

Fifteen consecutive chewing cycles were registered, a cycle being taken as the movement of the mandible between two consecutive closures. In 11 of the 206 registrations (5 per cent), the patient performed less than 15 cycles during the 20-

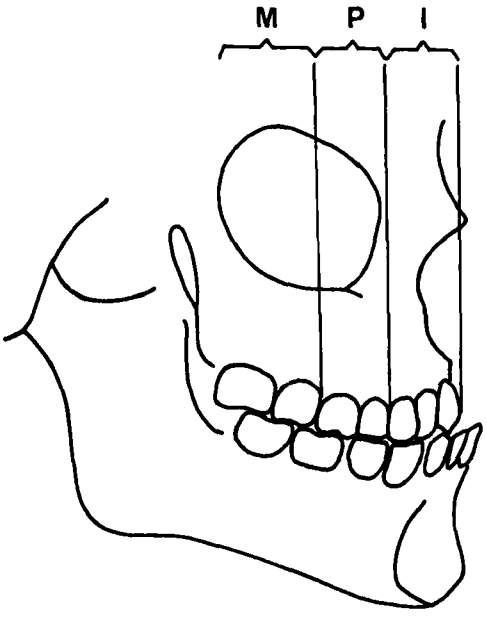

Fig. 1. The regions of the dental arch used in the analysis of the lateral projection.

second period and consequently less than 15 cycles were registered. The biting and the very first chewing cycles were not included in the anlysis.

The reliability of the method has been analysed earlier (*Hedegård et al.* 1967, *Lundberg et al.* 1967 and *Wictorin et al.* 1968) and found satisfactory.

At the follow-up the patients were asked whether they considered their chewing ability *increased*, *equal* or *decreased*.

Statistical methods

The following characteristics and abbreviations are used in the text: The mean value ($\bar{x}$), the mean difference ($\bar{d}$), the standard deviations ($S.D._k$) and the standard error of the mean ($S.E.M._k$). The statistical methods have been presented in the earlier studies mentioned above (*Hedegård et al.* 1967, *Åstrand et al.* 1973).

RESULTS

Preoperative registration

The participation of the various regions, expressed as the mean number of cycles per subject was calculated for both bread and toffee. The participation in per cent of the total number of chewing cycles was also calculated. In lateral projection (Table IV) the I region participated in 54 per cent and the P and M regions in 84 and 64 per cent respectively using bread as test food. For toffee the corresponding figures were 46 per cent for the I region and 58 and 46 per cent for the P and M segments respectively.

In frontal projection (Table V) the right and left sides participated in 46 and 62 per cent respectively for bread and in 32 respectively 61 per cent for toffee. The frontal region participated in 57 per cent and 56 per cent for bread and toffee respectively.

Table IV. *Before operation. The mean number of chewing cycles in the material as a whole (n=30) in different jaw regions; lateral projection*

	Bread			Toffee		
	I	P	M	I	P	M
$\bar{x}$	8.2 (54%)	12.5 (84%)	9.5 (64%)	6.9 (46%)	8.8 (58%)	6.9 (46%)
$S.D._k$	6.5	5.1	6.7	6.4	6.1	6.9
$S.E.M._k$	1.2	0.9	1.2	1.2	1.1	1.3

Table V. *Before operation. The mean number of chewing cycles in the material as a whole (n=30) in the different jaw regions; frontal projection*

	Bread			Toffee		
	R	F	L	R	F	L
$\bar{x}$	7.0 (46%)	8.6 (57%)	9.3 (62%)	4.9 (32%)	8.3 (56%)	9.2 (61%)
S.D.$_k$	6.6	6.7	6.1	6.5	6.5	5.9
S.E.M.$_k$	1.2	1.2	1.1	1.2	1.2	1.0

To ascertain whether there were any significant differences in the use of the various regions in the lateral projection, a t-test was performed for paired differences (Table VI). For bread, an almost significant difference was found between the P and I and between the P and M segments. No other significant differences were found.

The above figures represent the total masticatory frequencies in the various regions. In order to analyse when the different regions participate during the 15 cycles, diagrams for each region and test food were drawn. The diagrams of the lateral projections showed the use of the regions during the 15 cycles to be approximately the same. This is illustrated in figure 2 where bread is the test food. The x-axis represents the cycle number and the y-axis the number of engaged cycles for the respective regions (each y-value is the total value of the number of masticatory cycles for the whole material). The diagrams of the frontal projection with toffee as test food showed a similar pattern except that when bread was the test food (Fig. 3) there were slight variations and the left region was used more in the first cycles than in the later ones. The right side was most used during the cycles 6—11.

In order to analyze the importance of the degrees of prognathism and open bite, the patient material was divided into three groups. Group 1 consisted of persons with

Table VI. *Before operation. The mean differences for the material as a whole (n=30) in the chewing frequency among the three jaw regions; lateral projection*

	Sections	$\bar{d}$	S.E.M.$_k$	Sign. level
Bread	P—I	4.3	1.8	*
	P—M	3.0	1.1	*
	M—I	1.3	2.3	
Toffee	P—I	1.9	1.9	
	P—M	1.9	1.5	
	M—I	0.04	2.4	

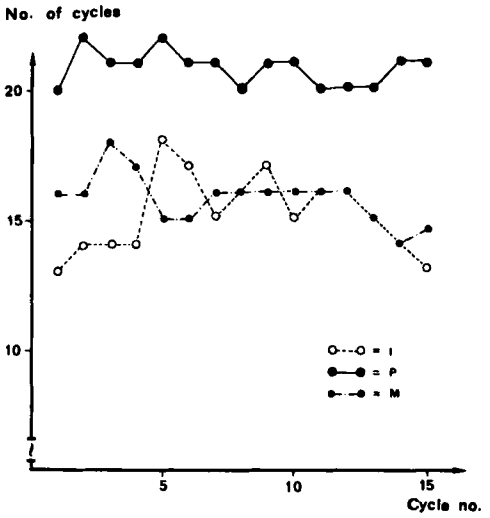

Fig. 2. The position of the bread-bolus preoperatively; lateral projection (n=30).

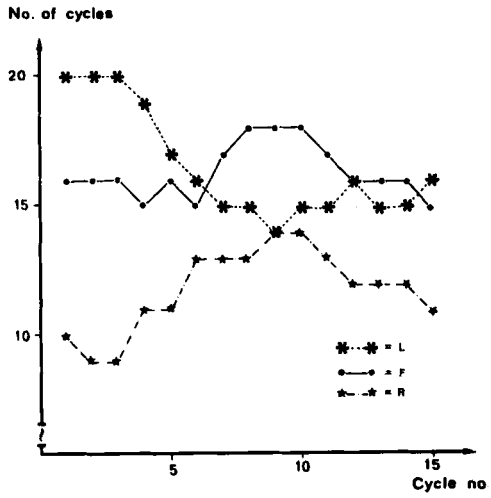

Fig. 3. The position of the bread-bolus preoperatively; frontal projection (n=30).

Tabl VII. *The numbers of patients in the different groups at the preoperative and at the postoperative registrations. H.O. = horizontal overbite, V.O. = vertical overbite*

Patient group	*Preop. reg.*	*Postop. reg.*
1. H.O. $\leq$ —3 mm V.O. > 0 mm	17	12
2. H.O. —3—0 mm V.O. > 0 mm	6	6
3. H.O. < 0 mm V.O. < 0 mm	7	5
	30	23

a negative horizontal overbite of 3 mm or more and a positive vertical overbite, group 2 of persons with a negative horizontal overbite less than 3 mm and a positive vertical overbite and group 3 of persons with a negative horizontal overbite combined with an anteriorly open bite (Table VII). The mean frequencies in lateral projection for the various regions in the three groups were calculated (Table VIII) and the mean differences between the groups analyzed (Table IX). There were significant differences between groups 1 and 2 and groups 1 and 3 in respect to the I and M regions for both bread and toffee (almost significant between 1 and 2 in region M using bread as the test food).

Postoperative registration

The participation of the various regions in lateral projection for bread and toffee is shown in Table X. When bread was

Table VIII. *Before operation. The mean numbers of chewing cycles in different jaw regions in groups 1, 2 and 3; lateral projection*

		Bread			Toffee		
		I	P	M	I	P	M
Group 1 n = 17	$\bar{x}$	13.5	11.5	6.3	11.2	8.2	2.3
	S.D.$_k$	2.6	6.0	7.0	5.0	6.0	4.6
	S.E.M.$_k$	0.6	1.5	1.7	1.2	1.5	1.1
Group 2 n = 6	$\bar{x}$	5.0	12.7	12.5	2.7	10.5	10.5
	S.D.$_k$	4.1	4.4	4.1	2.7	3.8	5.4
	S.E.M.$_k$	1.7	1.8	1.7	1.1	1.6	2.2
Group 3 n = 7	$\bar{x}$	0.0	15.0	15.0	0.0	8.6	15.0
	S.D.$_k$	0.0	0.0	0.0	0.0	7.4	0.0
	S.E.M.$_k$	0.0	0.0	0.0	0.0	2.8	0.0

Table IX. *Before operation. The difference among the means of the groups; lateral projection*

Regions		Bread			Toffee		
		I	P	M	I	P	M
Groups compared							
1—2	diff	8.5	—1.2	—6.2	8.5	—2.3	— 8.2
	sign. level	***		*	***		**
1—3	diff	13.5	—3.5	—8.7	11.2	—0.4	—12.7
	sign. level	***	*	***	***		***
2—3	diff	5.0	—2.3	—2.5	2.7	1.9	— 4.5
	sign. level	*			*		

Table X. *After operation. The mean numbers of chewing cycles in the material as a whole (n=23) in the different jaw regions; laterial projection*

	Bread			Toffee		
	I	P	M	I	P	M
$\bar{x}$	9.0 (60%)	13.3 (89%)	13.5 (90%)	4.5 (30%)	12.3 (82%)	11.8 (79%)
$S.D._k$	6.7	1.1	3.4	5.1	4.2	4.3
$S.E.M._k$	1.4	0.9	0.7	1.1	0.9	0.9

used as the test food, the I segment participated in 60 per cent and the P and M regions in 89 and 90 per cent of the chewing cycles respectively. For toffee the corresponding figures were 30 per cent for the I region and 82 and 79 per cent for the P and M regions respectively. Significant differences between the P and I regions and the M and I regions (Table XI) were found for both bread and toffee.

In the frontal projection the right side participated in 68 per cent and the left side in 65 per cent of the cycles with bread and in 43 and 56 per cent respectively with toffee. The frontal segment participated in 42 and 23 per cent of the cycles with bread and toffee respectively (Table XII).

Table XI. *After operation. The mean differences for the whole material (n=23) in frequency of usage among the jaw regions; lateral projection*

	Regions	$\bar{d}$	$S.E.M._k$	Sign. level
Bread	P—I	4.3	1.3	***
	P—M	—0.2	1.2	
	M—I	4.5	1.7	**
Toffee	P—I	7.8	1.2	***
	P—M	0.5	1.2	
	M—I	7.3	1.2	***

The comparison of the different patient groups (Tables XIII and XIV) resulted in no significant differences between the groups.

Table XII. *After operation. The mean numbers of chewing cycles in the material as a whole (n=20) in the different jaw regions; frontal projection*

	Bread			Toffee		
	R	F	L	R	F	L
$\bar{x}$	10.2 (68%)	6.3 (42%)	9.7 (65%)	6.5 (43%)	3.5 (23%)	8.4 (56%)
$S.D._k$	5.8	6.5	6.4	5.5	4.8	6.4
$S.E.M._k$	1.3	1.4	1.4	1.2	1.1	1.4

Table XIII. *After operation. The mean numbers of chewing cycles in the different jaw regions in groups 1, 2 and 3; lateral projection*

		Bread			Toffee		
		I	P	M	I	P	M
Group	$\bar{x}$	7.8	12.1	13.3	6.0	12.3	10.8
1.	$S.D._k$	7.0	5.3	1.2	6.2	4.1	5.1
n = 12	$S.E.M._k$	2.0	1.5	1.2	1.8	1.2	1.5
Group	$\bar{x}$	10.3	14.8	14.0	2.3	10.2	12.7
2.	$S.D._k$	6.3	0.4	1.8	1.9	1.9	3.1
n = 6	$S.E.M._k$	2.6	2.3	0.8	0.8	2.0	1.3
Group	$\bar{x}$	10.2	14.4	13.6	3.4	14.8	13.4
3.	$S.D._k$	5.7	0.8	2.3	3.3	0.4	1.9
n = 5	$S.E.M._k$	2.6	0.4	1.1	1.8	0.2	0.8

Table XIV. *After operation. The differences among the means of the groups; lateral projection. The differences do not differ significantly from zero*

	Bread			Toffee		
	I	P	M	I	P	M
Groups compared						
1—2	—2.5	—2.7	—0.7	3.7	2.1	—1.9
1—3	—2.4	—2.3	—0.3	2.6	—2.5	—2.6
2—3	0.1	0.4	0.4	—1.1	—4.6	—0.7

Table XV. *The mean differences for the groups and the material as a whole between pre-operative and post-operative registrations using bread as test food*

Group no.	Region I			P			M		
	$\bar{d}$	S.E.M.$_k$	Sign. level	$\bar{d}$	S.E.M.$_k$	Sign. level	$\bar{d}$	S.E.M.$_k$	Sign. level
1	4.3	1.5	*	0.2	2.6		—5.6	1.8	*
2	— 5.3	3.6		—2.1	2.0		—1.7	2.0	
3	—10.2	2.8	*	—0.6	0.4		—1.4	1.2	
1+2+3	— 1.4	1.8		—0.3	1.4		—3.0	1.2	**

Comparison between the preoperative and postoperative registrations

The paired differences between preoperative and postoperative registrations are presented in Tables XV and XVI. There were significant differences between the registrations for the M region for both bread and toffee in the material as a whole. A diagram (Fig. 4) comparing the participation of this region through the 15 cycles illustrates the higher participation after operation but shows the use to approximately the same during all the cycles. There was an almost significant difference for the P region (Table XVI) when toffee was used as the test food. Differences in this region between the different cycles

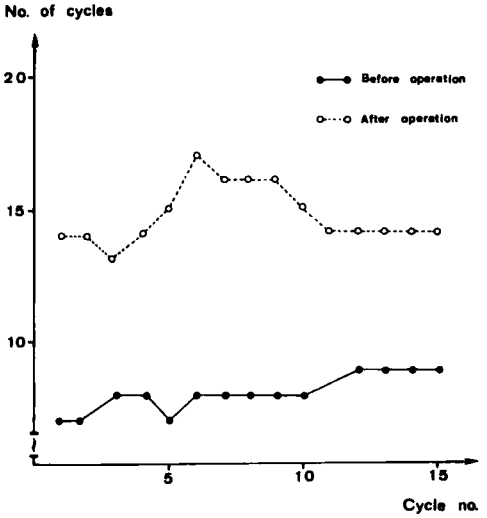

Fig. 4. The use of region M in the patients in whom postoperative registration was performed (n=23). Mastication of toffee before and after surgical treatment.

Table XVI. *The mean differences for the groups and the material as a whole between pre-operative and post-operative registrations using toffee as test food*

Group no.	Region I			P			M		
	$\bar{d}$	S.E.M.$_k$	Sign. level	$\bar{d}$	S.E.M.$_k$	Sign. level	$\bar{d}$	S.E.M.$_k$	Sign. level
1	4.8	1.5	**	—3.8	2.1		—8.8	1.6	***
2	0.4	1.6		0.3	2.1		—2.2	1.3	
3	—3.4	1.6		—5.8	3.6		1.6	0.9	
1+2+3	2.1	1.4		—3.2	1.5	*	—4.8	1.3	***

examined, were however not revealed in the diagrams.

In group 1 there were almost significant differences for bread and significant differences for toffee between the pre- and postoperative registrations for the I and M regions (Table XVI), that in the I region being lower and that in the M region being higher postoperatively. In group 3 (anterior open bite) there was an almost significant increase for the I region when bread was used as test food (Table XV).

As to the patient's own opinion of their chewing ability three of them considered it unchanged while 20 considered it increased.

DISCUSSION

Mandibular prognathism was the diagnosis in all patients but there was a slight inhomogeneity according to bite conditions. This inhomogeneity was compensated by division of the material into groups. The post-operative registration failed in some of the patients. This was however mainly due to technical errors and it is not probable that this loss of material has influenced the results of the investigation. The fact that less than 15 cycles were registered in some cases has been taken in account and found not to influence the results.

In the pre-operative registrations, the most striking result was that the upper incisal region participates more in mastication than has been found in a patient group with "normal" occlusion examined with the same method (*Wictorin et al.* 1968) and it is probable that the masticatory ability is poor when the premolar and molar teeth participate minimally in the chewing act.

Six months after operation the chewing pattern had changed. The participation of the incisal region had decreased in some patients and the mean participation of the posterior teeth, especially the molar region had increased. Because of this change in bolus position the operation appears to offer possibilities for a better mastication. This observation was confirmed by the patients' own opinions and stresses the functional indication of the operations. Another interesting fact ist hat the differences between the groups, which were observed before operation, had disappeared. The observation time is short, only six months, and it is possible that further investigations will reveal even better masticatory function.

After the operation the bolus position seems to be closer to that of the »normal» patients earlier studied by *Wictorin et al.* (1968). Whether or not this change in bolus position influences the chewing efficiency cannot, however, be decided on the bases of the present evidence. Investigations of this problem are now in progress.

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