

From: The Departments of Prosthetics and Oral Roentgenology, School of Dentistry, Karolinska Institutet, Stockholm, and the Department of Oral Roentgenology, School of Dentistry, University of Umeå, Sweden.

## MASTICATORY FUNCTION — A CINERADIOGRAPHIC INVESTIGATION

### II. POSITION OF THE BOLUS IN FULL DENTURE WEARERS

*by*

M. LUNDBERG

L. WICTORIN

E. HEDEGÅRD

#### INTRODUCTION

In an earlier paper by *Hedegård, Lundberg and Wictorin* (1967) reporting a study of the position of the bolus during chewing in patients with a full upper and a partial lower denture, a cineradiographic method that had been found to be reliable for such research was presented.

In a yet unpublished study in full denture wearers and patients with a full complement of natural teeth *Sheppard* (1966) found that chewing occurred chiefly in the premolar and molar regions and that the left and right sides were used to about the same extent. Bilateral chewing was found to be more common where all the teeth were present.

In the study reported below the pattern of mastication was analysed in full denture wearers; the same cineradiographic technique as in our previous study was applied.

## MATERIAL

The study was carried out on nine women and two men ranging in age from 57 to 73 years, mean 64. These patients had been supplied with full upper and lower dentures in the course of 1965 at the Department of Prosthetic Dentistry, School of Dentistry, Karolinska Institutet, Stockholm. They had previously worn full dentures for 6—13 years. The ridge position was classed as neutral with the mandible in occlusion.

When the patients were examined about 6—12 months after they had received their dentures, the dentures were checked for retention and stability, and a brief report was made of the patients' wearing habits and their comments on the denture. Seven of the patients wore their dentures continuously, and four removed them at night; nine considered that the dentures functioned well.

The clinical test disclosed that the retention and stability of one denture in each of two cases were unsatisfactory. The other dentures were classed as good.

## METHOD

The position of the test bolus and the direction of movement during the act of mastication was recorded by cineradiography. The apparatus, which consisted of a roentgen tube, an image intensifier and a 30 mm cine camera, has been described elsewhere (*Lundberg, 1963*).

The test foods consisted of wheat bread and toffee, both containing 30 per cent of barium sulphate. The bread was fairly easy to chew, unlike the toffee, which was tough and hard.

An account of the method has been given in an earlier paper (*Hedegård, Lundberg, and Wictorin, 1967*).

**Analysis of the method**

The registration apparatus was tested for its geometric systematic and random errors (*Torlegård and Wictorin, 1966*). The systematic error, expressed as the radial distortion ( $dr$ ) proved to be quite small ( $dr_{\max} = 0.04$  mm) and can be neglected in a qualitative study of this type.

In the analysis of the films the five observers independently

recorded the positional changes of the bolus. The error in film analysis was determined as the deviation of the individual observer from the majority result; this error was determined from the values for five randomly chosen patients (Table I). The deviations occurred chiefly in the lateral projection, as would be

Table I. Deviations from the majority results for the five observers and five patients in registration of five randomly selected patients.

Observer Patient	A		B		C		D		E		Total		Mean per observer and patient	
	Lat	Front	Lat	Front	Lat	Front	Lat	Front	Lat	Front	Lat	Front	Lat	Front
1	1	0	0	0	3	0	2	1	1	1	7	2	1.4	0.4
2	1	0	3	0	1	0	3	0	0	0	8	0	1.6	0
3	0	0	5	0	3	0	7	0	3	1	18	1	3.6	0.2
4	0	0	2	0	1	0	0	0	2	0	5	0	1.0	0
5	0	0	3	0	1	0	0	0	4	0	8	0	1.6	0
Total	2	0	13	0	9	0	12	1	10	2	46	3	9.2	0.6
Mean per patient and observer	0.4	0	2.6	0	1.8	0	2.4	0.2	2.0	0.4	9.2	0.6	1.8	0.12

Table II. Mean number of cycles per segment in mastication of bread and toffee

Segment	Bread	Toffee
	$\bar{x}$	$\bar{x}$
Incisor (I)	16.5	10.5
Premolar (P)	17.4	17.6
Molar (M)	16.0	14.0
Left (L)	13.0	10.5
Frontal (F)	12.5	2.5
Right (R)	11.4	6.3

Table III. Mean differences ( $\bar{d}$ ), standard error of the mean (S. E.), and values of  $t$  for difference between segments in analysis of the whole series; lateral projection

	Bread			Toffee		
	P—I	I—M	P—M	P—I	M—I	P—M
$\bar{d}$	0.9	0.5	1.4	7.0	3.5	3.5
S. E.	—	—	—	1.8	2.99	1.62
$t$	—	—	—	3.88 <sup>++</sup>	1.17	2.16 <sup>+</sup>

Table IV. Mean differences ( $\bar{d}$ ), standard error of the mean (S. E.), and values of  $t$  for difference between segments in frontal analysis of the whole series; frontal projection

	Bread			Toffee		
	L—F	F—R	L—R	L—F	R—F	L—R
$\bar{d}$	0.5	1.1	1.6	8.0	3.7	4.2
S. E.	—	—	—	2.04	1.32	2.98
$t$	—	—	—	3.92 <sup>++</sup>	2.80 <sup>+</sup>	1.40

Table V. Mean differences ( $\bar{d}$ ), standard error of the mean (S. E.), and values of  $t$  for mastication of toffee (T) and bread (B) in the same region

	Masticatory segment					
	I <sub>B</sub> —I <sub>T</sub>	P <sub>B</sub> —P <sub>T</sub>	M <sub>B</sub> —M <sub>T</sub>	L <sub>B</sub> —L <sub>T</sub>	F <sub>B</sub> —F <sub>T</sub>	R <sub>B</sub> —R <sub>T</sub>
$\bar{d}$	6.0	0.2	2.0	2.5	10.0	5.1
S. E.	2.67	—	—	—	1.9	2.71
$t$	2.25 <sup>+</sup>	—	—	—	5.26 <sup>+++</sup>	1.88

expected in view of the difficulty of locating accurately the limits of the segments on the film with this direction of projection. While the incisor region is clearly demarcated by the metal cramps of the front teeth there is no distinct boundary between the premolar and molar segments. In the frontal projection the incisor cramps delimit the anterior segment from the right and left sides.

The observer deviations were fairly evenly distributed among the observers, and the frequency was about 10 per cent for the lateral and two per cent for the frontal projections.

The reliability of the film analysis was also determined from the frequency of complete agreement between the five observers; the values for the lateral and frontal projections were 70.4 and 96.7 per cent, respectively. Both values may be considered acceptable, especially the latter.

#### RESULTS

The means for the various segments per subject were calculated for bread and toffee from the majority results (Table II).

The percentages for the segments were calculated on the number of chewing cycles in which the respective segments participated.

In *lateral projection* the premolar segment (P) participated most frequently for both bread and toffee (91 and 90 per cent, respectively). For bread the molar (M) and incisal (I) segments were used to about the same extent (84 and 86 per cent), while for toffee the corresponding values were lower (72 and 54 per cent).

In *frontal projection* the premolar and molar segments participated slightly less often for bread (72 and 64 per cent for left (L) and right (R), resp.), while the value for the anterior segment (F) was about the same 70 per cent as for the posterior segments. For chewing toffee the posterior segments were used much more often (57 and 34 per cent for left and right, resp.) than the anterior segment (14 per cent).

The mean differences between the three segments in lateral projection were not significant for bread, but for toffee the

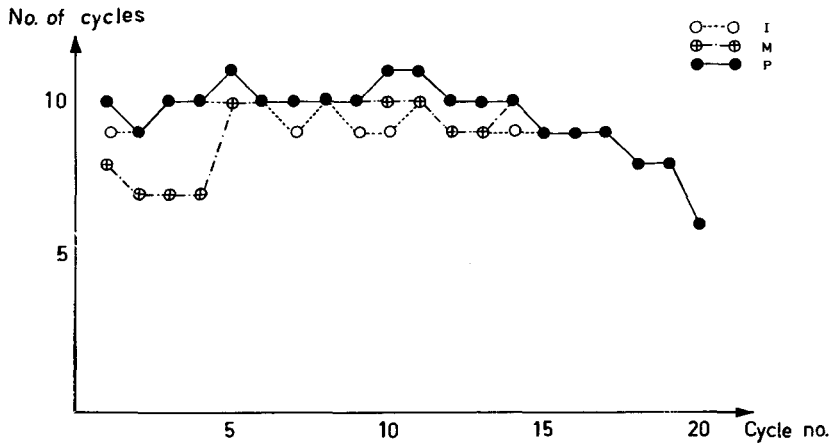


Fig. 1. Bolus position of the eleven cases during 20 cycles in lateral projection; mastication of bread.

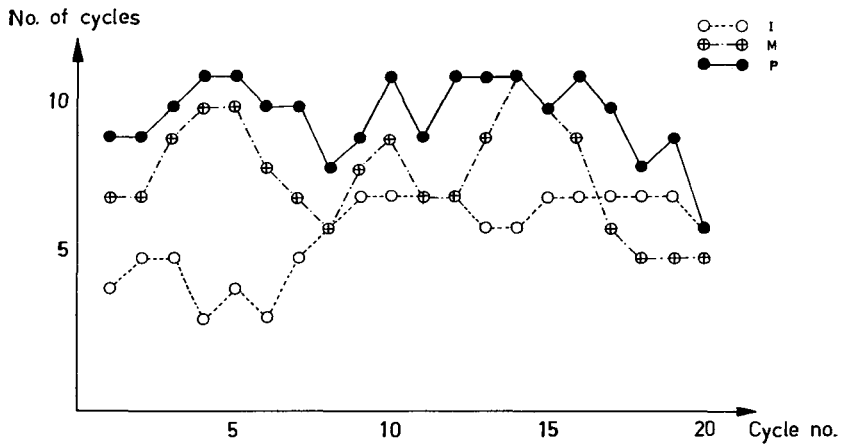


Fig. 2. Bolus position of the eleven cases during 20 cycles in lateral projection; mastication of toffee.

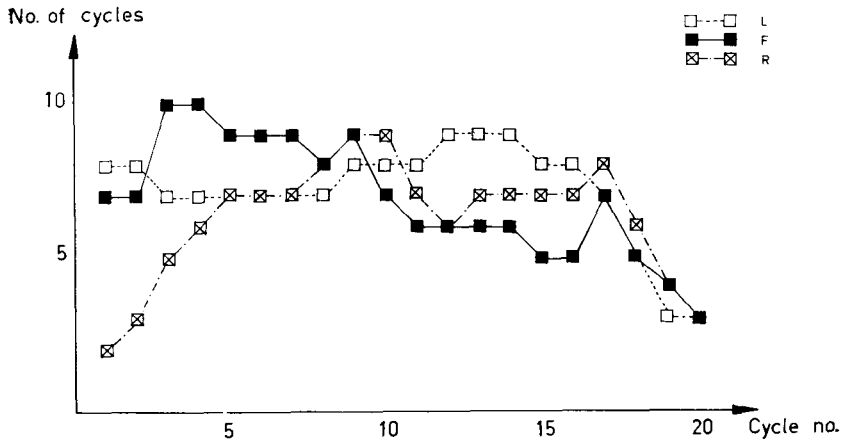


Fig. 3. Bolus position of the eleven cases during 20 cycles in frontal projection; mastication of bread.

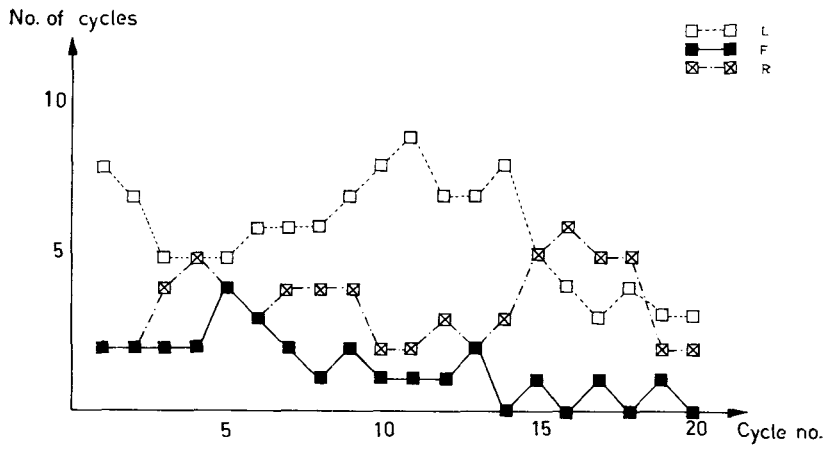


Fig. 4. Bolus position of the eleven cases during 20 cycles in frontal projection; mastication of toffee.

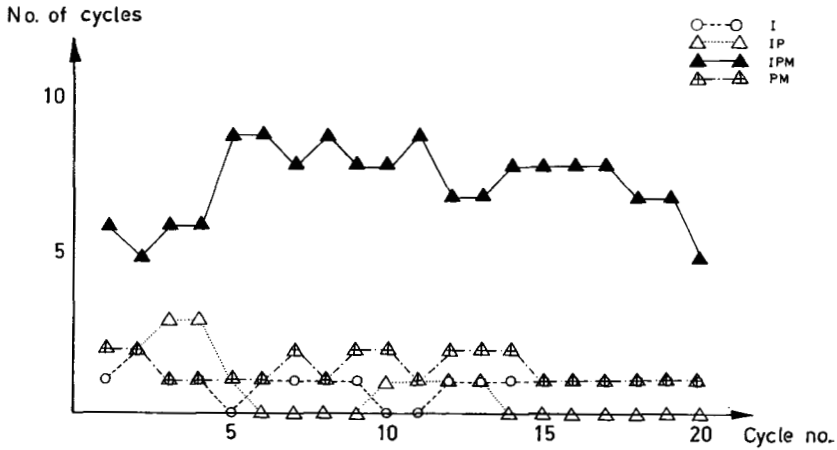


Fig. 5. Bolus position of the eleven cases during 20 cycles in lateral projection (combination of segments); mastication of bread.

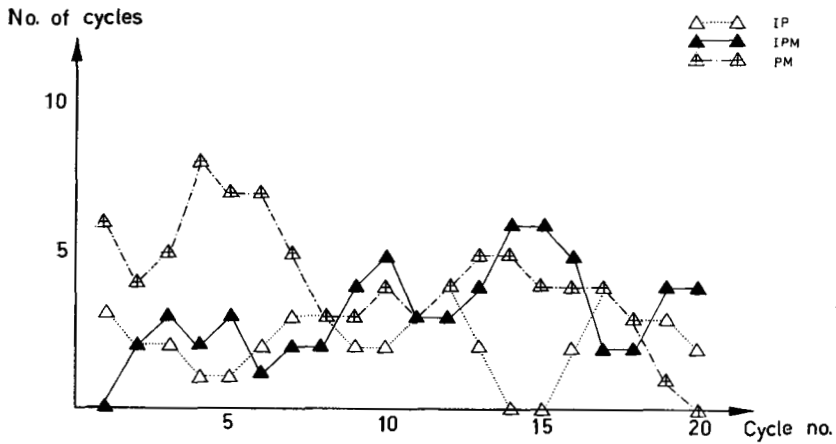


Fig. 6. Bolus position of the eleven cases during 20 cycles in lateral projection (combination of segments); mastication of toffee.

premolar segments differed significantly from the incisal and molar segments (Table III).

For the frontal projection the situation was similar to that of the lateral projection, there being no significant difference for bread, but for toffee a significant difference between each of the posterior segments and the anterior segment (Table IV).

As regards the difference between the bread and toffee for a particular region (Table V) significant differences were found for the anterior segment in both lateral and frontal projections. The position of the bolus during mastication thus appeared to be governed to some extent by the consistency and character of the food.

From an analysis of 20 cycles it was evident that the participated segments were uniform to practically any part to the ranges for bread. For toffee the participating of the I-segment was less frequent especially during the first ten cycles (Figs. 1 and 2). It was notable that in respect of toffee the frontal projection values were higher for the left than right sides (Figs. 3 and 4).

To further examine the extent to which combinations of segments were used simultaneously an analysis was made of the frequency with which four combinations of segments were used in each of 20 cycles (Figs. 5 and 6). For bread the combination of incisal, premolar and molar segments (IPM) was by far the most common, whereas for toffee the pattern was less regular, though the premolar — molar combination (PM) predominated slightly in the early cycles.

#### DISCUSSION

The inter-observer differences in the frequency with which the various segments were used were slightly smaller than in the previous study on patients with full upper and partial lower dentures. This in spite of the fact that the borders between the segments were not so distinct in the present series of full denture patients, because of the absence of the natural boundary between the residual anteriors and the denture teeth, the position of the anteriors being indicated only by the metal cramps. The slightly lower inter-observer discrepancy is probably due to the practice the observers gained in the first study.

The reliability of the analysis was satisfactory for the purpose of the study.

The results for the full denture wearers shows that in the chewing of bread all the segments are used frequently and to much the same extent in the two projections. It would seem that the bread bolus was placed in at least two regions simultaneously almost throughout the act of mastication. With one exception none of the segments was used more than the others at any particular part of the sequence; only in the first three or four cycles, viewed in the frontal projection, was there a lower frequency for the right side than for the anterior segment and the left side.

For the chewing of toffee a different chewing pattern was recorded. In both lateral and frontal projections the premolar and molar segments were engaged considerably more than the anterior, and the premolar segment was used to a significantly greater extent than the other two regions; this bears out the text book statements.

Although there was no significant difference between the right and left lateral segments there was a clear tendency for more frequency use of the left side for chewing toffee. This was particularly marked for the fifth to fifteenth masticatory cycle (Fig. 4). It may be pointed out that there was a similar tendency for tough food in the first study on patients with full upper and partial lower dentures.

From the significant difference between bread and toffee as regards the use of the anterior teeth, it would seem that the position of the bolus is dependent on the consistency of the food. While all three segments were involved in the chewing of bread, for toffee the premolar region was preferred. This would be expected since the tough food probably requires a greater masticatory pressure and a more horizontal direction of the forces, and then the food would be placed in the segments where there is greater stability and better support.

It is evident from the study that wearers of full dentures are able to masticate extremely tough food, and that all the segments are used during chewing, though to a degree that is dependent on

the consistency of the food. This underlines the importance of observing the laws of mechanics in the restoration of the dentition with upper and lower dentures.

#### SUMMARY

The position of the bolus has been examined by a cineradiographic method in 11 wearers of full upper and lower dentures. The dentures had all been worn for 6—12 months. In checks of the recording and analytical methods the error of the method was found to be small, so that the reliability of the method can be considered satisfactory. The test foods were bread and toffee, with the addition of 30 per cent of barium contrast medium. The chewing pattern was analysed continuously over 20 cycles.

For toffee there were significant differences between the segments (Tables III and IV). The highest frequency of use was recorded for the premolar segment (Table III). It would thus seem that the position of the bolus is dependent on the properties of the food (Figs. 5 and 6).

Bread was distributed fairly uniformly over the arch, there being no significant differences between the segments (Tables III and IV).

#### RÉSUMÉ

##### LA FONCTION MASTICATRICE. ETUDE CINÉRADIOGRAPHIQUE. II POSITION DU BOL ALIMENTAIRE CHEZ LES PORTEURS DE PROTHÈSES COMPLÈTES.

La position du bol alimentaire a été étudiée par une méthode cinéradiographique chez 11 porteurs de prothèses complètes du haut et du bas. Les prothèses étaient toutes en usage depuis 6—12 mois. Des contrôles des méthodes d'enregistrement et d'analyse ont montré que l'erreur liée à la méthode était petite et que la méthode utilisée permettait d'obtenir une sécurité considérée comme satisfaisante. Les aliments utilisés pour l'essai étaient du pain et des caramels, et étaient additionnés de 30 % d'un produit opaque aux rayons X à base de baryum. Le mode de mastication a été analysé d'une manière continue au cours de 20 cycles masticatoires.

Le pain était réparti à peu près uniformément sur l'arcade, aucune différence significative n'ayant été enregistrée entre les segments (Tableaux III et IV).

Pour les caramels, il existait des différences significatives entre les différents segments (Tableaux III et IV). La fréquence d'utilisation la plus élevée a été enregistrée pour le segment prémolaire (Tableaux III).

Il semblerait donc que la position du bol alimentaire dépende des propriétés de l'aliment (Fig. 5 et 6).

#### ZUSAMMENFASSUNG

##### KAUFUNKTION. EINE CINERADIOGRAPHISCHE UNTERSUCHUNG

##### II. DIE LAGE DES BISSENS BEI VOLLPROTHESETRÄGERN

Die Lage eines Bissens wurde bei 11 Personen mit totalen Ober- und Unterkieferprothesen untersucht. Die Patienten hatten ihre Prothesen 6—12 Monate vor der Untersuchung erhalten. Bei Kontrollen der registrierenden und analytischen Methoden wurde ein kleiner Fehler der Methoden festgestellt, so dass die Zuverlässigkeit der Methode als ausreichend angesehen werden kann. Die untersuchten Bissen bestanden aus Brot und Sahnebonbons, die jeweils ungefähr 30 % Bariumkontraststoff enthielten. Die Analyse wurde bei 20 aufeinander folgenden Kauzyklen ausgeführt.

Bei den Sahnebonbons wurden signifikante Unterschiede zwischen den Segmenten festgestellt (Tab. III und IV), und zwar wurden hauptsächlich die Praemolarsegmente benutzt (Tab. III). Es scheint also so zu sein, dass die mechanischen Eigenschaften des Bissens für die Lage in der Mundhöhle eine Rolle spielen, (Abb. 5 und 6) da das Brot ziemlich gleichmässig über den Zahnbogen verteilt wurde und sich hierbei keine signifikanten Unterschiede zwischen den Segmenten feststellen liessen (Tab. III und IV).

#### REFERENCES

- Hedegård, B., M. Lundberg and L. Wictorin, 1967: Masticatory Function — A Cineradiographic Investigation. I. Position of the bolus in full upper and partial lower denture cases. Acta odont. scand. 25: 331.*

*Lundberg, M.*, 1963: Free movements in the temporomandibular joint. Acta radiol. suppl. 220.

*Sheppard, I.*, 1966: Personal communication.

*Torlegård, K., L. Wictorin*, 1966: Interior Orientation of a Cineroentgenographic system. Acta radiol. In press.

Addresses:

*B. Hedegård,*

*L. Wictorin,*

*Department of Prosthetics,*

*School of Dentistry,*

*Karolinska Institutet,*

*Stockholm, Sweden.*

*M. Lundberg,*

*School of Dentistry,*

*University of Umeå,*

*Umeå, Sweden.*