

Retention of complete maxillary dentures as a result of changes in design

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The influence of complete maxillary denture design on retention was studied under clinical conditions simulating chewing. Five persons with an edentulous maxilla and a natural dentition of at least 10 teeth in the mandible participated. Retention was measured with a miniature bite force sensor. The occlusal load required to provoke denture dislodgement was recorded. The general principles of denture design were as follows: 1) the bicuspid and molars were set on top of the residual ridge; 2) the thickness of the denture borders was determined functionally; and 3) the palate was covered to the vibration line, without attempts at border compressions. The details that were changed to evaluate their influence on denture retention were as follows: 1) the point of attack of the dislodgement-provoking load alternated between three distinct pits, situated 2 mm apart in the buccopalatal direction on the occlusal surface of the first right bicuspid; 2) the vestibular denture border on the left side was reduced stepwise to 75%, 50%, and 25% of its original thickness; and 3) the distal extension of the palatal denture border was shortened stepwise (2 + 2 mm, as measured in the midline). Measurements pertaining to one specific problem were carried out within a period of 2 h. The results confirmed the concepts that lingualized occlusal contact, functionally determined filling in of the vestibular sulcus, and full palatal coverage to the vibration line all have a positive influence on the retention of complete maxillary dentures. □ *Denture design; denture retention*

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Several details in design may have an impact on the retention of complete maxillary dentures (1). Thus, full coverage of and a close fit to the denture-supporting area are considered most important to exploit the retentive forces of the salivary film (2, 3). For the same purpose the denture borders should fill in the vestibular sulcus, and the vestibular polished surfaces should have a contour favoring denture fixation by the mimic muscles (4). Finally, the occlusal forces should be guided towards the central part of the denture-bearing area with a minimum of horizontal or tilting components (5).

These recommendations seem to have a sound theoretical foundation. Their influence on retention has been demonstrated in model studies (6) and to some extent in clinical experiments (7).

We have previously described a method to quantify the retention of complete maxillary dentures in a clinical situation simu-

lating chewing (8). Retention was then defined as the ability of a denture to remain seated when subjected to unilateral occlusal loads. The aim of the present study was to investigate how the following changes in certain details in denture design will affect this ability: 1) occlusal contact point; 2) border thickness; and 3) palatal extension.

Materials and methods

Participants

Five persons without maxillary teeth participated voluntarily in the study. Their age, sex, and previous denture experience are shown in Table 1. All participants had clinically healthy mucosa, moderately resorbed residual alveolar ridges, and normal intermaxillary relations. Their mandibular dentitions consisted of at least 10 teeth, with incisors, canines, or bicuspid present.

Table 1. Age, sex, and previous denture experience of the participants

Patient	Age, years	Sex	Previous complete denture experience	
			Years	No. of dentures
T	83	M	36	3
C	68	F	3	2
S	75	M	15	2
W	68	F	9	2
H	58	F	2	1

Denture design

A semidynamic impression technique (1) was used to achieve a functionally determined filling in of the vestibular sulcus by the denture borders. The palatal denture border was extended to the vibration line. No attempts were made to produce a central relief area or compressions along the denture borders. The vestibular surfaces were made concave to facilitate muscular fixation.

The incisors and canines were orientated primarily to achieve acceptable aesthetic results. Two bicuspid and one molar in the lateral segments were arranged and individually adjusted to conform with the following principles: 1) the posterior teeth were set on top of the residual ridge; 2) bilateral contact with emphasis on firm contact in the bicuspid region (5) was established in the retruded position (RP); and 3) bilateral contact was maintained for lateral movements up to 3 mm as measured in the bicuspid region. Posterior bilateral balancing contacts were established for protrusive movements to edge-to-edge contact relation.

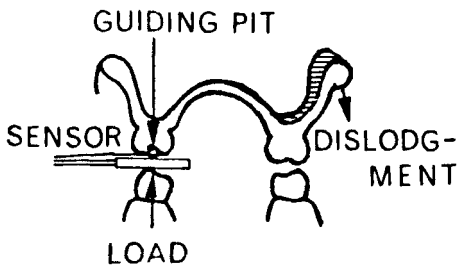


Fig. 1. Schematic drawing of denture dislodgement provocation. Transverse section in the bicuspid area.

Each patient was supplied with four dentures, one original made from heat-cured polymethyl-methacrylate and three copies made from a pour-type polymethyl-methacrylate as described previously (8). One copy was used in each of the three design studies.

Changes in denture design

Occlusal contact. The point of occlusal force application was for experimental purposes obtained by grinding a distinct pit into the central part of the occlusal surface of the first right bicuspid (Fig. 1). This provided a reproducible positioning of the bite force sensor (9). Two additional pits were ground in the same bicuspid to study how changing of the point of force attack would influence retention. These pits were located 2 mm palatally and 2 mm buccally to the central pit (Fig. 2a).

Denture border thickness. The denture border thickness was measured on the left side (contralaterally to the side exposed to occlusal load). Measurements were performed at four distinct locations, intersecting the denture in five equally long anteroposterior parts (Fig. 2b and Table 2), using a graded caliper (Tesa, Switzerland). During the experiment, the border was thinned stepwise to 75%, 50%, and 25% of the original value (Fig. 2c). The accuracy of the procedure was within ± 0.1 mm. Each reduction was terminated by polishing the denture surface to its original smoothness.

Palatal extension. The effect of shortening the palatal coverage, originally extended to the vibration line, was also studied. Fig. 2d

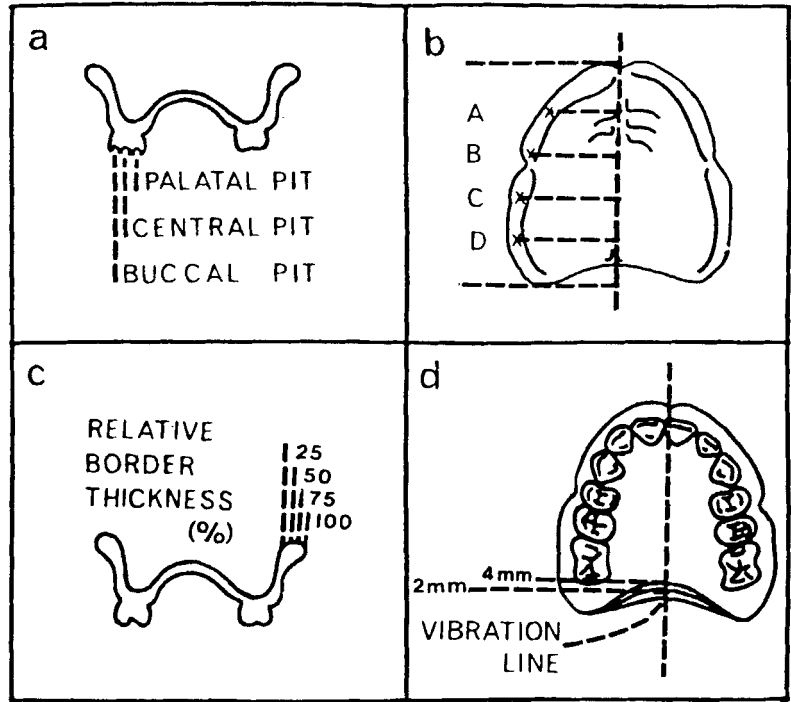


Fig. 2. Experimental changes in denture design. 2a. Three different points of attack for the experimental loads located at 2-mm intervals. 2b. Location of measuring points for the assessment of denture border thickness. 2c. Stepwise reduction of denture border thickness. 2d. Stepwise shortening of the palatal denture roof.

shows how a stepwise shortening was achieved. Linear measurements were done along the median line corresponding to the median raphe. From this location and laterally towards the tuberosities, the reduction tapered off to zero. The supporting area of each denture was interpreted as a projection of the denture onto the supporting tissue, as

advocated by Stanitz (10). Before reduction, the denture was placed on photographic paper (Agfa Brovira H-310 PE) in a dark-room and then exposed to light. An identical exposure was then carried out after the denture shortening. The photographically recorded projections were developed in a standardized manner, cut out, and weighed. The values presented in Table 3 denote the reduction of the supporting surface of the

Table 2. Thickness of the vestibular denture borders as a result of a semidynamic impression technique. The borders were measured at four points (A, B, C, and D) along the left part of the denture. Perpendiculars from the measuring points towards the sagittal midline intersected each denture in five equally long anteroposterior parts

Participant	Denture border thickness (mm)			
	A	B	C	D
T	5.1	5.2	5.8	5.7
C	4.6	4.2	3.4	3.1
S	3.3	1.6	3.6	4.3
W	3.1	2.1	1.9	3.1
H	4.2	3.7	3.5	2.9

Table 3. Percentage reduction of denture-supporting area. The palatal roof of each denture was reduced 4 mm along the midline. The reduction tapered off to zero towards the tuber maxillae

Participant	Reduction of denture supporting area (%)
T	0.7
C	0.9
S	1.4
W	1.1
H	1.0

dentures after a 4-mm reduction as measured along the palatal midline.

Denture retention

Retention was measured as the ability of the denture to remain seated when subjected to unilateral occlusal load (11). Thirty consecutive single loads were applied at 30-sec intervals, and the mean and standard deviation of the values causing dislodgement were calculated.

The study of a given design factor was always based on alterations of one denture copy, and measurements pertaining to a specific problem were carried out within a period of 2 h.

Results

Influence of changing the point of load attack (Fig. 3)

The dentures were consistently able to withstand unilateral occlusal loads better if the point of attack was shifted in the palatal direction. On the average, the participants could apply 81 N before the denture came loose, provided the point of attack was in the most palatal position. The corresponding

retention values for central and buccal points were 59 N and 35 N, respectively. The inter-individual variations were substantial, both with regard to the denture retention and the effect of changing the point of occlusal contact.

Influence of changing the denture border thickness (Fig. 4)

In all subjects the retention was best when the dentures had a functionally determined full border thickness (mean, 79 N). Reductions in border thickness always resulted in a decrease in retention. On the average, reductions to 75%, 50%, and 25% of the original thickness were accompanied by a decrease in retention to 63 N, 54 N, and 33 N, respectively. The loss of retention seemed to be fairly proportional to the degree of reduction of the denture border thickness.

Influence of shortening the palatal roof (Fig. 5)

For all participants denture retention was impaired after a moderate reduction of the posterior part of the palatal roof. On the average, a reduction of 2 mm along the midline reduced the retention value from 58 N

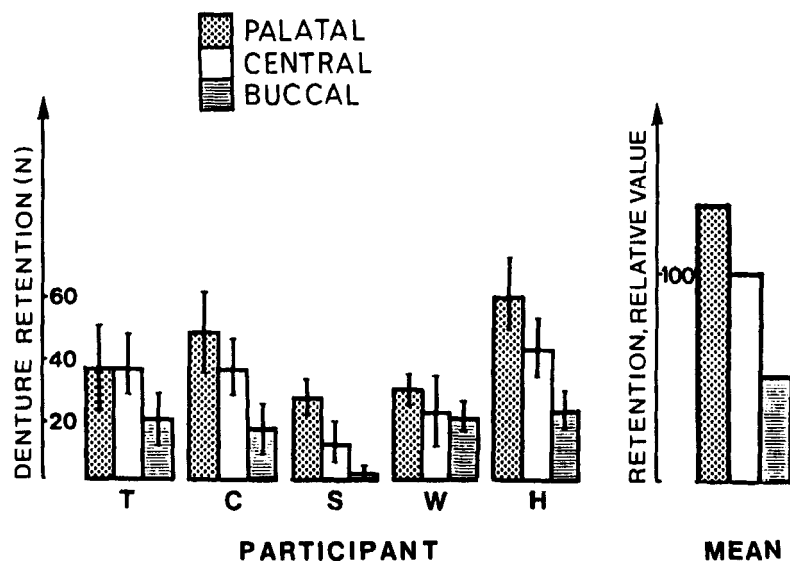
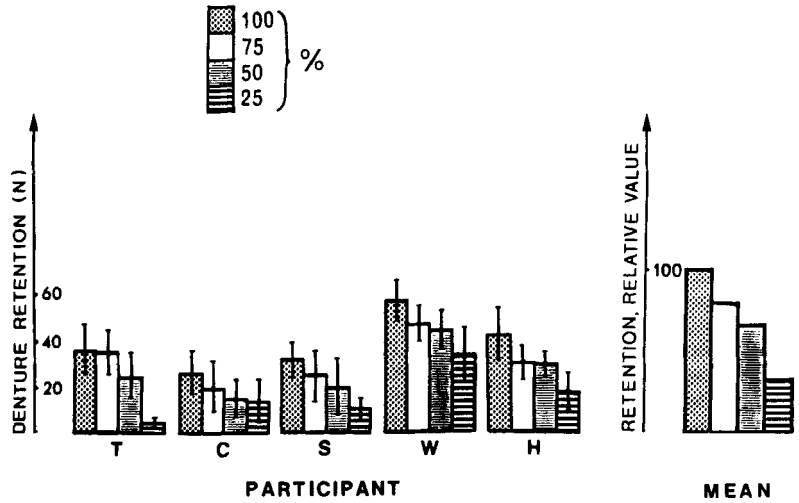


Fig. 3. Influence of varying the point of occlusal loading on denture retention. For each participant/denture modification, retention was determined as the mean and standard deviation of 30 consecutive loads causing abrupt dislodgement. The loadings were directed to guiding pits located palatally, centrally, and buccally on the first right bicuspid.

Fig. 4. Influence of reducing denture border thickness on denture retention. Retention was determined as the mean and standard deviation of 30 consecutive loads causing abrupt dislodgement, initially with dentures having functionally determined borders, then after a stepwise reduction of the border thickness as indicated.



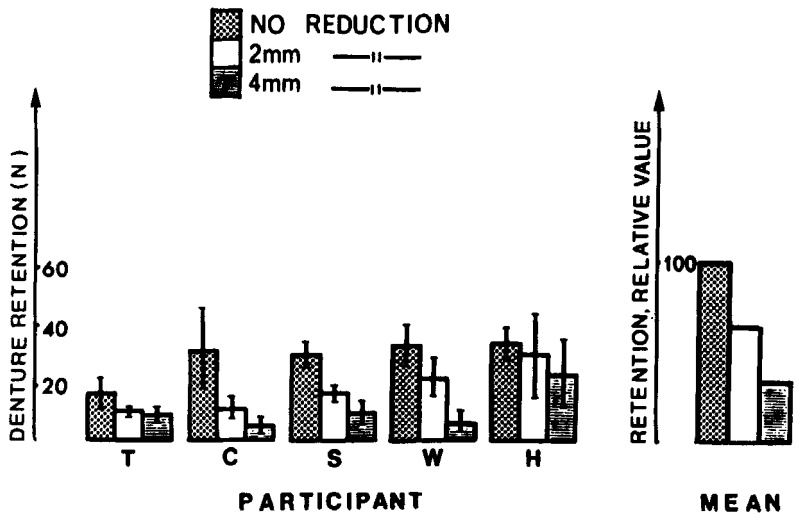
to 37 N, and after a 4-mm reduction the retention value was only 21 N. The quantitative effect of this shortening of the palatal roof on denture retention varied considerably among the participants.

Discussion

The experimental design aimed at evaluating the retentive capacity of complete maxillary

dentures when certain details in design were deliberately changed. The dislodging loads were applied unilaterally, as experienced by the denture wearer when chewing solid food. Due reservations should be made as to what extent the experimental conditions imitate the clinical situation. The size of the bite force sensor is comparable to usual dietary ingredients. On the other hand, the hardness of the metal gives the sensor little resemblance to edible objects. The electrical tube

Fig. 5. Influence of reducing the distal extension of the palatal roof on denture retention. Dentures initially extended to the vibration line were tested before and after stepwise shortening of 2 and 4 mm as measured in the midline. Retention was determined as the mean and standard deviation of 30 consecutive loads causing abrupt dislodgement.



and the examiner's presence surround the participant with an unfamiliar milieu.

The results should not be interpreted as absolute values for denture retention during mastication. In a previous study (8) we have shown that the method gives fairly reliable answers as to what extent unilateral loads will be tolerated before the dentures are dislodged. The method seems suited for investigations of how certain changes in design affect the ability of complete maxillary dentures to resist dislodgement.

The effect of changing the point of occlusal loading on denture retention can be explained solely by mechanistic considerations: With a palatal point of load attack, the tilting—that is, dislodging components of the bite force—worked on a short lever. The lever increased with central and buccal points of load attack. Thus the load needed was subsequently reduced. Palatal occlusal contact was the change in denture design that seemed to favor denture retention in all participants (Fig. 3).

The influence of thinning the vestibular border and also that of shortening the palatal extension are open to interpretation. Neither of these procedures can easily be reversed. For all participants, all reductions from the assumed optimal denture extension resulted in reduced retention values (Figs. 4 and 5).

The results of this experiment pose the question of the relative importance of the retention-promoting effect of 1) the adhesive/cohesive properties of the salivary film and 2) the passive/active muscular fixation.

The results appear to suggest that reducing the border thickness and the palatal extension influences denture retention by interfering with the muscular activity. Particularly the marked reduction in denture retention (up to 65% (Fig. 5)) when moderately reducing the palatal extension, corresponding to a reduction of the denture-supporting area of less than 2% (Table 3), can hardly be explained by impaired conditions for physical retention.

The results may be interpreted as a sup-

port of the view that muscular retentive forces are of great importance to denture retention. It may be reasonable, however, to assume that these modest changes in denture design would not be equally detrimental to retention in every clinical context. The changes may have altered the participants' notion of the dentures as optimal and thereby have elicited expectations of 'premature' loosening. Each little change in design might per se have disturbed muscle-fixating reflexes conditioned by the original denture outline. Given the opportunity to practice and get used to the changed dentures, the participants could perhaps develop new neuromuscular reflexes and thus tolerate the dentures in their new design.

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