Retention of complete maxillary dentures related to soft tissue function

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The influence of free tongue, lip, and cheek function on the retention of complete maxillary dentures was investigated for five experienced denture wearers. Test dentures were designed with full palatal coverage and functionally determined filling in of the vestibular sulcus. The front teeth were arranged primarily to meet cosmetic demands—that is, anterior to the top of the residual alveolar ridge. Retention was measured as resistance to dislodgement-provoking loads applied vertically to the incisive edge of the central incisors, using a miniature bite force recorder. All the participants were able to load their front teeth with 35 N or more without loss of retention. None of them experienced denture dislodgement provided the tongue, lips, and cheeks were allowed to act freely. If the peripheral soft tissues were separated from the vestibular denture flange, no obvious effect on denture retention could be detected. Physically preventing the tongue from pressing against the posterior part of the denture reduced the retention significantly. Measurements of anterior loads tolerated after stepwise reductions of the denture extension indicated that the tongue acted primarily by pressure against the tuber regions. Tongue pressure against the central parts of the palate and lip or cheek pressure against the vestibular flange seemed to be of less importance. □ *Denture retention; muscular activity*

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The retention of complete maxillary dentures depends on several factors, including physical forces—that is, cohesion and adhesion in the salivary film between the denture and the supporting tissues (1–3)—and physiological forces—that is, active and passive muscular fixation (4).

Even extremely unfavorable conditions for physical retention do not necessarily cause inadequate denture function. This is often experienced by both patient and clinician. Long-term clinical studies have led to the conclusion that loss of physical retention can be compensated for by improved muscular fixation (5).

The relative importance of the two main factors in denture retention is hard to assess. The detrimental effect of anesthetizing the oral mucosa on denture retention (6) seems to indicate that the physiological forces may be of major importance.

We have previously described a method whereby the retention of complete maxillary dentures can be quantified under defined clinical conditions simulating chewing (7). In the present study a modification of the same method was used to investigate how and to what extent experienced denture wearers were able to retain complete maxillary dentures by muscular activity of the tongue, lip, and cheek.

Materials and methods

Participants

Five experienced wearers of complete maxillary dentures were selected from patients seeking treatment at the Department of Prosthetic Dentistry. None of them had functional problems with their dentures but sought treatment solely for cosmetic reasons. The clinical examination revealed no abnormalities in the denture-supporting tissues. The age, sex, and previous denture experience of the participants and their remaining dentition in the mandible are shown in Table 1.

Table 1. Age, sex, previous experience as complete denture wearer, and residual mandibular dentition of the participants

Participant	Age, years	Sex	Denture experience (with present denture), years	Remaining teeth
E	74	F	36	44, 43, 42, 41, 31, 32, 33, 34
H	63	F	24	44, 43, 42, 41, 31, 32, 33, 34, 35
P	62	F	12	46, 45, 44, 43, 42, 41, 31, 32, 33, 34, 35, 36
O	63	M	6	43, 41, 32, 37
S	65	F	17	43, 42, 41, 31, 32, 33

Experimental dentures

The participants received new complete maxillary dentures. The dentures were designed in accordance with the principles of palatal coverage to the vibration line and functionally determined thickness of the vestibular borders (8). The anterior teeth were arranged primarily to meet cosmetic needs—that is, the teeth were placed vestibularly to the top of the residual ridge to achieve esthetically pleasing support of the lip and cheek. In patients with remaining mandibular bicuspids and molars the occlusal tooth contacts were evenly distributed in the lateral segments when the mandible was in the retruded contact position (RP). The same applied for protrusive movements to incisor edge-to-edge relations.

Each participant was supplied with three copies of the master denture, made of a pour-type polymethyl-methacrylate as described previously (7).

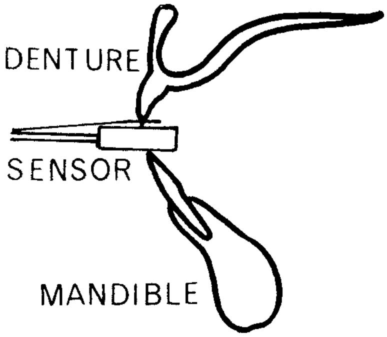

Fig. 1. Schematic drawing of denture dislodgement provocation.

Denture retention

Retention was defined as the ability of the denture to remain seated when exposed to vertical loads directed cranially against the incisal edges of the front teeth. The load was applied when the patient was biting (Fig. 1) or by manual pressure by the operator. The loads were measured by means of a miniature bite force recorder (9). All comparisons of results described in the following are based on data obtained with one denture within an experimental period of 1 h.

Soft tissue function

Retention was measured under conditions during which no restraints were placed on the participant's free use of the tongue, lips, and cheeks for fixation of the dentures. To eliminate the influence of tongue pressure, dislodgement provocations were carried out after inserting a circumferential saliva ejector with a transversal connection over the dorsum of the tongue. The tongue was thereby prevented from contacting the denture (Fig. 2A).

Attempts were made to minimize the influence on retention exerted by the lip and cheek muscles. This was done simply by retracting these structures away from the vestibular denture surfaces during the dislodgement provocations (Fig. 2B).

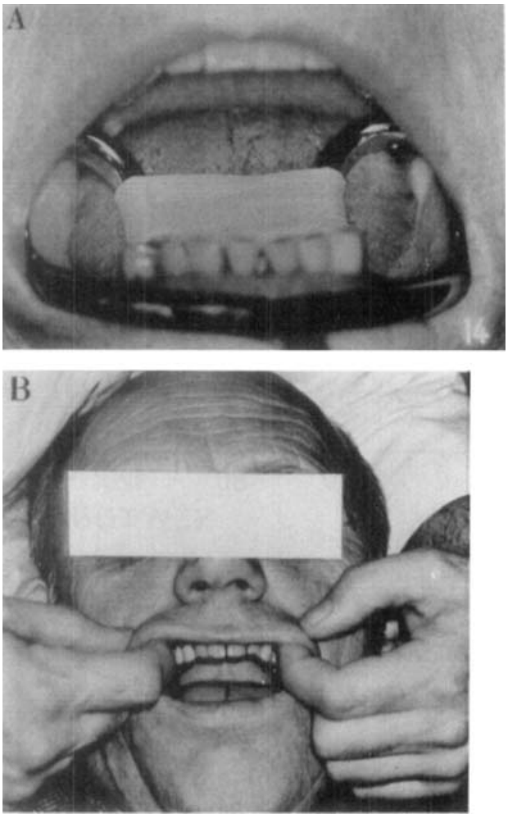

Fig. 2A. Circumferential saliva ejector with transversal connection preventing the tongue from touching the denture during retention tests. 2B. Operator-governed separation of the vestibular denture flange and the inside of the lip and cheek during retention tests.

Changes in denture design

Each of the three experimental dentures was modified in accordance with different patterns, all aiming at removal of those parts of the denture believed to be important for good denture retention.

Denture 1

In the center of the palatal coverage a hole with a diameter of 7 mm was drilled. The fenestration was subsequently extended to include the entire palatal coverage, except a peripheral zone extending 10 mm from the posterior denture border and from the palatal surfaces of the teeth.

Further reduction of the denture consisted of removing the remaining posterior transversal bar. Finally, the entire vestibular flange was cut off, flush with the vestibular tooth surfaces. The stepwise changes of the denture have been visualized in Fig. 3A.

Denture 2

Stepwise shortening of the palatal extension of the denture was done as indicated in Fig. 3B. The first reduction was limited by a transversal line touching the distal surfaces of the first molars. The second reduction stopped at a line touching the distal surfaces of the second bicuspids. The final reduction

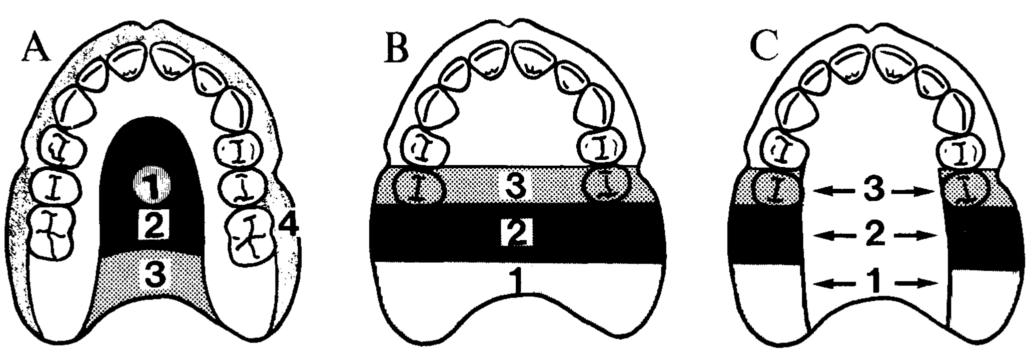

Fig. 3. Modes of reducing the complete maxillary dentures. 3A. 1 = perforation in center of the palate, 2 = deprival of main part of palatal coverage, 3 = removal of remaining transversal palatal bar, and 4 = removal of entire vestibular flange. 3B. Stepwise shortening of the entire posterior palatal coverage. 1 = Reduction to a transversal line touching the molars, 2 = reduction to a line touching the second bicuspids, and 3 = reduction to a line touching the first bicuspids. 3C. Stepwise shortening corresponding to description 2B, but with the part covering the palate kept intact.

was extended to a line touching the distal surfaces of the first bicuspids.

Denture 3

This denture was also reduced stepwise from the posterior. The reduction included only the lateral parts of the denture—that is, those covering the tuber maxillae and the posterior parts of the alveolar ridge and the corresponding parts of the vestibular flange (Fig. 3C). Compared with the changes in design made on denture 2, the central part of the palatal coverage of denture 3 was kept intact.

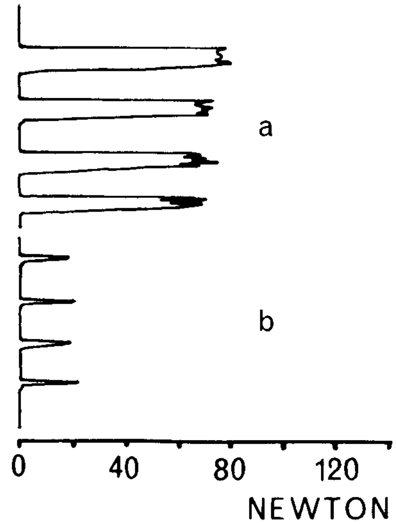

Fig. 4. Typical graphic recordings of maximum loads generated by the patients' own biting. 4a. Fluttering plateau above which the patient refused to increase the load. 4b. Abrupt drop to zero coinciding in time with sudden dislodgement of the denture.

Results

General findings

The vertical loading of the complete maxillary dentures in the cranial direction and the point of loading at the incisal edges entail tilting components likely to cause dislodgement of the dentures (Fig. 1). However, unless restraints were placed on soft tissue function, none of the participants experienced loosening of their denture. In contrast to the abrupt drop in the load recorded when the retention of a maxillary denture fails (7), the maximum load recorded was reflected on the graphic chart as a fluttering plateau (Fig. 4a). This sort of recording could also be observed when testing dentures with drastically reduced extension, but the amount of anterior loading tolerated by the participants was then reduced.

In contrast, when a mechanical device prevented the tongue from contacting the denture, immediate loss of retention ensued. This was discernible on the graphic chart as an abrupt drop in the recorded load (Fig. 4b).

Denture retention with unrestrained soft tissue function

All participants were able to keep their denture seated when asked to bite as hard as possible on the load sensor located between antagonizing front teeth. The maximum bite force varied among the subjects, ranging from 35 to 120 N (Table 2). The maximum load values could be increased by applying operator-governed manual pressure, ranging from 40 to 140 N. Even at these levels, no abrupt loosening of the dentures occurred. Additional increase of the experimental load was not tolerated because the participants experienced pain in the denture-supporting tissue and/or in the musculature of the neck.

Table 2. Maximum anterior load accepted by the participants when no restraints were put on free soft tissue function. Denture dislodgement was not observed

	Accepted anterior load on denture (N)	
Participant	Bite load	Manual load
E	120	140
H	50	80
P	35	40
O	90	100
S	65	80

Table 3. Anterior loads causing denture dislodgement when the tongue was prevented from contacting the denture. Maximum anterior load accepted with retracted lips and cheek

Participant	Blocked tongue function, dislodgement-provoking load (N)	Blocked lip/cheek function, maximum load accepted (N)
E	<20	110
H	<20	80
P	<20	40
O	<20	100
S	<20	80

Influence of restrained soft tissue function on denture retention

Obstruction of free tongue action by inserting a mechanical device over the dorsum of the tongue profoundly changed the effect of anterior dislogement-provoking loads. Even modest loading in the cranial direction on the front teeth caused immediate loss of denture retention. The loads recorded never exceeded 20 N (Table 3).

When the lips and cheeks were prevented from exerting pressure against the vestibular denture flange, similar effects were not observed. With this type of interference with soft tissue function, the dentures remained seated even when exposed to substantial anterior dislodgement-provoking loads (Table 3).

Influence of changes in denture design on denture retention

Fenestration/elimination of the palatal coverage. The maximum anterior load accepted by the denture wearers remained virtually unchanged when the palatal coverage was perforated (Fig. 5). It seems that fenestration was of no consequence for denture retention in the present experimental group.

Gross removal of the palatal coverage was also well tolerated. Only slightly reduced maximum anterior load values were

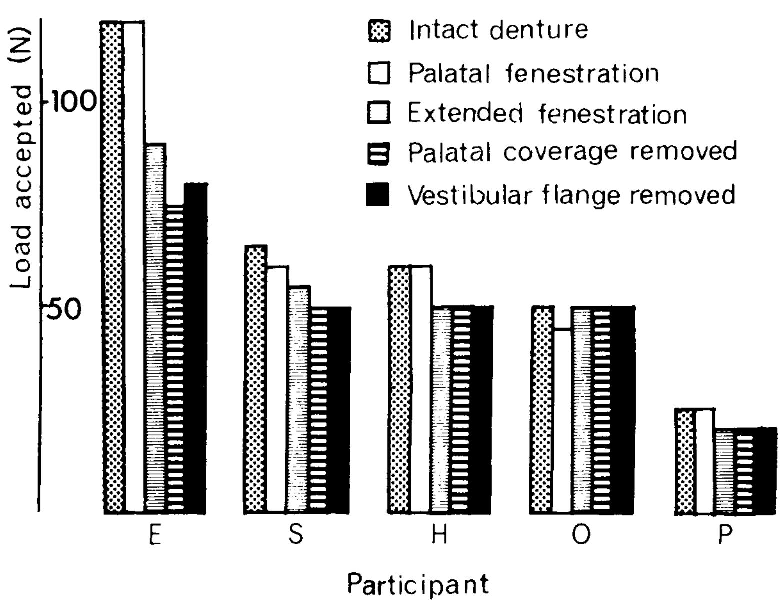

Fig. 5. Maximum anterior tilting load accepted by five denture wearers during stepwise reduction of the palatal and vestibular parts of the dentures. For details concerning the reduction steps, see Materials and methods.

recorded after reducing the palatal coverage to a 10-mm-broad posterior palatal bar. The same observation was made even after removing this last remnant of the palatal coverage (Fig. 5).

Elimination of the vestibular flange. When the 'roofless' dentures were finally deprived of their entire vestibular flange, no additional negative effects on denture retention could be observed. Compared with the results obtained with fully extended dentures, the patients still accepted loads ranging from 67% to 100% of the initial values (Fig. 5). Still no abrupt denture dislodgement occurred.

Elimination of the entire posterior part of the denture. Shortening the denture along its entire posterior border—that is, removing parts of the palatal roof and the tuber-covering parts—resulted in a gradual decrease in the maximum anterior loads recorded, without causing dislodgement (Fig. 6). Compared with the results obtained by removing the distolateral parts only, no additional effect was observed when removing the palatal coverage. On the contrary, the subjects seemed to tolerate the overall posterior shortening better.

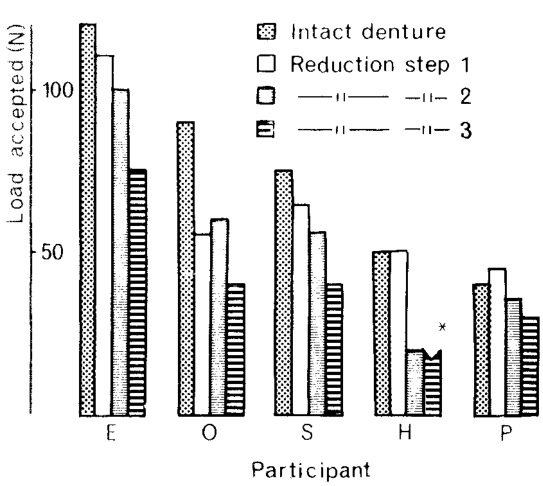

Fig. 6. Maximum anterior tilting load accepted by five denture wearers during stepwise reduction of the entire posterior extension of the dentures. For details concerning the reduction steps, see Materials and methods. * Values below 20 N not recorded.

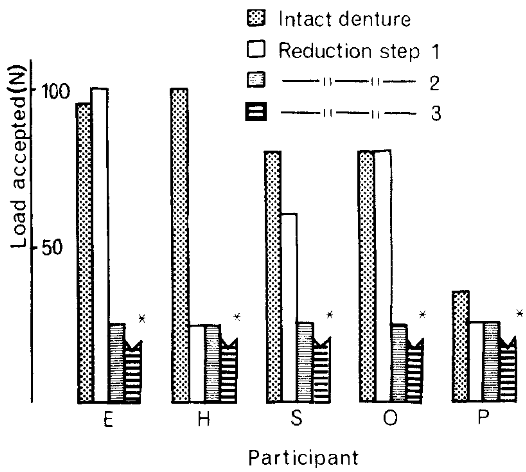

Fig. 7. Maximum anterior tilting load accepted by five denture wearers after stepwise removal of the latero-posterior parts of the dentures. For details concerning the reduction steps, see Materials and methods. * Values below 20 N not recorded.

Elimination of the distolateral parts of the denture. A striking effect on the amount of anterior load tolerated was seen when the parts of the denture covering the maxillary tuber regions, the posterior parts of the alveolar ridges, and the corresponding parts of the buccal flanges were removed. With this type of reduction, a substantial drop in the accepted load was found for all participants. The drop, however, manifested itself at different stages in the stepwise procedure (Fig. 7). For those with the highest initial tolerance against incisal loads the reduction amounted to some 70–80% of the initial value. It should be noted that the participants did not experience denture dislodgement but merely refused to increase the anterior load above a certain value.

Discussion

The participants represent a highly selected group of denture wearers with no functional problems. They described their dentures as perfectly well-fitting and suited for all kinds of biting and chewing. All of them showed a spontaneous tongue reflex counteracting tilting forces applied to the incisal edges of the front teeth. The results are probably not representative for the retention of complete maxillary dentures in general but rather serve to describe how experienced denture wearers overcome retention problems by appropriate function of the oral soft tissues. The individuals all refused to increase the bite force above a level compatible with the maintenance of denture retention, even when the extension of the dentures had been substantially reduced.

However, removal of strategic parts of the dentures resulted in a lower level of anterior load accepted. This finding may shed some light on what governed the amount of dislodgement-provoking load each person was willing to apply. They all claimed that the loads generated when biting represented their physical limit. Other denture wearers tested for maximum bite force have claimed the same (10). This explanation is hardly in keeping with the fact that the maximum load varied considerably with the denture design.

Another explanation might be that the maximum loads were governed by the patient's experience of pain or fear of pain. This factor is generally accepted as a limitation when measuring maximum bite force (11, 12). With fully extended dentures, an increase of the anterior load only moderately above the patient-governed maximum elicited pain reactions. Nevertheless, it may be tempting to assume that in the present material fear of losing control of the denture, rather than the fear of pain, directly governed the maximum bite force. This assumption constitutes a possible explanation of the fact that a moderate reduction of the denture base in an area subjected to tongue pressure reduced the maximum load accepted by 80% or more (Fig. 7).

In agreement with previous reports the maximum biting loads varied considerably among the individuals (Table 2). However, all of them were willing to increase the load up to 30 N or more. With due respect to the pitfalls connected with comparisons of bite force recordings obtained with different techniques (11), this finding seems to imply that the present denture wearers were able to retain their dentures when applying loads required for ordinary chewing. According to Bates et al. (13), it is generally accepted that the range of average chewing forces is of a magnitude of 2 to 20 N. Higher values for chewing forces have been reported by several authors studying patients with natural dentitions (14, 15) and patients with fixed bridges carried by osseo-integrated implants (16). Even these higher values for chewing forces were of the same magnitude as those found compatible with the maintenance of denture retention in the present material (Table 2).

Good denture retention depends on favorable conditions for physical retention and on efficient action of physiological forces such as passive and active muscular fixation (4, 17). For complete mandibular dentures, a dominant role of muscular factors has been observed (6). Brill et al. (6) ventured the conclusion that 'muscle activity transcends in importance all other factors responsible for denture retention'. The present data seem to corroborate this view. Denture retention remained nearly unchanged after removal of the main part of the impression surface of the dentures (Fig. 5), whereas interference with free soft tissue function (Fig. 2A,B) resulted in almost spontaneous loosening of the dentures after exposure to anterior tilting loads.

Active tongue pressure appears to represent a powerful retention potential for complete maxillary dentures, by far overshadowing a possible effect of the lips and cheeks. Thus, whereas physically preventing the tongue from exerting pressure against the dentures would lead to almost spontaneous dislodgement of all the dentures tested, substantial anterior loads were tolerated when separating the denture flanges from contact with the lip and cheek. Similarly, removal of minor but tongue contact-relevant parts of the denture had a far more pronounced effect on the amount of load tolerated (Fig. 7) than had removal of the entire vestibular flange (Fig. 5). This latter part of a denture is believed to be of major importance as a receptor for stabilizing forces from the lip and cheeks (18).

The present data are suggestive concerning what parts of a complete maxillary denture provide the most feasible point of attack for tongue fixation pressure. The results presented in Fig. 7 indicate that those parts covering the posterior areas of the alveolar ridges are most important in this context. Tongue pressure against the central parts of the palatal coverage seems to be of minor importance (Fig. 6).

It may seem surprising that an overall posterior reduction of the denture has less impact on retention than removal of the lateroposterior parts alone. One possible explanation may be that the overall posterior reduction interferes less with the outline of the denture in the area important for tongue fixation. It has been suggested that muscular control of dentures develops through conditioned reflexes (19). Such reflexes are likely to be disturbed by the altered outline resulting from shortening the dentures only in the tuber areas.

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