Retention of maxillary implant overdenture bars of different designs

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Statement of problem. The specific degree of retention for overdenture attachments is unknown in relation to design, location, and alignment to supporting dental implants.
Purpose. The purpose of this study was to evaluate the initial retention characteristics of 5 implant maxillary overdenture designs under in vitro dislodging forces.
Material and methods. A simulated edentulous maxilla was fabricated with 4 screw-type 3.75 × 13-mm implants anteriorly. Five overdenture designs with the following attachments were evaluated: 4 plastic Hader clips with an EDS bar; 2 plastic anterior Hader clips with an identical EDS bar; 2 Hader clips with 2 posterior ERA attachments; 3 Zaag attachments on a bar; and 4 Zaag attachments with no bar. Overdentures were fabricated with full palatal coverage. Each design was subjected to 10 consecutive retention pulls on a universal testing machine. Data were subjected to analysis of variance and *t* tests to determine differences.
Results. The highest average value after 10 pulls was 19.8 lb for the combination ERA and Hader clip design. The lowest retentive values were recorded for the 2 and 4 Hader clip designs (5.08 ± 0.89 lb and 5.06 ± 0.67 lb, respectively). Retention decreased over the course of consecutive pulls for all designs, especially for the most retentive designs. The smallest retention decrease occurred with the least retentive designs.
Conclusion. The results of this in vitro study suggest that the precise selection and placement of attachments may affect the clinical success of maxillary implant-retained overdentures. (J Prosthet Dent 2001;86:603-7.)

CLINICAL IMPLICATIONS

Patient satisfaction often is based on the degree of retention of the final restoration. The results of this in vitro study suggest that the selection and placement of specific attachments may affect the retention of maxillary implant-retained overdentures.

Patient satisfaction with implant-retained overdentures is related to esthetics and function. The clinical comfort achieved is dependent on many factors, including the degree of retention provided by the proper location and orientation of implants, restorative component fit, use of attachment elements, and proper denture fabrication.

Attachments used with a minimal number of implants are dependent on the denture-bearing capacity of the soft tissue and the relative movements that may be allowed by differential support. These attachments should be durable and easily replaced. Several studies have investigated the longevity and retention of mandibular overdentures supported by 2 implants.[1,2] Petropoulos et al[1] evaluated the relationship between degree of retention and the time to release of denture retention. They compared 2-implant mandibular overdentures with a bar and clip, direct ball attachment, Zest attachment, or magnet and keeper. Bergendal and Engquist[2] reported on the clinical function and long-term prognosis of overdentures retained by a 2-implant prosthesis.

Gamborena et al[3] studied the retention of different ERA attachments (APM-Sterngold, Attleboro, Mass.) and the effect of multiple retentive pull cycles on retention. No difference was found between the various attachments after 1500 cycles within a specific testing alignment. However, in the initial 500 cycles tested, definite ranking profiles were established.

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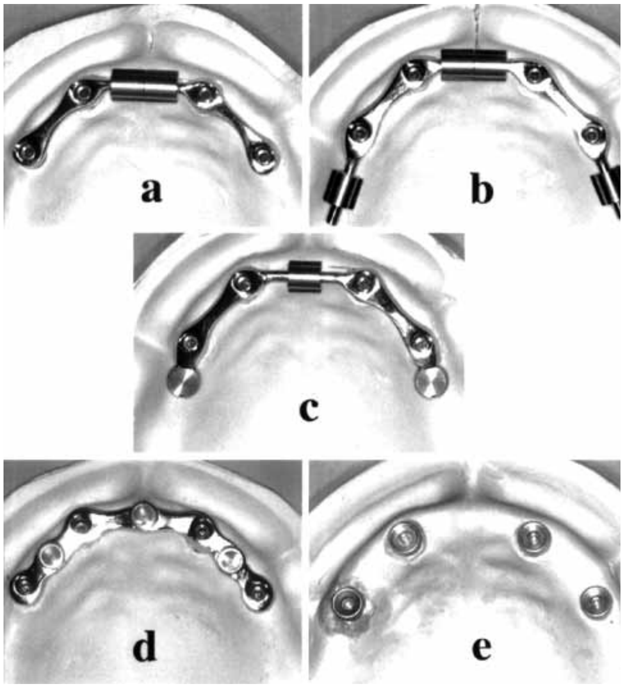

Fig. 1. Attachment designs on casts: 2 Hader clips *(a)*, 4 Hader clips *(b)*, 2 Hader clips with ERA attachments *(c)*, 3-Zaag direct *(d)*, and 4-Zaag direct *(e)*.

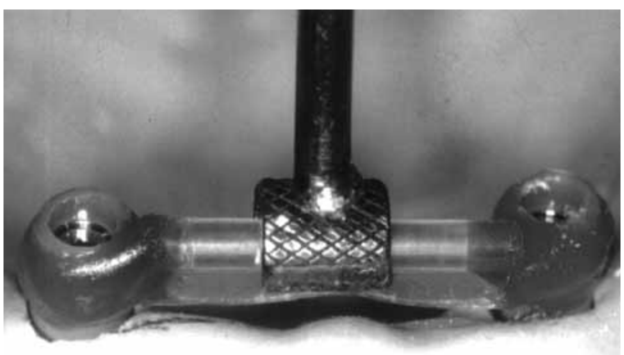

Fig. 2. Proper attachment location and placement with use of surveyor.

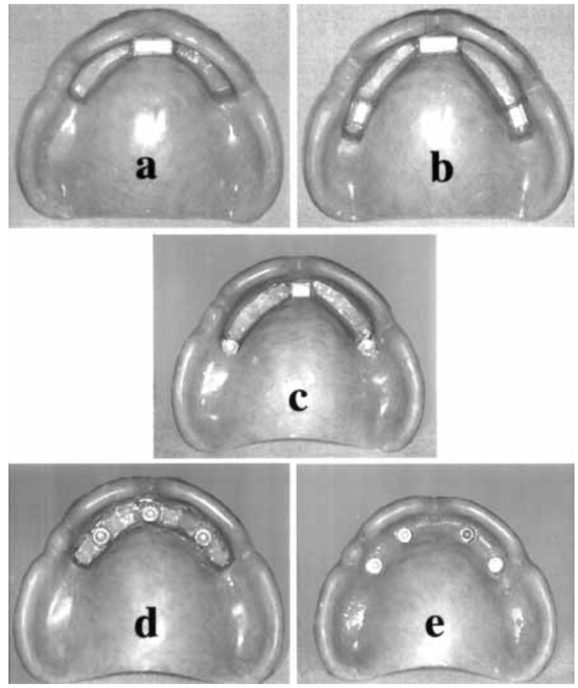

Fig. 3. Denture intaglios with attachments: 2 Hader clips *(a)*, 4 Hader clips *(b)*, 2 Hader clips with ERA attachments *(c)*, 3-Zaag direct *(d)*, and 4-Zaag direct *(e)*.

Breeding et al[4] evaluated the initial retention of Hader clips on an implant bar. They suggested that the greatest changes in initial retention occurred within the first pull separation. Other studies on overdenture retention, stability, and load transfer evaluated mandibular 2- or 4-implant designs with or without splinting bars.[5-7]

In contrast to the mandible, implant placement within the maxilla may be limited by the anatomy and its relationship to the sinus architecture. Overdenture treatment for the maxilla commonly involves 4 implants in the anterior region. These implants may provide improved retention, support, and resistance to displacement and thus reduce the necessity for palatal tissue coverage.[8] Previous studies have not evaluated how attachment selection and placement may influence these factors related to the clinical performance of maxillary overdentures. The purpose of this study was to evaluate and compare the initial retentive characteristics of 5 different overdenture designs with the use of a 4-implant maxillary overdenture model.

MATERIAL AND METHODS

A model that simulated an edentulous maxillary patient was fabricated from dental stone and then poured with four 3.75 × 13-mm screw-type implants (Osseotite; 3i, West Palm Beach, Fla.) placed at the locations of the canines and first premolars. A master cast for overdenture bar fabrication was made with standard impression coping procedures. The overdenture bars were fabricated with conventional casting methods and soldering techniques as required for proper fit and placement.

Five overdenture attachments designs were selected for evaluation: (1) 4 plastic Hader-type clips with an EDS bar (Attachments International, San Mateo, Calif.); (2) 2 plastic anterior Hader clips with an identical EDS bar; (3) 2 Hader clips with 2 posterior ERA attachments; (4) 3 Zaag attachments on a bar (Zest Anchors Inc, Escondido, Calif.); and (5) 4 Zaag attachments with no bar (direct to nonsplinted implants) (Fig. 1). The EDS bars and ERA matrix elements were cast from preformed plastic patterns, and the attachments were placed with the proprietary alignment instrumentation. The alignment and spacing of the attachment elements coincided with crestal positioning on the alveolar ridge and related simulated tooth locations (Fig. 2).

Overdentures embodying each of the attachment designs were individually processed and polymerized directly on the specific design to be evaluated. Conventional heat-polymerized processing techniques were used (Lucitone 199; Dentsply Caulk, Milford, Del.). Proprietary metal attachment housings were used to position the attachment components within the denture (Fig. 3). All bars and attachments were evaluated for passivity of fit with the use of disclosing wax and paste (Kerr, Romulus, Mich.).

After denture fabrication, autopolymerizing resin (Teets; Co-oral-ite Dental Mfg, Diamond Springs, Calif.) was used to place 3 coupling hooks on the occlusal tooth surfaces on the anterior central and the posterior left and right first molar areas. The overdentures were stored in water for 2 weeks before retention testing. The coupling hooks were connected by three 12-in segments of link chain to the movable head of a universal testing machine (Instron Corp, Canton, Mass.). The movable head incorporated a universal joint to accommodate a uniform direction of pull by the connecting chains (Fig. 4). Overdentures with each of the 5 attachment designs were subjected to 5 tests of 10 consecutive pull separations at a crosshead speed of 2 in/min. New clips or attachments were placed before initial separation for each of the 5 tests. Data were collected and analyzed with analysis of variance and *t* tests with post hoc corrections for multiple tests.

RESULTS

Retentive forces as a function of consecutive pulls for all overdenture designs are summarized in Figure 5. The lowest retentive values were recorded for the 2- and 4-clip Hader designs (5.08 ± 0.89 lb and 5.06 ± 0.67 lb, respectively). No significant differences were found between the retentive characteristics of these 2 overdenture designs. The next highest retentive values were recorded for the 3-Zaag bar design (9.30 ± 1.13 lb) and the 4-Zaag unsplinted direct design (9.66 ± 1.36 lb), which demonstrated similar overall retention. No significant differences were found between the retentive characteristics of these 2 overdenture designs, which indicates that the presence of the bar did not influence the results. Retention values for these 2 designs were significantly higher than for the Hader clip designs ($P<.05$). The highest retention was recorded for the ERA/Hader design (19.14 ± 1.79 lb), which demonstrated substantially better retention than any other design ($P<.01$).

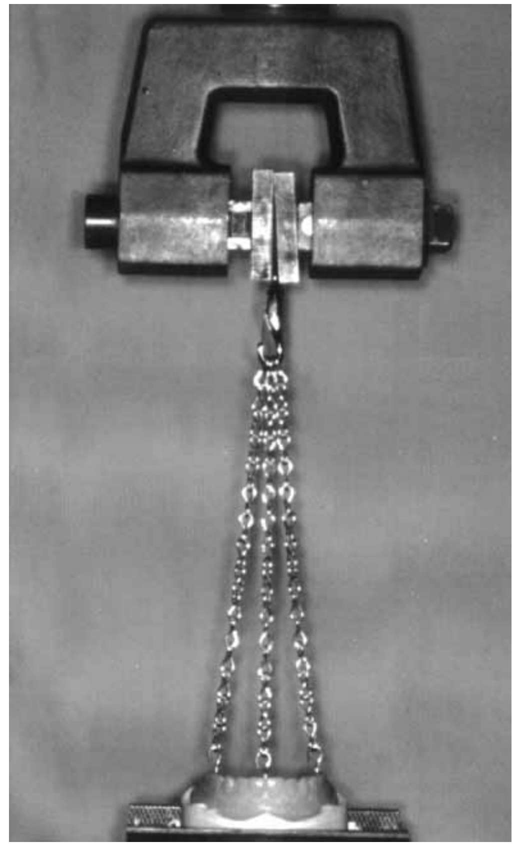

Fig. 4. Retention test set-up on universal testing machine.

All designs demonstrated a decrease in retention from the initial to the tenth and final pull test (Fig. 6). This decrease was significant only for the 4-Zaag and 2-clip Hader designs ($P<.05$).

DISCUSSION

The initial retention of a particular attachment system or design may indicate its clinical predictability and performance and influence patient acceptance of the prosthesis. Several studies have evaluated the retention of attachments on implant-retained overdentures. The use of a greater number of implants increases the potential for variations in the alignment, position, material, and proprietary design of attachments. These factors may play a significant role in the use and success of a particular implant overdenture treatment.

Attachments used with a minimal number of implants are dependent on the denture-bearing ability of the soft tissues and relative movement allowed by the combined nature of hard and soft tissue support. These attachments may exhibit increased wear, resilience, and mobility because of greater reliance on soft tissue support. Increasing the number of supporting implants decreases the potential for single-axis fulcrum movement between attachment points and

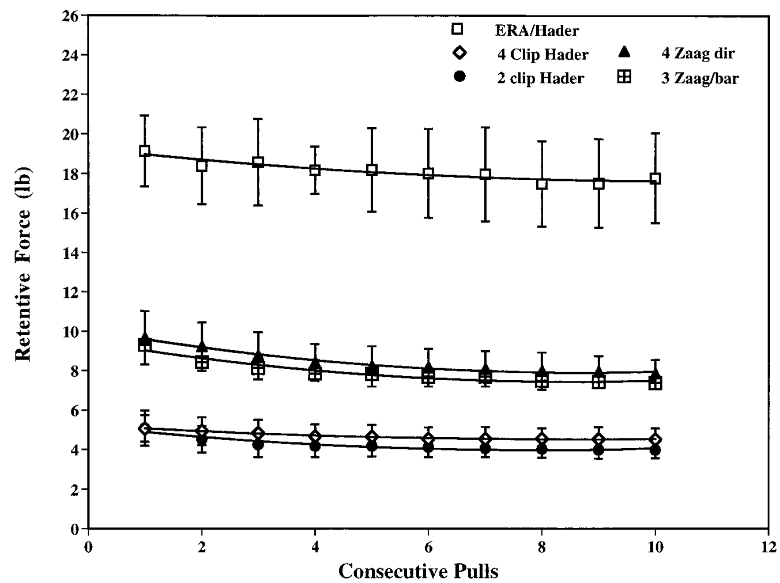

Fig. 5. Retention of overdenture designs as function of number of removals. Vertical bars represent ± standard deviation.

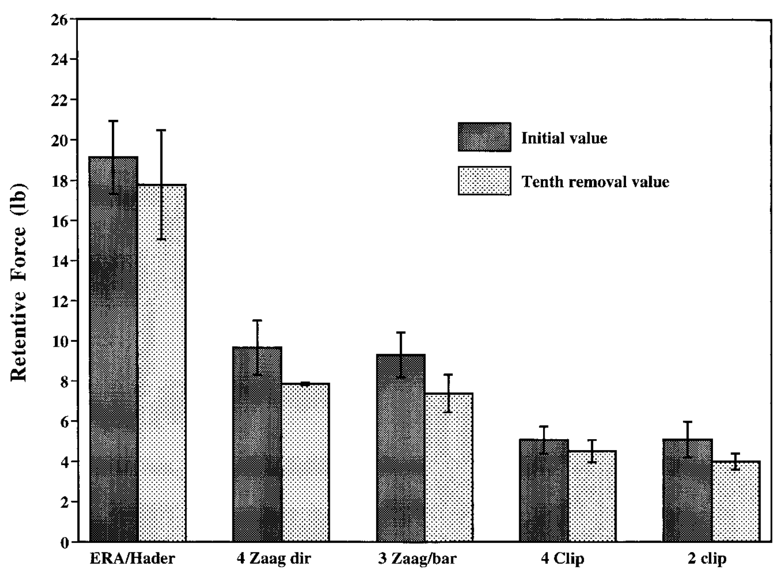

Fig. 6. Maximum (initial) and minimum retention values for overdenture designs. Vertical bars represent ± standard deviation.

lessens the effect of a specific retention release period during functional movements.

The design requirements for maxillary and mandibular overdenture prostheses may vary because of differences in anatomy, dependence on retention, and dependence on palatal coverage. Intra-arch spacing and the alignment of multiple implants within a particular dental arch can help determine the prosthesis design for a particular patient. While 2-implant overdenture designs are referred to as tissue-supported and implant-retained, 4-implant overdenture designs imply a greater dependence on the implants for both retention and support and are designated by some clinicians as implant-supported and retained. The degree of prosthesis retention and stability is based on attachment type, design, alignment, and position.

Determination of a clinically acceptable degree of retention should be made relative to prosthesis behavior during function and the patient's ability to adequately place and remove the prosthesis. Patient satisfaction, psychologic profile, and emotional status may be related to expectations of the level of retention and support provided by the implants and attachments used. Blomberg[9] addressed psychologic requirements before treatment with dental implants for patients who wore conventional dentures. Zitzmann and Marinello[10] demonstrated patient satisfaction with both fixed detachable and implant-supported overdenture prostheses.[10] The clinician's ability to appropriately use and position overdenture attachments may contribute to patient satisfaction with the treatment outcome.

Retention of the maxillary 4-implant overdenture is dependent on the placement and stability of individual attachments. Breeding et al[4] demonstrated a higher retentive value for 2 clips than for 1 clip in a direct vertical pull test of clips from a single bar unit.[4] In the present study, a full overdenture bar assembly with attachment housings within a processed complete denture was used for testing. Increased numbers of Hader clips did not significantly increase retention. This finding is surprising, given that the retention provided by each clip might be expected to be cumulative. The discrepancy in expected retention may be related to the functional position of the retentive clips on the bar-denture apparatus or to placement of the attachment housing on the maxillary model.

The advisability of using connecting bars between overdenture implants is related to several factors: facilitation of attachment location and placement, the potential to stabilize implants of less than ideal or guarded prognosis, and the potential to provide added surface area for vertical support under load. Bars with various attachments involve higher fabrication costs than non-bar restorations that use individual attachments. Of the designs evaluated in this study, the non-bar direct Zaag retained overdenture prosthesis may be the most attractive choice for patients with financial limitations.

CONCLUSIONS

This in vitro study evaluated the retentive characteristics of 5 different overdenture designs on 4 maxillary implants. The mean initial retention values ranged from 5.06 to 19.14 lb. The highest retention value was recorded for the combined ERA/Hader clip design and the lowest for the 2 Hader clip designs. The remaining designs exhibited one third to one half of the highest values recorded. The retention of all designs decreased over the course of 10 consecutive pulls.

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