Short Communication

Magnetic Retention and Bar-Clip Attachment for Implant-Retained Auricular Prostheses: A Comparative Analysis

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Retention systems for implant-retained auricular prostheses using either bar-clip attachments with 2 or 3 clips or retention with 2 or 3 magnets were wear tested (insertion and removal cycles) to simulate clinical periods of use. Measurements were taken at intervals of 540 cycles, which represents a period of use of approximately 6 months, for up to 3,240 cycles. Assessments of retentive force were carried out before, during, and after the wear test. Statistical analysis indicated that the bar-clip systems provided higher retention than the magnetic systems. The bar-clip attachment with 2 clips showed a significant loss of retentive force after wear testing ($P < .05$), suggesting lower durability and shorter clinical life. The retention provided by the bar-clip attachment with 3 clips remained stronger than that provided by all other systems tested. At the end of the wear test, the magnetic systems showed very little loss of retention but were still less retentive than the bar-clip systems, suggesting higher durability under clinical simulation despite the lower retention initially provided.
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An implant-retained auricular prosthesis is currently the best treatment for restoring congenital and acquired ear defects. Such prostheses fulfill the requirements of retention, functional performance, biocompatibility, and esthetics.[1–4] However, because of the frequent insertion and removal of the prosthesis, the retention decreases with time. This study evaluated and compared the mechanical behavior of 2 retention systems—bar-clip attachments with 2 or 3 clips and retention with 2 or 3 magnets)—for implant-retained auricular prostheses before, during, and after wear testing.

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Materials and Methods

The samples were manufactured using heat-curing acrylic resin. Titanium implants (3.5 × 4.5 mm) (INP system) were positioned in the samples according to Tjellström.[5] Thinking of the circle as a clock—with implants placed 20 mm from the center, ie, the ear canal opening—two different conditions were used: 2 implants were placed at the 8- and 11-o'clock positions, or 3 implants were placed at the 8-, 9:30- and 11-o'clock positions (Fig 1).

To avoid intrasystem variability, 5 specimens of each of the following retention systems were tested (Figs 2 and 3):

- Bar-clip attachment: Bar for overdenture with 2 or 3 plastic clips. The custom bars were fixed to the implants via abutments (INP system) and cast in nickel-chromium alloy. The clips were placed on the metal bars and fixed to the holders with acrylic resin.
- Magnet system: 4.0 × 2.0 mm neodymium-iron-boron magnets coated with nickel (Metalmag). Two or 3 magnets were fixed to the abutments with acrylic resin. Lateral holes were drilled in all acrylic samples to adapt them for wear testing.

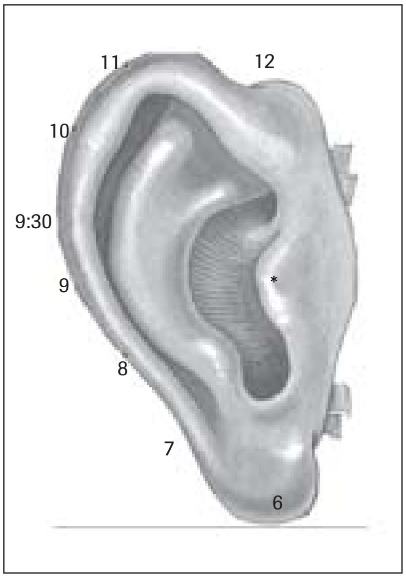

Fig 1 Location of the implants in the samples tested.

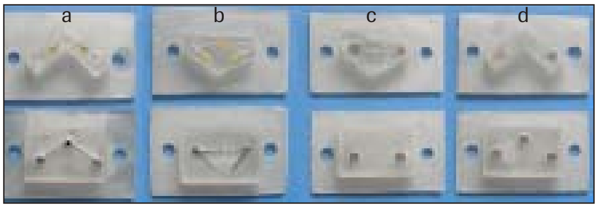

Fig 2 Retention systems: **(a)** bar-clip attachment with 2 clips; **(b)** bar-clip attachment with 3 clips; **(c)** magnetic retention with 2 magnets; **(d)** magnetic retention with 3 magnets.

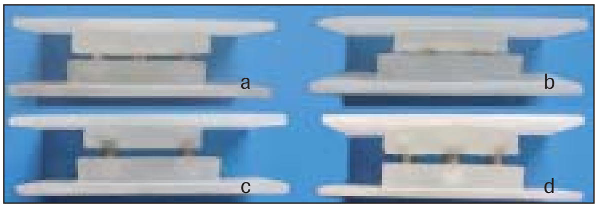

Fig 3 Samples of the retention systems in position: **(a)** bar-clip attachment with 2 clips; **(b)** bar-clip attachment with 3 clips; **(c)** retention with 2 magnets; **(d)** retention with 3 magnets.

The wear testing machine was composed of a 3-phase electric motor (Eberle, 1 HP/0.75 KW, 30 cycles/min) that moved a bar using a belt and gearing system. The bar had 2 extremities and performed a cyclic movement of elevation and lowering with 2 cm of amplitude. Two metal bases with an insertion guide were constructed to maintain the vertical insertion axis. One of the metal bases was attached to one of the extremities of the bar and carried the samples with the different retention systems. A spring was attached to a cycle counter at the other extremity of the bar. The other metal base carried the implants and was fixed to the machine's support structure with screws.

To determine the testing cycles, this experiment considered that an auricular prosthesis is removed 3 times a day. Thus, a period of 6 months would correspond to 540 insertion and removal cycles. Samples were measured at 7 intervals: 0 cycles, 540 cycles, 1,080 cycles, 1,620 cycles, 2,160 cycles, 2,700 cycles, and 3,240 cycles. The experiment was stopped after 3,240 insertion and removal cycles because facial prostheses generally need to be replaced after approximately 3 years as a result of silicone wear.

At all measurements, the samples were submitted to the pull-out test to determine tensile strength. The evaluation of tensile strength was performed using a mechanical testing machine (Kratos) with a load of 3 kg, dislocation of 20 mm, and velocity of 10 mm/s. Three measurements were taken for every sample to establish a mean at each interval.

Results and Discussion

One sample with a bar-clip attachment with 2 clips ruptured when submitted to 2,160 cycles. Thus, 1 sample was discarded in each of the other groups to maintain the same number of samples per group ($n = 4$). The highest tensile strength was observed among the samples that had 3 clips for retention, followed by those with 2 clips, 3 magnets, and 2 magnets. This result remained constant at the different measurement intervals, although all retention systems showed decreased retentive force at the end of the test (Table 1).

The percentage of reduction in the force needed to remove the samples at the end of the wear test was 60.2% for the 2-clip system, 34.2% for the 3-clip system, 11.5% for the 2-magnet system, and 17.7% for the 3-magnet system. This reduction was statistically significant (analysis of variance; $P < .05$) for the samples with 2 clips. The comparative analysis of the systems is shown in Table 2.

During the wear test, the removal and insertion axis was always perpendicular to the base that carried the retention system. This condition is not necessarily true during the clinical use of auricular prostheses, because the retention system may undergo small dislocations toward other planes. These dislocations lead to deformations of the retention system, faster loss of retention, and hence a decrease in the clinical longevity.[6,7]

With regard to the bar-clip attachment system, the amount of resin used to fix the clips may be a determinant factor for the retentive force observed, since a larger amount of resin limits the flexibility of the clips and makes them more retentive.[8] In this experiment, the amount of resin was standardized for all specimens tested.

The progressive alteration in the texture and color of the silicones employed in auricular prostheses makes their replacement necessary after 2 or 3 years. At this time, the retention system of the prosthesis should also be assessed. The loss of retention presented by the different systems after the removal and insertion cycles reflects the clinical durability of the system; thus, the retentive elements must be evaluated and replaced if necessary. Retention and durability are extremely important factors for patient satisfaction and success of the rehabilitation.

The decrease in the pull-out force of all retention systems after the insertion and removal cycles is in agreement with several studies.[6–8] The retention system with 2 clips showed the highest retention loss (60.2%) after the wear test, but was, in absolute values, the second best retention system in terms of retentive force. The Tukey-Kramer test showed that the retention system with 2 clips was not statistically different from the retention system with 3 magnets. It was, however, statistically different from the retention system with 3 clips at all measurement intervals and from the retention system with 2 magnets up until the fifth interval (2,160 cycles). The retention system with 3 clips differed from all other systems at all measurement intervals. The retention system with 2 magnets did not differ from that with 3 magnets. These results show that retention systems with 2 or 3 magnets have similar behavior with regard to durability and that bar-clip attachments with 2 clips are more susceptible to wear. It has been reported that magnetic retention systems do not show a decrease in tensile strength after wear testing.[9] The small decrease in the retention strength of the magnetic systems in this study was attributed to the occurrence of microdeformation on the surface of the nickel coating during the test.

The present study corroborates other reports in the literature stating that bar-clip systems provide higher retention than magnetic systems.[2,10,11] It was confirmed that the number of clips or magnets does influence initial and final retention capacity.[8]

The bar-clip systems showed an increase in tensile strength after some insertion and removal cycles. This was also reported in other studies of retention systems for implant-retained dentures, where some retention systems showed an increase in tensile strength after the first 1,500 insertion and removal cycles.[6] This increase in retention occurs as a result of the activation of the elastic memory of the materials used in the manufacturing of clips.

Table 1 One-Way Analysis of Variance: Tensile Strength Force in the Retention Systems Tested

Cycles	2 clips	3 clips	2 magnets	3 magnets
0				
Mean	0.9527	2.0008	0.1233	0.3433
SD	0.3476	0.6231	0.0223	0.0538
α	.5532	.9915	.0354	.0856
540				
Mean	0.8683	1.6850	0.1133	0.3341
SD	0.4151	0.4840	0.0142	0.0624
α	.6606	.7702	.0225	.0993
1,080				
Mean	0.7750	1.5266	0.1100	0.3158
SD	0.3388	0.3898	0.0187	0.0532
α	.5391	.6203	.0297	.0846
1,620				
Mean	0.6933	1.5941	0.1183	0.3358
SD	0.2551	0.4310	0.0197	0.0390
α	.4060	.6858	.0314	.0621
2,160				
Mean	0.6408	1.4133	0.1075	0.3108
SD	0.2643	0.4531	0.0128	0.0620
α	.4206	.7210	.0204	.0986
2,700				
Mean	0.4983	1.4716	0.1067	0.3100
SD	0.1277	0.4648	0.0226	0.0662
α	.2031	.7395	.0360	.1053
3,240				
Mean	0.3767	1.3158	0.1091	0.2825
SD	0.0889	0.4983	0.0232	0.0502
α	.1415	.7929	.0369	.0799

Table 2 One-Way Analysis of Variance: Final Reduction of Tensile Strength Force

	Final force reduction			
Cycles	2 clips	3 clips	2 magnets	3 magnets
F*	10.0929	2.9482	0.7786	2.7314
*P***	.0191	.1368	.4115	.1495

*F > 5.9874; ***P* < .05.

Two or 3 implants may be used for the retention of an auricular prosthesis. The placement of 2 implants for bar-clip attachment allows the use of 2 or 3 clips. With regard to magnetic retention, however, 2 implants allow the use of only 2 magnets, and thus 3 implants are required when 3 magnets are indicated. This emphasizes the importance of understanding the behavior of different retention systems when an implant-retained auricular prosthesis is planned.

Bar-clip attachment prostheses are more difficult to insert than magnet-retained prostheses because of the limited visual access. For patients with little manual skill, the magnetic attraction facilitates the correct positioning of the auricular prosthesis during placement.[1] Lifestyle should also be considered when choosing the appropriate retention system. Physical activities and sports demand better retention for safety; thus, a bar-clip attachment may be better for active patients. An auricular prosthesis weighs approximately 50 g, and all systems assessed in this study maintained a minimal retentive force to keep such a prosthesis in place after a 3-year experimental period.

Conclusion

Bar-clip attachment provides better retention than magnetic systems for auricular prostheses. The relationship between the number of retentive elements and the retention that they provide remained statistically constant at the end of the wear test. Bar-clip attachment with 2 clips showed significant loss of retention at the end of the wear test, suggesting lower clinical durability. Bar-clip attachment with 3 clips and magnetic retention with 2 or 3 magnets showed little loss of retention at the end of the wear test, indicating higher durability regardless of the retention initially provided. All systems proved to be experimentally capable of keeping the prostheses in place after a 3-year period.

References

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Literature Abstract

Clinical and radiographic evaluation of one- and two-visit endodontic treatment of asymptomatic necrotic teeth with apical periodontitis: A randomized clinical trial

The aims of this randomized clinical trial were to record the 2-year clinical and radiographic outcomes of 1- and 2-visit endodontics performed on a previously studied group of patients and to evaluate the significance of microbiologic sampling results on the outcome of treatment. Patients with asymptomatic teeth with necrotic pulps and apical periodontitis, as verified radiographically, were consecutively enrolled in the study. Using tooth group and size of peri-apical lesion as the 2 randomization factors, patients were randomly assigned to 1- or 2-visit treatment groups, using the "minimization method." Ninety-four patients with 101 eligible teeth consented to participate in the study. Each toed immediately after completion of the chemomechanical preparations. For the 1-visit group, canals were filled with Tubulicid Plus for 20 seconds, dried with paper points, and refilled for another 20 seconds. Subsequently, the canals were filled with 5% iodine-potassium-iodide solution for 10 minutes. A post-medication microbiologic sample was obtained prior to gutta percha obturation and rosin chloroform sealer. For the 2-visit group, calcium hydroxide (CH) was placed in the root canals and sealed. After 1 week, the CH was removed and irrigation was done with VMGA I. A post-medication microbiologic sample was obtained before obturation as per the 1-visit group. Four endodontists performed treatment. All preoperative and follow-up radiographs were coded blind and randomly organized. Two independent examiners evaluated the radiographs. In case of disagreement, joint reevaluation was done until a consensus was reached. Outcome of treatment was classified using the modified Strindberg criteria. Twelve teeth were lost to follow-up. Thirty-two teeth (65%) in the 1-visit group and 30 teeth (75%) in the 2-visit group were classified as healed. Thirteen teeth (27%) in the 1-visit group were deemed healing uncertain, compared to 5 (13%) in the 2-visit group. Four teeth (8%) in the 1-visit group and 5 teeth (12.5%) in the 2-visit group were unhealed. Forty-nine of 61 teeth (80%) obturated after a negative bacteriological sample were healed, while 12 of 27 teeth (44%) that showed positive samples were healed. The authors found no statistically significant difference in healing outcomes between the 1- and 2-visit treatment modalities (P = .75). They also reported a tendency toward a more favorable outcome in teeth yielding a negative culture immediately before obturation. Hence, they suggested that postmicrobiologic sampling could replace radiographically based long-term studies and be used as a surrogate endpoint.

Molander A, Warfvinge, Reit C, Kvist T. *J Endod* 2007;33:1145–1148 **References:** 33. **Reprints:** Dr Anders Molander, Clinic of Endodontics, Public Health Service, Medicinaregatan 12, SE 413 90, Gothenburg, Sweden. E-mail: anders.molander@odontologi.gu.se—*Elvin W.J. Leong, Singapore*