Locator retention: does variation in number and configuration matter?

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This pilot study was designed to collect initial data on overdenture attachment retention in varying configurations of attachment location in an implant-retained mandibular overdenture. A clear acrylic model of a mandible with 6 numbered implants and Locator resilient abutments was used to simulate implant placement in a patient. A clear acrylic denture was fabricated with 6 Locator housings to match the implants in the model. Attachments were tested in 4 different configurations: 2 implants, 2 and 5 (T25); 4 implants, 2-5 (T2345); 4 implants, 1, 3, 4, and 6 (T1346); and 6 implants, 1-6 (T1-6). Clear nylon male inserts were used for each test. The mean overall retentive strength across all 20 pulls was 576.0 N for configuration T1-6, 354.9 N for configuration T1346, 350.7 N for configuration T2345, and 189.9 N for configuration T25. Mean retentive strength also stabilized after the 7th pull for all 4 configurations, resulting in nonsignificant declines in retentive strength within each specific configuration after 7 pulls. Configuration T1-6 exhibited the greatest retentive strength relative to all other configurations both initially and after repeated application of force. Configurations T1346 and T2345 had similar retentive strengths, and both had greater retentive strength than T25. However, despite these differences, all 4 configurations exhibited similar losses in retentive strength from the repeated application of force during the first 7 pulls until stabilization occurred shortly thereafter.

Received: April 15, 2015
Revised: August 21, 2015
Accepted: September 29, 2015

GENERAL DENTISTRY
SELF-INSTRUCTION
CE CREDIT
Exercise No. 397, p. 41
Subject code: Implants (690)

The number of patients with at least 1 edentulous arch is expected to reach 38 million by the year 2020.[1] Bone loss is accelerated when a patient wears a removable denture. The entire load of mastication is transferred to the bone surface alone, and the overall blood supply is reduced. Combined with friction, these processes contribute to a breakdown of the bone, resulting in continual changes to its shape. This bone loss is accelerated further by ill-fitting soft tissue–borne prostheses or prostheses that are worn both day and night. To prevent accelerated bone loss, it is essential to have a retentive, well-fitting denture. Implants provide mechanical retention that is superior to the soft tissue retention that is provided by denture adhesives; therefore, an implant-retained, mucosal-borne complete removable dental prosthesis (CRDP) using freestanding implant attachments is an excellent option for edentulous patients.[2]

In 2002, the McGill Consensus concluded that, for the mandibular arch, 2 implants should be the minimum standard of care in implant-retained CRDPs for the edentulous patient.[3] Although the utilization of 2 implants in the mandibular arch with this type of restoration has long been recognized as the standard of care in the dental literature, it is just now beginning to be recognized by third-party payers.[3-5] As this recognition allows implant dentistry to become more mainstream, the number of patients who are choosing this type of treatment is increasing accordingly.

As previously mentioned, it is ideal to have the most retention possible to eliminate movement of the prosthesis and thus preserve the bone. The present study compared Locator universal hinge, resilient attachments (Zest Anchors) in 4 configurations to determine if variations in the number or configuration of attachments impact the retention of an implant-retained CRDP, and, if so, the number and configuration that provide the maximum retention.

Materials and methods

The study was conducted using a clear acrylic model of a mandible in which 6 Zimmer tapered 3.7-mm screw implants (Zimmer Dental) were placed to simulate placement in a patient. A clear acrylic denture was made with 6 Locator housings to match the implants in the mandibular model. Clear male nylon Locator inserts were used for testing in the housings. The implants were numbered 1 through 6 as they were placed around the model from mandibular left to right (Fig 1).

The Locator attachments used for this pilot study were tested in 4 different configurations. The first configuration (T25) used only 2 Locator housings (implants 2 and 5). The second configuration (T2345) used the 4 most anterior housings (implants 2, 3, 4, and 5). A clinical arrangement (T1346) using implants 1, 3, 4, and 6 was the third configuration tested. The final configuration (T1-6) utilized Locator attachments in all 6 housings.

Fig 1. Implants 1-6 in the mandibular model.

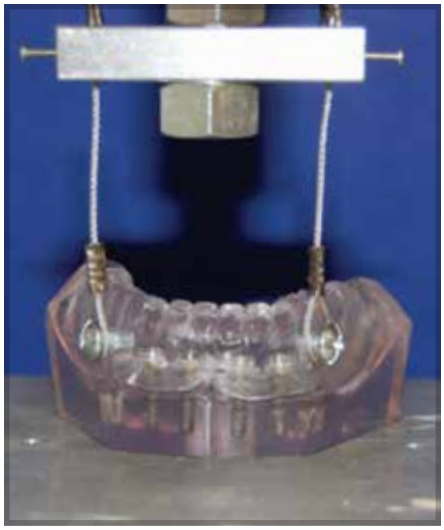


Fig 2. Setup for testing retentive strength of the resilient attachment.

Table 1. Mean retentive strength (N) across all pulls and for the 1st and 20th pulls.

	Overall		1st Pull		20th Pull	
Configuration	Mean	95% CI	Mean	95% CI	Mean	95% CI
T1-6	576.0	549.7, 602.3	733.3	703.2, 763.5	544.5	518.6, 570.4
T1346	354.9	330.2, 379.6	478.4	450.4, 506.4	334.9	309.8, 360.0
T2345	350.7	324.4, 377.0	471.7	441.5, 501.9	339.7	313.8, 365.6
T25	189.9	163.6, 216.2	240.0	209.8, 270.2	179.9	154.0, 205.8

Abbreviations: CI, confidence interval; T1-6, implants 1-6; T1346, implants 1, 3, 4, and 6; T2345, implants 2-5; T25, implants 2 and 5.

Prior to testing, the Locators were soaked in deionized water for 24 hours in an oven at 37°C to simulate the lubricating effects of saliva on the retentive force of the attachments. The retentive strengths of the attachments in the housings were tested with an MTS 858 Mini Bionix Universal Testing Machine (MTS Systems). The acrylic mandibular model was mounted to a plate attached to the load cell on the base of the machine (Fig 2). The denture was attached to the actuator of the machine, in line with the mandibular model, via 2 attachment screws and a custom mount. This allowed the denture to be pulled at a vertical angle that simulated the rocking motion used by patients when they remove the denture from the mouth. The dentures were loaded at a load rate of 50.8 mm/min (2 in/min) until the attachment matrix and patrix separated.[5]

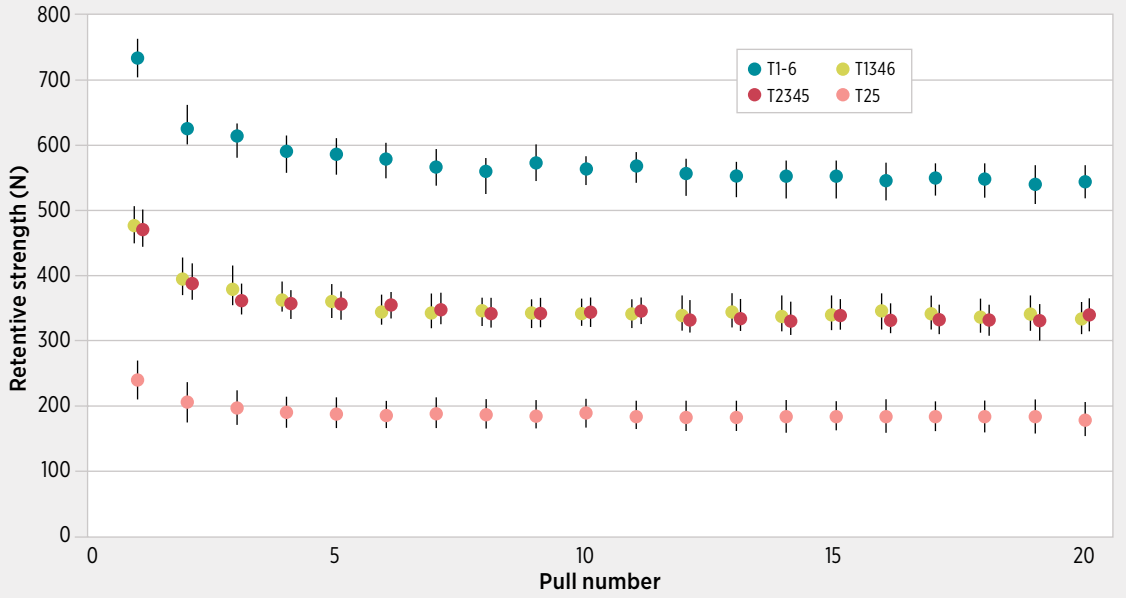
Each set of attachment configurations was tested through 20 cycles (known as *pulls*), and the peak load for each test was recorded using TestStar IIs software (MTS Systems).[6] This testing was repeated 11 times for each attachment configuration. Thus, 11 sets of clear Locator males were tested through 20 cycles, the peak load was recorded for each set, and a mean value was calculated for that configuration. The male nylon inserts were changed between each pull using a Locator Core Tool (Zest Anchors).

The data sets were transferred to Microsoft Excel (Microsoft) in preparation for statistical analysis. Absolute retentive strength and percent decrease in retentive strength were both analyzed using linear mixed models. The implant configuration, pull number, and an interaction between the configuration and pull number were used as fixed effects of retentive strength measures on the mandibular model. Different types of error covariance structures where examined, and Akaike information criterion values were used to select the most appropriate covariance structure. Pairwise comparisons were made between different configurations overall and between different configurations at specific time points using Tukey correction to adjust the significance level for multiple comparisons. All analyses were conducted with SAS version 9.3 software (SAS Institute).

Results

The mean overall retentive strength across all 20 pulls was 576.0 N for configuration T1-6, 354.9 N for configuration T1346, 350.7 N for configuration T2345, and 189.9 N for configuration T25 (Table 1). Mean retentive strength stabilized after the 7th pull for all 4 configurations, resulting in nonsignificant declines in retentive strength within each specific configuration after 7 pulls. The Chart shows the mean retentive

Chart. Mean retentive strength for each configuration of dental implants by pull number.



Abbreviations: T1-6, implants 1-6; T1346, implants 1, 3, 4, and 6; T2345, implants 2-5; T25, implants 2 and 5.
Error bars represent 95% confidence intervals around the means.

Table 2. Difference in mean retentive strengths (N) between the 4 configurations overall and for the 1st and 20th pulls.

	Overall			1st Pull			20th Pull		
Groups	Mean	95% CI	*P* value	Mean	95% CI	*P* value	Mean	95% CI	*P* value
T1-6 vs T1346	221.1	185.0, 257.2	< 0.001	255.0	213.9, 296.1	< 0.001	209.5	173.5, 245.5	< 0.001
T1-6 vs T2345	225.4	188.4, 262.4	< 0.001	261.7	219.1, 304.3	< 0.001	204.8	166.0, 243.6	< 0.001
T1-6 vs T25	386.1	349.1, 423.1	< 0.001	493.3	450.7, 535.9	< 0.001	364.7	328.2, 401.2	< 0.001
T1346 vs T2345	4.28	−31.8, 40.3	1.000	6.68	−34.4, 47.8	1.000	−4.76	−40.8, 31.3	1.000
T1346 vs T25	165.0	128.9, 201.1	< 0.001	238.4	200.3, 276.5	< 0.001	155.1	119.1, 191.1	< 0.001
T2345 vs T25	160.7	123.7, 197.7	< 0.001	231.7	189.1, 274.3	< 0.001	159.9	123.4, 196.4	< 0.001

Abbreviations: CI, confidence interval; T1-6, implants 1-6; T1346, implants 1, 3, 4, and 6; T2345, implants 2-5; T25, implants 2 and 5.

strength for each configuration of dental implants by pull number. The overall retentive strength and retentive strength at the 1st and 20th pulls are compared by configuration in Table 2.

Discussion

Initially the impact of configuration on retentive strength was examined. There were significant differences in retentive strength among the different configurations overall (across all 20 pulls) and at specific numbers of pulls. Configuration T1-6 had significantly greater overall retentive strength than did the other 3 configurations ($P < 0.001$ for all comparisons). Configurations T1346 and T2345 had significantly greater mean retentive strengths than did configuration T25 ($P < 0.001$ for both). However, there was no significant difference in overall retentive strength between configurations T1346 and T2345 ($P = 1.00$).

The specific pull number was also considered, to determine if the differences in retentive strength were maintained with increased exposure to force. Configuration T1-6 had significantly greater retentive strength at each pull relative to the other configurations ($P < 0.001$ for all comparisons). Also, similar to the overall results, configurations T1346 and T2345 had significantly greater retentive strengths at each pull compared to configuration T25 ($P < 0.001$ for all comparisons). However, there was no statistically significant difference in retentive strength by pull number between configurations T1346 and T2345.

The configurations used for this pilot study were selected because they are some of the most commonly used treatment options. The combinations of implant arrangements were kept to a minimum because this was serving as a pilot study for

further studies. Future expansion of the study would include not only other attachments systems but also more combinations of configuration. These additional configurations could help to predict loss of retentive values when 1 or more implants fail.

The impact of the type of configuration on the decrease in retentive strength with repeated exposure to force (measured by pulls) was also examined. The 4 configurations lost, on average, between 14% and 17% of their original retentive strengths after the 2nd pull and between 25% and 30% of their initial retentive strength by the 20th pull. The majority of the loss of retentive strength occurred during the first 7 pulls, and all 4 configurations stabilized quickly thereafter. Configuration T25 had the smallest overall decline in retentive strength, with an average decrease in retentive strength of 22.1%, while configuration T1346 exhibited the greatest overall percent decrease in retentive strength at 27.3%.

While it is ideal to have the greatest possible amount of retention possible, some additional considerations must be evaluated when the number and configuration of Locators are selected for each patient. Many patients may not possess the physical strength to exert the 576 N of force required to remove an implant-retained CRDP utilizing 6 Locators. Some elderly patients or those suffering from physical disabilities may even have difficulty exerting the force necessary to remove an implant-retained CRDP that utilizes 4 Locators. Both the strength and the manual dexterity of the patient are critical considerations for the patient's home care of the prosthesis. The present study evaluated the number and configuration of Locators that provide the maximum retention and determined the decrease in retentive strength over time. The practitioner can combine this information with the special considerations that are unique to each patient and determine the ideal plan for the individual.

Conclusion

In this study of resilient implant attachments, configuration T1-6 exhibited the greatest retentive strength relative to the other configurations both initially and after repeated application of force. Configurations T1346 and T2345 had similar retentive strengths to each other and greater retentive strengths than T25. However, despite these differences in retentive strength, all 4 configurations exhibited similar losses in retentive strength with repeated application of force. All 4 configurations experienced this loss during the first 7 pulls, stabilizing shortly thereafter. These data support the need for a larger, more comprehensive study.

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Disclaimer

The authors have no financial, economic, commercial, or professional interests related to topics presented in this article.

Acknowledgments

The statistical analysis for this project was provided by the South Carolina Clinical & Translational Research Institute (SCTR) at the Medical University of South Carolina. SCTR is supported by a National Institutes of Health (NIH) Clinical and Translational Science Award (CTSA) program grant (UL1TR000062). The CTSA program is led by the NIH's National Center for Advancing Translational Sciences (NCATS). This project was also supported by an NIH F31 training grant (DE023486) to Gregory J. Wright.

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