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Effect of locator abutment height on the retentive values of pink locator attachments: An in vitro study

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ABSTRACT

Statement of problem. Currently, no guidelines exist to help in the selection of Locator abutments for implants at different heights.

Purpose. The purpose of this in vitro study was to evaluate the effect of the differential heights of pairs of Locator abutments on the retention of overdentures after 6 months of simulated function.

Material and methods. In vitro testing was performed with 4 sets of average-sized edentulous mandible analogs with 2 implants placed in the canine positions. There were 10 specimens in each of the 4 groups, with a total sample size of 40. Four groups of 2 implant-retained overdentures were fabricated, with Locator attachments at different vertical levels with differences of 0, 2, 4, and 6 mm. The overdentures were subjected to simulated function for a period corresponding to 6 months of clinical service and then tested with a universal testing machine for changes in peak load-to-dislodgement. The data were analyzed using 1-way ANOVA followed by the Tukey honest significant differences test (α=.05).

Results. Varying the heights of Locator abutments had a statistically significant effect on the retentive values of the pink Locator attachments after 6 months of simulated function (F=7.342, *P*=.001). The peak load-to-dislodgement ranged from 32.3 N (95% confidence interval [CI]: 26.0 to 38.6) for group 0 mm to 53.6 N (95% CI: 46.3 to 60.8) for group 6 mm. When the difference in Locator abutment heights was 2 and 4 mm, the peak load was 37.1 N (95% CI: 32.3 to 42.0) and 41.9 N (95% CI: 31.2 to 52.7). Statistical analysis revealed that the retention of group 0 mm and group 2 mm was significantly lower than group 6 mm. The retention of group 4 mm was not significantly different from groups 0 mm, 2 mm, or 6 mm.

Conclusions. Although significant differences were found among the groups, these differences were small and may not be clinically detectable. (J Prosthet Dent 2017;117:283-288)

In implant overdenture treatment, implants should be placed parallel to one another and to the path of insertion of the prosthesis.[1] Clinically, these guidelines may be difficult to fulfill because of the anatomy and morphology of bone and the presence of vital anatomic structures.[1,2] Excessively angulated implants, when used to retain overdentures, may present a restorative challenge, particularly when free-standing attachment systems are used.[3] Concerns have been expressed that horizontal forces directed to angled implants may contribute to bone resorption[4-7] and the expedited wear of attachments.[8,9] The implants may also be positioned as perpendicular to the occlusal plane as possible so that they are loaded axially without a bending moment.[10] In some situations, implants are placed at different vertical heights because of limitations in the anatomy of the alveolar bone. Currently, no guidelines exist regarding the position of the head of the implant and the level of the restorative platform relative to the other implant when used for overdenture treatment. Abutments of different heights may compensate for the different levels of implant positions.

One method of restoring implants for overdentures is by using attachments, with the Locator attachment being one of the most popular. In a previous study, Nguyen et al[11] evaluated the changes in retention of pink Locator attachments after exposure to various denture cleansers.

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Clinical Implications

The difference in retentive values between the groups was not clinically significant. Therefore, tissue thickness should be the main consideration in selecting the height of locator abutments for implants placed at different levels.

Pink Locator attachments were soaked for the equivalent of 6 months of clinical use in the following solutions: water (control), Polident Regular (GSK group), Efferdent (Prestige Brands Inc), 6.15% sodium hypochlorite, Polident Overnight (GSK group), and Cool Mint Listerine mouthwash (Johnson & Johnson Consumer Inc). Peak load-to-dislodgement was recorded to reflect changes in the retention of the Locator attachments after soaking. The retentive values ranged from 7.83 ±2.50 N for Locator attachments soaked in NaOCl to 51.10 ±5.31 N for Locator attachments soaked in Listerine. The authors concluded that soaking Locator attachments in NaOCl or Cool Mint Listerine was not recommended because of their effect on retentive values and on the color of the Locator attachments. A follow-up study evaluated the effect of a similar group of denture cleansing solutions on the retention of pink Locator attachments after multiple pulls.[12] After the initial pull, the retentive values of the pink Locator attachments ranged from 12.6 ±1.5 N for NaOCl to 22.3 ±3.1 N for Listerine. After 6 months of simulated use, the retentive values for attachments ranged from 7.3 ±1.0 N for NaOCl to 15.8 ±4.7 N for Listerine. The authors concluded that NaOCl significantly decreased the retentive value, whereas Listerine significantly increased the retention over time of the Locator attachment. Denture cleaners are detrimental not only to pink Locators but also to other attachments. In another study, clear, pink, and blue Locator attachments were tested in 3 different denture-cleansing solutions (NaOCl, sodium perborate, and sodium perborate-sodium bicarbonate) for a simulated 6 months of clinical use.[13] The retention of the blue attachments decreased significantly with the sodium bicarbonate and NaOCl solutions. Sodium bicarbonate solution decreased the retention of clear attachments significantly, whereas the retention of pink attachments was not affected by any of the test solutions.

Studies have shown that, with normal function, Locator attachments lose retention over time.[14,15] Implant angulation was determined to have a significant negative effect on attachment retention longevity. Locator attachments with dislodging forces of <20 N on implants 0 to 5 degrees to each other maintained their retentive forces for 5 to 6 years, whereas Locator attachments on implants angulated at 20 degrees needed replacement after only 1.8 years.[15] Furthermore, Locator attachments on 20-degree angulated implants displayed significantly greater reduction in peak load-to-dislodgement compared with Locators on parallel implants.[14]

The effect of the vertical angulation of implants on the retention of overdenture attachments has been investigated.[9,15] However, the authors have not identified studies that have investigated the effect of discrepancies in the different vertical heights of implants relative to each other. Should the same protocol for choosing Locator abutments be based on the soft tissue thickness, or should the Locator abutment height be used to compensate for the different vertical heights of the implants?

The purpose of this in vitro study was to evaluate the effect of the different heights of Locator abutments on the retention of overdentures after 6 months of simulated function. The research hypothesis was that after simulated function of 6 months, a significant difference would be found in the peak load-to-dislodgement of Zest Locator abutments with a 0, 2, 4, or 6 mm difference in height relative to each other.

MATERIAL AND METHODS

This study was conducted in vitro, using 4 sets of edentulous mandible analogs with the implants positioned at different heights relative to each other. An average sized edentulous mandibular analog was fabricated with autopolymerizing acrylic resin (Jet Acrylic; Lang Dental Mfg Co, Inc), similar to the methods previously described by Damghani et al.[16] After polymerization of the acrylic resin in a cast former (Model V50; Columbia Dentoform Teaching Solutions), a laboratory tungsten carbide bur (H79G; Brasseler USA) was used to prepare 2 holes in the area of the mandibular canines. Using a dental surveyor (Ney Dental Intl), 2 parallel implant analogs (Replace Select, trilobe internal hex, regular platform; Nobel Biocare) were fixed in the prepared sites with autopolymerizing acrylic resin. The implant analogs were placed in the canine position, bilaterally, 22-mm apart, which is the average distance between 2 natural mandibular canines.[17] The difference in implant levels was simulated by using Locator abutments of different heights, 0, 2, 4, and 6 mm, to standardize and limit differences between the mandibular analogs (Fig. 1).

The resiliency of mandibular soft tissue was simulated by removing 4 mm from the surface of the oral analog and replacing it with rubber gingival material (Gingival Mask HP; Henry Schein Inc).[16] Depth grooves were carved on the surface of the oral analog by using a tungsten carbide bur (H129E; Brasseler USA) to ensure that a uniform layer was removed. Gingival material was uniformly injected on the surface of the oral analog, and the oral analog was reseated in the model former.

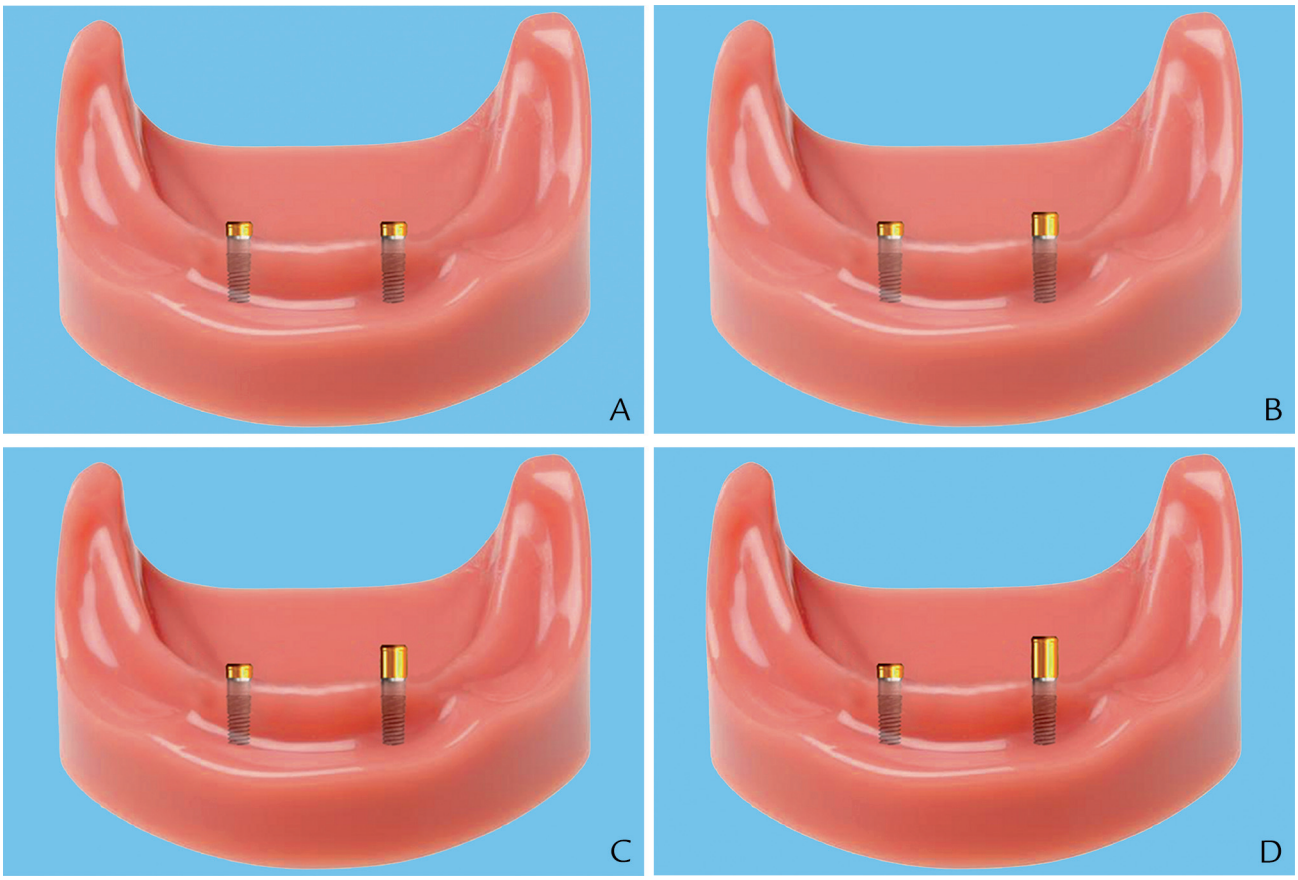

Figure 1. Four edentulous mandible analogs with implant analogs placed in canine positions. Various heights of Locator abutments attached to implants, with 0 mm height on right implant and 0, 2, 4, and 6 mm height on left implant. A, Locator abutment of 0 mm height on both right and left. B, Locator abutment of 0 mm height on right and 2 mm on left. C, Locator abutment of 0 mm height on right and 4 mm on left. D, Locator abutment of 0 mm height on right and 6 mm on left.

The Locator abutments (Zest Anchors LLC) were attached to the implants on the oral analog with the abutment driver (Locator Core Tool; Zest Anchors LLC) and tightened to 30 Ncm with a wrench (Locator Torque Wrench; Zest Anchors LLC) following the manufacturer's instructions. The attached Locator abutment was 0 mm in height on the right implant and 0, 2, 4, and 6 mm in height on the left implant (Fig. 1).

Custom trays were fabricated using a light-polymerizing custom tray material (Triad; Dentsply Intl) adapted onto 2 layers of baseplate wax (TruWax; Dentsply Intl) on the oral analog. The custom trays were polymerized for 4 minutes (Triad 2000 Visible Light curing Unit; Dentsply Intl) on both the intaglio and the cameo surfaces, according to the manufacturer's recommendation. Stops were created on the intaglio of the custom trays, 1 in the anterior and the other 2 in the area of the retromolar pads. A thin layer of polyvinyl siloxane adhesive (Caulk Tray Adhesive; Dentsply Intl) was brushed onto the custom trays and allowed to air dry for 5 minutes. Definitive impressions of each specimen were made using light-body polyvinyl siloxane impression material (Aquasil Monophase; Dentsply Intl). The impressions were then poured in a vacuum mixed Type III dental stone (Denstone Golden; Heraeus Kulzer GmbH).

Light-polymerized denture base material (Triad pink denture base material; Dentsply Intl) was adapted over each cast and light polymerized for 4 minutes. After that, a wax rim (TruWax; Dentsply Intl) was adapted and sealed over the record base with sticky wax (Sticky Wax; Kerr Corp). The dimension of the wax rim was 34×8×8 mm. The dimensions of the occlusal rims corresponded to an average dimension of premolars and molars.[18] Similar occlusal rims were fabricated for the remaining 3 denture bases by making a putty (Coltène Whaledent Inc) index of this occlusal rim.

The borders of the record bases were sealed onto the casts with baseplate wax (TruWax; Dentsply Intl). The casts were invested in denture processing flasks (Teledyne Hanau Processing Flask; Whip Mix Corp) using Type II dental plaster (Modern Material Dental Plaster; Heraeus Kulzer GmbH). The flasks were put into a boil-out tank (model 687; Nevin Laboratories Inc) for 8

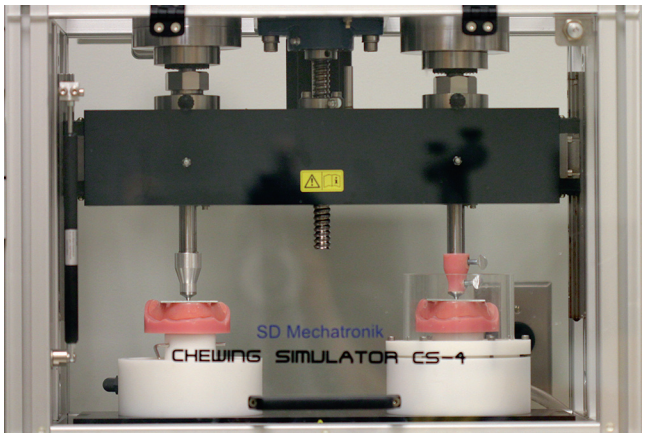

Figure 2. Two assemblies of denture base on mandible analog subjected to 6 months of simulated function, using mastication simulator.

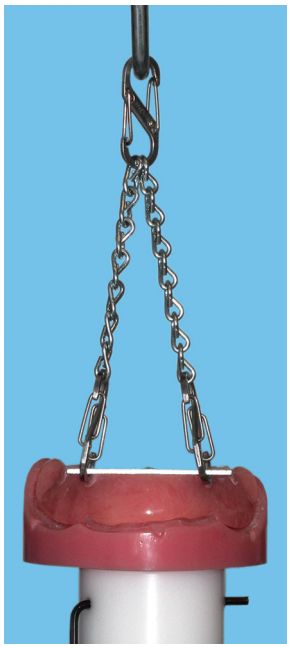

Figure 3. Application of tensile force from universal testing machine.

minutes for wax elimination. The cope and drag were separated, and the remaining wax was rinsed with hot running water. A layer of separating medium (Modern Material Separating Medium; Heraeus Kulzer GmbH) was painted on the plaster of the investment and allowed to bench cool.

Heat-polymerizing poly(methyl methacrylate) resin (Lucitone 199; Dentsply Intl) was mixed according to the manufacturer's instructions and trial packed at 10 MPa 3 times in the doughy stage (Nevin Pneumatic Press Unit; NevinLabs) and at 21 MPa for the final pack. The flasks were clamped (Hanau Flask Compress; Whip Mix Corp) and polymerized at 74°C for 9 hours (Nevin 4900 Electronic Denture Curing system; NevinLabs). After bench cooling, the flasks were separated, and the denture bases were retrieved, finished, and polished.

Pressure indicating paste (Mizzy Pressure Indicating Paste; Keystone Industries) was painted on the intaglio of the denture bases and adjustments were made to ensure intimate contact of the ridge to the denture base. Relief for the housing/patrix part of the attachment (Locator Attachment; Zest Anchors LLC) was made on the denture bases with a no. 8 acrylic resin round bur (Brasseler USA). The Locator housings with black processing attachments were picked up in the denture base using autopolymerizing acrylic resin (Jet Acrylic; Lang Mfg Co). The black attachments were replaced by pink Locator attachments using a Locator Core Tool (Zest Anchors LLC). Pink Locator attachments were tested in this experiment, as they are the most widely used by dentists (Zest Anchors LLC, personal communication, 2014).

Each specimen, involving the full assembly of the simulated denture base on the oral analog, was subjected to a mastication simulator (CS 4.2; SD Mechatronic GmbH) to simulate intraoral conditions and to provide dynamic cyclic loading (Fig. 2). Each specimen was subjected to a dynamic cyclic load with both vertical and lateral components (120 000 cycles, 49 N load, 3 mm height, 0.7 mm lateral movement, vertical and lateral speeds of 60 mm/s, frequency of 1.6 Hz).[19] According to published reports, 120 000 cycles in a mastication simulator corresponds to 6 months of clinical service.[20,21] The load was applied to each specimen by means of a stylus in contact with the center of a flat metal plate embedded on the occlusal surface of the denture base (Fig. 2).

The specimens were tested for peak load-to-dislodgement with a universal testing machine (Satec Material Testing Equipment, T Series; Instron) after simulated function. The universal testing machine was used at a crosshead speed of 50.8 mm/min.[22,23] The oral analogs were clamped and stabilized to the lower member of the universal testing machine. The denture bases with the metal housing embedded in it were clamped to the upper part of the universal testing machine. A tensile force was applied to each testing specimen until the Locator attachment separated from the Locator abutment. After each separation of the denture bases, the measured peak load-to-dislodgement value was recorded (Fig. 3). Each specimen was subjected to 10 consecutive pulls.[24] The same procedure was repeated for each of the 10 specimens in the four groups. The mean of the 10 pulls was determined for each specimen. The overall mean for each group was found by averaging the means of each specimen in that group. This mean retentive value was compared statistically across the 4 groups.

A power analysis was conducted using the clinical relevance of 6.7 N (the retentive value of pink locator), a decrease of 50% in retention between the pink nylon

Table 1. Peak load of 4 groups after 10 pulls

Group	Pulls, n	Peak Load, N (mean ±SD)	Range	F	P
0 mm	10	32.3 ±8.8[a]	27.2	7.342	.001
2 mm	10	37.1 ±6.9[a]	21.0		
4 mm	10	41.9 ±15.0[a,b]	50.6		
6 mm	10	53.6[b] ±10.2[b]	32.6		

Groups with same superscript letter were not significantly different (*P*>.05).

Table 2. Mean difference in retention of 4 groups after 10 pulls

Group	Mean Difference (%)	Mean Difference for Peak Load (N)	P	95% CI for Mean	
				Lower Bound	Upper Bound
6 mm					
4 mm	21.6	11.6	.087	-1.2	24.4
2 mm	30.6	16.4	.007	3.6	29.3
0 mm	39.7	21.3	<.001	8.4	34.1
4 mm					
2 mm	11.5	4.8	.741	-8.0	17.6
0 mm	23.0	9.6	.197	-3.2	22.5
2 mm					
0 mm	13.0	4.8	.744	-8.0	17.6

insert and the blue nylon insert, as described previously by Greenbaum et al (thesis). Using 1-way ANOVA, with 10 in each group, an effect size of .65, a 1-tailed test, and a *P* value of ≤.05, power was equal to .92 for implant level. Therefore, an n of 10 in each group was used in this study.

Using the Levene test for homogeneity of variance, no significant differences were found among the variations in the 4 groups. Therefore, ANOVA and Tukey honest significant difference (HSD) tests were used to examine the results for significant differences (α=.05).

RESULTS

The varying height of Locator abutments had a statistically significant effect on the retentive values of the pink Locator attachments after 10 pulls following 6 months of simulated function (F=7.342, *P*=.001) (Table 1). The peak load-to-dislodgement after 10 pulls ranged from 32.3 N (95% confidence interval [CI]: 26.0 to 38.6) for group 0 mm to 53.6 N (95% CI: 46.3 to 60.8) for group 6 mm. When the difference in Locator abutment heights was 2 and 4 mm, the peak load was 37.1 N (95% CI:32.3 to 42.0) and 41.9 N (95% CI: 31.2 to 52.7). The results of ANOVA and the Tukey HSD showed that the retention of group 6 mm was significantly higher than that of group 0 mm (*P*<.001) and 2 mm (*P*=.007). The retention of group 4 mm was not significantly different from groups 0 mm (*P*=.197), 2 mm (*P*=.741), and 6 mm (*P*=.087).

DISCUSSION

The results of this study rejected the null hypothesis that after simulated function of 6 months, no significant difference would be found in the peak load-to-dislodgement of Zest Locator abutments with a 0, 2, 4, or 6 mm difference in height relative to each other. The peak load-to-dislodgement of group 6 mm was significantly higher than that of group 0 mm and 2 mm. Reductions of 39.7% in retention from group 6 mm to group 0 mm, of 30.6% from group 6 mm to group 2 mm, and of 21.6% from group 6 mm to group 4 mm were found (Table 2). However, the differences were less than 50% among the different groups and may not be clinically detectable. Also, the retentive value of 32.3 N in group 0 mm is in excess of 20 N, which according to published studies is the minimum force required to maintain a denture in position.[25,26] Although a statistically significant difference was found between groups 0 mm, 2 mm, and 6 mm, this difference may not be clinically relevant since all the results exceeded 20 N.

The enhanced retention observed in this study as the difference in Locator height increased may be due to increased friction or a rotational path of dislodgement or both. The tallest Locator abutment of 6 mm had the largest surface area in contact with the intaglio surface of the denture compared with the shorter Locator abutments of 0, 2, or 4 mm. Although this contact area was relieved during the pick up of the Locator housing, it may not have been sufficiently relieved and thus acted as a guide plane, adding to the measured peak load-to-dislodgement.

Also, during testing, separation of the 2 Locator attachments from the 2 abutments did not occur at the same time, but often one followed the other. The Locator abutment with the shorter height was often dislodged first, followed by the taller Locator abutment. The different levels of the 2 Locator abutments might have provided a rotational path of dislodgement, therefore requiring a higher cumulative level of tensile force. This increased tensile force could then be transferred to the implant and result in unfavorable stresses on the implant and surrounding alveolar bone. Additional research is required to determine the amount of force transferred from the Locator abutment to the implant and surrounding alveolar bone during insertion and removal of implant-retained overdentures.

The peak load-to-dislodgement values from this study ranged from 32.3 N to 53.6 N. Another study that tested pink Locator attachments evaluated the peak load-to-dislodgement values of pink Locator attachments in pairs after soaking them in various solutions for an equivalent of 6 months of clinical use.[11] The mean peak load-to-dislodgement value for the control group which was soaked in tap water was 45.25 N. The retentive value of the control group from that study is within the range of retentive values in this study. Other

similar studies which evaluated the effect of various solutions on the retention of pink Locator attachments only tested 1 Locator attachment at a time instead of 2 in each test assembly. The peak load-to-dislodgement values ranged from 22.2 N[12] to 27.3 N[13] in those control groups, which is approximately half the values in this study.

A crosshead speed of 50.8 mm/min was used because it is the average speed at which patients remove implant overdentures from their fixtures. However, patients may remove their dentures at different rates, which in turn may affect retention.[12]

This study has several limitations. The Locator attachments were tested for only a simulated time of 6 months. Testing for longer periods may be necessary, as Locator attachments can last up to 1.8 years.[15] Also mastication simulation was done with 1 axis of rotation, whereas masticatory forces exert multiple axes of rotation on a denture. Multiple axes of rotation and a longer period of mastication simulation may cause the Locator attachments to wear more quickly, accelerating retention loss and therefore resulting in more apparent differences in retention across the 4 groups. Lastly, dentures function dynamically in the oral cavity, subjected to a complex and variable biomechanical environment. Additional research should involve thermal cycling, biologic fluid environment, a longer period of simulated function, and the effects of fatigue on material properties.

CONCLUSIONS

Within the limitations of this in vitro study, the following conclusions were drawn:

1. A statistically significant difference was found between the various groups tested, suggesting that differences in the height of locator abutment pairs may influence the retention of overdentures.
2. However, these results should be interpreted with caution, as the differences in retentive value may not be clinically significant and that adjusting heights of Locator abutments to compensate for the different vertical heights of the implants may not be clinically important.

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