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A comparative evaluation of retention and stability of implant supported overdenture with locator attachment at different implant locations- An invitro study

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Abstract

Statement of problem: Dental implants and the retentive attachments for overdenture held in place according to the preferences of the physician, the opinion of experts, or empirical data. Regarding implant placement, dispersion, and its impact on mandibular implant overdenture' stability and retention, not much is known.

Aim: The purpose of this study is to assess how different implant locations and distribution affect an implant-supported overdenture with locator attachment on retention and stability.

Material and Method: A mandibular edentulous ridge model was used in the experiment, and 8 dental implant analogs were positioned in places that roughly corresponded to the positions of the teeth in the normal dentition. 4 metal loops were attached on 4 different heat cure denture base by acrylic resin. Metal chains were used and attached to a universal testing machine on one end and to the loops by other end, were used to measure peak load (N) required to disconnect the attachment. Four different locations were used. First part of the study evaluated retention followed by stability of 4 implant-retained overdenture based upon implant distribution. For each group, 10 measurements were made by peak dislodging forces. Means were calculated and differences among the groups were identified using a repeated measured analysis of variance at the $p < 0.05$ level. For differences observed between measurements, the Bonferroni post hoc method at the 5% level of significance was used to determine the location and magnitude of difference.

Results: Until upto the second premolar, the distal implant position improved the retention and stability of stimulated overdenture prosthesis. Specific location and attachment types have varying effects on stability and retention, vertical retention of a stimulated overdenture prosthesis increased withe increased interimplant distance. Antero-posterior and lateral stability of an implant overdenture prosthesis increased with distal implant location.

Conclusion: Within the limitation of this study, retention and stability of implant overdenture prosthesis are significantly affected by implant location and distribution.

Keywords: Implant; locator attachment; mandibular implant overdenture; retention; stability.

Introduction

In number of countries, the proportion of older people in the population has been rising. As the senior population grows, there will likely be a corresponding rise in the number of persons with edentulism and a corresponding need for edentulism therapy.[1] Residual ridge resorption continues to be primary complication of edentulism. Although a conventional complete denture is regarded as the traditional treatment for edentulism, the outcome of a complete denture is limited, mainly because of the instability of dentures, impaired masticatory efficiency, and constant bone resorption, especially in the mandible.[2] However, the efficacy of some endosseous implant systems now allows patients to be successfully treated with implant-retained overdentures for rehabilitating edentulous patient with such residual ridge resorption.[3] Current consensus is that reducing the numbers of implants from four to two does not affect the implant or the prosthodontic success rates.[4] The 2002 McGill Consensus Conference concluded that the evidence available at the time suggested the restoration of the edentulous mandible with a conventional denture is no longer the most appropriate first-choice prosthodontic treatment and states that mandibular two-implant overdenture as first choice standard of care for edentulous patients.[5,6]

It is well known that implant-retained/supported overdenture provide improved retention, support, stability, function, and comfort for patients.[7,8] Besides providing retention, implants retained overdenture assist in reducing the impact of tissue borne edentulous prosthesis. They slow the rate of residual ridge resorption, increase the masticatory efficiency.[3] Multiple prosthetic designs, materials, and techniques have been extensively described in the literature.

Implants can be utilized in combination with attachments in individuals who are entirely edentulous to improve overdenture stability and retention. There are many different attachments provided by a large number of manufacturers around the world.[9] The choice of the attachment is dependent upon the retention required, jaw morphology, anatomy, mucosal ridge, oral function, and patient compliance for recall.[10,11] Generally, these can be classified as clips-and-bars attachment, ball attachments, magnetic attachment, and telescopic attachments (rigid or no rigid). Stud attachments are easier to use, preferred when the patient's existing overdenture is to be transformed to an implant overdenture and very straightforward to use and provide reasonable retention and stability for implant overdenture.

The locator attachment system is type of stud attachment used in patient with atrophic alveolar ridge, less inter-arch space,_inadequate denture height. This attachment is self-aligning and has dual retention (inner and outer) and in different colors with different retention values. Locator attachments are available in different vertical heights, they are resilient, retentive, and durable, and have some built-in angulation compensation. Different colours of locator attachment like white, pink and blue have different retentive values. The extended range attachments are available in two colors: red for extra-light retention and green for normal retention. These attachments may be utilized to adjust implant angulation up to 60 degrees.[12,13]

The mechanical characteristics of the different types of prostheses is of extreme value in the planning treatment, to determine if the behaviour of the prosthesis in response to chewing efforts will meet the functional needs of the patient. For this purpose, concepts such as retention and stabilization need to be better understood. Denture retention consists of the resistance of the prosthesis to movement in the direction opposite to that of insertion, and in the case of overdentures is directly related to the retention system employed. In contrast, the concept of stability, or stabilization, of the prosthesis is described in the ninth edition of the Glossary of Prosthodontic Terms (GPT9) as the seating of a fixed or removable denture so that it will not tilt or be displaced under pressure.[14]

Many research have mentioned the effect that various attachment mechanisms have on the stability and retention of overdentures. But few studies have accurately evaluated the effect of implant distribution based on location and number upon retention and stability of implant overdenture prosthesis.[15] Therefore, the goal of this study was to offer an in vitro evaluation utilizing a locator attachment system to examine the stability and retention of overdentures supported by implants placed in different locations and with varied numbers of implants.

Materials and Methods

This invitro study was carried out to evaluate and compare the retention and stability of mandibular implant supported overdenture with locator attachment at different implant locations. An study was carried out by using a model that simulated a mandibular edentulous ridge with dental implants analog in positions that approximated the tooth positions in the natural dentition. Silicone was used to fabricate a duplicate mold from the stone cast. Standard clear epoxy acrylic was used to create a study model by using silicone mold. Trial denture bases with wax occlusion rims were fabricated, and acrylic resin teeth were arranged. Mandibular trial dentures were flasked and packed with clear heat-polymerizing resin and finished and polished by using the conventional method. This trial denture was used as guide template for marking the exact tooth position by drilling in the middle of the tooth. 8 implant analogs with dimensions of 3.5 x 10.0mm were procured and utilized for the study. Straight hand piece was mounted on the milling machine to drill eight parallel implant houses and parallel pins were used to verify parallelism of drilled implant houses. Then implant analog were placed in Canine; 1st Premolar; 2nd Premolar and Molar location bilaterally. 4 locator attachments of 0.5mm were procured and utilized for the study. 40 Silicone insert and 12 metal caps housing were procured and utilized in the study. Silicon inserts were placed and metal housing was assembled on it. Alginate impression was made for each group and stone cast were fabricated. All the 4 stone cast were blocked at the attachments site and overdenture was fabricated.

All the 4 metal housing were picked up by using auto-polymerizing poly methyl methacrylate (PMMA) acrylic resin (vent holes were made for flow out of excess material). Universal Testing Machine will be used to test the force required to dislodge the prosthesis in axial direction. 4 metal hooks were incorporated from the framework at canine and molar region bilaterally. A 15 cm long custom made iron chain was connected to each hook of the overdenture. A metal plate of 5X5 cm dimension with four perforations was joined to the chain end by adjustable screw. The metal plate was connected to the head of a universal testing machine by additional (main) chain in the center of the plate.

An axially directed 4 points vertical pull was applied on the metal plate till separation of attachments occurs, was used to determine retention against vertically directed dislodging force parallel to the path of insertion. A cross head speed of 50mm/min was used to approximate the denture dislodgement speed during mastication. The maximum load needed to separate the experimental overdenture was recorded in newton (n) to represent the retention force. Each measurements were recorded for all the 4 groups with new nylon insert for 10 consecutive recordings. A 2-point anterior/posterior/oblique pull was used to determine stability and resistance against para-axial, oblique dislodging forces. Data was tabulated and subjected to statistical analysis for interpretation of results. One way analysis of variance followed by post hoc Bonferroni test was applied for pair wise comparison. Conclusions were drawn based on the statistical analysis.

Results

Data was entered into Microsoft Excel spreadsheet .The data was analysed by SPSS (21.0 version), tabulated and subjected to statistical analysis. One way ANOVA of mean values was performed. The level of significance was set at $p \leq 0.05$. Table 1: Shows descriptive statistical comparison for peak load of vertical retention forces at different implant locations among different groups. The mean retention between the groups is 4.92 +/- 0.299. Table 2: Shows descriptive statistical comparison for peak load of anterior stability at different implant locations among different groups. The mean stability between the groups is 4.22 +/- 0.42. Table 3: Shows descriptive statistical comparison for peak load of posterior stability at different implant locations among different groups. The mean stability between the groups is 3.84 +/- 0.266. Table 4: Shows descriptive statistical comparison for peak load of right lateral stability at different implant locations among different groups. The mean stability between the groups is 3.93 +/- 0.325. Table 5 Shows descriptive statistical comparison for peak load of left lateral stability at different implant locations among different groups. The mean stability between the groups is 3.75 +/- 0.44. Table 6: Show descriptive statistics and one way analysis of variance (ANOVA) for stability and retention of different locations. The p value for all the groups was less than 0.001 shows statistically significant difference in peak load of retention and stability among different groups. (Graph 3)

Discussion

Treatment options and materials used in dentistry progressed remarkably in the last two decades. It is clear that a lot of overdenture therapy ideas are derived from actual patient experiences. The preservation of the mandibular denture support structures through the use of overdentures has been recommended as a way to improve stability and retention. The prosthetic and attachment system elements of effective mandibular implant overdentures have been extensively documented. Bone loss after complete edentulism, especially in the mandible, has been observed for years in the literature. Soft tissue abrasions are more symptomatic of horizontal movement of the prosthesis under lateral forces. An implant-supported overdenture may limit lateral movements and direct more longitudinal forces. For implant-retained overdentures during long-term function, retention strengths between 5 and 8 N are sufficient, according to an in vitro research that assessed a variety of attachment types.[38] A prospective cross-over clinical investigation found that around 10 N of retention was successful after assessing patient satisfaction and the relationship to force values.[17]

The present in vitro study investigated the effect of implant position on the retention and stability of a simulated prosthesis. The results of this study indicated that implant location affects the in vitro retention and stability of an implant overdenture, thus rejecting the null hypothesis. Retention is a major concern to patients, and one of the greatest challenges that faces clinicians is in providing prosthetic treatment that provides the retention patients desires.[4]

There are various attachments available for the clinicians in the market today, such as ball attachments, locators, magnets, bar connections and rigid or non-rigid telescopic copings etc. The amount of retention required, the amount of interarch space available, the patient's manual dexterity, the dentist's expertise, and lastly the cost all play a role in the attachment system selection process. The present invitro study evaluated the retention and stability by using the locator attachment. The locator attachment system is an attachment system that features dual retention (inner and outside) and a self-aligning function

Table 1: Descriptive statistics of peak load for vertical retention forces of implant supported overdenture at different locations among different groups.

Vertical	n	Mean	SD	SE	min	max
Group I	10	5.11	0.33	0.10	4.70	5.88
Group II	10	4.84	0.27	0.08	4.22	5.20
Group III	10	5.01	0.15	0.04	4.72	5.23
Group IV	10	4.70	0.25	0.08	4.36	5.25
Total	40	4.92	0.29	0.04	4.22	5.88

Table 2: Descriptive statistics for peak load for anterior stability of implant supported overdenture at different locations among different groups.

Anterior Stability	n	Mean	SD	SE	min	max
Group I	10	4.66	0.29	0.09	4.05	5.15
Group II	10	3.75	0.12	0.04	3.50	3.90
Group III	10	4.42	0.14	0.04	4.21	4.70
Group IV	10	4.04	0.31	0.09	3.68	4.61
Total	40	4.22	0.42	0.06	3.50	5.15

Table 3: Descriptive statistics for peak load of posterior stability of implant supported overdenture at different locations among different groups.

Posterior Stability	n	Mean	SD	SE	Min	Max
Group I	10	3.49	0.20	0.06	3.18	3.84
Group II	10	3.86	0.10	0.03	3.75	4.09
Group III	10	4.01	0.19	0.06	3.80	4.37
Group IV	10	4.00	0.12	0.03	3.79	4.21
Total	40	3.84	0.26	0.04	3.18	4.37

Table 4: Descriptive statistics for peak load of right lateral stability of implant supported overdenture at different locations among different groups.

Right Lateral	N	Mean	SD	SE	Min	Max
Group I	10	3.62	0.28	0.08	3.18	3.91
Group II	10	3.88	0.15	0.04	3.67	4.12
Group III	10	3.90	0.17	0.05	3.63	4.27
Group IV	10	4.33	0.17	0.05	4.04	4.61
Total	40	3.93	0.32	0.05	3.18	4.61

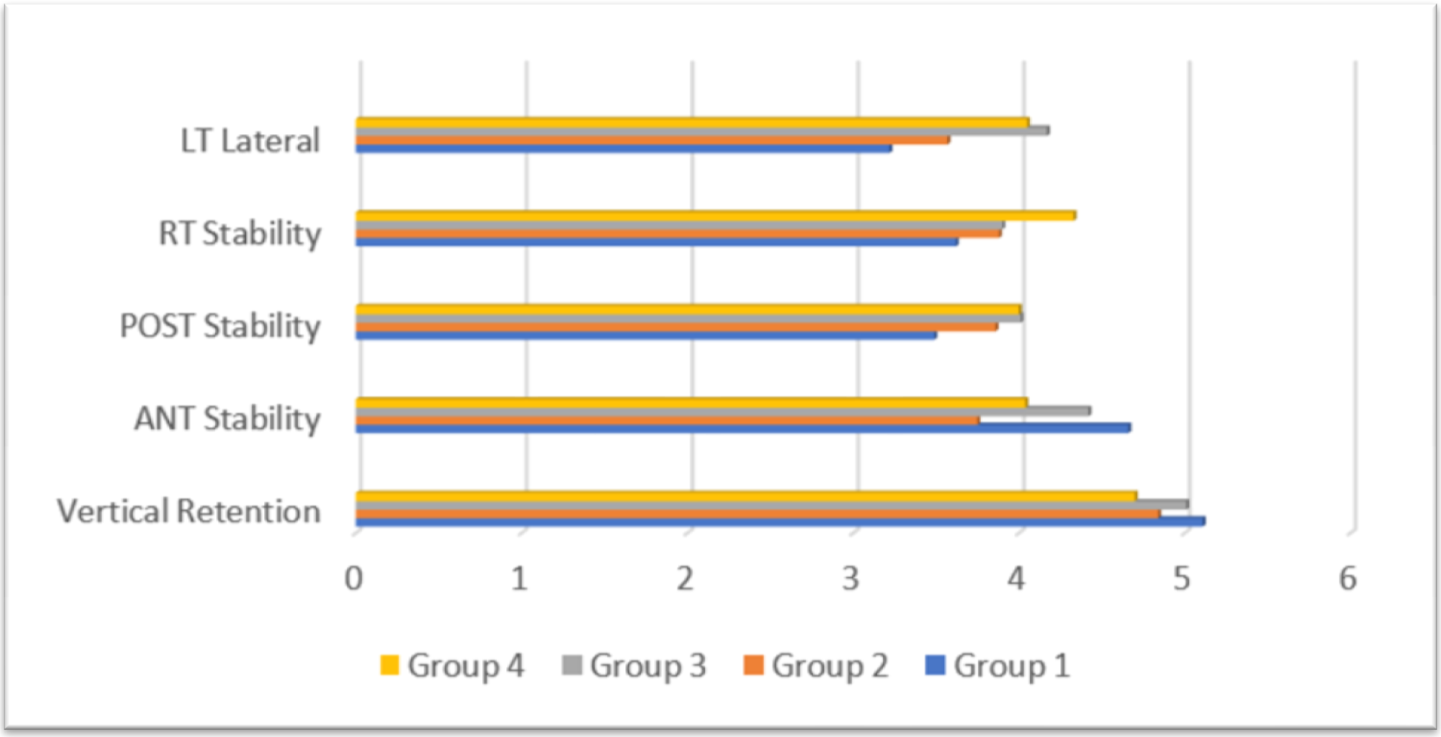
Table 5: Descriptive statistics for peak load of left lateral stability of implant supported overdenture at different locations among different groups.

Left Lateral	N	Mean	SD	SE	min	max
Group I	10	3.22	0.26	0.08	2.90	3.79
Group II	10	3.57	0.22	0.07	3.27	3.91
Group III	10	4.17	0.21	0.06	3.89	4.45
Group IV	10	4.05	0.21	0.06	3.64	4.31
Total	40	3.75	0.44	0.06	2.90	4.45

Table 6: One way analysis of variance (ANOVA) for stability and retention at different locations among different groups. (Graph I)

	Vertical		Anterior Stability		Posterior Stability		Right Lateral		Left Lateral		ANOVA
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P value
Group I	5.11	0.33	4.66	0.29	3.49	0.20	3.62	0.28	3.22	0.26	<0.001
Group II	4.84	0.27	3.75	0.12	3.86	0.10	3.88	0.15	3.57	0.22	<0.001
Group III	5.01	0.15	4.42	0.14	4.01	0.19	3.90	0.17	4.17	0.21	<0.001
Group IV	4.70	0.25	4.04	0.31	4.00	0.12	4.33	0.17	4.05	0.21	<0.001

Graph 1: One way analysis of variance (ANOVA) for stability and retention at different locations among different groups.



The retentive values of locator attachments vary according to the type of insert used—white, pink, transperent and blue. The extended range attachments are available in two colors: red for extra-light retention and green for normal retention. The present in vitro study used transparent insert. They may be used to adjust implant angulation up to 20 degrees. When retrofitting an old denture or in situations where interocclusal space is restricted, the attachment's lower height is beneficial. Moustafa Abdou ELsyad et al[10] observed that the highest initial retention was noted with Locator transparent, followed by Locator pink, Locator blue.[1]

The current study assessed the stability and retention of an overdenture supported by a mandibular implant with a locator attachment at four implant positions. For all implant sites, a standard clear nylon insert with ball attachments was utilized. Five repetitions of each test were conducted, which is comparable to the number of tests conducted in the research by Petropoulos et al[7] and Tabatabaian et al.[18] A metallic chain was employed in some experiments to link the load cell to the overdenture, which makes it difficult to distribute forces equally and necessitates constant chain adjustments to ensure that the chains are the same height as employed by Petropoulos et al. and Tabatabaian et al.[18] So a 4 point of chain pull was created for equal distribution of forces, 4 hooks were attached in canine and molar region bilaterally and chains were extended for measurement of peak load at various locations.

Following this, the chain located in the right molar and canine area was disconnected, and the 2 legs of the chain were attached to the 2 loops corresponding to the left molar and canine region. This resulted in an oblique lifting force, simulating function. Following that, the chains in the molar region remained, while the chain in the anterior region was removed .This resulted in a rotational pull, an anterior-posterior lifting force (ie, lifting forces applied to the distal extension bases) simulating function.[18] This type of pull was a measure of denture stability. Stability is the resistance to horizontal and rotational forces that prevents lateral or anterior-posterior shunting of the denture base. The dislodging tensile forces applied by the testing machine yielded the peak load measurement (maximum dislodging forces): the maximum force that developed before complete separation of the attachment components from the implant abutments.

Similar to a 2014 study by Scherer et al[4] found that the vertical retention and horizontal stability of a simulated overdenture prosthesis increase with distal implant location up to the second premolar and the values dropped when the implants moved into the molar location, the current study indicates that the maximum vertical retention and stability is seen in the canine and second premolar region.

Regardless of the implant number, upon anterior and canine loading, the vertical displacements at the right distal edge and the loading point of the overdenture suggest that the IOD was pressed into the mandible at the loading point and raised above it at the distal edge. This resulted in rotation around the implant. In contrast, upon premolar and molar loading, although the IOD was pressed into the mandible at the loading point, the IOD hardly rotated and was slightly raised at the distal edge. The denture-bearing area of the molar region is larger than that of the anterior region and resisted occlusal force more strongly.[1]

The results of this study indicate that 4-implants may produce effective in vitro retention and stability of overdenture prosthesis. The testing performed is limited with specific conditions and methods and does not completely replicate clinical situations as the implant overdenture clinical reality is much more complex than a laboratory setting can replicate.[32] Furthermore, the findings of this study also do not account for attachment wear, resiliency, and tissue effects. While this in vitro based analysis shows a statistical difference between groups, long-term comparative prospective controlled studies are needed to reach agreement on an accepted treatment concept. Factors such as the type and location of implants placed, quality and quantity of bone, and type of superstructure should be part of these studies.[18]

The current study has a number of limitations, despite the fact that in vitro investigations enable test standardization by removing oral circumstances. Saliva reduces wear and enhances retentive force because it creates friction between the attachments' patrices and matrices.[40] Additionally, using non-axial dislodging to model denture stability is oversimplified and does not represent the actual non-axial dislodging forces that the denture base may encounter in vivo. The clinical reality of the implant overdenture is much more complex than a laboratory setting.

Conclusion

The present study was conducted to compare and evaluate the effect of different location of implant on the retention and stability of two implant- supported overdenture with locator attachment. An experiment was undertaken utilizing a model simulating a mandibular edentulous ridge with 8 dental implant analog in positions on the model approximating the tooth position in the natural dentition. The implant attachments were secured for four different study Groups I, II, III and IV. Over that 4 acrylic test denture were constructed in the conventional way with vent holes for all the metal housing corresponding to the 4 implant positions. Metal chains were used and attached to a universal testing machine by end and on loops by other end, was used to measure peak load (N) required to disconnect an attachement. Each measurements were recorded for all the 4 groups with new nylon insert for 10 consecutive recordings. Each test denture was subjected to three different tests. Test No. 1 was conducted to evaluate the effect of vertically directed dislodging forces. Test No. 2 was conducted to evaluate the effect of oblique rotational dislodging forces which included right and left oblique forces. Test No. 3 was conducted to evaluate the effect of posterior rotational dislodging forces. The result of the present study showed a significant difference between the 4 groups (Group 1: bilateral canine and first premolar region. Group 2: bilateral canine and second premolar region. Group 3: bilateral canine and 1st molar region. Group 4: bilateral 1st premolar and 1st molar region) and thus rejected the null hypothesis. So, within the limitation of this in-vitro study, it was concluded the comparison between groups:

1) Statistically significant difference was found with vertically directed dislodging forces at different implant location with highest mean value seen in relation to greater interimplant distance that is in canine and premolar region- Group II.

2) Statistically significant difference was found with anterior rotational dislodging forces at different implant location with highest mean values seen in realtion to canine and premolar region the anterior most location- Group I

3) Statistically significant difference was found with posterior rotational dislodging forces at different implant location as we move distally. With highest mean values seen in relation to canine and molar region Group III followed by premolar and molar region-Group IV

4) Statistically significant difference was found with oblique rotational dislodging forces at different implant location with highest mean values seen as we move distally as canine- molar region Group-III and premolar-molar Group- IV region in left oblique forces and right oblique forces respectively.

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