ISSN (O) : 2582-3271
PubMed-National Library of Medicine - ID: 101766917

International Journal of Dental Science and Clinical Research (IJDSCR)

Dr. Angel Vaidic Publication

Available Online at: http://www.ijdscr.org

Volume – 2, Issue – 5, September - October - 2020, Page No. : 24- 32

Comparison of Retention and Stability of Implant Retained Overdentures Placed On Ball, Locator and Bar Attachment Systems – Invitro Study

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Citation Of This Article: Dr. Himabindu Ravella, Dr. Gudala Siva Kumar, Dr. Yalavarthi Ravi Shankar, "Comparison of Retention and Stability of Implant Retained Overdentures Placed On Ball, Locator and Bar Attachment Systems – Invitro Study", IJDSCR September - October - 2020, Vo2. – 2, Issue -5, P. No. 24-32.

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Type of Publication: A Review Article

Conflicts of Interest: Nil

Abstract

Aim

The study was done to evaluate retention and stability of implant supported over dentures placed on ball , locator and ball attachment systems with color coded elastic inserts.

Materials and Methodology

Ball, Locator attachments (Rhein 83) with color coded elastic inserts(white, pink and yellow) and for Bar attachment system (Rhein 83) inserts (yellow, pink) are used in this study. Edentulous mandibular acrylic resin models are fabricated and four implant analogs are placed in the canine and second premolar regionusing fabricated guiding template . Attachments with different inserts were placed on the implant analogs and 8 over dentures were fabricated. The retention and stability of overdenture with each color coded insert was tested with Universal testing machine before and after thermocycling.

Result

The obtained values were subjected to statistical analysis and a statistically significant difference was observed (p value< 0.05).

Conclusion

Locator attachment had the highest retention and stability values followed by Balland Bar attachments.

Keywords

Implant attachment, elastic insert, implant analog, over denture, thermocycling, retention and stability.

Introduction

As the neuromuscular coordination and the muscle strength decreases in older people achieving the retention and stability of dentures over edentulous ridges becomes quite difficult. The efficient treatment planning in these cases is an “over denture" placed on dental implants. Implant-supported overdentures result in patients being able to masticate hard and tough food with an increase in bite force compared to conventional dentures.[1,2]Bone loss is an ongoing process following tooth loss affecting the mandible more than the maxilla.[3] In patients with edentulous mandibles, the stability and retention of a complete denture is a common problem that can be managed by the selective placement of implants [4]. Therefore this study has been done to evaluate the retention and the stability on the Implant-retained mandibular overdentures with different attachment systems. Denture ***retention*** is defined as the resistance to vertical and torsional stresses of insertion and ***stability*** is the resistance to horizontal and rotational forces [5].

Materials & Methodology

Fabrication of guiding template for implant placement

At first dental stonecast was poured in mandibular edentulous rubber mold and on the castdenture base was fabricated with self-cure acrylic resin (DPI cold cure) . Occlusal rim was fabricated on denture base with modeling wax(Cavex)and a complete set of mandibular teeth are arranged .Alginate impression of this was made and a stone cast was poured. Over this stone cast vacuum sheet was adapted with vacuum forming device (Easy-Vac2) . This vacuum formed template is used as a guide for the placement of implant analogsat indicated positions in the resin edentulous cast.

Fabrication of edentulous resin cast

In the next step hard modeling wax was melted and poured in the previously used mandibular edentulous rubber mold . Four implant analogs (ADIN) are placed in the wax model two in the canine region and two in the second premolar region using the above fabricated guiding template(Fig 1).Twist drills and a Jelenko surveyor were used to ensure their parallelism . Impression posts (ADIN) were attached to the implant analogs (Fig 2).

Figure 1: Edentulous wax model with implant analogues

Figure 2: Open tray impression posts attached to implant analogues.

Then thewax model was stabilized on a glass plate with sticky wax. A duplicating flask was placed over this wax model and duplicated with duplicating silicone (Unisil-

Flow) . The wax model was carefully separated after the duplicating silicone material has set. Implant analogs were attached to open tray impression posts, and this assembly was carefully inserted into the orientation holes formed in the duplicating silicone.(Fig 3)

Figure 3: Duplicated Mold

Into the impression epoxy resin (Hakson's ultra-clear) was poured . The obtained epoxy resin model was the master cast with four implant analogs placed in canine and premolar regions. The impression posts were removed from the model, and the model was finished and polished properly. A total of 3such epoxy resin dies were fabricated with implant analogs .

Fabrication of Attachments

Group 1: **Ball attachment (Rhein83)** available as pre-fabricated and divided into three subgroups. Three different color-coded nylon inserts were used in this study as they stand for withstanding different retentive forces .The different colored elastics indicate subgroups :**1(a)** White cap insert has standard retention and slightly elastic, **1(b)** Pink cap insert has soft retention and elastic and **1(c)**Yellow cap insert has extra soft retention and very elastic .Each elastic cap was inserted on the respective epoxy resin model and tightened up to 30N torque.(Fig 4

Figure 4: Epoxy model with ball attachment.

Group2: **Locator attachment(Rhein83)** contain Locator abutment and Locator matrix. The Locator matrix was attached to the fitting surface of the overdenturedivided into three subgroups.**2(a)**Locator with white capinsert ,**2(b)**Locator with pink cap insert and **2(c)**Locator with yellow cap insert . Each elastic cap was inserted on the respective epoxy resin model and tightened up to 30N torque.(Fig 5).

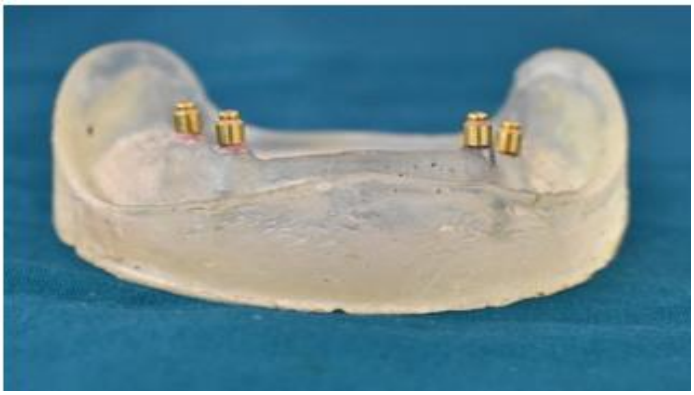


Figure 5: Epoxy model with locator attachment.

Group 3: **Bar attachment (Rhein83)** Castable attachments are placed over implant analogs joined by pattern resin (**Fig 6**). The framework was casted in metal , polished and seated over the epoxy resin model and tightened with 30N torque (**Fig 7**) . Divided into two subgroups**3(a)**Bar attachment with yellow clip insert with medium retention **3 (b)** Bar attachment with pink clip insert with soft retention .

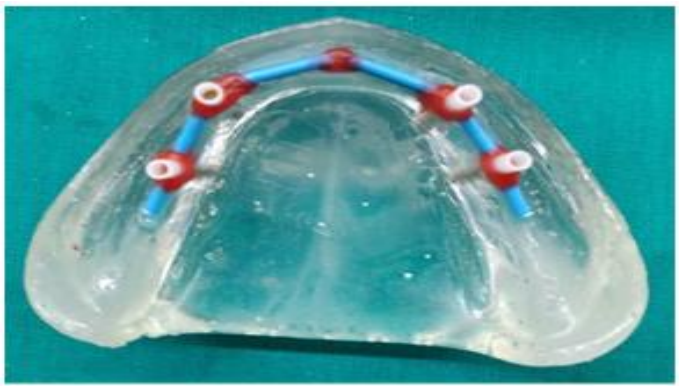


Figure 6: Wax framework of bar attachment.

Figure 7: Metal Framework fabricated for bar attachment

Fabrication of Overdenture

Color coded elastic inserts or housings were attached to the Ball, Locator, and Bar attachments on the epoxy resin models and duplicated with duplicating silicone material for each different insert .After duplicating material was set, epoxy resin models were retrieved carefully. Casts were poured with dental stone into each duplicated silicone mold for overdenture fabrication. Denture bases were fabricated with self-cure acrylic and on them occlusal rims were fabricated with modeling wax. Four metal hooks were attached to the wax occlusal rim, two in the canine region, and two in the second premolar region and it was invested in a dental flask . The resin polymerized[6] overdentures with hooks **(Fig 8)** were trimmed using tungsten carbide burs using low-speed micromotors. Later overdentures with different colored elastic inserts were checked for fit individually on resin models before testing .Total 8 overdentures are fabricated, 3 over dentures each for Ball and Locator attachments, and 2 overdentures for Bar attachment.

Figure 8: Overdentures for bar, ball and locator attachments.

Testing for Initial Retention and Stability

Initial Retention: Four metal chains were attached to metal hooks incorporated into each individual overdenture for testing with Universal testing machine. The Instron universal testing machine (8801 Norwood) controlled by a computer was used to apply maximum seating and dislodging forces for each elastic insert at a cross head speed of 2 mm/secuntil the attachments separated. The maximum peak to dislodgement load in Newtons (N) calculated. Each pull repeated ten times and values were noted and the mean was calculated to represent initial retention of each overdenture . (Fig 9)

Figure 9: Overdenture tested for retention.

Initial Stability: Three types of oblique dislodgement were used to measure denture stability of each overdenture with different colored inserts against rotational movement.

Anterior dislodgement: chains attached to canine area hooks were activated (Fig 10).

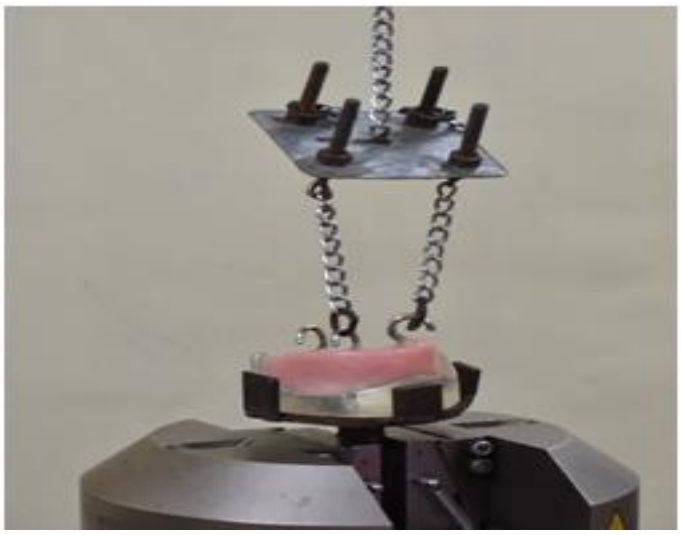


Figure 10: Overdenture tested for anterior stability

Posterior dislodgement: chains attached to posterior premolar area hooks were activated (Fig 11).

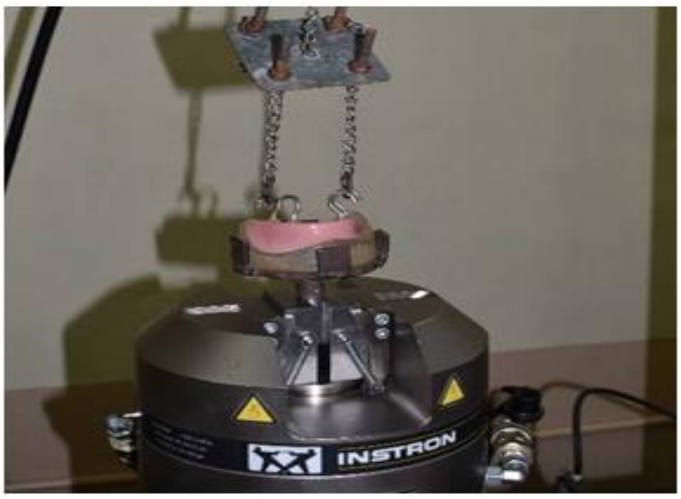


Figure11: Overdenture tested for posterior stability

Lateral dislodgement: chains attached to the right canine and premolar area hooks were activated (Fig 12). The two-point oblique force needed to dislodge the attachments was recorded in (N)[7].Each measurement was repeated ten times, and the mean was used to represent initial stability.

Figure 12: overdenture tested for lateral stability

Thermocycling : After initial testingeach overdenture was inserted and removed from the indicated cast 540 times manually to simulate six months period of overdenture use, based upon the patient's average use of three insertions and removal cycles per day[8]. Then the overdentures were placed in thermocycling unit (Wiliytec 30, Germany) and subjected to thermocycling of 5500 cycles, with temperature control tub ranging from 5 to 55^0 C. Many researchers have employed thermocycling associated to stipulated time of functional wear. Gamborena*et al*. considered that 5,500 placement-removal cycles can simulate 3 years of *in vivo* wear based on an average of five placements and removals daily[9].

Testing for final retention and stability

Final retention

After thermocycling a four-point vertical tensile load or dislodging force was applied on each overdenture at a constant crosshead speed of 2 mm/secuntil the attachments separated in the Universal Testing Machine (UTM). The maximum peak to dislodgement load in Newtons (N)calculated. Each measurement repeated ten times and the mean was used to calculate final retentive values .

Final stability

After thermocycling, similar to initial testing overdentures were subjected to anterior, posterior and lateral dislodgment forces . The two-point oblique force needed to dislodge the overdentures recorded in Newtons(N) . Each dislodgment was repeated ten times, and the mean was used to represent final stability.

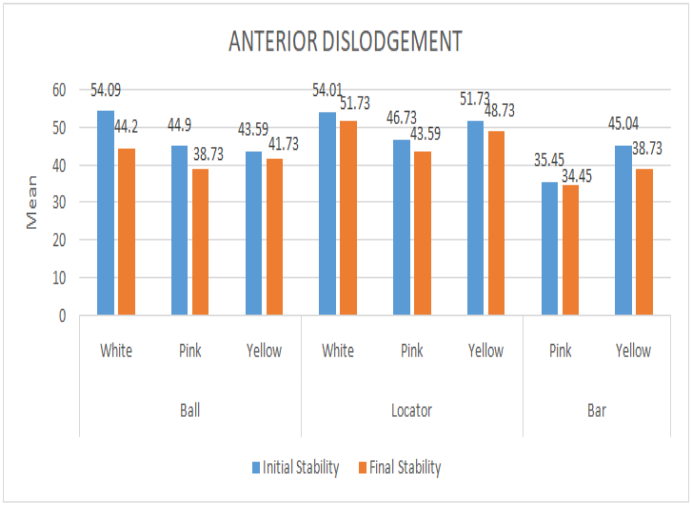
Result

In the **inter-group** comparison The initial and final retention and stability values of Ball attachment (**Group 1**) with white elastic cap insert was found to be high followed by Yellow and Pink inserts .The initial and final retention and stability values of Locator attachment(**Group 2**) with White elastic cap insert was found to be high followed by Yellow and Pink .The initial and final retention and stability values of Bar attachment(**Group 3**) with Yellow elastic clip insert was found to be high followed Pink clip insert.

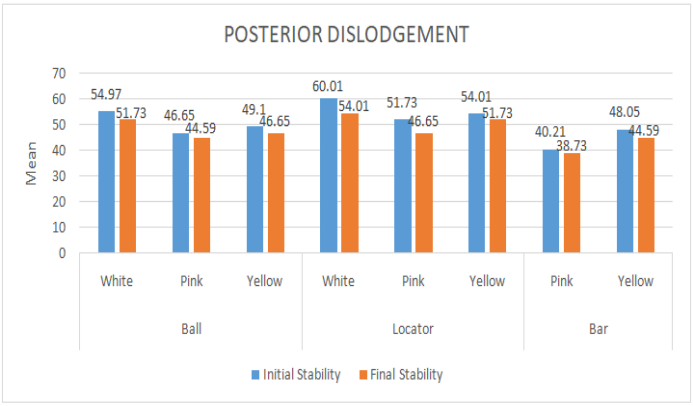
In the **intra-group** comparison the initial and final retentive values of Locator attachment with white elastic cap(Group 1a) insert was higher than rest of all the attachments with different elastic inserts**(Graph 1).**

Graph 1: Comparison of both initial and final retention

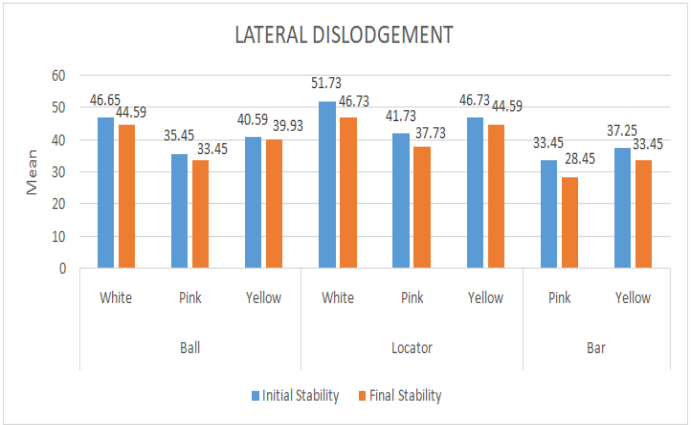
In the intra group comparison of the initial and final stability anterior, posterior and lateral dislodgement values of Locator attachment White elastic insert(Group 1a) were found to be higher than all other attachments with different elastic inserts**(Graph 2, 3, 4)**.The mean values were statistically analyzed using ANOVA, independent t-test and Turkey Post Hoc test. P value <0.05 considered as statistically significant.



Graph 2: Comparison of both initial and final stability in anterior dislodgment



Graph 3: Comparison of both initial and final stability in posterior dislodgment



Graph 4: Comparison of both initial and final stability in lateral dislodgment

Rehabilitation of edentulous ridges poses a high challenge to the prosthodontist. Oral rehabilitation of complete edentulous patients with conventional complete dentures exhibited difficulties of adaptation, lack of retention and stability and lifting of especially mandibular dentures during mastication ,because of alveolar ridge resorption, less denture bearing area compared to maxillae , and tongue movements. A study by Carlsson, on edentulous patients with implant supported complete dentures, suggests that increased occlusal force to 240N, with improved masticatory efficiency, wherein the conventional complete dentures got the occlusal force of only 80N.[10]Zitzmann and Marinello demonstrated patient satisfaction with both fixed detachable and implant-supported overdenture prostheses [11]Investigators have found that a direct relationship exists between prosthesis retention and patient satisfaction.[12]

Another study conducted by the Toman et al [13]compared the masticatory forces and efficiency between the natural dentition, conventional complete dentures and the implant supported over dentures and masticatory efficiency was measured with the kinesiography. It was found that the highest masticatory performance was seen with the natural dentition, followed next with the implant supported over dentures and least was noted with the conventional complete dentures. The concept of attachment system, initially originated in 1869, Gilmore popularised it [14].The type of the attachment system plays a key role in the retention strength [15]. It is necessary to evaluate the retention strength values of these abutments since a proper retention of attachments improves the patient satisfaction. The "attachments", connect the implant fixtures to the over denture .

On comparing the values of initial retention and final retention Locator attachment with White elastic insert had the highest values of retention than other attachments .The significant decrease in retention from the initial testing to the final pull-out test occurred regardless of attachment design [8].This loss of retention has been attributed to wear of attachment components.[16]The retention loss is associated with the increase time period of removal and insertion. Several studies found various degrees of retention loss of different overdenture attachments at the end of the experimental procedures .[17]Wear of attachments appears mainly through friction between the matrix [18]and patrix and plastic deformation of the nylon inserts.[19,20]

In the present study Locator attachment showed better values of retention and stability .The same had been reported in many other studies.[21,22] This could be attributed to the fact that locator attachment has dual retention feature that means the male part will retain on the inside and outside of the abutment.[23]Moreover, the greater cross-section of the locator attachment increases surface area available for frictional contact between components of these attachments.[23]However, the bar attachment showed less resistance to rotational dislodgment due to limited contact areas between the clips and bars. Furthermore, in function, overdentures are subjected to three dimensional displacements, and the direction of forces can be a combination of vertical, oblique, rotational, and horizontal.[24] Therefore, overdenture resistance to nonaxial dislodging forces (stability) is important, as is resistance to axial dislodging forces (retention).

Conclusion

Locator attachment with white elastic silicon cap insert (group 1a) was found to be having highest retention and stability when compared to other attachments .The least

retention and stability was found in Bar attachment with pink elastic clip insert (group 3b) . It can be concluded that locator attachment system has better retentive and stability values than ball and bar attachment implant systems.

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