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Original Research Article

A comparative evaluation of retention capacity of different dental implant supported overdenture attachment systems- An in vitro study

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ABSTRACT

Background/Introduction: The most common way to treat full edentulism is with a complete denture. In the mandible as opposed to the maxilla, there is greater worry over the durability and retention of a traditional complete denture. The mandibular arch's decreased surface area for support and retention is the main cause of this. For a fully edentulous mandible, implant-supported overdentures are a reliable course of treatment.

Aim: This in-vitro study aimed at comparing the retentive capacity of Ball, Locator and OT Equator Implant supported overdenture attachment system when subjected to 14600 cycles of insertion and de-insertion.

Materials and Methods : Fifteen mandibular dentures were fabricated with heat polymerized polymethyl methacrylate resin to test the retentive capacity of Ball, Locator and OT Equator attachment system. Metal housing with retentive nylon caps were picked up in all the sample using cold cure acrylic resin. The samples were subjected to fatigue testing and only monodirectional force was applied. Ball, Locator and OT Equator attachment system sample were subjected to 14,600 insertion/ de insertion cycle on Universal Testing Machine and data was recorded and statistical analysis was done.

Result: All the three groups showed significant differences.

Conclusion: The retentive capacity of the Ball attachments lasts longer than that of the Locator and Equator attachments. After ten years of use, All three systems continue to have clinically acceptable retention.

1. Introduction

The most common way to treat full edentulism is with a complete denture. In the mandible as opposed to the maxilla, there is a greater concern of the durability and retention of a traditional complete denture. The mandibular arch's smaller surface area for support and retention is the main cause of this. Consequently, for a fully edentulous mandible, implant-supported overdentures constitute a dependable therapeutic option.[1]

The discovery of dental implants, which offer dependable and predictable "root analogues," restored interest in the application of the overdenture idea. Mc Gill says the typical treatment for an edentulous mandible should be an overdenture supported by two implants.[2]

Mandibular over dentures are held in place using a variety of attachment methods, such as magnets, studs, and bars with clips. Because of their uncomplicated use, studs and magnets are becoming increasingly common in clinical practice,[3]

Because they are cost-effective, easy to use, require little chair side time, and may be utilised with both

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implant- and root-supported prostheses, ball attachments are among the most basic types of stud attachments. The locator attachment system is an attachment system with dual retention (inner and exterior) and self-aligning properties. When retrofitting an old denture or in situations where interocclusal space is limited, the attachment's lower height is beneficial.[4] A robust and self-aligning attachment mechanism with steady retention is the OT-Equator. It is simple to utilise in patients with significantly compromised inter-arch space because of its modest profile.[5] This in-vitro study aimed at comparing the retentive capacity of Ball, Locator and OT Equator Implant supported overdenture attachment systems.

2. Materials and Methods

This study was conducted at Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital in Navi Mumbai, in the Department of Prosthodontics and Crown & Bridge. Edentulous mandibular clear acrylic model with Ball, Locator and Equator attachment systems placed in the canine region were used in this study. The attachment system was placed in the acrylic model using milling machine to maintain the parallel path of placement.

2.1. Implant supported overdenture attachment system

For every group, three overdenture models and five complete dentures were made. (Figures 1, 3 and 5) The Mold of the master model was made using condensation silicone. Mandibular dentures made of heat-polymerized polymethyl methacrylate resin were made in the conventional manner after mandibular dental stone casts were poured into and removed from the mould.

Housing pickup (Figures 2, 4 and 6)

1. Metal housing with a processing insert was placed over the attachment.
2. The denture was prepared for the intra oral processing of the matrices/metal housing.
3. A protective disk/ring was placed prior to placement of metal housing such that extra adhesive doesn't flow.
4. Metal housings were bonded with a denture using cold cure acrylic resin.
5. After polymerization, the denture was removed and excess resin around the metal housing was trimmed and finished
6. The processing inserts were replaced with nylon retention inserts.

Group A

This group included Ball attachment with metal housing and nylon retention inserts.

Group B

This group included Locator attachment with metal housing and nylon retention inserts

Figure 1: Ball analog placed in the edentulous model

Figure 2: Denture with metal housing and nylon insert

Figure 3: Positioner analog placed in the edentulous model

Figure 4: Denture with metal housing and nylon insert

Group C

This group included OT Equator attachment with metal housings and nylon retention inserts.

Figure 5: OT Equator analog placed in the edentulous model

On the acrylic edentulous mandibular models, acrylic overdentures were placed with corresponding attachment mechanisms. In order to attach the dentures to the universal testing equipment, metallic wire was attached to the first molar region on both sides of the dentures and sealed with clear autopolymerized acrylic resin. Several attachment points on a metallic wire that could be quickly inserted and removed for testing were integrated into the overdenture. (Figure 7). A surveyor table was used for fixing the acrylic edentulous model into position. (Figure 7)

A vertical force was used to dislodge the overdenture with the Universal Testing Machine from the centre of the acrylic block that connected the two metallic wires.Each of the five specimens in each group underwent 14,600 insertion/de-insertion cycles according to the test machine's programming. Over a ten-year period, this statistic indicates

Figure 6: Denture with metal housing and nylon insert

the wearer's estimated daily usage of the prosthesis, removing and reinserting the overdenture four times each day.[6]

The movement in the cycle was 2 mm upward at 50 mm/min crosshead speed, followed by a similar downward movement. According to reports, the denture will move away from the edentulous ridge at a crosshead speed that approximates clinically relevant movement.[7] Twelve values at cycles 0, 100, 500, 1000, 2000, 3000, 4000, 5000, 7500, 10,000, and 14,600 were averaged and reported for statistical analysis.

Figure 7: Testing of Sample on UTM machine Observation and Result

The mean retention capacity and standard deviation for each group at 0 cycle was calculated and the readings were noted. After that all the samples were subjected to 14600 cycles and mean values and standard deviation was calculated after insertion /de-insertion cycle.

The above (Table 1) compared the mean retention capacity of Ball, Locator and OT Equator attachment system at 0 cycle. The graph showed highest mean for Ball Attachment System and lowest mean for OT Equator

Table 1: Comparison of mean and standard deviations of all test groups at 0 cycle

Group	Mean	Standard d eviation	p value
A	43.6100	1.41163	
B	37.0460	1.18879	0.01
C	27.5260	1.30307	

Attachment System at 0 cycle.

Table 2: Comparison of mean and standard deviations of all test groups at 14600 cycle

Group	Mean	Standard deviation	p value
A	4.9000	0.7074	
B	3.6920	0.5274	0.01
C	1.9300	0.4566	

The above (Table 2) compared the mean retention capacity of Ball, Locator and OT Equator attachment system at 14600 cycles. The graph showed highest mean for Ball Attachment System and lowest mean for OT Equator Attachment System at 14600 cycles also.

The highest mean was found for Group A (43.61) at 0 cycle as well as 14600 cycle (4.90) i.e., ball attachment system with metal housing and retentive nylon insert, while the lowest mean was for Group C (27.52) at 0 cycle as well as 14600 cycle (1.93) i.e., equator attachment system with metal housing and retentive nylon insert.

Highest standard deviation was found for Group A (1.41) at 0 cycle as well as 14600 cycle (0.70) i.e., the ball attachment group. The least standard deviation was for Group C (1.30) at 0 cycle as well as 14600 cycle (0.45) i.e., equator attachment group.

ANOVA test was done to compare the mean retentive capacity among different groups. Highest mean was recorded in group A, followed by group B and group C. Difference in mean among the groups was found to be statistically significant (p=0.01)

As the results of ANOVA test revealed a significant difference (p=0.01) amongst the groups, post hoc test (Bonferroni) was done for further analysis. Significant difference was noted while comparing one group with another at 0 cycle and at 14600 cycless. The study proves alternate hypothesis i.e., there is significant difference between each group as well as different group and rejects null hypothesis.

3. Discussion

When it comes to mandibular complete dentures in particular, residual ridge resorption is one of the primary causes of denture instability and retention loss. A sunken face aspect, unstable and non-retentive dentures, and accompanying pain and discomfort are the result of extreme resorption of the maxillary and mandibular ridges.[8–12] As a result, it presents a clinical barrier for the creation of an effective removable prosthesis. Comparing the ball attachment to the bar attachment and the magnet attachment, RNaert et al.[13] found that the ball attachments are the best in terms of soft tissue complications and satisfaction among patients.

In 2011, Rutkunas et al.[14] looked at Locator pink, white, and blue (LRP, LRW, and LRB), ERA orange and white (EO and EW), and OP anchor (OP). For wear simulation, five specimens were used. To mimic the wear of overdenture attachments, 15,000 continuous insertion-removal cycles in an axial direction were performed. With the exception of OP, all attachments showed retention loss after 15,000 insertion-removal cycles. However, there was a noticeable and statistically significant decline in the retention of EO and EW (87–88%). The result of present study is in accordance with study as, after 14600 insertion/de insertion cycle the attachment exhibited loss in retention and the decrease in retention was statistically significant.

Suetz J et alinvestigated bar, ball and magnetic attachment.[15] All these attachment systems were subjected to 15000 insertion and removal. The range of retentive forces was 3–85 N. Initial force increase with certain attachments were found during the fatigue test. Again supporting the current investigation, after 15,000 cycles, the majority of the attachments exhibited minimal retention loss when compared to the original retentive forces. Despite having a distinct attachment system, they underwent 15,000 insertion and removal cycles. Retention decreased, and this decline was statistically significant. 1.9 N to 43 N was the range of the retentive force when compared to the stud attachment mechanism.[16]

Using maximum retentive force, Rutkanas et al.[3] assessed the wear and tear of stud ERA Overdenture (orange and white), Locator Root (pink), OP anchor, and magnetic (Magfit EX600W) attachments. Two thousand cycles of insertion-removal were carried out on specimens. At the baseline, the retentive force was measured between 3 and 12 N. Nevertheless, it dropped to 3-6 N after 2000 insertion-removal cycles. Once more, different stud attachments were used, but the retention force gradually decreased. Following the 2000 cycle, locator attachment revealed a 30.98N drop in retention capacity.

Following 14,600 insertion/de-insertion cycles of fatigue testing, Tomas N. et al. (2006)[6] examined the development of the retention capacity of two overdenture attachment systems, Locator and Equator. There was a noticeable decline in retention capacity over time, which is shown in favour of this study.

In this study, the retention capacities of three overdenture attachment systems tested with 14,600 insertion/de-insertion cycles were compared. Over a ten-year period, this statistic indicates the wearer's estimated daily usage of the prosthesis, removing and reinserting the overdenture four

Table 3: Comparison of all groups using one way ANOVA at 0 cycle

	Sum of s quares	df	Mean s quare	F	Sig.
Between groups	654.019	2	327.010	192.211	.01
Within groups	20.416	12	1.701		
Total	674.435	14			

Table 4: Comparison of all groups using one way ANOVA at 14600 cycles

	Sum of s quares	df	Mean s quare	F	Sig.
Between groups	22.308	2	11.154	33.895	.01
Within gGroups	3.949	12	0.329		
Total	26.257	14			

times each day.[6]

Following 14,600 cycles, the current study's final retention values for the ball system were 4.9+0.7 N, 3.62± 0.5 N for the Locator system, and 1.9 ± 0.4 N for the Equator system. For the ball system, the mean value at 10,000 cycles was 12.70, for the Locator system it was 9.24, and for the OT Equator system it was 5.25. All of these values were within the permissible ranges for OD stability maintenance.

There are certain restrictions on the experimental setup for this investigation, which assessed the retentive forces of three distinct kinds of anchorage systems utilised for implant-supported overdentures. The study was carried out under controlled experimental simulation.

1. The specimen used had a very small sample size.
2. The application of monodirectional pressures alone does not adequately replicate a clinical scenario with overdentures. The primary forces are generated at the first molars, and through leverage, these forces rotate the attachments.
3. The samples were not subjected to thermocycling to simulate the oral condition.

4. Conclusion

Within the limitation of this study, it can be concluded that:

1. The Ball attachments are more retentive than the Locator and Equator attachments in terms of retention time.
2. All three attachment techniques showed a statistically significant decrease in retention force following exposure to 14600 cycles, which correspond to regular prosthetic use over a ten-year period.
3. After ten years of use, all three systems continued to have clinically acceptable retention.

5. Clinical Significance of Study

The aforementioned study will assist the practitioner in selecting an overdenture attachment system. To attach implant to overdenture, a large range of commercially available attachment systems are used. This study compared the retention capacities of three commonly used overdenture attachment systems: the Ball, Locator, and OT Equator attachment systems. The results showed that all three systems have clinically acceptable retention and can be used; however, selecting the right overdenture attachment type requires careful consideration of a number of factors, including the mandibular anatomy, desired level of retention, available interarch space, ability to maintain hygiene, implant parallelism, and cost considerations. Additionally, the issues associated with conventional dentures are resolved by the attachment-retained implant-supported overdenture.

6. Author Contributions

1. Dr. Saimah Shamim: Data curation, Formal analysis, Methodology, Validation, Writing – original draft.
2. Dr. Mridula Joshi: Data curation, Investigation, Methodology, Project administration, Supervision.
3. Dr. Mangal Mishra: Data curation, Investigation, Methodology, Software.
4. Dr. Sumit Bedia: Formal analysis, Methodology, Resources, Visualization.
5. Dr. Mahesh Ghadage: Project administration, Resources, Supervision, Writing – review editing.
6. Dr. Uttam Shetty: Methodology, Resources, Software, Writing – review editing.

7. Source of Funding

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8. Conflict of Interest

None.

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