Original Article

Effect of Locator and Telescopic Attachment on Retention value for Two-Piece and One-Piece Implant-Supported Palateless Maxillary Over Denture: An In-vitro study

kawan S. Othman[1*]

Abstract

Objective: This study aims to evaluate the effect of two different implant designs (one-piece dental implant and two-piece dental implant) with attachment systems on retention value in implant-supported palate less maxillary overdenture.

Methods: Two edentulous maxillary models were fabricated from cold-cure polymethyl methacrylate resin. Four implants were inserted for each model as follows: Model I (Four one-piece implants were inserted, two implants in the canine region and two implants in the second premolar region), while Model II (Four two-piece implants were inserted, two implants in the canine region and two implants in second premolar region). The maxillary denture was constructed over each model. In model I, four ready-made titanium telescopic attachments corresponding to implant abutments were embedded in the inner surface of the overdenture. In contrast, in model II, four locator attachments corresponding to implant abutments were embedded in the inner surface of the overdenture. Initial anterior, posterior, and central retention values of overdentures were recorded and compared with the retention after 540 and 1080 cycles of insertion and removal using a digital force gauge.

Results: Statistical analysis revealed significant differences in the initial, secondary and tertiary retention values for anterior, posterior, and central retentions for both models (higher values were recorded before insertion cycles). The higher anterior and central retention values were recorded in Model II (44.93 and 25.9) N respectively, on the other hand, the higher posterior retention value was recorded for Model I 23.3N.

Conclusions: The type of attachment affects the retention value of maxillary overdenture. Continuous insertion and removal of the prosthesis lead to a decrease in the retention values.

Keywords: *Overdenture, Locators, Telescopic attachment, Retention.*

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1. *Department of Prosthodontics, College of Dentistry, University of Sulaimani, Sulaimani, Iraq.*

** Corresponding author: kawan.othman@univsul.edu.iq*

Introduction

Maxillary implant-supported overdentures can be considered a suitable treatment option in cases of insufficient bone volume and complaints about retention and stability of the complete denture[1]. Moreover, these overdentures are indicated for patients with the atrophied maxilla, poor bone quality, high lip line, buccal bone inclination, thin mobile mucosa, and insufficient lip support to achieve proper aesthetics and phonetics[2].

Selection of palateless maxillary overdenture over full palatal coverage offers several benefits for the patients, including an enhanced taste sensation, better control of the gag reflex, a positive effect on salivary flow rate, and even phonetic benefits. Also, it can be used in patients with large maxillary tori or bony exostoses[3]. In addition, it has been demonstrated that palateless maxillary overdenture as an effective, predictable treatment for edentulous maxilla; a prospective clinical study was concluded that a maxillary four implant palateless overdenture was a successful treatment option in terms of implant survival and implant marginal bone level[4].

Different implant designs (Two-piece and One-piece dental implant) and different attachments are available for overdentures. Attachment systems were classified into splinted attachments as bars and non-splinted attachments as locators, ball attachments, magnets, and telescopic crowns[5]. The selection of a particular attachment for maxillary overdentures is dependent on the retention required, inter-arch distance, jaw anatomy, and patient compliance for recall to perform adequate maintenance[6]. Non-splinted attachments are considered more favorable since they are more economical, easier to clean, and less technique sensitive than splinted attachments[7].

Implant design and attachment type may affect the retention of maxillary implant-supported overdentures and consequently patient satisfaction. In reviewing the literature, few studies evaluated the retention of maxillary implant-supported overdenture with O-ring, Locator, and Hader bar attachments[6]. However, the retention of palateless maxillary implant-supported overdenture with locater and ready-made titanium telescopic attachment is not evaluated yet. Therefore, this in-vitro study aimed to evaluate and compare the retention of locater and ready-made telescopic attachments used to retain palateless maxillary implant-supported overdenture.

Materials and Methods

Study models

Two edentulous maxillary models were fabricated from cold-cure polymethyl methacrylate resin (Orthocryl Clear Acryl Resin- Dental Dentaurum-Germany). To simulate edentulous mucosa, the denture bearing area was covered by approximately 2 mm thick silicone resilient liner (Soft base-Bisico-Germany); for controlling the uniform thickness of the soft liner, a ready-made ethylene sheet plate (Nightguard plate) was adapted inside the edentulous maxillary mold for providing space for the silicon resilient liner material[8].

In the model, I, four one-piece compressive long necks (bendable) dental implants (Rootts implants - TRATE AG - a Swiss-based company) 4.0 mm in diameter and 10.0 mm in length were placed (2 implants in the canine region and two implants in the second premolar region), while in model II, four two-piece Rootform dental implants (Rootts implants - TRATE AG - a Swiss-based company) 3.8 mm in diameter and 10.0 mm in length were placed (2 implants in the canine region and two implants in second premolar region).

A maxillary denture was used as a surgical guide to indicate the exact location for each implant site. Simultaneously, the parallelism of the dental implant was achieved by using a dental surveyor[9].

Impression technique

A primary impression was taken for each model using a putty consistency condensation silicone impression material (MAJOR - Prodotti Dentari S.p.A - Italy)**.** After the transfers (TRA-Rootts-TRATE AG-Switzerland) were placed on the implants, the secondary impression was taken with a special tray using addition silicone (medium consistency) impression material (PD – President Dental – Germany) by single-step impression technique. Then the analogs were placed inside the transfer position in the impression then poured with dental stone (SHERAPLASTER-Type 3- SHERA-Germany).

Telescopic and locator attachments

For Model I, four ready-made Titanium telescopic caps (TCE1, Rootts - TRATE AG - a Swiss-based company) were used as a secondary coping with imbuing inside the denture base. As a result, the implant's abutment is regarded as a primary coping (7mm length, 3mm

diameter, 5^0 tapers) (Figure 1 A). While for Model II, four ready-made Locator abutments (Root - TRATE AG - a Swiss-based company) were screwed on the implants, and the corresponding parts were embedded inside the denture (Figure 1 B).

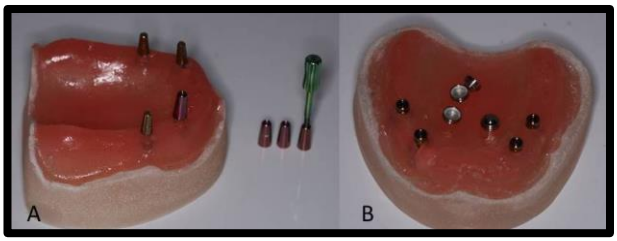

Figure 1: (A) Model I; one-piece dental implants with ready-made titanium telescopic cap. (B) Model II; two-piece dental implants with locator attachment.

Overdenture fabrication

Two experimental palateless overdentures were constructed, one for each model. Each overdenture was individually processed and polymerized. A conventional heat-polymerized processing technique was used[10]. The titanium telescopic caps and the locators were embedded into each denture base (Figure 2). For evaluation of retention value, four U-shaped stainless-steel wire loops (0.9 mm diameter) with retentive tags were attached via cold cure acrylic resin to the denture's polished surface, palatal to canines, and second molars. The U-shaped loops on both sides of the denture were connected with stainless steel wires (0.5 mm diameter)[11].

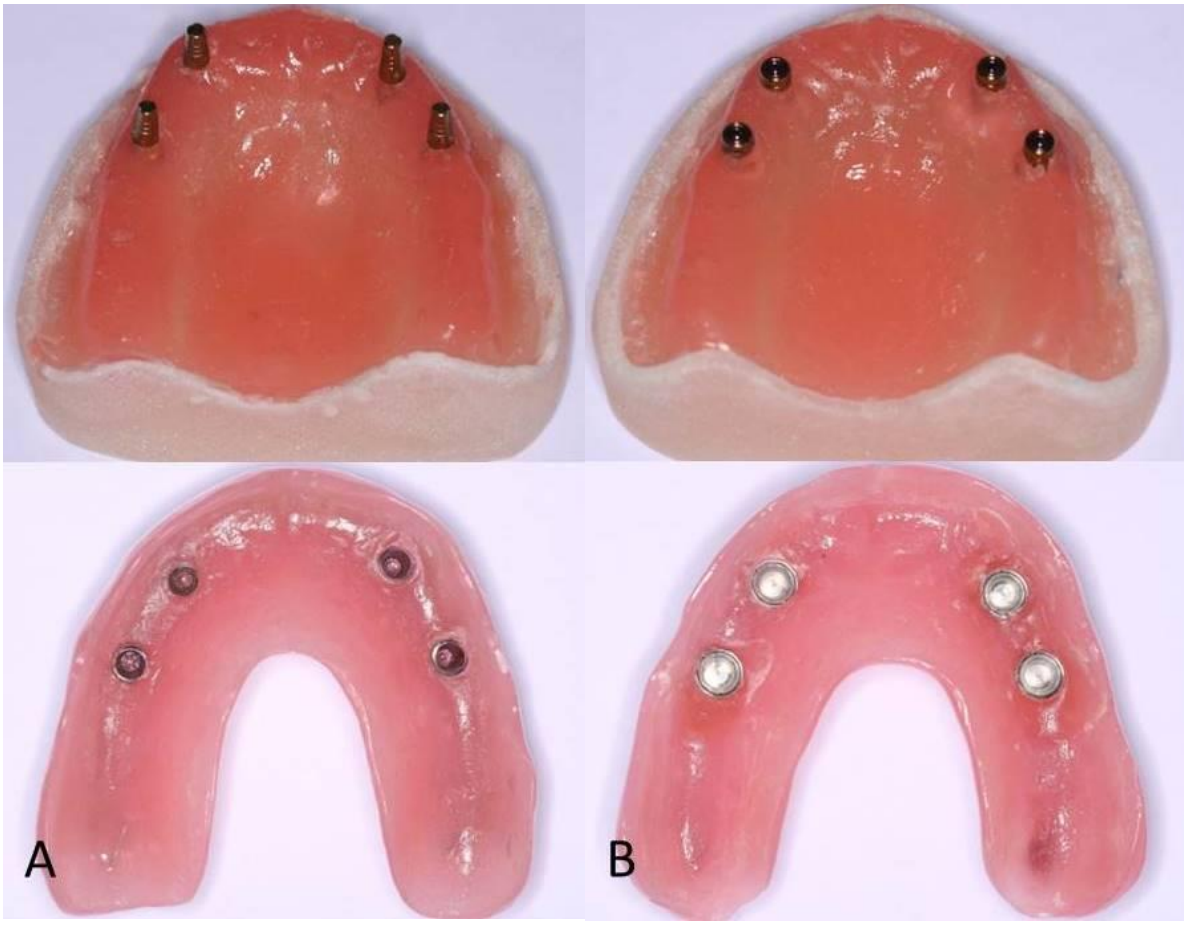

Figure 2: Models with overdentures; (A) overdenture with telescopic attachments, (B) overdenture with locator attachments.

Retention evaluation process

Artificial saliva (SALIVEZE™-WYVERN MEDICAL LTD-UK) was applied to the models and the inner side of the overdentures before recording the retention value in order to mimic the oral environment (between every ten insertions and removal to maintain the moisture of the surface)[12]. A digital force gauge (Nextech DFS500-Nextech-Thailand) was used to record maximum dislodging forces[13,14]. The digital force gauge was fixed to the upper portion of the stand, and the model was stabilized to the stand base by screwing it (Figure 3 A). The hook of the force gauge was attached to anterior, posterior, and central wires to measure overdentures anterior, posterior, and central retentions, respectively. The digital force gauge was slowly lifted by rotating the stand until the denture base was dislodged, and the peak value was recorded in Newton as a retention value[9,15].

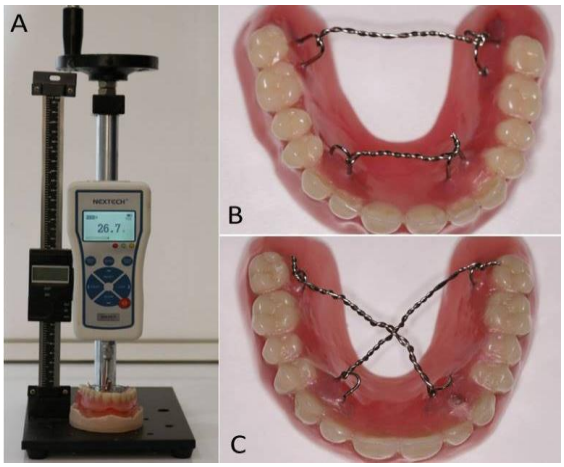

Figure 3: (A) Digital force gauge and the model attached to test stand, (B) anterior and posterior wire to measure anterior and posterior retention, (C) two diagonal wires meet in a crossing point to measure central retention.

Ten measurements (maximum dislodging force) were recorded for each site (anterior, posterior, and central). First, the average of the ten readings was calculated, and the mean value was used to represent initial retention. Then each overdenture was inserted and removed (540 times in central crossing point) to simulate six months of overdenture use (assuming three daily removals and insertions for oral hygiene). Then another ten measurements were performed for each site (anterior, posterior, and central), and the means were used to represent secondary retention. Then each overdenture was inserted and removed another 540 times more to simulate another six months of overdenture use (1year use). Finally, another ten measurements for each site (anterior, posterior, and central) were recorded, in which the means were used to represent tertiary retention[16].

For oblique (non-axial) dislodging force: two types of rotational dislodgements were investigated; first, anterior rotational dislodgement, when a stainless-steel wire connecting two hooks of left and right canines, and the wire was attached to the digital force gauge. Second, posterior rotational dislodgement occurred when a stainless-steel wire connected two hooks on the left and right second molars, and the wire was attached to the digital force gauge (Figure 3 B). For vertically (axial) dislodging force: two diagonal wires meet in a crossing point to measure central retention (Figure 3 C)[9,17].

Statistical analysis

SPSS (ver. 25) software (SPSS Inc.) was used for statistical analysis. A one-way ANOVA test was applied to determine the difference between the initial, secondary, and tertiary retention values. While Independent sample t-test was applied for determining the difference between the means of retention values of Telescopic and Locator attachment, where the significance alpha level was set at $p<0.05$.

Results

Locator attachment

One-way ANOVA test revealed statistically significant differences in the initial, secondary and tertiary retention values for anterior, posterior, and central retentions (Table 1).

There was a big drop down in the value of anterior retention from initial to secondary and then from secondary to tertiary retention nearly about 10 N. While posterior retention showed a decrease in retention value from the initial to secondary nearly about 5 N and then a little decrease was observed between secondary and tertiary retention less than 1 N. On the other hand, there was a slight gradual decrease in the central retention value between initial, secondary, and tertiary retention evaluation.

Telescopic attachment

One-way ANOVA test also showed statistically significant differences in the initial, secondary, and tertiary retention values for all anterior, posterior, and central retentions. In general, anterior, posterior, and central retention values were decreased by nearly about 5 N in between initial, secondary, and tertiary retention testes, Table 2.

Table 1: Comparison of initial, secondary and final retention value in locator attachment (in Newton).

		N	Mean ± SD	p-value
Anterior	Initial anterior retention	10	55.79 ± 1.1939	≤ 0.001
	Secondary anterior retention	10	45.90 ± 0.5944	
	Tertiary anterior retention	10	33.12 ± 1.0810	
Posterior	Initial posterior retention	10	22.76 ± 0.4971	≤ 0.001
	Secondary posterior retention	10	17.79 ± 0.5466	
	Tertiary posterior retention	10	17.00 ± 0.3399	
Central	Initial central retention	10	26.77 ± 1.2338	≤ 0.001
	Secondary central retention	10	25.84 ± 1.4135	
	Tertiary central retention	10	22.68 ± 1.2514	

SD: standard deviation
P-value is significant at 5% level

Table 2: Comparison of initial, secondary and final retention value in the telescopic attachment (in Newton).

		N	Mean ± SD	p-value
Anterior	Initial anterior retention	10	21.56 ± 1.09565	≤ 0.001
	Secondary anterior retention	10	16.38 ± 1.38066	
	Tertiary anterior retention	10	12.07 ± 1.18795	
Posterior	Initial posterior retention	10	28.78 ± 1.59708	≤ 0.001
	Secondary posterior retention	10	23.39 ± 2.61638	
	Tertiary posterior retention	10	17.74 ± 0.69154	
Central	Initial central retention	10	28.51 ± 2.63205	≤ 0.001
	Secondary central retention	10	18.74 ± 1.36072	
	Tertiary central retention	10	15.07 ± 1.06776	

SD: standard deviation
p-value is significant at 5% level

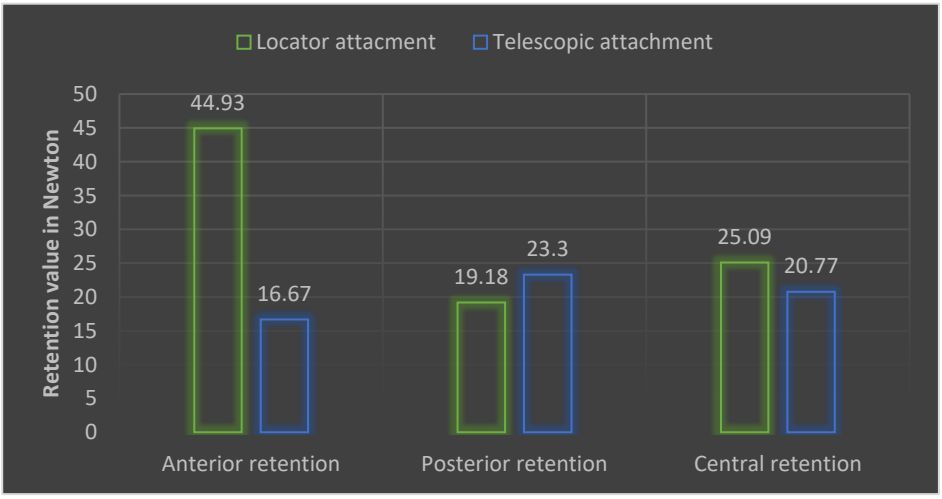

Figure 4: Comparison of retention value (initial, secondary, and tertiary) in locator and telescopic attachment (in Newton).

Comparison between Locator and Telescopic attachment

Independent sample t-test revealed statistically significant differences in anterior, posterior, and central retention values between Locater and Telescopic attachment, Figure 4.

Higher anterior and central retention values were recorded for Locator attachment 44.93 and 25.09 N, respectively, while higher posterior retention values were recorded for Telescopic attachment 23.3 N.

Discussion

Locator attachment

Anterior retentions recorded greater retention values than the central and the posterior retentions. The central retentions recorded greater retention values than the posterior in all three different readings (Initial, secondary, and tertiary). These differences in the number of retention values are attributed to the horizontal distance between the dislodging force point and the nearest locator's location.

In anterior retention tests, the horizontal distance between the point of dislodging force (Anterior loop) and the anterior locators (Canine regions) is too little; that's why great retention value was recorded in initial, secondary, and tertiary tests 55.79, 45.9, and 33.12 newtons respectively. On the other hand, while the horizontal distance between the dislodging force (posterior loop) and the distal locators (2nd premolar area) in testing the posterior retention is greater than the distance in the anterior retention test, that's why the lowest retention value was recorded in initial, secondary and tertiary posterior retentions 22.76, 17.79, and 17.00 newton respectively. On the other hand, during central testing retention, the horizontal distances between the dislodging force (central loop) and the locators (canine and 2nd premolar regions) were shorter, compared to that distance in posterior retention test, and longer compared to that distance in anterior retention test, so the central retention values were greater than posterior retention values and smaller than anterior retention values in all initial, secondary, and tertiary tests 26.77, 25.84, and 22.68 newtons respectively. This result agrees with the study by Scherer et al., in which they stated that the posterior retention value increases when the implant locations are placed distally[18]. And it's also concomitant with the study of Michelinakis et al., who revealed that inter implant distance could affect the retention of implant-supported overdenture[19].

A significant decrease in the amount of retention (secondary and tertiary) values was noted after 540 and 1080 times insertion and removal; this is greatly related to some plastic deformation that may happen inside the locater plastic rings during multiple removals and insertions, as a result of the withdrawal of the rings in the undercuts of the attachment abutments.

Telescopic attachment

The advantages of telescopic attachment are ease in performing routine oral hygiene, long-term patient satisfaction, better marginal adaptation, and axial force transmission. At the same time, the disadvantages are difficulty in achieving aesthetics, complex laboratory procedures, and additional cost to the patient[20]. To overcome the disadvantage of conventional telescopic attachment, a ready-made titanium telescopic attachment was used in this study. This type of telescopic attachment has several advantages over the conventional one, as a simple laboratory procedure, less time-consuming, cost-effective, and simple repairing procedure.

In opposite to locater attachment, in the telescopic attachment model greatest retention value was recorded in the posterior region (not in the anterior region), followed by the central region. The lowest retention was recorded in the anterior region (Table 2); this change in the amount of retentions in response to the different dislodging force points is related to the height of the abutment of one-piece dental implant and height of the titanium telescopic cup, which is 7mm. In the posterior retention test, the dislodging force was far away from the distal implants, so during the test, the height of telescopic attachment and the abutment will create greater resistance for the denture to be dislodged from the model or rotate around the axis of the fulcrum line (which is located anterior to anterior implants).

Similar to the locater attachment here also the retention values were significantly decreased after repeated removal and insertion of the overdenture on the model (540 and 1080 times); the reason behind that may be related to the slight wearing of the inner side of the telescopic cup as a result of multiple frictional forces of removal and insertion. There may be another reason besides that, in the telescopic attachment, the amount of insertion or adaptation force that was put on the prosthesis to be seated on the model will affect dislodging force, that's to say whenever the adaptation

force was greater after putting the denture on the model, the dislodging force or the retention value was greater too. This circumstance was related to the specific design of the ready-made telescopic cup with the abutment of the one-piece dental implant.

Pigozo et al. stated that the retention value from 5 to 7 N was sufficient to stabilize overdentures during a long-term function to achieve good patient satisfaction[20]. However, in the present study, the lowest retention value recorded for telescopic attachment after 1080 insertion and removal was 12.07 N, which is nearly double that satisfied range value.

Conclusions

Based on this in vitro study, it can be concluded that: The type of attachment can affect the value of retention; locator attachments show greater retention value than telescopic attachment (especially in anterior and central retention). The horizontal distance between the dislodging force and attachments affects the retention value; the shorter the horizontal distance is, the higher the retention value becomes. While in locator attachments, besides the horizontal distance between the dislodging force and the telescopic attachments, the height of the abutment and telescopic cup also affects the retention value; that's to say, taller abutment provides more surface area with the telescopic cup, so more frictions and greater retention values become. For both Locator and Telescopic attachments, retention values were continuously reduced after continuous insertion and removal of the prosthesis for daily hygiene practice.

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