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The Influence of Palatal Coverage on the Retention Force and Fatigue Resistance of Mini Dental Implant Maxillary Overdenture

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Abstract

Purpose: evaluation and comparison of the influence of palatal coverage on the retention force and fatigue resistance of attachment system of mini dental implant (MDIs) overdenture.

Materials and methods: heat-cured polymethylmethacrylate resin maxillary acrylic resin models were used for this study. Five 2.5 × 13 mm dummy mini-dental implants with O-ring attachment were placed parallel to each other. Ten palateless implant retained overdenture, and ten full coverage implant retained overdenture were constructed on the models. Both of them, retention and cyclic fatigue tests of each overdenture were measured using BENDAO tools of the universal testing machine and average reading was calculated.

Result: (Group I) mini-dental implant overdenture with palatal coverage recorded higher retention means value (25.55 ± 2.17 N) than (group II) mini-dental implant overdenture without palatal coverage (palate-less overdenture) (24.215 ± 3.64 N). the cyclic fatigue test for the (group I) mini-dental implant overdenture with palatal coverage Showed that the retention decreased significantly with time as indicated by ANOVA test ($p < 0.05$), While for (group II) mini-dental implant overdenture without palatal coverage (palate-less overdenture) was found that the retention was insignificant decrease in the first month; then it significantly decrease in the remaining periods of the study as indicated by ANOVA test ($p < 0.05$).

Conclusion: Within the limitations of this *in vitro* study it can be concluded that the mini-dental implant overdenture with palatal coverage showed superior retentive properties when compared with mini-dental implant overdenture without palatal coverage (palate-less overdenture). Both study groups showed a reduction in retention after cyclic fatigue period.

Keywords: Mini implants; Palate-less overdentures; O-ring attachment; Retention; Cyclic fatigue test

Introduction

Dental science has developed gradually over the years from its prelude up to now; presenting numerous solutions for edentulism. One of the most annoying problem adversely affect the quality of life of denture wearer is improper prosthesis retention [1,2].

When designing a maxillary denture, complete palatal coverage has been generally extended to near the vibration line; [3] results in a superfluous projection into the mouth, as morphological changes of the palate are less comparing the residual ridges over the denture-wearing period [4]. Omission of palatal coverage of the maxillary denture unpropitious have an impact on its retention, so implants were installed to maintain support, stability, and retention [5,6]. Implant-retained maxillary overdentures considered an appropriate treatment in insufficient bone condition and complaints about stability and retention of the complete denture [7].

The use of mini dental implant (MDIs) overdenture becomes a rapid and technically easier replacement of the conventional implant overdenture [8]. In comparison with conventional-diameter implants, MDIs are cost-effective, have fewer complications during flapless implant placement and, can be used in edentulous arches with minimal remaining bone in a facial–lingual dimension to avoid bone graft [9].

MDIs also have the advatntages of single-stage conventional-diameter implants including short healing time, minimal post-operative discomfort and immediate restoration of mastication and aesthetics for patients during the healing period [10]. While, narrow diameter of MDIs put a question mark for the capability of osseointegration. Moreover, with the absence of palatal portion, which indeed sharing in support and retention, may cause inconspicuous success rate. The minimum number of MDIs required for convenient retention of complete removable dentures may be 6 in the maxilla and 4 in the mandible [11].

As claimed by Lehmann and Arnim [12], attachment retention forces from 5 to 7 N should be sufficient to stabilize overdentures during function. However, daily wear, such as overdenture removal and insertion, as well as the oral microbiological environment may lead to forfeiture of overdenture component function, and accordingly fiasco of the attachment system. Few researches have correlated extent of overdenture use with common attachments to procure dependable information concerning attachment retention during fatigue tests to assist in the election of an adequate attachment system for each situation [13].

Based on existing literature, the goal of this research was to evaluate and compare the influence of palatal coverage on the retention force

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and fatigue resistance of attachment system of mini dental implant (MDIs) overdenture.

Material and Method

Fabrication of study models

Edentulous maxillary models with V-shaped palatal vault were fabricated from heat-cured polymethylmethacrylate resin which was obtained from a maxillary edentulous silicone mold (Nissin Ltd Inc., Japan), to produce a cast made from base plate wax (Cavex Holland BV, 2003 RW Haarlem, the Netherlands). The wax was converting into heat polymerized acrylic resin (Meliodent, Heraeus Kalzer Dental Ltd., Germany) and covered with a 2-mm thick silicone layer (Fit Checker, GC, Japan) to simulate oral mucosa.

Five 2.5 X 13mm dummy mini-dental implants (TUT Dental implants, Egypt) were placed parallel to each other bilaterally at canine and the second premolar in both sides, and the fifth fixture was mounted directly lateral to the midline using the parallometer of a milling machine and the guide template (Degussa AG, Frankfurt, Germany). Dummy mini-dental implants were retained using a resin cement (Superbond CB; Sun Medical, Kyoto, Japan) to simulate osseointegration (Figures 1 and 2) [14].

Maxillary overdenture fabrication

Twenty experimental overdentures (10 for each group) were constructed as follow**:**

The female attachment counterparts were mounted over the 2.5 mm ball of the dummy mini-dental implants. Blocked out any undercuts on the simulator cast, refractory casts were constructed by duplication the master cast with agar-agar (Gilvest, German.) and duplication flask. In accordance to the aim of this research, two refractory casts were made to construct, conventional palatal coverage maxillary overdenture (group I). The second refractory cast was used to construct palateless maxillary overdenture (group II)**.**

Group II refractory cast was beaded to determine the border of the palateless maxillary overdenture. Cast chrome-cobalt frameworks were fabricated to act as a denture base [15]. For both groups; the overdentures were constructed by setting of teeth anatomically, flasking. Packing of heat cure acrylic resin and, curing then finishing and polishing of the overdenture. After denture construction, the female housing was picked up to each intaglio surface of overdentures by using auto-polymerized acrylic resin (Figures 3 and 4).

Retention evaluation process

A metallic cobalt chrome bar (2 mm,15 mm, 120 mm), with a grasping hook in the middle, was hovered by auto-polymerized acrylic resin in the area of 2nd bi-cusped and 1st cusped of each overdenture. The simulation models were secured on the horizontal table of A Universal testing machine (utm) (Model 3345; Instron Instrument Ltd., USA). The cross head speed applied in this study was 10 mm/min. After artificial saliva was applied (1.5mm Ca, 3.0 mm P, 20.0 mm Na Hco_3, PH 7.0) beneath overdentures, the vertical hook arm was attached to grasping hook and the process of test retention was carried out 10 times (Figure 5).

Cyclic fatigue test

According to Fatalla et al., [16] the fatigue test was used with metal S shape hook of bendao tools, attached to UTM. The maximum loads required to remove the denture at 0, 120, 720, and 1440 continuous cycles (corresponding to 0 as a base line, 1 month, 6 months and 12 month of simulated clinical use of a denture). Data for both groups were recorded by the computer software (Bluehill Lite; Software computer program). For fatigue strength initially (0 cycles), the O-ring attachments were tested, and also after being subjected to 120, 720, and 1440 cycles of overdenture dislodgement, over one month, six months, one year, respectively. The variables were: the base line, measured force in Newton (N) in to complete overdenture dislodgement from the O-ring attachment. And the fatigue cycles test, expressed as the reduction of the retentive force from the base line.

Figure 1: heat cured polymethylmethacrylate edentulous maxillary models with V-shaped palatal vault with the dummy mini-dental implants placed parallel to each other.

Figure 2: Heat cured polymethylmethacrylate edentulous maxillary models with V-shaped palatal vault with the dummy mini-dental implants placed parallel to each other and with O-ring.

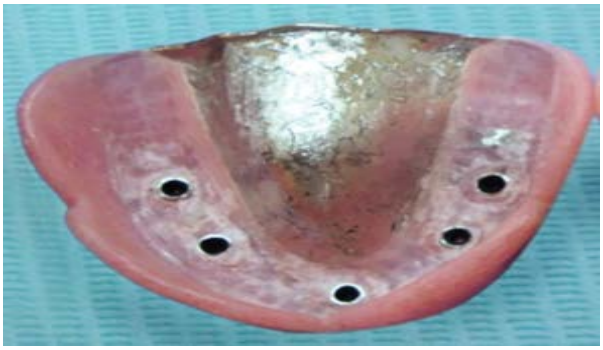

Figure 3: group I mini-dental implant overdenture with palatal coverage intaglio surface with female housing.

Figure 4: group II mini-dental implant overdenture without palatal coverage intaglio surface with female housing.

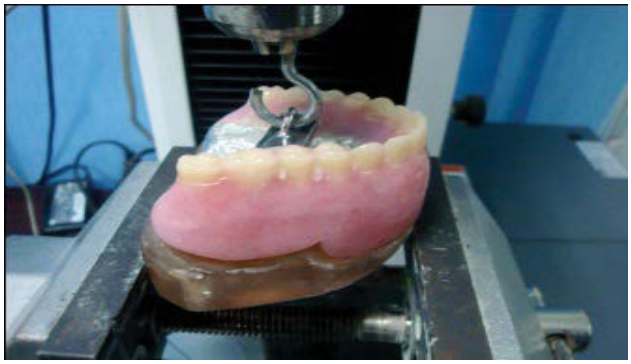

Figure 5: The simulation models were secured on the horizontal table of A Universal testing machine.

Statistical analysis

Data analysis was performed in several steps. Initially, descriptive statistics for each group results. Student t-test was performed to detect significance between two groups. One way analysis of variance ANOVA was done between aging time subgroups for each group. Statistical analysis was performed using Aasistat 7.6 statistics software for Windows (Campina Grande, [1]Paraiba state, Brazil). P values ≤ 0.05 are considered to be statistically significant in all tests.

Results

Results of retention

Table 1 demonstrates t-test analysis to compare the palatal coverage effect on the retention force -measured in Newton - of the mini-dental implant overdenture with and without palatal coverage. It was found that (group I) mini-dental implant overdenture with palatal coverage, recorded higher retention means value (25.55 ± 2.17) than (group II) mini-dental implant overdenture without palatal coverage Palateless overdenture (24.215 ± 3.64). This difference in retention force is statistical insignificant for both groups.

Results of cyclic fatigue

Table 2 shows the results of the two-way ANOVA tests to represent the influence of the cycle number on retention force of (group I) mini-dental implant overdenture with palatal coverage. There were significant differences in retention force values between the all period of this study corresponding to 0 as a base line, 1 month, 6 months and 12 month, at 0 , 120, 720, and 1440 continuous cycles simulated clinical represent the influence of the cycle number on retention force values of (group II) mini-dental implant overdenture without palatal coverage (palate-less overdenture). There were insignificant differences in retention force values between 0 cycle as a base line and, 120 cycles as 1 month of retention force values of (group II) mini-dental implant overdenture without palatal coverage (palate-less overdenture). There were significant differences in retention force values between 0 cycle as a base line and, 720 cycles as 6 month; and between0 cycle as a base line and, 1440 cycles as 12 month of retention force values of (group II) mini-dental implant overdenture without palatal coverage (palate-less overdenture).

Discussion

Overdenture without palatal coverage were declared by many examinations to be less in weight, provide better stereognosis, more comfortable, tongue recognition, taste and temperature perception, as use of a denture. High significantly decrease on retention force values of (group I) mini-dental implant overdenture with palatal coverage were observed at 0 cycles than after 1440 cycles (corresponding to 0 as a base line and, 12 month).

Table 3 reveled the results of the two-way ANOVA tests to

Variable		Group I	Group II
Mean ± SD		25.55 ± 2.17	24.215 ± 3.64
t- test	t-value	0.6295	
	P value	0.5365 ns	

Table 1: t-test analysis to compare the palatal coverage effect on the retention force -measured in Newton - of the mini-dental implant overdenture (Group I) with and without palatal coverage (Group II).

	Group I (mini-dental implant overdenture with palatal coverage)	Rank	ANOVA
Baseline (0 cycle)	25.55 ± 2.17	A	P value <0.0001*
One month (120 cycles)	18.78998 ± 4.647861	B	
Six months (720 cycles)	12.5048 ± 1.878114	C	
Twelve months (1440 cycles)	11.63166 ± 2.078064	D	

Table 2: Two-way ANOVA tests to represent the influence of the cycle number on retention force of (group I) mini-dental implant overdenture with palatal coverage.

	Group II (mini-dental implant overdenture without palatal coverage)	Rank	ANOVA
Baseline (0 cycle)	24.215 ± 3.64	A	P value <0.0001*
One month (120 cycles)	21.26688 ± 8.864782	A	
Six months (720 cycles)	11.4728 ± 0.968723	C	
Twelve months (1440 cycles)	7.306284 ± 0.762243	D	

Table 3: Two-way ANOVA tests to represent the influence of the cycle number on retention force values of (Group II) mini-dental implant overdenture without palatal coverage (palate-less overdenture)

well as more effective phonation, mastication, and, swallowing [6,17,18]. Implant Palateless overdentures were proposed to recompense for limited physical means of retention of palateless dentures caused by reducing the maximum palatal coverage [19].

Four implants are the minimum number to assist palateless denture. This contradicts with other clinical trial or *in vitro* researches investigated the reduction of this number to the half. For mini-implant, due to narrow diameter, the increasing in number of implant is a positive factor to with stand stress induced. The Dummy mini-implants were inserting in the prepared sites using Cold-cured acrylic resin material to simulate osseointegration. Implants were impeded in an acrylic resin model, which has youngs modulus similar to that of bone [20]. On the refractory castes, to avoid the overdenture fracture during experimental test, metal reinforcement frameworks for the laboratory test were constructed the same as in the clinical test for standardization [21].

The results of this study revealed that, (group I) mini-dental implant overdenture with palatal coverage recorded insignificant higher value of retention force necessitated to displace mini-dental implant overdenture with palatal coverage away in comparing with (group II) mini-dental implant overdenture without palatal coverage (palate-less overdenture), with insignificant value (P = 5365) between two results. Though, the reduction of surface area required in physical retention in mini-dental implant overdenture without palatal coverage (palate-less overdenture), both designs are quietly equal in displacement forces required. This may be attributed to the dominant mechanical retention by implant superstructure rather than physical retention in conventional denture without implant assessment. This is in accordance with Williams et al., [22] who concluded that; the results of the *in vitro* study suggest that the precise selection and placement of attachments may affect the clinical success of maxillary implant-retained overdentures.

In daily handling of any removable Dental prosthesis, patient remove maxillary denture many times daily for cleaning. Nocturnally patient is advised to remove the denture, after each meal to allow emission of any forces on mucosa and paradental structure and for improvement of oral hygiene. Four times each day: the overdenture prosthesis was placed and removed in the morning (placement), after breakfast, lunch, dinner (removal and placement) and before bed (removal). Thus, according to the equation (Number of cycles=Number of days×4) the number of cycle calculation was made [16].

All study samples showed reduction in retention after cyclic fatigue. These findings are consistent with the result of most *in vitro* studies investigating the retentive properties of attachment systems. The behavior of reduction on retention may differ between different attachment systems [23].

In this study, the result reported significant decreases in retention in both groups. This may be attributed to that the Attachment systems suffer wears during movements of insertion and removal as well as under functional load. This wear is due to friction between the base and attachment and leads to decreased retention values [13].

Compared to intraoral conditions, the wear experiment used in this study was extremely simple. Forces were exclusively applied in the path of insertion. Within clinical situations, the load of an attachment system is far more complex and different clinical experiments have confirmed that three-dimensional loads orderly happened [24]. The overdenture may fluctuate lightly when food is chewed on denture base. These movements may result in deformation in the male portion, resulting in reducing the retention or fracture of the attachment [25].

Conclusion

Within the limitation of study, we can conclude that the retention is predominate effect by mechanical retention rather than physical factors in retention of mini-dental implant overdenture with and without palatal coverage. While, this mechanical retention adversely affected by repeatable removal and insertion of the overdenture.

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