Research Article

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A Within-Patient Comparative Study of The Influence of Number and Distribution of Ball Attachment Retained Mandibular Overdenture

Ahmed M. Ibrahim[1], Fatma A. EL Waseef[2], and Salah A. Hegazy[3]

[1]*B.D.S., Faculty of Dentistry, Mansoura University, Egypt.*

[2]*Associate Professor of Removable Prosthodontics, Faculty of Dentistry, Mansoura University, Egypt.*

[3]*Professor of Removable Prosthodontics, Faculty of Dentistry, Mansoura University, Egypt.*

***Correspondence:**
Fatma A. EL Waseef, Associate Professor of Removable Prosthodontics, Faculty of Dentistry, Mansoura University, Egypt.

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ABSTRACT

Background: *The number and location of dental implants for implant overdenture therapy are varied and deemed arbitrary. Yet, less favorable prosthetic outcomes are reported more often.*

Purpose: *the purpose of the current study was to evaluate the influence of implant number and location on the retention and chewing efficiency of implant supported mandibular overdenture using ball attachment.*

Materials and Methods: *Fifteen completely edentulous male participants, with a mean age 55- year, were involved in this within- patient study. All patients received a new set of conventional complete dentures before implant positioning. Three implants were placed in the midline and first premolar areas in the mandible, using a stereolithographic template. After healing period, the conventional dentures were converted into implant supported overdentures attached, with ball attachments, to single (group I), two (group II) and three implants (group III) respectively. Retention was evaluated immediately after overdenture delivery (T0) and 1 month later (T1) by forcemeter. Masticatory efficiency was also assessed one month after denture insertion (T1) by two-colored chewing gum. Unmixed Fraction (UF) was then computed.*

Results: *The highest retention values were revealed in group III followed by group II and group I respectively for both observation times. Much higher values were elaborated after one month of dentures delivery (T1) compared to (T0). Masticatory efficiency values showed a statistically significance difference between group (II) and group (I) after 5, 10 and 20 strokes ($P<0.001$).Whereas, no statistically significant difference between the two groups was shown after 30 and 50 strokes ($P>0.05$). A statistically significance difference between group III and group I was noticed after 5,10,20,30 and 50 strokes ($P<0.001$). Nonetheless, masticatory efficiency values exhibited no significant differences between Group II and Group III ($P>0.05$).*

Conclusion: *Within the limitations of this short-term clinical study, edentulusim treated by 3- implant overdentures has appropriate promising outcomes. Based on this study finding, a triangular design of overdeture is a reliable option for maximizing both retention and chewing efficiency when compared to single implant or 2-implant mandibular supported overdentures.*

Keyword

3-implant overdenture, Retention, Chewing efficiency, Ball attachment.

Introduction

It has always been a defiance to devise and conceive the best way to replace missing teeth. Formerly, conventional dentures were considered the standard way for replacing them. Notwithstanding, progressive and inevitable irreversible loss of basal bone may lead to incrementally increasing obstacles for the denture wearing patients. This is in particular true in relation to the mandible, making problems implied; loss of stability and retention, hyperplasia and

ulceration of the underlying mucosa, pain, discomfort , eventually, impaired psychosocial performance [1].

Admittedly, implant overdenture has become a routine strategy for treating a fully edentulous mandible. It was elaborated to contribute to preservation of the residual ridges, masticatory parameters enhancement and satisfaction of the patient, consequently, oral health-related quality of life (OHRQoL) [2]. Implant-supported overdentures have an increased maximum biting force with an effective chewing efficiency [3,4], prosthetic stability, retention and occlusal support results in enhancement of, function, facial esthetics and comfort [5].

In 2002, the McGill consensus statement proclaimed that an overdenture retained by two implants should be the first therapeutic option and the gold standard of care for treating the edentulous mandible [6,7]. Currently, there were handful reports suggesting a single-implant retained mandibular overdenture as a successful treatment modality. It could be appropriate for retention and records a high success rate if compared to those supported by multiple implants [8].

The notion of three implants to support a mandibular denture with splinted implants or separate solitary attachments has been posed and this therapeutic modality has been widely used in the clinic [9,10]. A third implant added in the symphyseal region could confer an indirect retention for the denture. This could be achieved by averting the anterior part of the denture to be intruded towards the tissues. Besides, rotational movements could be precluded without detrimental higher strains being resulted on the denture bearing mucosa, implants, abutments, or ridge [11].

Various overdenture attachment systems were used to enhance retention and stability. To name but a few, ball attachment provided excellent retention and stability. The main merit of such attachment is the versatility and applicability in various situations with no need for new dentures fabrication when put into function. This detachable prosthesis over implants using ball-type retentive attachments allows easier oral hygiene and provides superior esthetic and phonetics in cases involving advanced ridge resorption [12-15].

Though the concept of 3-implant overdentuers of triangular distribution is proved successful, only a few handful studies are to-date published implying comparing it to single or 2-implant overdentures. Therefore, the present study aims at evaluating both retention force and chewing efficiency of single implant, 2-implant and 3- implant (triangular distribution) mandibular overdentures using ball attachments.

Material and Methods

Participant Enrollment

Fifteen completely edentulous male patients of age ranged between 50-60 years were eligible from the outpatient clinic, Prosthodontics Department, Faculty of Dentistry, Mansoura University. The inclusion criteria were ;all eligible patients have sufficient residual alveolar bone quantity (height and width) and quality (normal trabecular pattern) anterior to mental foramen(verified by cone beam CT), the patients were of Angle"s class I maxillomandibular relation with acceptable inter-arch space verified by a tentative jaw relation. Exclusion criteria dictated that the participants had no systematic disorders affecting bone e.g. diabetes millitus and osteoporosis, history of parafunctional habits, heavy smoking and alcoholism, TMJ disorders or poor neuromuscular control, head and neck radiation . The study was accepted by the ethics committee of Mansoura University, Faculty of Dentistry. All the patients signed written consents after being informed about the detailed treatment plan and the needed follow-up visits.

Surgical and prosthetic procedures

New dentures were constructed for each participant, with bilateral balanced occlusal contact. The participants were permitted to wear their dentures for at least 1 months prior to implant installation to boost the adaptation. A stereolithographic surgical template was fabricated by the aid of CBCT software dual scan for accurate, precise sites and angulation of the three dental implants; midline implant and 1st premolar implants (Figure 1).

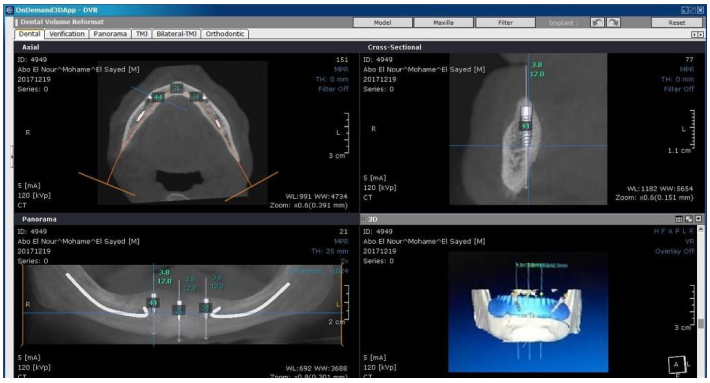

Figure 1: CBCT image with virtual implant placement.

Three implants of 3.8 mm diameter, 12 mm length (Biohorizons Tapered Implant) were surgically installed in the midline and 1st premolar areas using flapless surgical approach. Relining was carried out for the denture with a tissue conditioner material (Ufogel; Voco, Cuxhaven, Germany) (Figure 2).

Figure 2: Three implants in the receptor sites.

Patient grouping

According to implants position and number, three groups were included within each patient;

Group I: midline implant was used for retaining the overdenture using ball attachment

After three months of implant insertion, healing abutment was connected to the implant for 10-15 days to allow for mucosal healing. Two mm collar height ball abutment (Osteoseal OLS ABUTMENTS) was threaded into the fixtures 2 weeks later. Direct functional pick-up was performed. The occlusion was adjusted, the patients were instructed for proper oral hygiene, and 1-month recall visit was scheduled.

Retention Measurement

According to Burns et al. [16], modifications for the mandibular overdenture were made. Two hooks were added at the mid-labial flange ;one on each side (at the first molar area or between second premolar and first molar areas). 18-gauge orthodontic wire of 15 cm long was adapted to both hooks passing horizontally over the denture teeth.

The overdenture was completely seated intra-orally for about 15 minutes to settle. The "pull" end of the digital force-meter was attached to the midpoint of the wire. The peak force needed to dislodge the overdenture was then measured in Newton‟s. The maxillary denture was removed as an attempt to make the force-meter in a vertical direction as possible. The force gauge was vertically pulled until losing the denture retention, the prosthesis moved upward and displaced, the reading was then recorded. This procedure was carried out three times and the mean of all the readings was recorded (Figure 3).

Retention measures were taken at time of insertion (T0), and after one month (T1) thereafter.

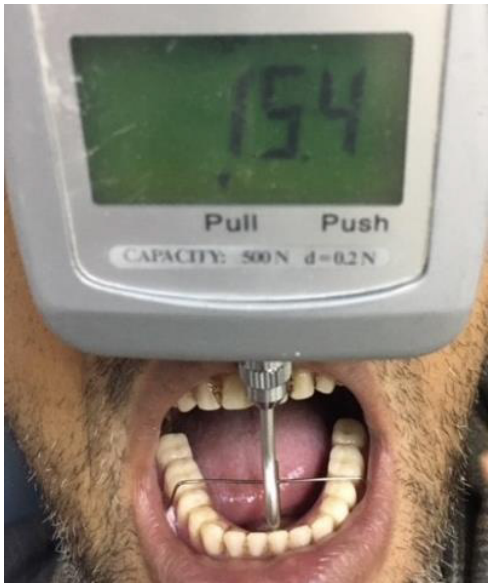

Figure 3: Forcemeter connected to the wire at the midpoint.

Masticatory efficiency measurement

Chewing efficiency was measured using two-color chewing gums one month after insertion (T1).

According to Schimmel et al. [17], to evaluate the masticatory efficiency ,a two-color chewing gum test was used as follows: two-color chewing gum samples were prepared from gums of both flavors; "mint" (white color) and "strawberries" (pink color). Strips of 30 mm length were cut from (white and pink) colors and manually stuck together, therefore, the presented test strip was 30x18x3 mm. Patients were guided to chew five samples of chewing gum for 5,10,20,30 and 50 chewing cycles respectively.

This test determines the ratio of correspondent pixels to unmixed color segments of the chewing gum to the number of pixels in the whole image. After flattening of all samples to 1mm thick wafers, they were then assessed. Using Adobe Photoshop Elements, the unmixed pixels were counted to calculate the ratio of unmixed color to the total surface.

The samples have been spat into transparent plastic bags. These bags were labeled with the corresponding numbers of strokes. To diminish the effect of fatigue, an interval of at least 1 minute was imposed between the different tests. The overall duration of the experiment was almost 8 minutes. Unmixed fraction (UF) was computed (Figure 4).

Figure 4: Gum samples after different chewing strokes.

Group II: 1st premolar implants were used for retaining the overdenture using ball attachments.

The ball attachment threaded into the midline implant was unscrewed and covered by a cover screw. Both implants at 1st premolar areas received healing abutments. After healing, two ball attachments threaded to both implants and functional pick was performed. The retention and chewing efficiency measurements were repeated as for group I.

Group III: all three implants (midline and 1st premolar) were used for retaining the overdenture using ball attachment.

Ball attachment was rethreaded into the midline implant and functional pick-up was performed, then denture was finished and polished (Figures 5 and 6). The retention and chewing efficiency measurements were repeated as previously mentioned.

Figure 5: Three ball abutments in place (group III).

Figure 6: Mandibular denture with ball matrices (group III).

Statistical analysis

Repeated measure ANOVA were used to compare more than 2 means, and post hoc tuckey test for in- between groups comparison.Comparison of retention values between observation times was made using paired t-test and between groups using One-way ANOVA. Comparison of UF among chewing strokes (5, 10, 20, 30 and 50 strokes), and also groups were made using repeated measures ANOVA then followed by Bonferroni test for multiple comparisons. Level of significance was set at <0.05.

Results

For all groups, no dropout occurred and no implant loss was detected (survival rate was 100%)

Retention

The results revealed a significant difference in retention (N) between different groups and observation times. For all groups, retention values were significantly higher after 1 month compared to base line (p<.001). For both observation times (T0 and T1), there was a significant difference in retention values between groups (p<.001). For both observation times, the highest retention value was observed with group III, followed by group II, and the lowest retention was observed in group I. There was a significant difference between each 2 groups (Bonferroni multiple comparison, p<0.001) as evident in Table 1.

	At time of overdenture insertion (T0)		one month after overdenture insertion (T1)		Paired samples t-test (p value)
	X	*SD*	*X*	*SD*	
Group I	7.88 a	.62	10.80 a	.21	<.001*
Group II	10.95 b	.60	14.28 b	.58	<.001*
Group III	15.75 c	.10	17.52 c	.18	<.001*
One-way ANOVA test (p value)	<.001*		<.001*		

Table 1: Comparisons of retention (N) between the 3 groups at different observation times.
Different letters in the same column indicate significant difference between each 2 group (Bonferroni test). * significant at 5% level of significance

Chewing efficiency UF

A significant difference was revealed between groups for different chewing strokes (P<0.027). Group I demonstrated the highest UF, followed by group II, and the lowest UF was noted with group III. Whereas, no significant difference in UF between group II and group III was noticed. A significant difference between chewing strokes for each group (P<0.018) was shown. UF decreased significantly with increasing the number of chewing strokes. 5 strokes exhibited the highest UF, followed by 10 strokes, then 20 strokes, 30 strokes and 50 strokes showed the lowest UF (Table 2).

	5 strokes		10 strokes		20 strokes		30 strokes		50 strokes		Repeated measures ANOVA
	X	*SD*	*X*	*SD*	*X*	*SD*	*X*	*SD*	*X*	*SD*	
Group I	.1750a	.0226	.1383b	.0299	.0850c	.0152	.0508d	.0136	.0070e	.0015	<.001*
Group II	.0747a	.0455	.0600b	.0261	.0332c	.0140	.0275d	.0319	.0052e	.0021	.001*
Group III	.0600a	.0363	.0398b	.0299	.0235c	.0262	.0135d	.0130	.0032e	.0023	.017*
Repeated measures ANOVA	<.001*		<.001*		<.001*		.026*		.017*		

Table 2: Comparison of UF between the groups and chewing strokes.
Different, letters in the same raw indicate significant difference between each 2 chewing strokes. * significant at 5% level of significance.

Discussion

With respect to retention measurements, the results of this within-patient study demonstrated that, retention values were significantly higher after 1 month of dentures delivery compared to base line values. This finding is possibly attributed to settling of the dentures and the physical role of the neuromuscular control exhibited one month after insertion. Eventually, overdentures elaborated higher degrees of stability and retention enhancements. This explanation is in consistent with Ferrario et al. [18].

According to the results shown in this study, the highest retention values were observed with group III, followed by group II, whilst

the lowest ones were noticed in group I. This could be clarified that the stability and retention of implant overdenture prostheses are significantly influenced by implants number and their distribution. This is coping with the reports of Scherer et al. [19]. This is also confirmed by Trakas et al. [20]. They advocated that more than two implants is endorsed in particular cases to produce more favorable overdenture stability and preserving the peri-implant supporting bone.

Likewise, an angular configuration between the implants could be created by the application of three implants rather than a straight-line configuration. In the three-implant-supported overdenture, the implant positioned at midline may contribute as an indirect retention for the overdenture. It helps prevent the denture anterior portion intrusion towards the tissues. This elucidation is in accordance to the conclusions of Ben-Ur et al. [21]. Contrarily, Fatalla et al. [22] affirmed that flexible acrylic attachments in quadrangular overdenture design increased retention force besides, it reduced the fatigue retention compared to triangular design.

Notably, the impact of attachment systems of overdentures, implants number and location has been alluded to several studies. Nevertheless, several studies justified the influence of the number of implants and their distribution based upon empirical information [11,23,24]. But few of them have precisely assessed the impact of implant distribution and number upon the prosthesis stability and retention.

From the results of the current study, there was a statistically significant decrease of UF between groups I, II, and III within the same patient. Additionally, the UF significantly reduced by increasing the number of chewing strokes. The possible explanation that throughout the time of chewing, the food bolus or food particles were reformed. They reduced in size, kneaded together and mixed with saliva by cusps of posterior teeth being contacted as hypothesized by Weijenberg et al. [25]. Obviously, More and more mixing between particles of two-colored chewing gums caused by the number of chewing cycles being increased for the same patient. This is concurred with Schimmel et al. [26].

One month after implants insertion, a statistically significant difference of masticatory efficiency values was cleared between Group III and Group I after 5,10,20,30 and 50 strokes. Notwithstanding, there was non-significant statistical difference between Group II and Group III. This could be attributed to the impact of increasing the number of implants and their distribution on boosting the retention, stability and masticatory efficiency as well. These results was in agreement and assured by Bhat et al. [27] and Elsyad et al. [28].

Conclusion

Within the limitations of this short -term study, placement of midline implant for mandibular overdenture could be reliable option for maximizing both retention and chewing efficiency, in comparison to single or 2- implant overdentures.

Yet both two and three implant supported overdentures revealed comparable results with respect to masticatory efficiency,3-implant supported overdenture could be a successful treatment when retention is deemed crucial.

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