Effect of Different Implants Number and Distributions Used to Assist Mandibular Complete Overdenture: A Study of Bite

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Abstract:

Objective: This within-patient study aimed to evaluate the influence of different numbers and distribution of implants used to assist mandibular complete overdenture on a patient's maximum biting force and masticatory efficiency .

Materials and Methods: Six healthy completely edentulous patients were selected for this study. Each patient received a conventional complete denture then four implants were installed in the canine and premolar areas bilaterally. The implants were delayed loaded by mandibular overdenture using locator attachments, patients were classified into Group I: anterior two implants loaded by the overdenture; Group II: posterior two implants loaded by the overdenture; and Group III: four implants loaded with the overdenture, The bite force and the chewing efficiency were evaluated immediately 3 and 6 months after insertion. The exchange of loading between patients was done after each evaluation session. **Results:** There was a statistically significant difference in bite force and chewing efficiency between conventional complete dentures and implant-assisted overdentures regardless of the number and distribution of the implants after different observation times. The four implant-assisted overdentures showed a statistically significant difference in bite force and chewing efficiency compared with the other groups after all periods of overdenture insertion. **Conclusions:** Regardless of the implant number and location, implant-retained mandibular overdenture significantly increased the bite force and masticatory efficiency compared with the conventional complete denture. The four implants assisted mandibular overdenture significantly increased the bite force and masticatory efficiency compared with only two implants in the canine or premolar areas.

Introduction:

The instability of mandibular dentures increases with the severity of mandibular atrophy.[1] Maximum bite force level in complete denture wearers has been limited to an extent due to the sensitivity or pain of the mucoperiosteum covering the mandibular edentulous ridge which gets sandwiched in between the dentures and bone.[2] One of the main goals of prosthetic dentistry is to reconstruct the masticatory system. Mandibular interforaminal implants have been widely used to stabilize dentures, consequently improving masticatory performance, psychological factors, and self-esteem in edentulous individuals.[3] It was reported that the number and positioning of implants influence force transfer and subsequent bone loss around implants. The increase in number improves the biomechanical implant behaviour, especially when subjected to bending forces.[4]

It was concluded that restoring the edentulous mandible with a conventional denture is no longer the most appropriate first-line prosthodontic treatment and that there is overwhelming evidence that a 2-implant overdenture should become the first-line treatment.[5] It was claimed that two implant-assisted mandibular overdenture can be considered the minimum standard to provide a significant improvement in retention and durability over a complete denture, as well as a significant improvement in quality of life.[6] Mandibular three-implant overdentures are an appropriate treatment technique that might be explored for the rehabilitation of edentulous individuals. Since the 1980s, three implants have been utilized to support a mandibular denture using separate stud attachments or splinted implants, and this treatment modality has been widely used in clinics.[7] Placement of anterior implant in a triangular configuration with two posterior implants in the interforaminal area prevents the anterior rotational movement of the denture base and preserves the residual alveolar ridge.[8] The four implant placement in a quadrilateral distribution performed better and higher survival rates in many long-term follow-up trials.[9]

Four implants give better stability during operation and minimize both rotational movements and excessive loading, both of which may compromise osseointegration.[10] Implant overdentures varies in type depending on the attachment design and the degree of support provided from the implant and the edentulous alveolar ridge mucosa. The overdenture design is influenced by the patient's needs, biomechanical principles, the amount of restorative space available, and the patient's economic ability.[11]

The purpose of the study will be to evaluate the influence of number and distribution of implants on bite force and masticatory efficiency of mandibular overdentures.The hypothesis of this study is that the number and distribution of implants used to assist

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mandibular complete overdentures will affect the bite force and masticatory efficiency.

Material and Methods:

Six healthy male patients ranged between 48-60 years old completely edentulous were selected from the Prosthodontic Department, Faculty of Dentistry, Mansoura University in Egypt according to the following criteria: all patients have maxillary and mandibular residual alveolar ridge covered with healthy firm mucosa, sufficient mandibular residual alveolar ridges verified by digital panoramic x-ray and ridge mapping, one year at least after last extraction, Angle's class I maxillomandibular relation, sufficient inter-arch space. patients with parafunctional habits, smoking, systemic disorders affecting bone as diabetes, history of radiation therapy in the head and neck region, TMJ or neuromuscular disorders were excluded. All patient were informed about the study procedures and follow up intervals and signed a written consent to participate in the study. The study procedures were reviewed and approved from the Ethical Committee of the Faculty.

Figure 1: Two positioners screwed into the canine fixtures – pick up of female part

For each patient, conventional complete denture was constructed. After one month of denture insertion, bone supported stereolithographic surgical guide was constructed by the aid of CT cone-beam software for exact site and angulations of dental implants to be used as a surgical guide for four Dentium® implants placement in the canine and premolar areas using flapless surgical and delayed loading protocol. A post insertion panoramic x-ray was made to evaluate the implant positions. After the osseo-integration period, the dental implants were exposed and healing abutments were screwed into the fixtures for two weeks. The healing abutments were replaced by Kerator® positioners and screwed into the fixtures according to a within patient cross over study design. The patients treated in three successive sessions according to the implant number and location. To avoid bias two patients started treatment with 2 anterior implants, two patients started with 2 posterior implants and the last 2 patients started with 4 implants and the six patients were evaluated. After each treatment and evaluation session, the patients were replaced with the other two treatment sessions and evaluations. Finally, the collected data of the treatment and evaluations sessions classified into three groups as follows:

Group I: where the overdenture loaded only two implants in the canine areas. Then female parts with white processing inserts were seated on the positioner abutments and directly picked up into the denture by auto polymerized acrylic resin. The white processing insert was replaced by the red retentive insert. . Figure.1.

Group II: where the overdenture loaded only two implants in premolar areas. The two positioners were unscrewed from the fixtures of canines and replaced by cover screws. The female houses were packed with soft gutta percha. positioner abutments were screwed into the fixtures of the premolar areas and the female parts were picked up as done in group I., Figure.2.

Figure 2: Healing abutments replaced by two positioners in premolar area.

Group III: where the overdenture loaded total four implants in the canine and premolar areas. the gutta percha in the female houses in the canine areas was removed and the positioner abutment were screwed into their fixtures. The denture was connected to the four positioner abutments. Figure.3.

Figure 3: The positioner abutments screwed again in canine fixtures.

Evaluation of biteforce: According to Sakaguchi et al,[12] measurement of maximum bite force was performed in the first molars region on each side using an occlusal force meter (GM10; Nagano Keiki, Tokyo, Japan). The instrument consisted of a hydraulic pressure device with a vinyl biting element covered with plastic sheath. The pressure gauge displayed the bite force values in Newton's (N) on its small digital screen. Measurements were made with the subject in upright position, with head in natural posture and the maxillary jaw approximately parallel to the floor. The transducer was positioned in the first molar region. The patients were instructed to bite as forcefully as possible three times per side, with a rest time of 2 min in between. Figure.4, The data were analyzed using the MBF displayed on the device's screen in Newtons. The individual's MBF was determined by the highest of

Figure 4: Bite force measurement.

the three measures.

Masticatory efficiency measurement: Masticatory efficiency was evaluated using the two-color chewing gum method as instructed by Schimmel et al.[13] Samples of a two-color chewing gum were prepared from Gums in the flavors "mint" (white color) and "strawberries" (pink color). Five samples of chewing gum were chewed in different cycles with different number of strokes 5,10,20,30 and 50.

Electronic assessment: Each trimmed specimen was scanned using a flatbed scanner at a resolution of 500 dpi and analyzed by the using ViewGum software which calculate the standard deviation of Hue based on the pixel values at the stroke areas and the distance of each pixel from these areas. Figure. 5 .The values were computed from calculation sent to excel, and exported for statistical analysis.

All evaluations were done for each group after complete denture insertion, immediately 3 and 6 months of overdenture insertion in each group.

Statistical analysis: The data (masticatory efficiency and bite forces) met the normal distribution and were parametric as indicated by Shapiro-wilk test. Comparison of UF and bite force between different observations (T0, T3 and T6), chewing strokes (5, 10, 20, 30 and 50 strokes), and groups (group I, II, and III) was performed using repeated measures ANOVA followed by Bonferroni tests for multiple comparisons. The data were analyzed using SPSS® software version 25 (SPSS Inc., Chicago, IL, USA) and SAS® software version 9.2 (SAS Institute, Cary, NC, USA). Statistical significance was set at .05 for all analyses.

Results:

A) Masticatory efficiency (unmixed fraction, UF): There was a significant difference in UF between different groups at different observation times (T0 present in Table 1, T3 present in Table 2 and T6 present in Table 3.

For all Groups, the highest UF was observed with group I, followed by group II and the lowest UF was noted with group III.

B) Maximum bite force: There was a significant difference in bite force between observation times and between groups present in Table 4.

Group III recorded the highest bite force followed by group II, and group I showed the lowest bite force.

Discussion:

The bite force and masticatory efficiency values immediately measured after implant overdenture insertion are statistically significantly higher than the conventional complete denture regardless the implant numbers and location. This may be due to mechanical retention of the attachment assembly. This result is agreed with a study of Burns et al[14] who found that there was a statistically significant difference between conventional dentures and implant overdentures using

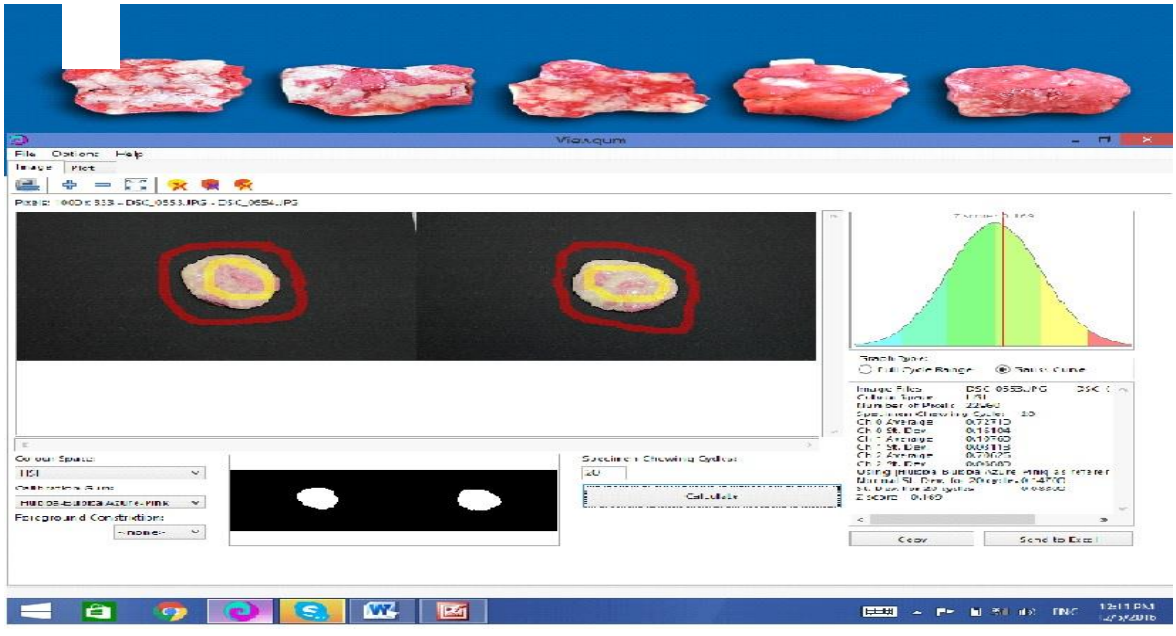

Fig 5 The software has segmented the gum area as shown by the black outline

Table 1: Comparisons of UF between different groups at T0

	Group I		Group II		Group III		Repeated ANOVA
	X	***SD***	***X***	***SD***	***X***	***SD***	
5 strokes	.1373c	.0079	.1123a	.0134	.1022b	.0070	<.001*
10 strokes	.1115c	.0096	.0982a	.0165	.0862b	.0092	<.001*
20 strokes	.0872b	.0072	.0721a	.0119	.0703a	.0062	<.001*
30strokes	.0772c	.0057	.0636a	.0129	.0535b	.0065	<.001*
50 strokes	.0655b	.0081	.0419a	.0090	.0331a	.0041	.003*

Table 2: Comparisons of UF between different groups at T3

	Group I		Group II		Group III		Repeated ANOVA
	X	***SD***	***X***	***SD***	***X***	***SD***	
5 strokes	.1237c	.0097	.1024a	.0095	.0939b	.0046	<.001*
10 strokes	.0988b	.0103	.0854a	.0060	.0806a	.0070	<.001*
20 strokes	.0783b	.0068	.0649a	.0092	.0596a	.0056	<.001*
30strokes	.0670b	.0065	.0476a	.0093	.0429a	.0060	<.001*
50 strokes	.0465b	.0094	.0313a	.0021	.0294a	.0029	<.001*

Table 3: Comparisons of UF between different groups at T6

	Group I		Group II		Group III		Repeated ANOVA
	X	***SD***	***X***	***SD***	***X***	***SD***	
5 strokes	.1515a	.0093	.1467a	.0120	.1348b	.0087	.007*
10 strokes	.1337a	.0120	.1303a	.0108	.1152b	.0088	.002*
20 strokes	.1022b	.0129	.0820a	.0064	.0807a	.0058	<.001*
30strokes	.0928b	.0113	.0721a	.0090	.0657a	.0056	<.001*
50 strokes	.0655b	.0081	.0501a	.0056	.0427a	.0039	<.001*

Different letters in the same raw indicates significant difference between each 2 groups* significant at 5% level of significanc

Table 4: Comparison of maximum bite force between observations and between groups

	T0		T3		T6		Repeated ANOVA
	X	***SD***	***X***	***SD***	***X***	***SD***	
Group I	241.50a	5.86	247.17a	6.21	194.33b	10.95	<.001*
Group II	250.67a	5.16	255.17a	6.34	217.00b	7.29	<.001*
Group III	266.33a	5.72	271.33a	4.72	239.33b	7.42	<.001*
Repeated ANOVA	<.001*		<.001*		<.001*		

O-ring and magnet attachments. It is well known that conventional denture wearers have impaired masticatory function, including lower maximum voluntary bite forces and lower levels of muscular effort during maximum clenching and mastication.[15] This could be attributed to denture instability probably prevents denture wearers from using the full potential of their jaw muscles, especially during unilateral biting and chewing.[16]

After 3 and 6 months of overdenture insertion, there was a statistically significant increase in bite force than was recorded immediately after overdenture insertion in all groups. Van Kampen and Bakke[17] reported that following stabilizing the dentures with mandibular implants, the edentulous individuals can do more muscular effort after 3 months or more months. They also reported an increase in the maximum bite force and muscle activity when they compared results before treatment with mandibular implants overdenture and after 3 months of treatment (from 41% to 58%, according to the attachment type).[18]

In this study, a statistically significant higher bite forces were observed with four implant overdentures, compared with two canine implants and two premolars implant assisted overdentures. These findings are in agreement with EI Syad et al[19] who proved that four implant-supported overdentures seem to present a functional advantage versus two implant- supported overdentures, independent of the chosen attachment system. Obviously, the presence of more implant attachments which stabilize the denture, and minimize the discomfort, allow the patient to exert higher bite forces.[20]

In case of two implant overdenture, bite forces were less than four implant overdentures. This may be due to the mandibular denture-bearing tissues being more subject to compression, denture shifting, and resultant painful irritation. The chewing efficiency was

statistically significant high with implant assisted overdentures; regardless the implant number and location; compared with conventional dentures. This result agrees with the findings of many authors and may be attributed to the improved stability and retention of conventional dentures by the mechanical retention provided by the attachment. In contrast, full prostheses supported by osseo-integrated implants in edentulous mandibles has shown considerable improvement in muscular activity and mandibular movements, mainly because of their association with a more stabilized occlusion, satisfaction, and comfort of patients.[21]

Moreover, implant stabilized overdentures, elevate bite force and chewing performance, improve patient satisfaction and decrease discomfort during chewing.[22]

Conclusions:

Regardless the implant number and location, implant-retained mandibular overdenture significantly increased the bite force and masticatory efficiency compared with the conventional complete denture.

The four implants located in the canine and premolar areas supported a mandibular overdenture significantly increased the clinical bite force and masticatory efficiency compared with only two implants in the canine areas or premolar areas. The implant location when only two implants used to retain mandibular overdenture has no impact on the bite force after six months of denture insertion. The mechanical retention value of locator attachment must be maintained by replacement of retention insert, if necessary, to confirm high biting force and masticatory efficiency.

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