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The Effect of Mini-Implants versus Conventional Implants Retained Mandibular Single Overdenture on Biting Forces

Noha Aligamaleldin[1] *, Abdelaal Mohamed*[1]

Aim: The purpose of this clinical investigation is to evaluate the biting force of patients restored with mandibular single over-dentures supported by Mandibular implants Two Conventional diameters versus four Mini Implants.
Materials and Methods: In this investigation, a total of twelve male patients with completely edentulous mandibles opposed by natural dentition were enrolled. Patients were distributed into two main groups;Group I received four inter-foraminal mandibular Mini-implants while Group li received two conventional implants with standard diameters in the inter-foraminal region as well. O-ring attachments were utilized in the lower denture to provide retention with the implants. The biting force of the participants was measured at insertion, 3 months and 6 months after insertion of the mandibular implant retained denture using a Load sensor. To evaluate significant changes within each group over time and to compare the two groups, one-way analysis of variance (ANOVA) and paired t-tests for pairwise comparison were utilized as analytical tests for all parameters. For all statistical tests, the significance threshold was established at 0.05.
Results: Statistical Analysis Comparison between the two groups revealed a significant difference between both groups where there were higher biting values in the Standard diameter Implant group than the Mini diameter implant group as $P<0.0001$*.
Conclusion: Within the limitation in this investigation, it can be determined that the standard diameter implants yielded more favourable biting forces in comparison with the mini-implant implant group supporting mandibular single implant retained over-denture.

Keywords: edentulous mandible, small diameter implants, Loading sensors, single denture

1. Department of Prosthodontics, Faculty of oral and dental medicine and surgery, Cairo University, Egypt.
Corresponding author: Noha Aligamaleldin , email: Noha.agamaleldin@dentistry.cu.edu.eg

Introduction

The construction of mandibular dentures opposed to a full set of natural dentitions usually has many drawbacks as improper support, reduced retention, and stability. Therefore, using dental implants as a therapy option to support and stabilize lower dentures is advised.

Small or mini-diameter dental implants have been utilized to successfully retain both detachable and fixed mouth prostheses. [1,2] If proven recommendations are done and the appropriate prosthetic restorations are fabricated, small-diameter implants provide better angiogenesis, and there is less bone dislocation in comparison to conventional diameter implants. There are many benefits to using mini implants for complete lower dentures, including decreased postoperative pain, reduced bleeding, implantation in narrow ridges, and immediate loading. [3,4]

Implants with higher fatigue strength may be advantageous for narrow-diameter implants since they may be more susceptible to overload. According to Al-Nawas et al.[5] study, utilizing narrow-diameter (3.3 mm) TiZr alloy implants for two years, the success and the survival rates were 97.6% and 97.8% after one year, and 97.6% and 97.4% after two years. A second trial by Polack and Arzadon [6] showed great success rates for the immediate loading of lesser-diameter titanium-zirconium implants.

A different study discovered that the 5-year survival rate for small-diameter and Mini dental implants was between 98.3 and 99.4%. [7] The benefits of these implants include shorter operating times, reduced postoperative discomfort, the capacity to direct loading after surgery without damaging the bone, and affordability.[8]

Narrow-diameter implants will provide a reliable minimally invasive alternative to augmentation techniques that are time-consuming and would require extensive surgical experience to reduce complications like postoperative pain, nerve injury, infections,bleeding, and implant or bone grafting failures. According to Klein et al.[9], narrow dental implants can be divided into three categories: Class 1: 3.0 mm ("mini-implants"), Class 2:3.0-3.25 mm, and Class 3: 3.30-3.50 mm3. In their systematic evaluation, Schiegnitz and Al-Nawas [10] found no appreciable difference in survival rates between narrow implants of category 2 and standard implants.

Materials and methods

From the outpatient clinic of the prosthodontics department at the faculty of oral and dental medicine in Cairo, twelve male patients were chosen. The following criteria were used to choose patients for inclusion; Patients with Completely Edentulous Mandibles opposed by a full or partial set of Natural Dentition, with Class I Angle classification, with no para-functional habits, and do not suffer from any medical conditions, temporomandibular joint disorders and no history of radiotherapy or chemotherapy. Patients selected in this study were with adequate residual alveolar ridge height and width covered with healthy dense mucoperiosteum, exhibiting enough inter-arch space. Additionally, Non-smokers were only included in this study.

Comprehensive details about the management protocol were discussed with all patients including the surgical and prosthetic steps, the risk, benefits, and the planned treatment alternatives were explained. All patients were motivated to the treatment and were informed to share in the study.Patients gave their acceptance by signing informed consent.

Mouth preparation

Supra and sub-gingival scaling and root planning for the maxillary teeth were carried out to render the oral cavity free of any infection or inflammation. Oral hygiene instructions were emphasized to render the oral cavity free of any pathosis and any carious cavities were restored.

Mandibular Complete denture construction

Prior to implant placement, all patients received full single mandibular dentures for rehabilitation. To create study casts, upper and lower primary impressions were poured with dental stone. To create the master cast from which the occlusion block was built, the final impression was created using light consistency rubber base impression material after usual border molding , which was then poured into dental stone. To place the maxillary cast on a semi-adjustable articulator, a maxillary face bow record was established. To mount the lower cast, a face bow record using the check bite technique was created. Before clinical remounting was performed, the final dentures were examined in the patient's mouth. At the time of the denture delivery, the patient was given instructions for denture use and asked for periodic recall visits.

Radiographic stent construction

The mandibular denture was duplicated into clear heat-cured acrylic resin. Eight gutta-percha cones wvere cemented on the labial surface of the stent, one in the middle of each tooth from the left first premolar to the right first premolar. The proposed inter-foraminal implant sites were determined at least six millimetres mesial to each mental foramen. The radiographic stent was modified into surgical stents by creating holes in the projected implant sites.

Implant Installation

Patients were instructed to clean with 0.2%Chlorhexidine mouthwash TID two days before surgery. Patients were also pre-medicated with a prophylactic one-gram dose of a combination of Amoxicillin. The surgical kit and instruments were sterilized. The patient's perioral skin was disinfected with Betadine. Patients were anesthetized by bilateral inferior alveolar nerve block assisted by infiltration field block anesthesia. The surgical stents were placed intraorally.The proposed implant sites were marked.

In this study, patients were divided into two equal groups:

Group A: Patients receiving four mini-diameter inter-foraminal mandibular mini-implants.

Group B: Patients receiving implants two conventional implants with standard diameters in the inter-foraminal region.

To anchor the lower denture with the intra-oral implants, O-ring attachments were utilized for all the patients in the two groups. The pre-surgical preparation required the construction of an adequate conventional mandibular complete denture.

Surgical Procedure

Group I (Mini implant group)

For each patient, four screw-type piece mini dental implants 2.1 mm and 13 mm in length were inserted in the predetermined implant sites in the inter-foraminal region. The position of the two distal implants was marked 6 mm mesial to each mental foramen. The position of the other two implants was marked equidistant from the distal implants 5 mm apart. At the marked implant site,a Cortical drill was used to penetrate cortical bone. The 1.1mm pilot drill was utilized to drill bone up and down in a vertical direction. Light intermittent finger pressure was applied and irrigation was at 800 RPM speed until the desired length was reached. The implant was manually threaded until resistance was felt. It was then threaded into the final position with a ratchet wrench until the mark on the neck portion was no more visible as shown in Figure 1.

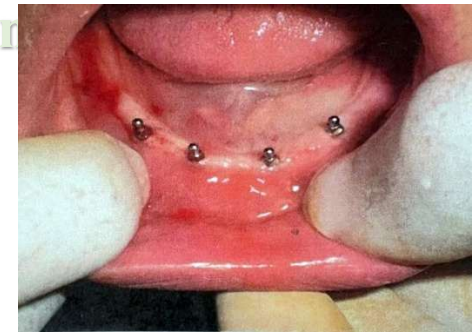

Figure 1: Four mini diameter inter-foraminal mandibular mini-implants

Group II (Conventional implant group)

The proposed implant sites were marked using the surgical stent. For each patient,two 4.3mm diameter and 10mm lengths screw type conventional implants were inserted in the symphysial region, Crestal incision extending about 5 mm distal to each proposed implant sites was cut. A mucoperiosteal flap was performed exposing the bone in the proposed area. The implant sites were marked with a round bur guided by the surgical stent. Preparation of implant sites started with the 2.3 mm diameter pilot drill placed parallel to the mid line in both implant sites. Two paralleling tools were used to check parallelism. The osteotomy preparation was continued using a drill 2.8 mm in diameter followed by 3.4 mm drill and finally by a 3.8 mm drill.The drilling was performed at 800 RPM speed. Vertical intermitted pressure was applied. Saline irrigation was used: The implant was manually threaded until resistance was felt and then slowly threaded into final position with ratched wrench until the implant top flushed with the ridge crest. The abutments were then screwed into position to the fixtures. The mucoperiosteal flap was sutured using 000 interrupted black silk suture. The patient was asked to bite on sterile, gauze for one hour post surgically as shown in Figure 2.

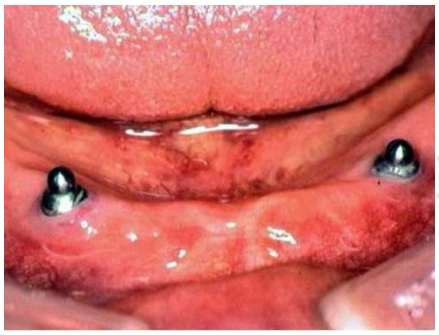

Figure 2: Two Conventional Implants with Standard Diameters in the inter-foraminal region

Prosthesis adjustment

Seven days after implants insertion the following adjustments were carried out: Areas opposing to the inserted implants were identified on the mandibular denture's fitting surfaces. Abrasive stone was used to relieve the marked areas and create enough space for the metal housing. The metal housings were seated on the implant heads. The denture was placed intraorally and checked for complete seating, retention, stability and adequate occlusion with the opposing maxillary teeth. The plastic rings were placed to block undercuts and a mixture of self-cured acrylic resin wasadded to the relieved areas and the denture was reseated intra-orally. Patients were instructed to close in centric occluding relation until complete polymerization took place. The lower single denture with the metal housings attached within the fitting surface was retrieved from the patient's mouth. Excess acrylic resin was removed.

Biting force measurement

The biting force of the participants was assessed using aload sensor sta (iload digital USB sensor),at insertion, three months and six months after insertion. Load sensors (iload digital USB sensor) wiring is intended for the use with computers. It was connected to PC USB using the cable with the device. It was connected to the power supply for at least 30 minutes before measurements to warm up. The load sensor was protected from significant fluctuations in temperature. The sensor was allowed to stabilize at the new temperature then use the 'tare" button on the display was set to the new "zero load" condition before connecting the load readings.

Direction of loading

A steel ball with a 3/8-inch diameter was put directly in the middle of the dome-shaped top of the compression-only iload sensor, and force was applied vertically to the top surface of the sensor. In order to insert the steel ball between the two triangular fossae of the upper second premolar and first molar, the sensor was placed horizontally at the second premolar and first molar embrasure area. The application of force was vertical,and the patient was advised to clench progressively. Figure 3 depicts the average of ten readings that were taken.

Figure 3: The Load sensor was positioned horizontally at the location of the second premolar and first molar embrasure with the patient seated upright.

Statistical Analysis

The data were collected, collated, and graphically represented. Using the statistical software SPSS 21 for Windows, the acquired data were statistically analyzed. Means, standard deviations, and mean percentage changes were all used to show descriptive data. To evaluate significant changes within each group over time and to compare the two groups, one way analysis of variance (ANOVA) and paired t-tests for pairwise comparison were utilized as analytical tests for all parameters.All statistical tests were set at a 0.05 level of significance.

Results

The results comprised the assessment of the mean values and standard deviation (S.D.) of the Biting Forces of patients restored with implant supported overdentures during denture delivery, 3, and 6months using two different implant diameters; the Mini Implant group and the Standard diameter Implants group. All implants were declared to have achieved osseointegration at the conclusion of this trial. None of the participants showed signs of clinical implant movement in any direction or peri-implantitis or mucositis. On palpation, percussion, or function, no discomfort was as noticeable.

Comparison of Biting Force values between the Mini-Implants Group I and the Conventional Implant Group II

Comparison between the two groups was performed by using the Independent t-test and presented in Table 1 and Figure 4. Statistical Analysis showed significant difference between both groups where there was more favorable biting values in the Standard diameter Implant group than the Mini-implant group as P<0.0001*.

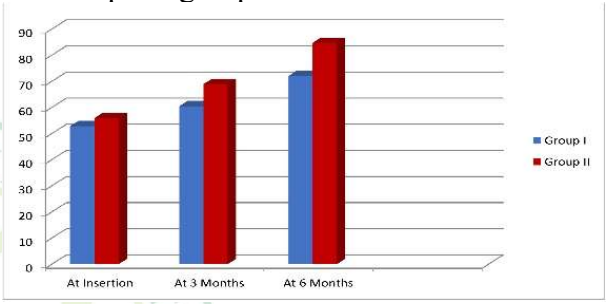

Figure 4: Bar Chart showing Comparison Biting Force Mean values between the Mini-Implants Group I and the Conventional Implant Group II

Comparison of Biting Force values between the follow-up periods for the Mini-Implants Group:

Comparison between the different time intervals of the Mini Implant Group I groups at different intervals was performed by using Paired t-test and presented in Table 2. In the Mini-Imnplant Group I,Statistical Analysis revealed a significant difference between all the time intervals as P<0.0001*.

Comparison of Biting Force values between the follow-up periods for the Conventional Implants Group 11

Comparison between the different time intervals of the Conventional Implant GroupII at different time intervals was performed by using Paired t-test and presented in Table 3. In the conventonal Group II,Statistical Analysis revealed a significant difference between all the time intervals as P<0.0001*(Table 1)

Table 1: Comparison of Mean and standard deviation of Biting Force values between the Mini-Implants Group I and the Conventional Implant Group II

Bone	Group I		Group II		P value
	M	SD	M	SD	
At Insertion	52.815	8.898	55.885	7.42	
After 3 mnonths	60.461	6.823	68.906	3.442	P<0.0001*
After 6 months	72.036	8.503	84.721	6.489	P<0.0001*

M:mean SD: standard deviation *Significant difference as P<0.05

Table 2: Comparison of Mean and standard deviation Biting Force values between the follow-up periods for the Mini-Implants Group I

Bone	Group I		P value
	M	SD	
At Insertion	52.815	8.898	
After 3 months	60.461	6.823	$P < 0.0001^*$
After 6 months	72.036	8.503	$P < 0.0001^*$

M:mean SD: standard deviation *Significant difference as P<0.05

Table 3: Mean and standard deviation of Biting Force values between the follow-up periods for the Conventional Implants Group II

Bone	Group I		P value
	M	SD	
At Insertion	55.885	7.42	
After 3 months	68.906	3.442	$P < 0.0001^*$
After 6 months	84.721	6.489	$P < 0.0001^*$

M:mean SD: standard deviation *Significant difference asP<0.05

Discussion

Several Studies revealed that four mini-implants installed in the inter-foraminal region fulfill the criteria of implant success. [11-12] For this reason, four mini-implants were used in this study and compared with two conventional implants as over-denture abuments for the rehabilitation of single lower denture cases.

Since it is recommended to perform minimally invasive surgery for lower edentulous ridges[13], it thus seemed beneficial to apply mini-dental implants with flapless surgery in this study.

Several studies revealed an insignificant difference between immediate and delayed implant loading by mandibular over-dentures. [14-17] Accordingly, the Immediate Implant Loading Protocol was followed in this study. Immediate biting force records were carried out after confirmation of the patient's comfort at the first inspection appointment as any pain certainly affects biting force records. The sensor was mounted horizontally to allow the vertical application of force.[18]

In the current clinical investigation, throughout the 6 months study period, it was reported that the biting force significantly increased with time in both groups which were in accordance with the results of other studies. [19-20]

It is obvious from the results of the study that the biting forces were significantly higher in the standard diameter implant group than in the Mini-implant group. This can be caused by the less favorable force distribution in the Small diameter group than in the standard diameter group. The biting force and chewing efficiency significantly increased after receiving stable dentures as instability of the dentures probably prevents patients from using their full jaw muscles forces as reported by Caloss etal.[21]

It seems that the rigidly interlocked conventional implants with the denture base exhibit more stable dentures than the mini-implants which have less surface area for anchorage and less fracture resistance.[22]

Conclusion

The conventional implants produced more favorable biting forces than the group of mini-implants supporting the mandibular single implant retained over-denture, within the confines of this study's limitations.

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Data availability

Data available from corresponding author upon reasonable request

Ethical approval and consent to participate

Submitted to research ethics committee (faculty of dentistry Cairo University) October 2022 and Approved.

Competing interest

No conflict of interests

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