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Conventional vs compressive implants for supporting immediate loading bar-retained mandibular overdenture: A study of peri-implant tissue health and implant stability

Mohammed H. Karkash
Postgraduate MSc Student, Department of Removable Prosthodontics, Faculty of Dentistry, Mansoura University, Dakahlia, Mansoura, Egypt, mohammedhussein8611@gmail.com

Khaled M. Zahran
Lecturer, Department of Removable Prosthodontics, Faculty of Dentistry, Mansoura University, Dakahlia, Mansoura, Egypt

Islam H. Kandil
Lecturer, Department of Oral Medicine, Faculty of Dentistry, Mansoura University, Dakahlia, Mansoura, Egypt

Ahmad A. Habib
Professor, Department of Removable Prosthodontics, Faculty of Dentistry, Mansoura University, Dakahlia, Mansoura, Egypt

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ORIGINAL ARTICLE

Conventional Versus Compressive Implants for Supporting Immediate Loading of Bar-retained Mandibular Overdentures: A Study of Peri-implant Tissue Health and Implant Stability

Mohammed H. Karkash [a,*], Khaled M. Zahran [a], Islam H. Kandil [b], Ahmad A. Habib [a]

[a] Department of Removable Prosthodontics, Mansoura University, Dakahlia, Mansoura, Egypt
[b] Department of Oral Medicine, Faculty of Dentistry, Mansoura University, Dakahlia, Mansoura, Egypt

Abstract

Objective: **This study was aimed to compare two implant design concepts used to assist immediately loaded mandibular complete overdentures as regards implant stability and peri-implant soft tissue health.**

Patients and methods: **Forty-four healthy fully edentate patients were chosen. Patients received conventional complete dentures and were randomly divided into group I: with four conventional implants. Group II: with four-compressive implants. For all patients, implants were installed in the interforamina areas and were immediately loaded with mandibular complete overdenture containing metal framework housing three clips and retained by an implant-screwed titanium bar. Implant stability was measured by Periotest and the tissue health was assessed with regard to the modified gingival index and pocket depth at T0, T6, and T12. Analysis of modified gingival index scores was done by the Mann−Whitney *U* test. Analysis of implant stability and pocket depth scores was done using the repeated measures analysis of variance test ($P < 0.05$).**

Results: **No significant difference ($P < 0.05$) in gingival scores between groups was detected at T0 and T12. There were significant differences regarding pocket depth ($P < 0.05$) (conventional implants scored higher pocket depth than compressive implants) and implant stability ($P < 0.05$) (compressive implants scored higher stability measures than conventional implants) at all observation times.**

Conclusions: **Compressive implants provided higher implant stability and lower pocket depth measures compared with conventional implants. The compressive implant could be considered a promising implant design for immediate loading protocol.**

Keywords: Bar, Compressive implants, Immediate loading, Implant stability, Modified gingival index, Overdenture, Peri-implant tissue health, Pocket depth

Introduction

Conventional complete dentures have been considered the most common treatment option for edentate patients for many decades.[1] Unfortunately, stability and retention of complete dentures are continually compromised with time due to ridge atrophy, especially mandibular ridge.[2] Conventional osseointegrated self-taping screw-type implants were widely used to stabilize complete dentures by different prosthetic rehabilitation modalities that improve retention and stability of the prosthesis.[3]

Accelerated improvement of the design and surface treatment of conventional implants encourages the application of early and immediate implant loading to replace the delayed loading protocol that was initially recommended for the osseointegration process of the early designed implants. The early

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* Corresponding author.
E-mail address: mohammedhussein8611@gmail.com (M.H. Karkash).

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and immediate implant loading protocols have shortened the 3–6 months of the delayed loading protocol and allowed the patient to receive his provisional restoration in the first 2 weeks or even during the 48 h after implant delivery in the case of the immediate loading protocol, which provides more satisfaction due to the rapid achievement of patient functional and esthetic demands. Unfortunately, the immediate implant loading protocol records a minimal success rate when the bone density is questionable.[4,5]

Many means of surgical techniques have been proposed to increase bone density and, therefore, obtain the required primary stability needed for immediate loading protocols. One of these techniques is to use undersized drills, in which self-taping implants with deep compressing threads are inserted in the undersized prepared beds compressing the bone to increase its density and thereby increasing the primary stability, allowing immediate loading. This concept is used in compressive implants, in which one pilot drill is used.[6]

The compressive implant manufacturers claim that compressive implants provide excellent primary stability in all bone types, which allow for immediate loading, as they are designed to adopt the concept of compressing the bone structure and enlarging the implant–bone interface's surface area by increasing thread depth, which subsequently increases the surface susceptible to osseointegration and, therefore, increases secondary stability as well.[7]

The claimed superior stability of compressive implants enables the use of immediate loading protocol within 24 h after surgery with high insertion torque, providing high stability measures, high bone–implant osseointegration, and good peri-implant tissue health superior to conventional implants.[7] Therefore, comparing implant stability and peri-implant tissue health between conventional and compressive implants over a year was thought to give us a clue as to whether compressive implants would really give higher primary and secondary stability scores than conventional implants and, therefore, enables us to use immediate loading protocols as a common practice regardless of bone quality, which is a demand nowadays by patients who want immediate results with excellent, successful outcomes.

Patients and methods

A total of 44 healthy, fully edentate patients were chosen from the Prosthodontic Department, Faculty of Dentistry, Mansoura University. A power analysis was made using the computer software G* Power (Heinrich-Heine-University Düsseldorf, Germany) for sample size determination. The sample size calculation yields a total of 44 patients (22 patients/each group) using independent samples t test. The following are details of the sample size calculation: effect size = 0.76, alpha (α) = 0.050, and power (β) = 0.80. The inclusion criteria were: the mandibular residual alveolar ridges of all patients were completely healed with sufficient height and width for the installment of four implants of suitable size in the interforamina area. The patients had an Angles class I maxillomandibular relation with sufficient mandibular restorative space, at least 14 mm, to allow the construction of the bar-retained mandibular overdenture.[8] Patients with parafunctional habits, heavy smoking (>10 cigarettes a day),[9] systemic disorders affecting the bone such as diabetes,[10] temporomandibular joint disorders, or neuromuscular disorders were excluded.[11]

The patients signed a written consent form to participate in the study after receiving information about the study procedures and follow-up schedule. The study procedures were reviewed and approved (No. A1206 0722) by the local ethics committee.

Conventional complete dentures were made for each patient 2 weeks before implant placement to allow the patient to regain normal jaw movements. The lower denture was used later on as a radiographic guide for the construction of the stereolithographic surgical guide. Radio opaque markers (8–10 gutta percha points) were incorporated in the lower denture. Cone beam computed tomography (CBCT) was used to double scan the denture (radiographic guide), first inside the patient's mouth and then outside. Using the CBCT software (Blue Sky Plan; Blue Sky Bio, Chicago, Illinois, USA), the two radiographs were superimposed and guided by the radiopaque markers, and then, using this data, a mucosal supported stereolithographic surgical guide was printed using a 3D printer (Shining 3D printer; SHINING 3D Corp., Zhejiang Province, Hangzhou, China) with the aid of the CBCT software (Blue Sky Plan; Blue Sky Bio) to guide implant placement in the target positions.[12] Flapless surgical protocol was followed to install four implants in the mandibular interforamina area.[13]

The patients were divided into two groups based on the implant design concept as follows.

Group I: where conventional implant design (jdevolution plus rootform dental implant; JDental-Care Co., Modena, Italy) was used with multiunit abutment and immediately loaded with a milled-in bar-retained mandibular overdenture (Figs. 1–3).

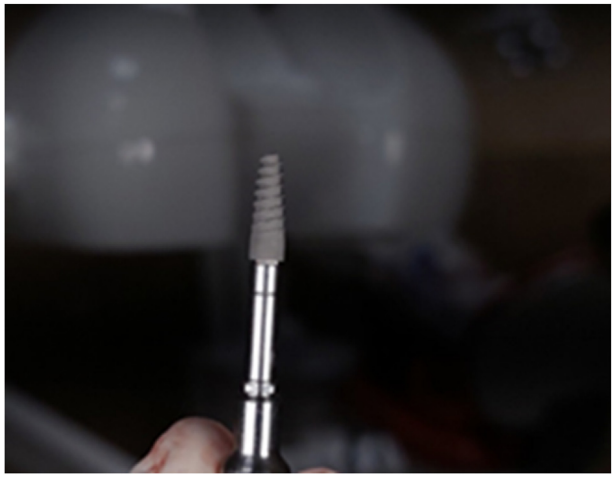

Fig. 1. Conventional implant.

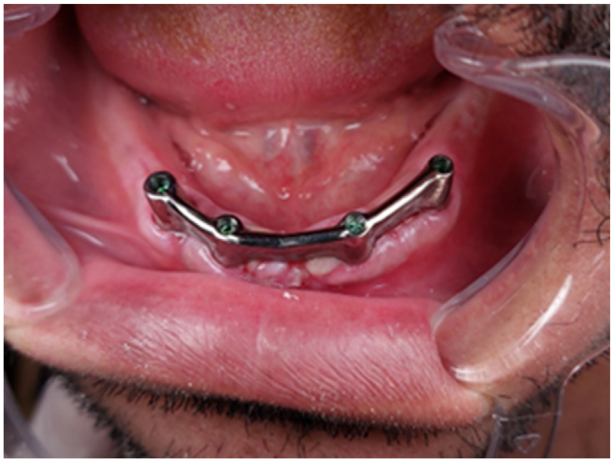

Fig. 3. Bar screwed in place.

Group II: where one-piece compressive implant design (Root compressive m, ROOTT Dental implants; TRTATE Dental Co., Zürich, Switzerland) was used and immediately loaded with a milled-in bar-retained mandibular overdenture (Figs. 4 and 5).

The study included conventional implants (jdevolution plus+) with a diameter of 3.7 mm and a length of 11.5 mm, whereas the compressive implants (Root compressive m) had a diameter of 3.5 mm and a length of 12 mm. A postinsertion panoramic radiograph was made to assess the implant positions (Fig. 6). After intraoral scanning of the implant positions using an intraoral scanner (Medit I700 Intraoral Scanner, model MD-IS0200; Medit Corp., Seoul, Korea), CADCAM milled-in titanium bars (rematitan blank Ti5; DENTARUM Co., Ispringen,

Fig. 4. Compressive implant.

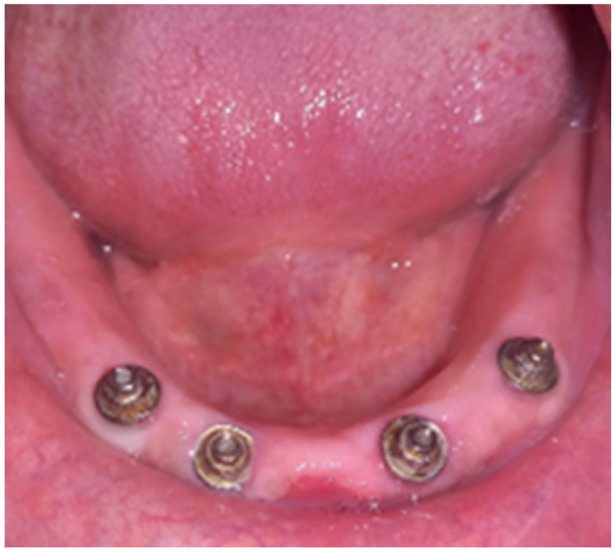

Fig. 2. Conventional implants with straight multiunit abutment.

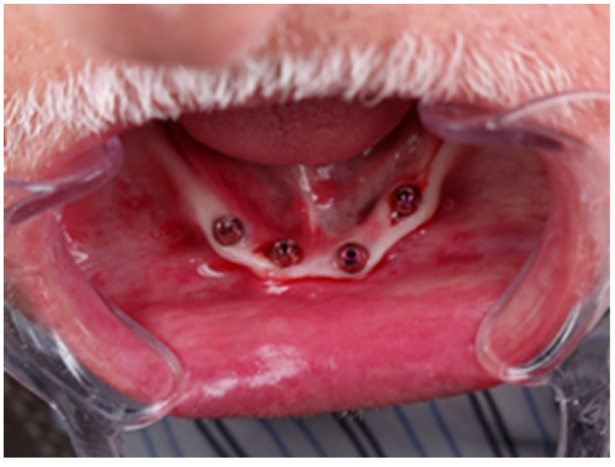

Fig. 5. Four-compressive implant screwed.

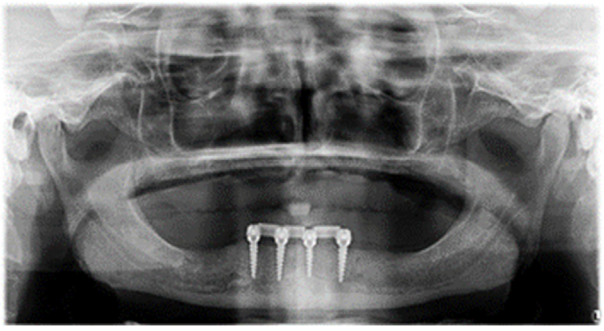

Fig. 6. Postinsertion panoramic radiograph.

Germany) were constructed for both groups, which were milled using a 3D milling machine (ED5X EMAR MILL, EMAR, Egypt) designed using a 3D designing software (Exocad DentalCAD 3.1 Rijeka, Exocad GmbH, Germany) (Fig. 3). After screwing the bars into the implant fixtures, three retentive plastic clips were seated on the top of the anterior and lateral parts of the bar, and the assembly was scanned intraorally to print a laser-sintered cobalt–chromium mesh framework using a laser printing machine (VM120 metal AM machine; VULCANTECH GmbH, Hannover, Germany). After the supporting framework was fabricated and checked for passivity and proper adaptation on the bar inside the patient mouth, two wax rims were applied to the posterior part of the supporting framework, and with the upper denture in place, the centric relation was recorded. A secondary impression was taken with the bar in place and poured into a secondary cast. The centric record and secondary cast were used to construct the lower denture which incorporated the supporting framework to reinforce the denture base of the newly constructed mandibular denture. Also, the inner surface of the metal housing contained three precise metal housings for the three plastic clips.

The implant stability was measured using Periotest (Periotests, Medizintechnik Gulden, Germany). Periotest handpiece was adjusted with a perpendicular contact angle not exceeding 20° on the abutment and maintained at 0.6–2.0 mm from the multiunit abutment in group I and the buccal surface of the implant in group II. Modified gingival index was measured visually using a 0–4 scale based on color, texture, edema, and spontaneous bleeding as follows: score 0 means healthy or normal gingiva; score 1 indicates slight inflammation with mild changes in gingival coloration and texture around the implants; score 2 indicates slight inflammation with more profound changes in color and texture around implants; score 3 indicates moderate inflammation, erythema, edema, and/or gingival enlargement; and score 4 indicates acute inflammation, erythema, edema, and/or gingival enlargement, and/or spontaneous bleeding, congestion, or ulceration. For each implant, modified gingival index scores were measured at all four surfaces (buccal, mesial, distal, and lingual).[14] A plastic probe was used to measure the pocket probing depth (H ZEPF 2445106; HELMUT ZEPF MEDIZINTECHNIK GMBH, Germany) placed under application angles of 20° to the longitudinal section of the implant and done with gentle pressure to avoid damage to gingival tissue.[15] All measurements were done soon after surgery at T0, after 6 months (T6), and 12 months (T12) from overdenture insertion. All measurements were done by the same operator.

The data were analyzed using a computer software program (SPSS v25; SPSS Inc., Chicago, Illinois, USA). Shapiro–Wilk tests were used for the normality of data. The nonparametric data (gingival scores) were presented as median (minimum–maximum), and the parametric data (probing depth and implant stability) were presented as mean ± SD for descriptive statistics. The comparison for modified gingival index between groups was made using the Mann–Whitney *U* test. The comparison of the modified gingival index between observation times was made using the Friedman test, followed by the Wilcoxon signed-rank test for multiple comparisons. The comparison of implant stability and probing depth between groups and observation times was made using repeated measures analysis of variance, followed by the Bonferroni test ($P < 0.05$).

Results

Results revealed that gingival scores significantly increased with advance of time for conventional implants ($P = 0.010$) at T6 only. There was no significant difference in gingival scores between observations for compressive implants. For conventional implants, gingival scores increased significantly from T0 to T6. There was no significant difference between T0 and T12 and between T6 and T12. There was no significant difference in modified gingival index between groups at T0 and T12. At T6, conventional implants recorded significantly higher gingival scores than compressive implants ($P = 0.045$) (Table 1).

After all observation times, there was a significant difference in probing depth between observation times for both groups ($P < 0.001$). For conventional implants, probing depth significantly increased from T0 to T6, then significantly decreased from T6 to T12. For compressive implants, probing depth significantly decreased from T0 to T6, then significantly

Table 1. Comparison of gingival scores between different observation times and between groups.

	T0 M (minimum–maximum)	T6 M (minimum–maximum)	T12 M (minimum–maximum)	Freidman test (*P* value)
Conventional implants	0.00[a] (0.00–0.00)	0.00[b] (0.00–2.00)	0.00[a,b] (0.00–1.00)	0.010
Compressive implants	0.00[a] (0.00–0.00)	0.00[a] (0.00–1.00)	0.00[a] (0.00–1.00)	0.351
Mann–Whitney test (*P* value)	1.00	0.045	0.293	

M, median.
P is significant at the 5% level. Different letters in the same row indicate a significant difference between each pair of observation times (Wilcoxon signed-ranks test, $P < 0.05$).

Table 2. Comparison of probing depth between different observation times and between groups.

	T0 (mean ± SD)	T6 (mean ± SD)	T12 (mean ± SD)	Repeated measures (*P* value)
Conventional implants	2.14 ± 0.09[a]	2.39 ± 0.10[b]	1.58 ± 0.03[c]	<0.001
Compressive implants	1.39 ± 0.08[a]	1.09 ± 0.07[b]	0.90 ± 0.04[c]	<0.001
Independent *t* test (*P* value)	<0.001	<0.001	<0.001	

P is significant at the 5% level. Different letters in the same row indicates a significant difference between each of the two observation times (Bonferroni test, $P < 0.05$).

Table 3. Comparison of implant stability between different observation times and between groups.

	T0 (mean ± SD)	T6 (mean ± SD)	T12 (mean ± SD)	Repeated measures (*P* value)
Conventional implants	3.01 ± 0.25[a]	3.86 ± 0.12[b]	4.55 ± 0.08[c]	<0.001
Compressive implants	5.29 ± 0.18[a]	4.36 ± 0.11[b]	5.08 ± 0.13[a]	<0.001
Independent *t* test (*P* value)	<0.001	<0.001	<0.001	

P is significant at the 5% level. Different letters in the same row indicates a significant difference between each of the two observation times (Bonferroni test, $P < 0.05$).

decreased from T6 to T12. For all observation times, there was a significant difference in probing depth between groups. Conventional implants recorded significantly higher probing depth than compressive implants at all observation times ($P < 0.05$) (Table 2).

After all observation times, there was a significant difference in implant stability between observation times for both groups ($P < 0.001$). For conventional implants, implant stability significantly increased from T0 to T6, then significantly increased from T6 to T12. For compressive implants, implant stability significantly decreased from T0 to T6, then significantly increased from T6 to T12. Multiple comparisons between each two observation times are presented in the same table. For all observation times, there was a significant difference in implant stability between groups. Compressive implants recorded significantly higher implant stability than conventional implants at all observation times ($P < 0.05$) (Table 3).

Discussion

Multiunit abutments were used for conventional implants in group I to simulate the abutment of the one-piece compressive implant in group II. In this study, the immediate loading protocol was applied due to the one-piece design of the compressive implant. However, the surgical site won't be exposed again to uncover the two-piece conventional implant, which may accelerate the healing process and avoid further trauma to gingival tissues.[15] The study's findings demonstrated that compressive implant design recorded a statistically significant lower mean gingival score at T6 compared with the conventional implant design. This observation may indicate that compressive implants are more compatible with gingival tissues due to their supra-crestal collar position. The modified gingival scores of conventional implants enhanced at T12 may be because of the extreme oral healthcare measures that were enforced on patients between T6 and T12. Also, the mean pocket depth was improved over time with compressive implants compared with conventional implants. The Matar *et al.*[16] study revealed that placing the machined collar supra-crestally (tissue level) has been associated with no loss of bone, whereas placing the collar below the alveolar crest resulted in loss of bone throughout a 2-year period. The better implant marginal soft tissue health of the

compressive implant design may be attributed to the self-cleansing ability of the supra-crestal implant collar and the one-piece design of the compressive implant.

Compressive implant stability showed a statistically significant difference compared with conventional implants throughout the entire study timeframe. At T0, the higher primary stability recorded with compressive implant design compared with conventional implant design may be attributed to its deep threads, which lead to higher insertion torque.[17,18] Deeper threads are useful in implant positions with inadequate bone quantity and quality and in immediate loading rehabilitations when primary stability is an essential requirement.[19] Bone tissue can withstand a certain amount of compressive strain, even beyond its elastic limit, without impairing the process of osseointegration. In addition, the elasticity of bone strengthens the physical bond between the implant and the bone, increasing primary stability.[19–21] At T6, there was a statistically significant decrease in compressive implant stability. This may be attributed to the fact that the primary mechanical stability was replaced by secondary biomechanical stability after the completion of the osseointegration process.[19]

At T6 and T12, compressive implant design recorded higher secondary stability than the conventional implant design. This may be due to the deep thread design pattern of compressive implants, which can increase the implant–bone interface exposed to the osseointegration process.[22] Furthermore, the improved secondary stability may be attributed mostly to the bone tissue's elastic reverse compression in the direction of the implant by the spring-back effect produced by self-taping of compressive implants. Compacted bone fragments around compressive implants and between compressive deep threads that were created during drilling serve as nucleating agents, accelerating de novo bone formation, fostering more rapid osteogenesis, and consequently resulting in higher secondary stability.[19]

This study has some limitations. This study's 12-month data are merely preliminary, and an extended follow-up is necessary to guarantee long-range results. However, the marginal bone height change around the compressive implant design must be monitored for longitudinal studies.

Conclusion

Compressive implants provided higher implant stability and lower pocket depth measures compared with e conventional implants. The compressive implant could be considered a promising implant design for immediate loading protocol.

Ethics information

The study procedures were reviewed and approved (No. A1206 0722) by the local ethics committee.

Funding

The study was completely self funded.

Data availability

Data is available via corresponding author.

Conflicts of interest

There is no conflict of interest.

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