The Effect of Varying Implant Position in Immediately Loaded Implant-Supported Mandibular Overdentures

Mohammed A. Shaarawy, MDSc, DDSc*
Ehab M. Aboelross, MDSc, DDSc

This study was carried out to evaluate the effect of varying implant position in immediately loaded implant-supported mandibular overdentures on peri-implant bone density, muscle activity, and patient satisfaction. Fourteen completely edentulous patients were selected for the study. After complete denture construction, patients were divided into 2 equal groups. Four dental implants were installed bilaterally in the interforaminal region in the first group, while in the second group, 4 dental implants were inserted bilaterally: 2 in the interforaminal region and 2 in the first molar area. Immediately after suturing, telescopic abutments were screwed to the implants, and the retaining caps were picked up into the fitting surface of the lower denture, which was delivered to the patient. Patients were recalled for radiographic bone density evaluation just after denture delivery and then at 3, 6, and 12 months thereafter. Muscle activities of masseter and temporalis muscles as well as patient satisfaction were also evaluated. The results of the study showed a high success rate approximating 98.2% of the immediately loaded implants. The electromyographic (EMG) records of both muscles in group 1 were significantly higher during chewing hard food after 3 months compared with group 2 ($P < .05$). Bone density changes were comparable in the 2 groups except at the end of the follow-up period, when group 2 showed a significant increase in peri-implant bone density values of the posteriorly placed implants compared with group 1 ($P < .05$). From the results of this study, it may be concluded that wide distribution of immediately loaded implants used for supporting mandibular overdentures through posterior placement beyond the interforaminal area results in a favorable response in terms of increased peri-implant bone density as well as decreased EMG activity of masseter and temporalis muscles.

Key Words: dental implant position, implant-supported overdenture, immediate loading, telescopic copings, bone density

INTRODUCTION

Implant-supported overdentures have gained increased popularity for rehabilitation of completely edentulous patients, providing many of the benefits of conventional tooth-borne overdentures while negating some of the most troubling problems, such as tooth decay and periodontal disease. Significant endodontic, periodontal, or prosthodontic treatments to maintain teeth as overdenture abutments are not as cost-effective or predictable as the use of implants.[1]

Faculty of Oral & Dental Medicine, Cairo University, Cairo, Egypt.
* *Corresponding author,* e-mail: muhalysh@hotmail.com
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The outcome of implant overdenture treatment is predictably and significantly better than that of conventional complete denture treatment. Patient satisfaction is improved remarkably with implant-supported overdentures. Mandibular implant-supported overdentures result in greater general satisfaction, ease of chewing, stability, and comfort compared with conventional dentures.[2,3]

To gain total support for the prosthesis, 4 or more interforaminal implants are used in implant-supported mandibular overdentures.[4,5] A distally extended cantilever bar up to 10 mm on each side had also been advocated to maximize the retention and stability of the distal component. However, this option could be associated with increased loads on the implants during mastication and thus is restricted to more demanding patients with poor to moderate posterior anatomy.[5,6]

The attachment types most commonly used for connecting overdentures to interforaminal implants are bar connectors, magnets, single spherical attachments (ball anchors), and rigid (cylindrical) and nonrigid (resilient) telescopic copings.[7] Implant-supported telescopic overdenture using 4 implants is a predictable treatment option for edentulous patients because it ensures a stable denture and facilitates oral hygiene.[8,9]

The use of telescopic crowns produces excellent retention through frictional fit between the crown and the sleeve. Telescopic crowns also provide favorable force distribution due to the circumferential relation of the outer crown to the abutment, which results in axial transfer of occlusal load and minimum rotational torque, thus preserving alveolar bone around abutments.[10–12]

Peri-implant bone density measurements seem to be of great importance, not only in primary implant stability but also in the predictability of implant outcome. It has been reported that peri-implant density measurements of progressively loaded implants show a continuous increase in peri-implant bone density by time, as the implants attempt to control the level of stresses transmitted to the damaged crestal bone. The applied load matches the load-bearing capacity of the maturing bone, leading to an increase in the peri-implant bone density.[13,14]

Electromyographic (EMG) activity of masseter muscle has been investigated in relation to implant-supported overdenture wearers during chewing hard and soft food. It was concluded that rehabilitation with implant-retained mandibular dentures may result in more regular chewing patterns with higher electrical activity of the masseter muscles, thus providing improved chewing function and comfort.[15]

Immediate loading of 4 interforaminal implants supporting overdentures has been used successfully in the past years and has proven to be a reliable method that significantly increases patient subjective satisfaction, objective chewing ability, and nutritional status and reduces bone resorption dramatically when compared with conventional complete dentures. Immediate loading of dental implants allows immediate restoration of esthetics and functions, reduces the morbidity of a second surgical intervention, and facilitates functional rehabilitation, thus increasing patient acceptance and satisfaction. It also eliminates the need for numerous and lengthy appointments that may place great demands on the practitioner's time for adjustment of provisional prostheses delivered to the patients during the healing period of delayed loaded implants.[16–19]

Implant distribution in the arch can help to minimize the stress exerted individually on the implants. In completely edentulous patients, this can be achieved by considering the importance of the anteroposterior distance (A/P). The A/P spread measurement is a formula used to calculate the maximum indicated cantilever length off the posterior-most implant on a fixed restoration. It is calculated by measuring the distance between 2 parallel lines, 1 drawn across the distal of the posterior-most implants and 1 drawn through the center of the anterior-most implant, and multiplying the result by a number ranging between 1.5 and 2.5.[5,20]

Long-term data on immediate implant loading exist only for interforaminally placed fixtures.[21] Therefore, the aim of this study was to evaluate the influence of shifting implants from their classic interforaminal position to a more posterior one on bone density changes, masticatory muscle activity, and patient satisfaction in cases of immediately loaded implant-supported mandibular overdentures. The null hypothesis tested was that shifting implant position would have no influence on peri-implant bone density changes, masticatory muscle activity, and patient satisfaction.

Materials and Methods

All patients attending the outpatient clinic of the removable prosthodontic department, Faculty of Oral and Dental Medicine, Cairo University, Egypt, over a period of 1 year were screened for participation in the present study. This research has been approved by the local research ethics committee. Participants had to have inclusive criteria of being 55–65 years age and free from any systemic disease that may interfere with proper osseointegration of implants, which was assessed by thorough medical investigations. All selected patients had been completely edentulous for at least 6 months. Patients having parafunctional habits or severe intermaxillary skeletal discrepancy as well as heavy smokers were excluded. The width and height of the lower ridge in the interforaminal region as well as the first molar area were initially evaluated by palpating the ridge between the thumb and index fingers. This was followed by cone-beam X-ray imaging for the evaluation of cortical bone quantity (thickness), quality, and morphology at the designated implant placement sites, as well as precise location of the mental foramen and inferior alveolar canal, which was essential before placement of 3.5- to 4-mm-width implants. Those who satisfied the inclusion criteria and agreed to sign informed consent were 14 patients (10 men and 4 women) with a mean age of 58 years.

Following the conventional steps, complete upper and lower dentures were constructed for each patient. At the delivery appointment, clinical remounting was done using a new centric relation record, and final occlusal adjustments and refinements were done on the articulator to provide lingualized occlusion. Before surgical intervention, dentures were delivered to the patients and adjusted periodically until they were functioning satisfactorily.

Patients (n = 14) were then divided into 2 equal groups, each consisting of 5 men and 2 women. In the first group, 4 implants were inserted bilaterally in the interforaminal region of the mandible (2 at the lateral incisal area and 2 at the cuspid area), while in the second group, 4 implants were inserted bilaterally (2 at the lateral incisal area and 2 at the first molar area).

The same steps for implant installation in both groups were carried out as follows. The delivered mandibular denture was duplicated to produce a clear acrylic radiographic template into which metallic balls were fixed on the crest of the ridge at the proposed positions of implant placement to evaluate the amount of bone available between the crest of the alveolar ridge and the base of the mandible as well as proximity to the inferior alveolar nerve using cone-beam X ray (Scanora 3D, Soredex, Tuusula, Finland). The balls were then removed and their sites widened to accommodate the use of the surgical drills.

The Ankylos implant surgical kit (Ankylos Dentsply Friadent, Mannheim, Germany) was used for implant installation. Surgical steps were carried out following the guidelines of the manufacturer. Parallel pins were inserted into the prepared osteotomy sites to ensure relative parallelism of the 4 implants. Implants were wound manually and then using a ratchet until the lower edge of their polished section contacted the bone.

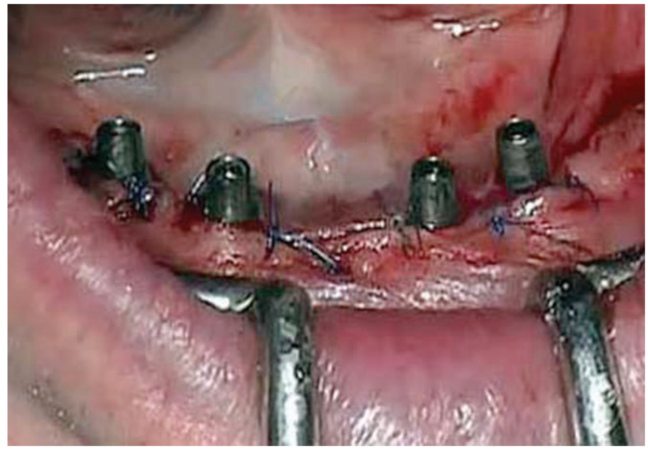

Figure 1. SynCone abutments tightened to the implants.

After implant installation, the cover screws of the 4 implants were removed. The prefabricated attachments of the Ankylos implant system composed of telescopic abutments (SynCone abutments, Ankylos Dentsply Friadent) and caps (Degunorm/SynCone copings, Ankylos Dentsply Friadent) were removed from their packing, and a 1-mm hex screwdriver was used to tighten the 6° taper abutments and/or angulated taper abutments to ensure relative parallelism between implant superstructures (Figure 1).

The edges of the flap were adapted and sutured along the convergent sulcus section of the abutments to form a tight seal around the implants.

Flexible polymerization sleeves were slipped over the abutment engaging its widest diameter to prevent self-cure resin from running into the sulcus and to protect the wound region. The prefabricated copings were secured firmly over the abutments, and the denture was marked for the positions of the abutments and opened to allow seating of the denture without interference with the SynCone caps. Chairside cold-curing resin (Rebaron, GC Corporation, Tokyo, Japan) was injected in the opening of the denture and left to polymerize while the patient was closing in centric occlusion with minimal pressure. The denture was removed, trimmed, and polished with the caps picked up in

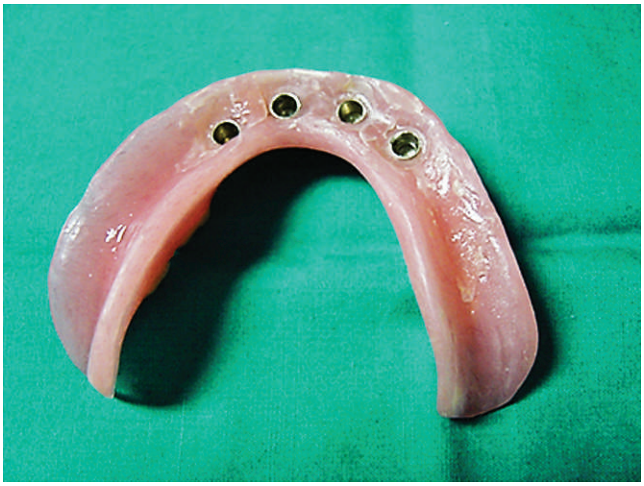

FIGURE 2. Denture finished and polished with the caps picked up in its fitting surface.

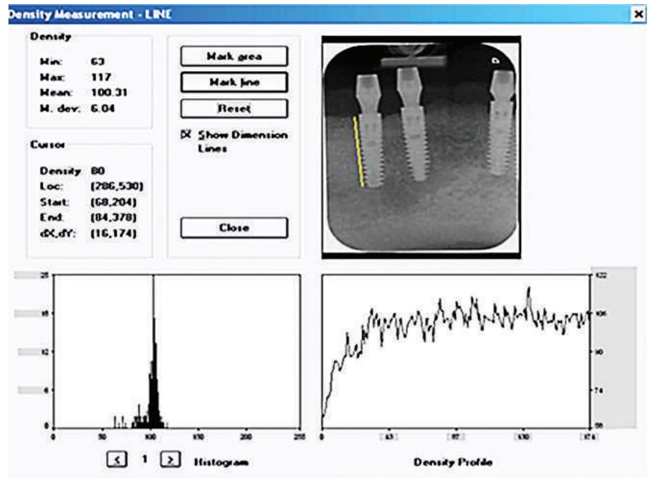

FIGURE 3. Bone density measurement for one surface.

its fitting surface (Figure 2). The denture was then delivered to the patient.

Following surgery, patients were instructed to apply a cold pack, follow the antibiotic regimen for 5 days, and use oral nonsteroidal anti-inflammatory drugs to reduce pain. Patients were advised to eat only a soft diet for 1 week without denture removal. Chlorhexidine mouth rinse 3 to 5 times daily was prescribed for patients for chemical plaque control.

One week following surgery, the dentures were removed and washed thoroughly, and new sore spots resulting from tissue healing were relieved. The sutures were removed, and patients were trained on insertion and removal of the dentures, which were worn again continuously for another week. Finally, patients were thoroughly instructed on how to perform proper oral hygiene measures and to shift their diet to more solid food gradually after 3 to 4 weeks.

All patients were recalled for radiographic and EMG evaluation. A questionnaire was also taken for patients of both groups to evaluate their acceptance and satisfaction of the delivered prosthesis.

Radiographic evaluation

Standardized periapical radiographs were carried out through the use of digital periapical radiography with paralleling technique using an acrylic bite block. Radiographs were taken at the day of surgery and 3 months, 6 months, and 1 year thereafter. Radiographs of both groups were compared with regard to bone density changes.

A radiographic acrylic template was constructed over the abutments and the edentulous ridge, and a bite block of the film holder (Hawe super bite anterior with ring, Kerr, Salerno, Italy) was attached to it using self-cure acrylic resin. The image plate was inserted into its disposable sleeve and mounted on the film holder. The image plate/film holder assembly was connected to the acrylic bite block and fixed in place in the patient's mouth. The long cone of the intraoral X-ray machine (70 KV, 8 mA, Orix70, Italy) was adjusted to fit into the aiming ring of the film holder, and the patient was asked not to move. The dose of X ray was fixed for all patients in all radiographs using the same X-ray machine. The image plate was inserted into a laser scanner to obtain a digital image on the monitor of the workstation for analysis.

The Digora software system (Digora for Windows 2.7, Soredex) was used for evaluating and analyzing the obtained digital images with regard to changes in bone density (radiometric analysis) mesial and distal to the implants. The density measurement system of the Digora machine enables the measurement of the relative bone density along a line or an area of controlled dimensions. Lines extending mesial and distal to the implants from the shoulder to the apex of the implant and parallel to its long axis were made and used for evaluation of the alveolar bone density around each implant (Figure 3). Bone density along each of the lines was recorded, and the mean value along each implant was then calculated, tabulated, and statistically analyzed.

EMG evaluation

The activity for the masseter and temporalis muscles was recorded using the EMG device (Nihon Kohden, Tokyo, Japan) after 2 weeks, 1 month, and 3 months following implant loading in both groups.

At each follow-up appointment, each patient was instructed to wear his or her denture for at least 2 hours prior to recording the muscle activity.

For each muscle, the EMG activity was recorded during maximum clenching, chewing soft food (banana), and chewing hard food (carrots). An interval of 5 minutes was left between each record to avoid muscle fatigue. Data were recorded after the first 3 cycles of chewing, when the EMG rhythm became more stable. Five records of the root mean square for each muscle, which represented the total integrated muscle activity, were obtained for each of the above-mentioned performances. The mean of the 5 records for each performance was calculated for each muscle at the different follow-up periods. A transparent template was prepared to be used at each subsequent follow-up visit to aid in repositioning of surface electrodes in their exact position.

Patient satisfaction

Each patient of both groups was presented with a self-administered questionnaire to indicate his or her degree of satisfaction with their dentures at the 2-week, 3-month, and 1-year follow-up period. The questionnaire consisted of 3 satisfaction aspects: stability, chewing, and overall comfort. Each aspect was qualitatively scored using a 3-point Likert-type scale as follows: *unsatisfactory* (US), *satisfactory* (S), and *highly satisfactory* (HS). For each scale level, the number of patients who selected each scale level was recorded for each satisfaction criteria for both groups at different follow-up sessions. Each satisfaction level was then given a score as follows: US =1, S = 2, and HS = 3 for statistical analysis.

Statistical analysis

Exploration of data was performed using Kolmogorov-Smirnov and Shapiro-Wilk tests of normality. Results of the tests showed that the EMG values and peri-implant bone changes data had normal (parametric) distribution. Data were described in terms of mean ± standard deviation at different time intervals. Comparison of quantitative variables between both groups in terms of EMG values and bone density changes was done using Student *t* test. A probability value less than .05 ($P < .05$) was considered statistically significant. Regarding patient satisfaction, a total satisfaction score was calculated for the different follow-up periods for both study groups. Mann-Whitney rank sum test was carried out for comparison between the 2 groups at different follow-up periods.

Results

Only 1 anterior implant of 56 failed from the first group, with a success rate of 98.2%. The lost implant failed because of poor primary stability at the time of implant insertion resulting from relatively poor bone quality at insertion site, which was further confirmed during implant insertion with a torque slightly less than 30 Ncm. The implant was removed 3 months postsurgically, when marked mobility and pain was obvious. However, in this case, the patient was satisfied with the outcome and continued to use the prosthesis successfully with only 3 implants.

Radiographic evaluation

Implants were categorized according to their positions into right and left anterior implants (RA and LA) and right and left posterior implants (RP and LP).

The mean alveolar bone density changes around all implants during the various time intervals in both groups are represented in Table 1. There was a reduction in bone density around all abutments in both groups during the first 3 months. This was followed by a gradual increase in bone density until the end of the study period.

Comparing both groups, there was no significant difference in bone density changes during all time intervals except between 6 months and 12 months, where group 2 showed a significant increase in bone density values around the posteriorly placed implants compared with group 1 ($P < .05$).

EMG activity

The EMG activity of the masseter and temporalis muscles of both groups during the different follow-up sessions is represented in Tables 2 and 3,

Table 1

Bone density changes in the 2 groups during different time intervals*

	Time Interval, mo	Group 1 Mean Difference	Group 1 SD	Group 2 Mean Difference	Group 2 SD	*t* Value
RA	0–3	−20.21	2.89	−17.59	2.72	−1.75
	3–6	28.03	2.42	25.77	2.38	1.76
	6–12	12.83	2.26	11.82	2.57	0.78
LA	0–3	−14.89	2.44	−17.07	2.61	1.61
	3–6	30.06	1.69	28.85	2.17	1.16
	6–12	13.48	2.16	15.68	2.36	−1.82
RP	0–3	−22.78	3.57	−25.29	3.21	1.38
	3–6	29.49	2.74	32.07	2.74	−1.76
	6–12	12.92	1.89	16.15	2.31	−2.86†
LP	0–3	−28.7	2.42	−30.11	3.24	0.92
	3–6	27.21	1.97	29.13	2.04	−1.79
	6–12	21.30	2.26	25.13	2.85	−2.79†

*RA indicates right anterior; LA, left anterior; RP, right posterior; LP, left posterior.
†Significant at $P < .05$.

respectively. There was no significant difference between the 2 groups after 2 weeks and 1 month following denture use for all the performed functions (clenching, hard food and soft food chewing) for both muscles. However, a significant difference was evident after 3 months for chewing hard food only, where group 1 was significantly higher in the case of both masseter and temporalis muscles ($P < .05$).

Patient satisfaction

All patients participating in the study attended the whole follow-up period that extended for 1 year. Most of the patients expressed high satisfaction with the delivered implant-supported overdentures regarding stability from the first day following surgery, which remained consistent throughout the different follow-up periods. On the other hand, they all suffered from the long procedures performed in a single visit and postoperative pain resulting from surgical trauma, suturing, and strict instructions about prosthesis immobilization, which was reflected by the high number of patients who expressed discomfort and chewing difficulty on using their dentures at the 2-week follow-up period. However, patient discomfort diminished, and chewing performance improved gradually over time, which was evident by the increase in the number of

Table 2

Mean recorded root mean square values of the masseter muscle activity throughout the different follow-up periods of the study

	Group 1 Mean	Group 1 SD	Group 2 Mean	Group 2 SD	*t* Value
2 wk					
Clench	0.741	0.033	0.722	0.031	1.11
Hard	0.625	0.038	0.591	0.035	1.74
Soft	0.341	0.022	0.319	0.026	1.71
1 mo					
Clench	0.712	0.034	0.683	0.029	1.72
Hard	0.503	0.037	0.475	0.036	1.44
Soft	0.261	0.015	0.249	0.024	1.12
3 mo					
Clench	0.616	0.035	0.604	0.033	0.66
Hard	0.405	0.040	0.347	0.039	2.75*
Soft	0.173	0.015	0.161	0.022	1.19

*Significant at $P < .05$.

Table 3

Mean recorded root mean square values of the temporalis muscle activity throughout the different follow-up periods of the study

	Group 1		Group 2		
	Mean	SD	Mean	SD	*t* Value
2 wk					
Clench	0.781	0.033	0.754	0.029	1.63
Hard	0.572	0.039	0.538	0.034	1.74
Soft	0.331	0.013	0.316	0.019	1.72
1 mo					
Clench	0.711	0.036	0.699	0.031	0.67
Hard	0.507	0.037	0.473	0.034	1.79
Soft	0.263	0.013	0.249	0.018	1.67
3 mo					
Clench	0.618	0.034	0.586	0.032	1.81
Hard	0.401	0.039	0.346	0.041	2.57*
Soft	0.177	0.014	0.164	0.020	1.41

*Significant at $P < .05$.

highly satisfied patients, reaching its maximum at the end of the follow-up period (Tables 4 and 5).

The total satisfaction scores for group 1 were 38, 57, and 61, while the scores for group 2 were 38, 62, and 63 at 2 weeks, 3 months, and 1 year, respectively. The results of the Mann-Whitney rank sum test for comparison between the 2 groups at different follow-up periods revealed no statistically significant difference between the 2 groups at 2 weeks, 3 months, and 1 year follow-up periods ($P =$ .281, .431, and .807, respectively).

Discussion

It is well known that implant-supported overdentures share their support between implants and soft tissues. To maximize the role of implants regarding their share in support and minimize that of soft-tissue support posteriorly, which may accelerate bone resorption, 4 instead of 2 implants were used in the present study.

The use of labial flange provides soft-tissue support and superior esthetics in cases with severe bone resorption compared with fixed prosthesis. In addition, further advantages are the ease of denture removal by the patient to perform proper oral hygiene and reduced laboratory cost.[5]

Peri-implant bone density measurements were our concern in this study as an evaluation of the overall bone response to the selected treatment protocols regarding distribution of immediately loaded implants supporting mandibular overdentures. The immediate loading protocol was preferred to the traditional delayed loading protocol according to the encouraging results of Barone et al,[22] who found that bone was significantly more dense around immediately loaded than unloaded oral implants. Moreover, Traini et al[23] analyzed the bone mineral density of peri-implant bone and found that bone around unloaded implants showed a low mineral density index under all the investigation methods used.

Selected patients had been completely edentulous for at least 6 months (ie, they were all new denture wearers). This was intended for 2 reasons.

Table 4

Patient satisfaction during the follow-up intervals in group 1*

Group I	2 wk			3 mo			1 y		
Denture quality	US	S	HS	US	S	HS	US	S	HS
Stability	0	1	6	0	1	6	0	1	6
Chewing	5	2	0	0	3	4	0	0	7
Overall comfort	5	2	0	0	2	5	0	1	6

*US indicates unsatisfied; S, satisfied; HS, highly satisfied.

Table 5

Patient satisfaction during the follow-up intervals in group 1*

Group 2	2 w			3 mo			1 y		
Denture quality	US	S	HS	US	S	HS	US	S	HS
Stability	0	0	7	0	0	7	0	0	7
Chewing	5	2	0	0	0	7	0	0	7
Overall comfort	6	1	0	0	1	6	0	0	7

*US indicates unsatisfied; S, satisfied; HS, highly satisfied.

The first was to ensure complete bone healing following teeth extraction, which is essential for initial implant stability for immediate loading, and the second was to put patients under the same situation (new denture wearers) for standardization of the results.

Criteria for the successful immediate loading of dental implants were strictly followed in this study according to the guidelines advocated by several authors,[16,24] Clinical assessment of primary implant stability was ensured by the insertion torque at the moment of implant placement, which was no less than 30 Ncm in almost all cases. This torque is considered by some authors[25,26] as the minimum torque necessary for osseointegration in cases of immediately loaded implants.

Screw-shaped implants used in this study possess a progressive thread design, which is grit blasted to produce a sharp edge and a rough surface, ensuring fast cellular adhesion and osseointegration, high primary mechanical stability in bone immediately after their placement, and increased total surface contact with surrounding bone, similar to multirooted teeth.[27,28]

The success rate of immediately loaded implants in this study was comparable to that of Eccelente and Piombino,[29] who studied the clinical results for immediate loading of overdentures retained by prefabricated telescopes and found that implants presented healthy peri-implant hard- and soft-tissue conditions; in addition to that, all patients appreciated function, esthetics, and retention of the restoration.

Mandibular implant-supported overdenture abutment sites and number can be planned and determined by the clinicians, which enables more favorable load distribution, improving long-term prognosis of the prosthesis. Inserting implants bilaterally in the first molar area in group 2 was intended to reduce, to some extent, the continued bone loss in the posterior region, where implant prostheses with posterior soft-tissue support may accelerate bone resorption distally according to Kordatzis et al,[30] which represents a main disadvantage of anteriorly supported implant overdentures.

Various attachments have been used to retain implant-supported overdentures, including bars, magnets, studs, and telescopes. Krennmair et al,[31] in a study comparing ball attachments and resilient telescopic crowns used on isolated implants in the edentulous mandible, found that the frequency of technical complications was significantly higher with ball attachments than with resilient telescopic crowns. Fayyad[32] also concluded that stresses around the implants supporting ball-and-socket–retained prosthesis were higher than those around implants supporting telescopic-retained prosthesis.

Owing to their improved comfort, remarkable stability, satisfactory transfer of masticatory forces to the implants, and simplified hygiene, the prefabricated telescopic concept through the use of prefabricated telescopic-borne superstructures was used in this study. It has proven to be a reliable method for retaining implant-supported overdentures. This concept is less challenging by eliminating the need for laboratory support and treating the patient immediately with a stable removable restoration. Moreover, implant-supported overdentures retained by the telescopic retainers provide a secondary splinting effect via a conical element rigidly integrated into the denture base, which is equivalent to primary splinting with a bar since the precision fit of the machined pair of conical elements results in stable, positive seating and retention of the secondary component on the primary one.[27,33] The fact that the secondary conical crowns are polymerized in place into the denture base by the direct pickup as the denture is in situ in its position of maximum intercuspation ensures uniform retention as well as prevention of any micromovement through precision fit of telescopic components.

As splinting disappears as soon as the denture is removed from the mouth, immobilization of the implants in the early healing phase was particularly important via continuous denture wearing during the first week following surgery (early healing phase), where it acts as a splint by remaining firmly placed on the implants. Moreover, functional load was minimized by a diet that excludes hard food, a protocol that was followed until the second week after suture removal. Only then can normal routines of multiple daily denture removals and normal masticatory activity begin gradually.

In the present study, telescopic abutments with 6° taper were used for both groups to ensure easy insertion and removal of the overdenture and to allow for accurate and passive fit of the telescopic retainers. Furthermore, in group 2, angulated abutments were used in some cases to compensate for lack of parallelism between installed implants.

Although interforaminal implant placement had been recommended for fixed complete denture rehabilitation due to high bone quality, lack of important vital structures, and absence of physiologic mandibular bending effect at that area, the effect of the cantilever design remains the main cause of expected distal implant failure and/or excessive bone resorption posteriorly. In the present work, widely separated implants were placed beyond the classical interforaminal area both to negate the cantilever effect and to allow better load distribution over a larger area. Moreover, telescopic attachments were used to minimize the effect of physiologic mandibular bending. All of these factors may contribute to the results of significantly higher peri-implant bone density changes of the posteriorly placed abutments in group 2 compared with group 1, especially at the end of the follow-up period.

Inspection of EMG results revealed a significant difference between the 2 groups after 3 months during chewing hard food for both muscles, whereby group 1 showed higher values. This may be because inserting the implants further apart by shifting them more posteriorly in group 2 may have resulted in better load distribution over a larger area, allowing for a wider area for chewing and hence better denture stability. Moreover, it renders the overdentures mostly implant supported, with no posterior soft-tissue contribution in support. All such factors eliminate the need for high muscle activity for food mastication.

The comparable patient satisfaction results of the 2 studied groups during the different follow-up periods confirms our suggested treatment option of shifting implants more posteriorly rather than the interforaminal recommendation protocol. Concerning different denture quality aspects, stability remained somewhat constant during the follow-up periods, which is related to the precision fit of the telescopic components of the overdentures. Chewing was mostly unsatisfactory during the first 2 weeks, which was expected following the single-visit surgical trauma and strict instructions about prosthesis immobilization at that time. However, it improved gradually as soft-tissue healing took place and patient accommodation to the prosthesis developed, a fact that was reflected by the decrease in EMG values by time. Patient overall comfort was also unsatisfactory during the first 2 weeks of denture use, which may be related to the expected postoperative pain. However, this discomfort gradually diminished following wound healing and denture adjustments over time.

Results of radiographic bone density changes were somewhat logical and appeared in accordance with EMG findings and patient satisfaction questionnaire results, a fact that may again reflect better load distribution and preferred chewing function to be directed more posteriorly.

Conclusions

Within the limitations of this study, it may be concluded that wide distribution of immediately loaded implants used for supporting mandibular overdentures through posterior placement beyond the interforaminal area results in favorable response in terms of increased peri-implant bone density as well as decreased EMG activity of masseter and temporalis muscles.

Abbreviations

A/P: anterior/posterior distance
EMG: electromyograph
LA: left anterior
LP: left posterior
RA: right anterior
RP: right posterior

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