ORIGINAL RESEARCH

Impact of Three Different Surgical Drilling Protocols on Early Loaded Single Implant in Posterior Maxilla: A 3-year Follow-up

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Abstract

Aim: This study aims to compare three different drilling techniques for implant site preparation to enhance the primary stability of the early loaded single implant in the posterior maxilla.

Materials and methods: A total of 36 dental implants were used in this study for the replacement of a missing single tooth or more in the maxillary posterior region with an early loaded dental implant. The patients were randomly divided into three groups. In group I, the drilling was performed using an undersized drilling technique, in group II, the drilling was performed using bone expanders, and in group III, the drilling was performed using the osseodensification (OD) technique. Patients were evaluated clinically and radiographically at regular time intervals immediately, 4 weeks, 6 months, 1 year, 2 years, and 3 years after surgery. All clinical and radiographic parameters were subjected to statistical analysis.

Results: All implants in group I were stable and successful, while 11 from 12 implants survived in both groups II and III. There was no significant difference in peri-implant soft tissue health and marginal bone loss (MBL) throughout the whole study period between the three groups, while there was a significant difference in implant stability and insertion torque between groups I, II, and III at the time of implant placement.

Conclusion: Preparing the implant bed using the undersized drilling technique with drills with similar geometry to the implant being inserted provides high implant primary stability without the need for additional instruments or cost.

Clinical significance: Dental implants can be early loaded in the posterior maxilla by using an undersized drilling technique, as it improves primary stability.

Keywords: Bone expanders, Early loaded dental implant, Osseodensification, Primary stability, Posterior maxilla, Undersized drilling technique.

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Introduction

Bone quality is one of the most important factors for the success of dental implants. Bone density, skeletal size, bone trabeculae, bone metabolism, cell turnover, mineralization, maturation, intercellular matrix, and vascularity are the factors that affect bone quality, for this reason, it is crucial to assess bone quality during implant planning.[1]

Misch[2] classified bone density according to macroscopic cortical and trabecular bone types into five groups (groups D1–D5); D1: dense cortical bone, D2: porous cortical bone and dense trabecular bone, D3: thin porous cortical crest and fine trabecular bone, D4: minimal to no crestal cortical bone and thin trabecular bone, and D5: immature bone.

The posterior maxilla is D4 which is 10 times weaker than D1. The bone of the posterior maxilla is soft and of poor quality. Also, radiographs show a lack of trabeculations.[3–5] Placement of dental implant in posterior maxilla needs special planning because of maxillary sinus pneumatization, poor bone quality, or ridge height or width deficiency. The long-term survival rates of dental implants in this area are influenced by both mastication dynamics and anatomical structure.[6,7] Limited visibility and decreased interarch space are other factors that may contribute to implant failure and difficulty in the posterior maxilla.[8]

Early or even immediate loading of a dental implant in the posterior maxilla is a challenging process but it can be done under certain circumstances.[9] High implant primary stability and insertion torque are the most important factors for immediate or early loading of a dental implant in the posterior maxilla to limit implant micromotion that would prevent osseointegartion.[10] Modifications to implant fixture/thread design, implant surface topography, and surgical drilling protocols are just a few of the methods and techniques that have been suggested for improving implant primary stability.[11] The modification of surgical drilling

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protocol is one of the strategies listed above that is thought to be among the easiest to adapt and is frequently used by surgeons in clinical practice.[12]

Undersized drilling technique is one of these surgical modifications. In this technique, the final drill is smaller than the actual implant diameter to enhance bone density.[13] There is a difference between the press–fit concept and the undersized drilling technique. Within the press–fit concept, the implant diameter is larger than the actual diameter of the final drill, so there is a limited degree of undersizing to allow self-tapping during implant insertion. While there exists an additional reduction in the drill diameter in the undersized drilling technique.[14] Another surgical modification is OD technique which was developed by Huwais. It is a non-excavation technique that has special burs.[15] It was reported by *in vitro* testing that these burs allow bone preservation andcondensation through compaction autografting by means of non-subtractive drilling, which in turn increases the mechanical stability of the dental implant and bone density.[16] Due to the springy nature and elastic strain of bone, OD osteotomy diameters were found to be lower than conventional osteotomies performed with the same burs. This roughly tripled the amount of bone that is available at the implant site.[16] Implant site preparation using motor-driven bone expanders has been developed to avoid complications of osteotomes and surgical mallet. The bone expanders compact bone laterally due to the special design of the threads. These expanders are used to prepare atraumatic implant sites in types II, III, and IV bones.[17]

Several clinical procedures, including the radiographic method, implant percussion, and periotest evaluation, are documented in the literature for the assessment of implant stability.[18–20] However, these methods lead to obtaining the results of the subjective evaluation or do not allow a linear evaluation of the stability. The resonance frequency transforms the evaluation from a self-interpreting form to a real evaluation that is linearly correlated with implant stability.[21]

As a consequence of the above-mentioned studies, it was interesting to compare different drilling techniques (undersized osteotomy, motorized bone expanders, and Densah burs) to improve primary stability of the early loaded single implant in the posterior maxilla as no clinical studies could be found comparing these different drilling techniques together to know which one will have the highest primary stability and insertion torque. The primary outcome of this study was the efficacy of the three different drilling techniques on implant stability by measuring the insertion torque of dental implants, and the changes in resonance frequency analysis (RFA). The secondary outcomes were implant success criteria during follow-up periods including peri-implant soft tissue health and MBL.

Materials and Methods

Study Population and Entry Criteria

This study was conducted in accordance with the seventh revision of the Helsinki Declaration in 2013 and approved by the Institutional Review Board (IRB) of the Faculty of Dentistry, Mansoura University, Mansoura, Egypt (M22030821). Patients were selected from the outpatient clinic in the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Mansoura University, Mansoura, Egypt from January 2018 till July 2018, for the replacement of missed single tooth or more in the posterior maxillary region by an early loaded dental implant. Written consent was obtained from all the participants.

Inclusion Criteria

- Patients with good oral hygiene.
- Patients' age of 20 years or more.
- Presence of missed single tooth or more in posterior maxillary region (D4 bone quality) to be replaced by a single implant.
- Period of edentulousness was 1 year or more.
- An 8 mm or more vertical bone height was present.
- A mesiodistal distance between adjacent teeth at least 7 mm.
- Bone width was at least 7 mm buccolingual at the edentulous site.
- Adequate crown height space of at least 8 mm.

Exclusion Criteria

- Uncontrolled systemic diseases.
- Uncooperative patients.
- History of abnormal parafunctional habits.
- Advanced periodontal diseases around surgical sites.
- Less than 1 mm buccal or lingual residual width after implant placement.

Study Design and Sample Distribution (Flowchart 1)

The sample size of the study was determined based on the null hypothesis of the study, which stated that the effect of the three different drilling techniques on the primary stability of the early loaded single implant in the posterior maxilla was not equal in their results.

Using G*power, version 3.0.10, calculated sample size-based t-test = 2.31; 2-tailed, α error = 0.05; and power = 90.0% with effect size = 2.63; the total calculated sample size was 10 implants in each group and to compensate for possible attrition by 20%, two implants were added (12 implants in each group).

The randomization of the edentulous spaces for every single missing tooth was done by one of the senior residents in the department, not included in the study, and was not aware of any related treatment protocol. Edentulous spaces for every single missing tooth were randomly distributed into three equal groups, 12 implants for each by using a computer-generated randomization list statistical package for the social sciences (SPSS, version 23.0). The distribution of the groups was as follows: Group I (undersized osteotomy group), group II (bone expander group), and group III (Densah bur group). All cases were operated by the same blind operator and were neither involved in the evaluation nor involved in the distribution process. The assessor did all the evaluation steps during the follow-up periods and was completely blind to the treatment protocol.

Clinical Procedures

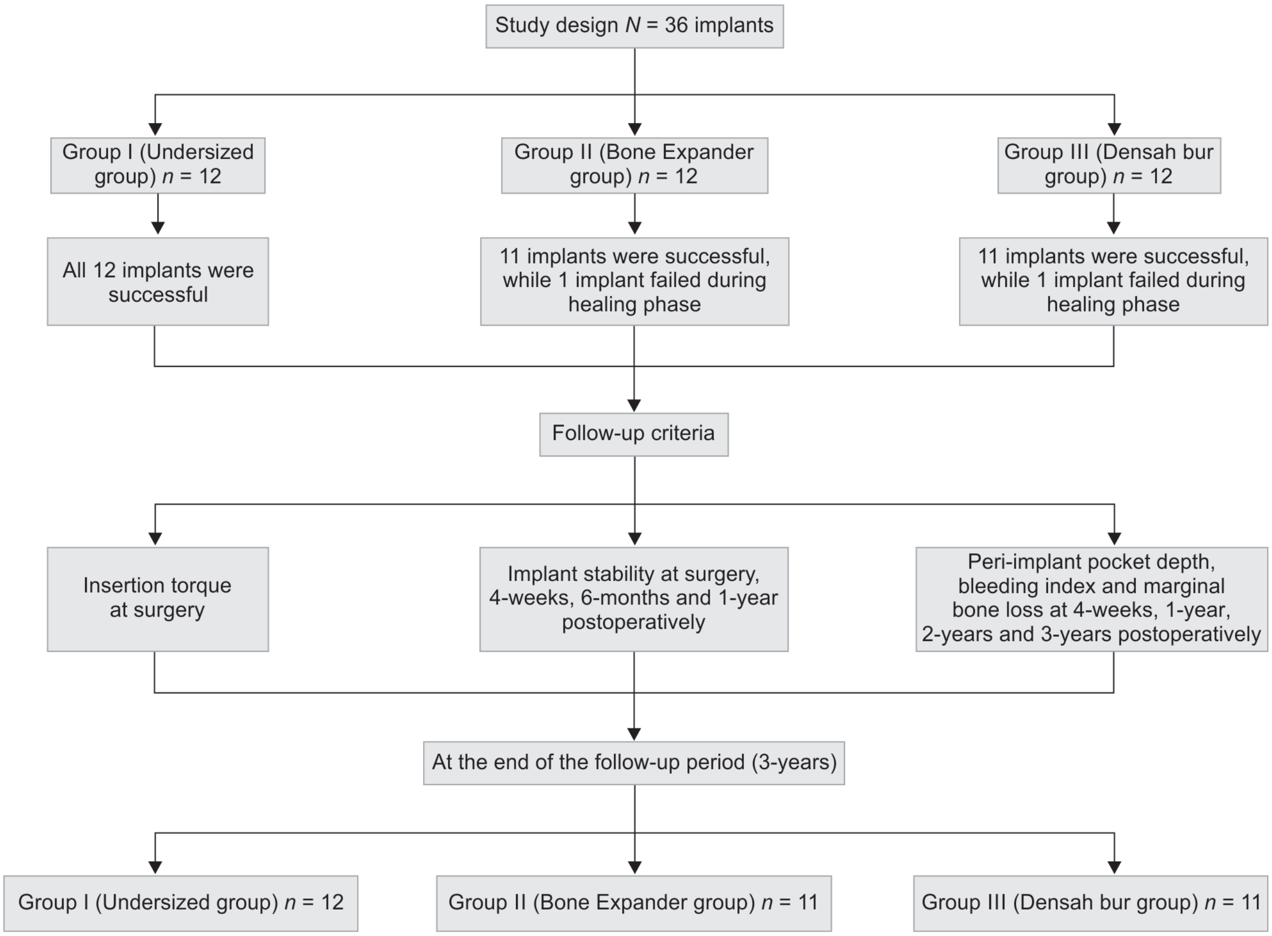
All patients underwent a thorough clinical examination after taking complete medical and dental history. The height and width of the ridge were measured using cone-beam computed tomography (CBCT) (Fig. 1A; Figs 2A and B).

Antimicrobial prophylaxis was administered with Amoxicillin 1 gm starting 1 hour prior to surgery.

Surgical Procedures

Group I (undersized osteotomy): After local anesthesia administration (Artinibsa 4% 1:100.000, Inibsa, Spain), a paracrestal incision was made, and the full-thickness mucoperiosteal flap was reflected to expose the ridge. The drilling was done using a low-speed reduction, high torque with coolant contra-angle handpiece with a surgical motor unit (NSK Surgical XT Implant Motor, NSK, Tochigi-ken, Japan). The speed of the drilling was 800–1,200 rpm. The implant preparation was smaller than the actual implant diameter by one drill (Fig. 1B).

Flowchart 1: Flowchart representation of groups distribution



The implant fixture (Neobiotech® System, IS II active, Seoul, Korea) was inserted 1–2 mm below the alveolar crestal bone. Insertion torque by manual ratchet was recorded and to be achieved ≥35 Ncm.

The cover screw was then placed (Fig. 1D). The flap was then repositioned and the edges were sutured using a combination of mattress and interrupted 4/0 Prolene sutures. The final position of the implant was checked by a periapical radiograph (Fig. 3A).

Group II (bone expander): Implant site preparation was made using a motorized bone expander self-drilling technique at a speed of 15–30 rpm (Split Master II, MCT Bio, Korea). The implant site preparation began with the use of the pilot drill of the system to the desired depth. The desired diameter of the osteotomy was reached by using bone expanders of various sizes in a sequential manner. All expanders were left 1 minute in their place before using the next one to allow bony adaption to the tension produced (Fig. 2C).

Group III (Densah burs): Implant site preparation was made using Densah burs (Densah® Burs, Versah, LLC, Jackson, MI, USA) following OD protocol (Fig. 2C). The osteotomy was performed using the pilot drill in a clockwise direction at 800–1,500 rpm with a copious amount of coolant until reached the desired depth. The following burs were used in counter-clockwise direction to densify the osteotomy. Modulate pressure with a pumping motion whenever feeling the haptic feedback of the bur pushing up out of the osteotomy to reach the desired depth.

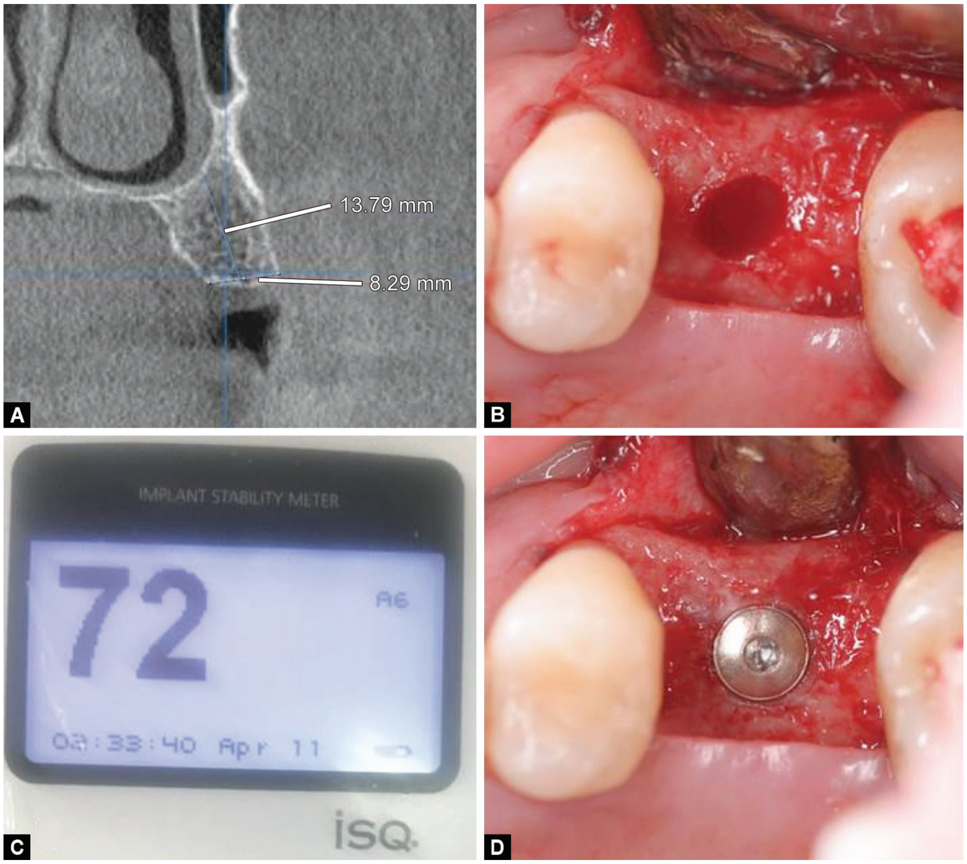
Postoperative care and instructions: All patients received Amoxicillin 1 gm twice daily for 5 days and analgesic (Diclofenac sodium 50 mg) was prescribed as and when required. Chlorhexidine 0.2% (Hexitol®, Arab Drug Company, Cairo) was advised for 2 weeks. On the first day, all patients were instructed to use extra-oral cold packs, to eat a soft diet for a week, and to avoid trauma during brushing. Sutures were removed after 7 days.

Second stage surgery: All implants were early loaded. Second-stage surgery was performed after 2 weeks by placing of healing cap for 10 days. After that, the impression was made by indirect impression technique. The final coverage for all implants was single crown coverage and made from porcelain fused to metal. The crown was cemented by temporary implant cement after checking the occlusion and margin.

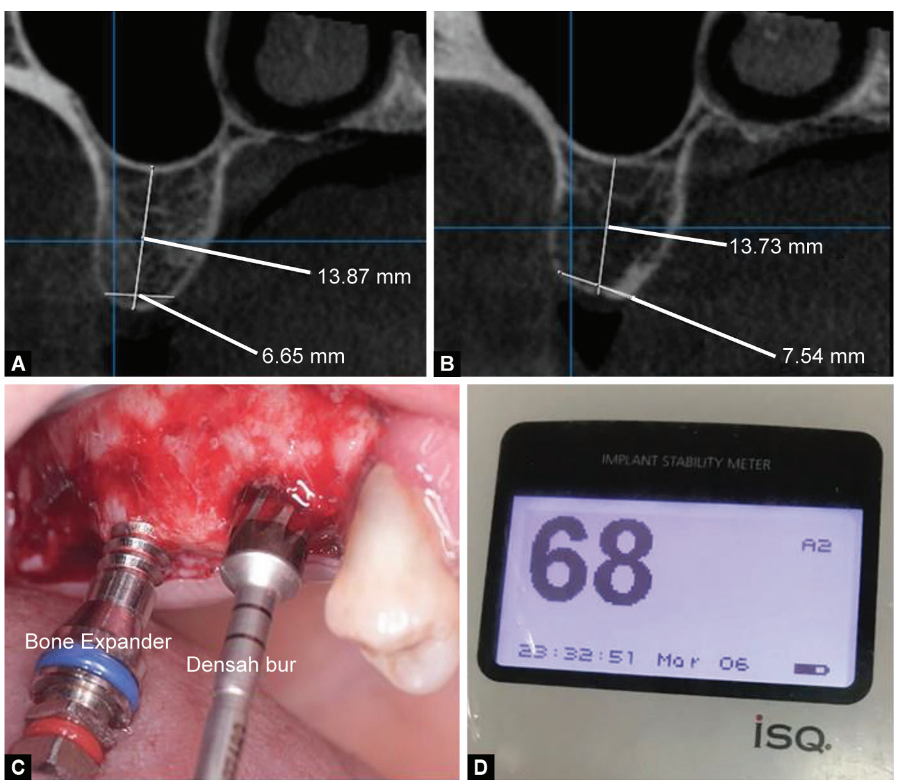
Evaluation: All patients were seen at regular time intervals for an evaluation immediately, 4 weeks, 6 months, 1 year, 2 years, and 3 years postoperatively.

Follow-up Criteria:

- Primary outcomes:
  - Implant insertion torque.
  - Implant stability measurements by use of resonance frequency analysis (RFA) by using an Osstell Mentor apparatus.

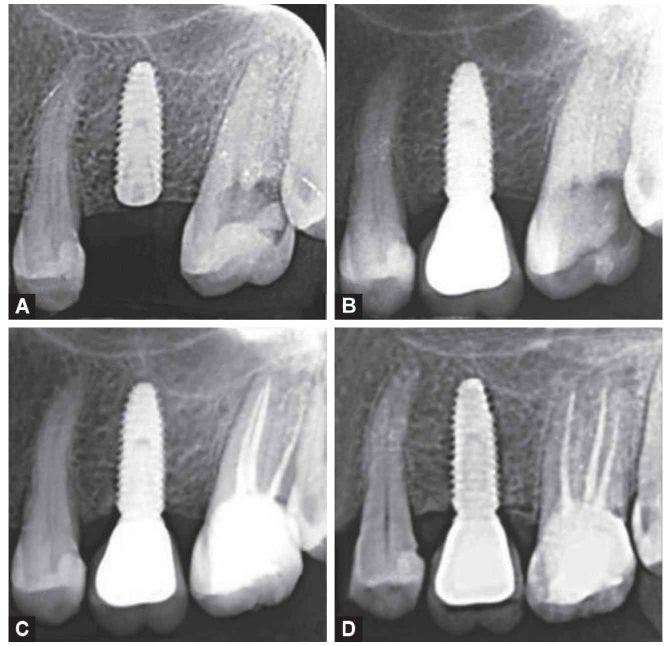


Figs 1A to D: (A) The preoperative cross-sectional CBCT image; (B) The osteotomy site after completion using an undersized drilling technique; (C) Primary stability measurement using Osstell; (D) The dental implant after complete installation and attachment of cover screw



Figs 2A to D: (A) The preoperative cross-sectional CBCT image at the maxillary first molar site; (B) The preoperative cross-sectional CBCT image at the maxillary second molar site; (C) The osteotomy preparation using Densah bur and Bone Expander; (D) Primary stability measurement using Osstell

- Secondary outcomes:
  - Peri-implant pocket depth.
  - Bleeding index.
  - Marginal bone loss.
- Implant insertion torque was measured at the time of surgery.
- Implant stability was recorded at the placement time, 4 weeks before cementation of the final restoration, 6 months, and 1 year postoperatively. Implant stability measurements were performed by use of RFA by using an Osstell Mentor apparatus (Osstell, Integration Diagnostics, Savadaled, Sweden). The smart peg (type 7) was attached to the dental implant. The results were expressed in implant stability quotient (ISQ) (Figs 1C and 2D).
- Other implant success parameters such as peri-implant pocket depth, bleeding index, and MBL were recorded in the following intervals: after loading (4 weeks), 1 year, 2 years, and 3 years.
- The marginal bone level was evaluated by using a standard digital periapical radiograph with the aid of Scanora™ 5.2 software program. Bone loss was measured on the mesial and distal aspects of each implant. The measurements of the bone level at implant placement were considered as baseline (Figs 3A and 4A). Radiographic MBL was calculated as the difference between the reading at loading, 1 year, 2 or 3 years, and the baseline value. To account for variability, the true length of the implant and the length of the implant on the magnified radiograph were used as a correction factor for the magnification (Figs 3B to D; Figs 4B to D).



Figs 3A to D: (A) An immediate postoperative periapical radiograph; (B) A periapical radiograph that was taken immediately after loading; (C) A periapical radiograph that was taken 1-year postoperatively; (D) A periapical radiograph was taken 3 years postoperatively

Statistical Analysis

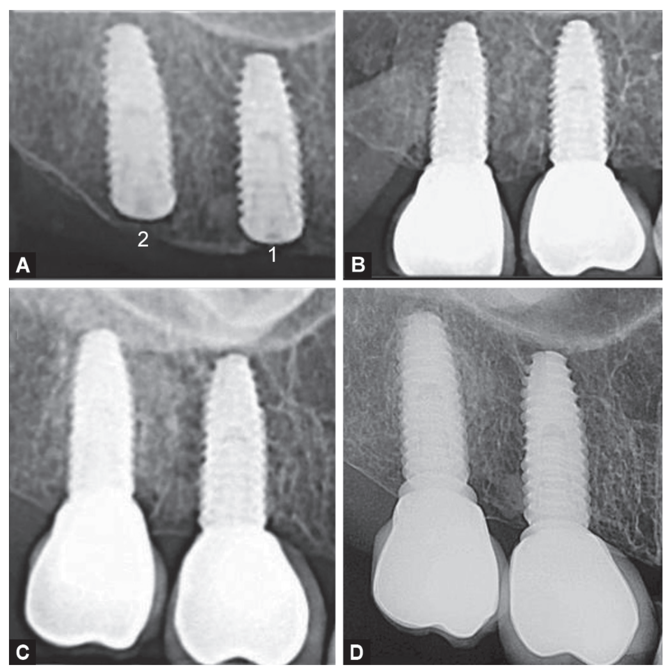
- Data were fed to the computer and analyzed using IBM SPSS Corporation Released 2013 statistics software for Windows, version 22.0 (Armonk, NY: IBM Corporation).
- Quantitative data were described using mean and standard deviation for normally distributed data after testing normality using Shapiro–Wilk test. One-way analysis of variance (ANOVA) test was used to compare more than two independent groups with the *post hoc* Tukey's test to detect pair-wise comparison. The significance of the obtained results was judged at the 0.05 level.
- Qualitative data: Monte Carlo test was used to compare of two or more groups.

Results

Demographic Data

This study involved 20 female patients who received 36 dental implants to replace missed single tooth or more in the posterior maxilla with an early loaded dental implant. The average age was 37 years (ranging from 20 years to 54 years). The distribution of replaced teeth was 24 maxillary first molar, eight maxillary second molar, two maxillary second premolar, and two maxillary first premolar. The implant size for all patients in the three groups was 4.5 mm × 11.5 mm. All patients received porcelain fused to metal crown restorations after 1 month (early loading) after implant placement.

At the end of the follow-up period (after 3 years), all 12 implants in group I were successful with a 100% survival rate, while 11 of 12 implants were successful in groups II and III, respectively, with a 91.6% survival rate. Two implants were lost (one from group II and the other from group III) during the healing phase at the time of second-stage surgery without any sign of inflammation, infection, or pain.



Figs 4A to D: (A) An immediate postoperative periapical radiograph: (1) The OD technique and (2) bone condensation technique by a bone expander; (B) A periapical radiograph that was taken immediately after loading; (C) A periapical radiograph that was taken 1-year postoperatively; (D) A periapical radiograph that was taken 3-years postoperatively

Comparison of Implant Stability between the Study Groups

Primary stability was evaluated using the peak insertion torque and ISQ at the surgery. There was significant difference between group I and the other groups (group II and group III)

(p-value <0.05). The ISQ values continued to be assessed during the follow-up period for a postoperative period of 12 months but there was no significant difference at loading, after 6 months and after 12 months (p >0.05) (Table 1).

Evaluation of the Peri-implant Soft Tissue Health

All of the mean values of the peri-implant pocket depth were within normal limits throughout the treatment period. There was no a statistically significant difference between the study groups (p >0.05) (Table 2).

Regarding the bleeding index, there was no significant difference between the three groups after loading ($p = 0.543$), after 1 year (p = 1), after 2 years (p = 0.321), and after 3 years (p = 0.991) (Table 2).

Marginal Bone Loss

There was no significant difference between the three groups in mesial and distal MBL after loading, after 1 year, after 2 years, and after 3 years (p >0.05) (Table 3).

Discussion

Immediate or early loading protocols have gained popularity in recent years as a result of the high patient demands for shorter treatment times. Due to the poor bone quality in the posterior maxillary region, it is challenging to apply these short-term treatments.[10] Therefore, the current study was designed to evaluate early loaded single implant in the posterior maxilla using different drilling protocols.

In group II, the failure may be because the expanders might exert high forces on the bone more than 20 MPa, which disturb the blood supply and displace bone marrow spaces. This result in more time for the bone to form new spaces for angiogenesis[22] and to repair this micro-damaged bone.[23]

In group III, Although no recorded implant failure has occurred, our research suggests that the failure may be caused by overcompressing the trabecular bone, which disturbs bone remodeling by activating osteoclasts and causing osteocyte death.[24] In addition, it is challenging to restore the original characteristics

Table 1: Insertion torque at surgery and ISQ at different time intervals

	Group I Mean ± SD	*Group II Mean ± SD*	*Group III Mean ± SD*	*p-value*
Insertion torque at surgery (Ncm)	42.08 ± 3.96^{AB}	38.75 ± 3.77^{A}	38.58 ± 3.50^{B}	0.048*
ISQ at surgery	71.08 ± 4.19^{AB}	65.5 ± 7.76^{A}	66.0 ± 5.26^{B}	0.049*
ISQ after 4 weeks	74.58 ± 4.56	72.09 ± 5.7	75.45 ± 4.34	0.26
ISQ after 6 months	77.50 ± 3.29	76.18 ± 2.44	77.73 ± 4.84	0.566
ISQ after 12 months	79.83 ± 1.11	79.27 ± 1.49	78.73 ± 3.55	0.518

*The p-values were calculated by *post hoc* Tukey's test, parameters described as mean ± SD; Similar superscripted letters denote significant difference between groups

Table 2: Peri-implant pocket depth and bleeding index at different time intervals

Peri-implant pocket depth		*Group I Mean ± SD*	*Group II Mean ± SD*	*Group III Mean ± SD*	*p-value*
After loading		1.22 ± 0.49	0.98 ± 0.23	1.10 ± 0.509	0.416
After 1 year		2.04 ± 0.46	1.79 ± 0.23	1.95 ± 0.52	0.382
After 2 years		2.19 ± 0.47	2.08 ± 0.25	2.26 ± 0.51	0.638
After 3 years		2.48 ± 0.45	2.46 ± 0.26	2.59 ± 0.40	0.710
Bleeding index	*Score*	*Group I Mean ± SD*	*Group II Mean ± SD*	*Group III Mean ± SD*	*p-value*
After loading	0	8 (66.7%)	5 (45.5%)	7 (63.6%)	0.543
	1	4 (33.3%)	6 (54.5%)	4 (36.4%)	
After 1 year	0	2 (16.7%)	2 (18.2%)	2 (18.2%)	1
	1	8 (66.7%)	7 (63.6%)	7 (63.6%)	
	2	2 (16.7%)	2 (18.2%)	2 (18.2%)	
After 2 years	0	1 (8.3%)	4 (36.4%)	1 (9.1%)	0.321
	1	7 (58.3%)	5 (45.5%)	8 (72.7%)	
	2	4 (33.3%)	2 (18.2%)	2 (18.2%)	
After 3 years	1	9 (75%)	8 (72.7%)	8 (72.7%)	0.991
	2	3 (25%)	3 (27.3%)	3 (27.3%)	

The p-values for peri-implant pocket depth were calculated by *post hoc* Tukey's test, parameters described as mean ± SD; The p-values for bleeding index were calculated by Monte Carlo test

Table 3: The MBL at different time intervals

Mesial MBL	*Group I Mean ± SD*	*Group II Mean ± SD*	*Group III Mean ± SD*	*p-value*
After loading	0.42 ± 0.12	0.34 ± 0.09	0.42 ± 0.12	0.174
After 1 year	0.76 ± 0.12	0.72 ± 0.10	0.82 ± 0.06	0.08
After 2 years	0.90 ± 0.14	0.87 ± 0.09	0.98 ± 0.07	0.058
After 3years	1.03 ± 0.14	1.02 ± 0.07	1.12 ± 0.08	0.07
Distal MBL	*Group I Mean ± SD*	*Group II Mean ± SD*	*Group III Mean ± SD*	*p-value*
After loading	0.40 ± 0.20	0.44 ± 0.10	0.36 ± 0.09	0.460
After 1 year	0.72 ± 0.18	0.80 ± 0.08	0.79 ± 0.09	0.315
After 2 years	0.87 ± 0.19	0.95 ± 0.09	0.93 ± 0.09	0.326
After 3 years	1.02 ± 0.19	1.09 ± 0.08	1.07 ± 0.09	0.399

The *p*-values were calculated by *post hoc* Tukey's test, parameters described as mean ± SD

of trabecular bone if a considerable number of trabeculae have been lost or destroyed.[25] Previous studies had shown that poor bone formation could occur as a result of tight contact between the implant and the host bone[26] or even host bone resorption.[27] Failure may also happen because of bone necrosis due to excessive heat generation with insufficient irrigation.

Assessment of implant stability with the ISQ value of RFA is a non-invasive method.[28] In this study, there was significant difference between group I and the other groups (group II and group III) at the time of implant placement ($p = 0.049$), but there was no significant difference between the three groups at loading, at 6 months, and at 12 months postoperatively.

This result is in line with Delgado–Ruiz et al.,[29] who found superior ISQ values are obtained when the implant bed is prepared using the underdrilling technique with drills that have a geometry comparable to the implant than when using universal OD drills with underdrilling.

In contrast to our study, Rastelli et al. found no significant difference in the primary stability with ISQ between conventional drilling, undersized drilling, bone expander, osteotome, and piezo techniques in an animal model in type IV bone.[30]

The required torque to insert the implant into the osteotomy site is known as insertion torque.[31] As a measure of primary stability, a common insertion torque has been utilized in numerous studies.[32] The implant's primary stability increases with increasing insertion torque value.[33] In the present study, there was significant difference between group I and the other groups (group II and group III) ($p = 0.048$).

This result is in line with Delgado-Ruiz et al.,[29] who found that the undersized drilling technique provides high insertion torque than using Densah burs.

In contrast to our study, Tian et al.[34] found that OD provides high insertion torque in comparison to the osteotome technique to increase primary stability.

Regarding group I, the undersized drilling technique increases the primary stability by compressing the bone.[35] This is in agreement with Alghamdi et al.,[28] who used the undersized drilling technique to place the implant in poor bone equality and achieved high primary stability. Tabassum et al.[36] stated that excessive bone compression causes a poor tissue response in the early stages of healing, so the undersized drilling technique has a biological limit.

Regarding group II, this technique showed a high ISQ values because expanders condense bone apically and laterally.[35] This is in agreement with Krafft et al.,[37] who got high primary stability when compared bone expanders with conventional drilling techniques.

Regarding group III, Densah burs increase primary stability through bone preservation and condensation.[38] This is in agreement with Huwais and Meyer[16] who stated that the OD technique would increase primary stability, the percentage of bone at the implant surface, and the insertion and removal torques of the implant when compared with the conventional drilling technique.

To diagnose the periodontium, peri-implant pocket depth was used. No significant difference was found between the three groups during the whole follow-up period, where $p > 0.05$. This is in line with Alghamdi et al.,[28] and Bhardwaj et al.,[39] who found a non-significant increase in peri-implant pocket depth, but in contrast to our study, Kumar et al.,[40] found a decrease in peri-implant pocket depth after18 months of loading.

In our study, the increase in peri-implant pocket depth was because the implant was placed 1–2 mm subcrustal. Also, the reflection of full-thickness mucoperiosteal flap resulted in a more apically positioned junctional epithelium.[41]

The bleeding index during the follow-up of this study was well controlled because patients maintained good oral hygiene, so most of the implant sites showed healthy gingiva. Bleeding from the junctional epithelium of the implant has been considered an early symptom of peri-implantitis.[39] For implants, Jepsen et al.,[42] reported that bleeding on probing had a high negative predictive value for monitoring peri-implant health.

There was no significant difference between the three groups after loading ($p = 0.543$), after 1 year ($p = 1$), after 2 years ($p = 0.321$) and after 3 years ($p = 0.991$).

Furthermore, MBL was well controlled in the three groups. No significant difference was found between the three groups at different time intervals. Many studies showed similar results regarding MBL.[43] In our study, full-thickness flap elevation resulted in early bone loss during the healing period.[44]

Based on our results, preparing the implant bed using the undersized drilling technique with the same drills of similar geometry to the implant being inserted provides a superior implant primary stability than using bone expanders or Densah burs, so the undersized technique could be the technique of choice for an early loaded dental implant in the posterior maxilla as it is an easy technique without certain precautions during osteotomy preparation and does not need additional drills or additional cost to the patients.

Limitations

The limitations of this study are as follows:

- All bone loss measurements were done using digital periapical radiographs, which are two dimensional. The CBCT results could serve as a better and more accurate tool and could give an overall picture of the actual bone loss in all dimensions.
- A larger sample size and measuring bone density using CBCT would result in stronger and more dependable results.

Conclusion

It is generally assumed that the placement of implants in the posterior maxilla requires considerably more caution during surgery. After an observation period of 3 years, the three drilling techniques are successful techniques for the early loading of implants in the posterior maxilla (D4 bone quality), but there was statistically significant difference between undersized group and bone expanders, and Densah burs groups regarding primary stability, so the undersized drilling technique is a suitable solution to improve primary stability in low-density bone without need of additional instruments or cost unlike bone expanders and Densah burs which need special drills with additional price and cost while undersized drilling protocol uses the same drills of implant system surgical kit.

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