REVIEW ARTICLE

ASSESSMENT OF BONE HEALING AROUND IMMEDIATELY LOADING DENTAL IMPLANTS IN POSTERIOR MAXILLA WITH TWO DIFFERENT OSTEOTOMY TECHNIQUES

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ABSTRACT

The posterior region of the maxilla is characterized by thin cortical bone and trabecular bone of low density. In addition, in many instances the height of the bone in this region is insufficient to achieve high primary stability because of the presence of the maxillary sinus. The aim of this study was to assess bone healing around immediately loaded dental implants in posterior maxillary region with two different osteotomy techniques, conventional technique versus condensing technique. Twenty implants were inserted in ten patients each patient received two implants. One implant was inserted by conventional technique other implant was inserted by condensing technique one on each side of maxilla. The follow up was done at the following intervals, immediate post-operative, six weeks, twelve weeks, and twenty four weeks. One implant from the group of condensing technique showed failure after four weeks. The results of this research demonstrate the success rate was 90% for condensing group and 100% for conventional group.

INTRODUCTION

Osseo integration occurs in two levels: primary and secondary. Primary osseo integration is associated with the mechanical engagement of an implant with the surrounding bone after implant insertion, whereas bone regeneration and remodeling offers secondary osseo integration (biological stability) to the implant.(1)

Primary stability, defined as the biometric stability immediately after implant insertion, is a critical factor that determines the long-term success of dental implants.(2) In other words, primary stability is the absence of mobility in the bone bed after the implant has been placed. The phenomenon behind this is the same as that applied for reduction of fractured long bones; that is, there should be utterly no movement between the fragments when the ends of a fractured long bone are reduced to endorse fracture healing. This is because movements even at the micrometer range can induce a stress or strain that may hinder the formation of new cells in the gap. Several studies have reported high success rates with immediate loading of dental implants, which are attributed to high primary stability.(3)

Primary stability has been regarded as a prerequisite for osseo integration of dental implant, especially when early or immediate loading protocols are considered as treatment modalities in dental implantology. The primary stability of dental implants can be regarded as the mechanical stability obtained immediately after insertion. The insertion torque measured through surgical hand-pieces during implant placement provides real-time feedback that can be used to predict implant survival and to estimate healing time before loading. The surgeons seek to obtain the highest levels of primary implant stability.(4)

Primary stability affects the strength, rigidity and resistance to movement of the implant before tissue healing and increases with increasing resistance to implant insertion. It must be measured immediately after insertion since stability levels may vary over time, due to bone remodeling at the implant bone interface. Secondary stability is provided by osseo integration and requires a direct contact between implant and bone without the interposition of connective tissue. The overall stability decreases in the first weeks and increases again when the stability provided by osseo integration dominates.(5)

A high primary stability assures a high resistance of the implant to micro movements. For successful osseo integration, the implant should not be subjected to micro movements of more than 50-150 µ.m.[31] Another advantage of a high primary stability is a reduction in patient treatment time, as clinicians have to wait for osseo integration to occur before starting prosthetic rehabilitation in the cases of less stable implants. (6)

Although the success of dental implants depends on primary stability, there are no minimum or maximum recommended values of primary stability from a theoretical standpoint. Degidi and Piatelli in 2005 yielded 100% success with a torque higher than 40 N cm and loaded with provisional prostheses installed within seventy two hours. Following placement they reported a success rate of 92.5% for immediately loaded implants as compared to a 100% success rate for delayed implants. They stated that high success rates with immediate loading of dental implants, were due to high primary stability.[7]

The primary stability and success rate of dental implants were reported by several researchers and the results suggested that there are many factors involved. The primary stability of dental implants is affected by the design (shape, diameter, length, and thread profile) and surface morphology of the implant. The quantity and density of bone available at the implant site and the surgical technique also affect the primary stability.[8] Although many studies have been conducted on the primary stability of dental implants, the mutual relation between implant design, bone quality and surgical technique remains relatively uncharted. [9]

The stability of implants for immediate loading is largely affected by the loading force, particularly soon after placement of the implant.[31,36] However, if the loading is beyond the tolerance of the bone-implant surface the stability of the implant will deteriorate, so control of loading is one of the most important biomechanical requirements for implants for immediate loading. To avoid excessive forces it is recommended that occlusal contact with the opposing teeth be reduced, however, the exact amount of force applied is uncertain. Besides there are few reports that investigated the effect of controlled loading on the primary stability of implants.[10]

The posterior region of the maxilla is characterized by thin cortical bone and trabecular bone of low density. In addition, in many instances the height of the bone in this region is insufficient to achieve high primary stability because of the presence of the maxillary sinus. Therefore, dental implants in this region show the highest rate of failure and surgical techniques have been proposed to increase their primary stability. The most widely used method is preparation of the site with tools one size smaller than the diameter of the implant. Other methods include bone condensation using an osteotome and the use of bicortical fixation.[11]

The osteotomy technique was introduced to increase the primary stability and success rate of implants in areas of poor bone density, such as the posterior maxillary region. Theoretically the osteotome condenses the bone to increase primary stability by lateral osseo compression. However, according to Blanco et al.[12] Who studied the placement of implants using the osteotome in the maxillary tuberosities of human cadavers and performed histomorphometric assessment around the implants, the increase in bone density is actually limited to the periapical area of the entire peri-implant area, and in the pericylinder area there was no increase in bone density with the osteotome technique. According to Nkenke et al.[13] use of the osteotome to condense the bone results in longitudinal cracks and gaps in the region of the bone collar, increasing the rate of implant failure. There is insufficient scientific and clinical evidence to support immediate loading in the posterior maxillary region.[14]

Several methods can be used to measure primary implant stability; these include biomechanical tests, which are represented by measurement of the insertion and removal torque and non-destructive measurements such as resonance frequency analysis (RFA). Biomechanical testing such as measurement of the insertion and removal torque is more accurate than non-destructive measurements such as RFA and the periotest.[47] However since biomechanical testing is destructive and can be applied only once, its clinical utility is limited. Therefore, non-destructive measurements such as RFA are commonly used in clinical practice. The use of RFA and the Periotest is also limited because of the high variability of these instruments during examination.[15] Currently, there is no gold standard for the accurate measurement of implant stability, and studies have cast doubt upon the correlation between the values of insertion and removal torques and RFA.[16]

In 1985, Lekholm and Zarb[17] listed four bone qualities: Quality 1 was composed of homogeneous compact bone. Quality 2 had a thick layer of compact bone surrounding a core of dense trabecular bone. Quality 3 had a thin layer of cortical bone surrounding dense trabecular bone of favorable strength. Quality 4 had a thin layer of cortical bone surrounding a core of low density trabecular bone.

Misch[18] described four bone categories D1 bone is primarily dense cortical bone (D1>1250 Hounsfield units in CT tomography). D2 bone has dense-to-porous cortical bone on the crest and, has underneath coarse trabecular bone (850 to 1250 Hounsfield). D3 bone type has a thinner porous cortical crest and fine trabecular bone in the region next to the implant (350 to 850 Hounsfield). D4 bone has almost no crestal cortical bone. The fine trabecular bone composes almost all of the total volume of bone next to the implant (150to350 Hounsfield). A very soft bone, with incomplete mineralization and large intertrabecular spaces, may be addressed as D5 bone, this bone type is most often immature bone in a developing sinus graft (D5< 150 Hounsfield).

The quality of bone is often dependent upon the arch position as the densest bone is usually found in the anterior mandible, and the least dense bone is typically found in the posterior maxilla. Following a standard surgical and prosthetic protocol, Adell et al.[19] reported an approximately 10% osseo integration was greater success rate in the anterior mandible as compared with the anterior maxilla. The highest clinical failure rates have been reported in posterior maxilla, where the force magnitude is greater and the bone density is poorer.[20]

In 2006, Wang et al.[21] provided a definition of immediate loaded implant based on a consensus from the international Congress of Oral Implantologists in which immediate loading was described as a technique in which the implant supported restoration is placed into functional occlusal loading within 48 hours of implant insertion. Furthermore, a distinction was made between the immediate restoration for aesthetic purposes, in which the restoration was placed out of occlusal contacts, and true immediate loading.

AIM

The aim of this study was to evaluate the bone healing around immediately loaded dental implants in the maxillary posterior region with two different osteotomy techniques.

PATIENTS AND METHODS

Twenty implants were placed into edentulous maxillary posterior region in ten patients. Each patient received two implants one on each side of maxilla. The implants were placed in the same positions bilaterally, using the bone condensation technique for one side and the standard drilling technique for the other side. The patients were selected from the out-patient clinic of oral & maxillofacial Department at the Faculty of Dentistry, Suez Canal University.

Preoperative examination: Medical and dental histories were taken through a printed questionnaire and discussion with the patient. The patients signed an informed consent explaining the surgical procedures & follow up scheme, potential complications and other alternative treatment. They also consented about inclusion of their data in the study. Pre-operative Panoramic x-ray was requested in order to evaluate the case.

Standardized periapical radiograph preoperatively was achieved via using XCP film holding device and film positioning stent. An aluminum step wedge was incorporated into the device to perform photodensitometric measurements for periapical radiographs. Radiographs for all subjects were done using the same exposure parameters. The x-ray films were developed and fixed manually using fresh chemicals always.

Surgical procedures: All surgical procedures were performed under aseptic conditions. This was achieved by asking the patient to rinse with 15 ml of 0.1% chlorhexidine mouth wash immediately before surgery to reduce the oral microbial count. A perioral facial preparation of the patient using povidene-iodine 10 % antiseptic solution was done. The field was then isolated with sterile towels. Articiane fort 4%(Ilerimplant-Spain) infiltration anesthesia was applied. Frontier dental implants were used in this study. Frontier dental implants[1] were used in this study.

Bone condensation technique (Figures 1-3): A midcrestal incision with two vertical releasing incisions was made bilaterally. Full thickness buccal and palatal mucoperiosteal flaps were reflected, exposing the alveolar ridge at the site of implant placement. Implant site at the bone condensation side was prepared by pilot drill, followed by expanders of sequentially increasing diameter; each expander remained at the implant site for one minute before the next diameter was introduced. Finally implants were inserted using torque wrench adjusted at 35 N/CM.

Conventional implant technique figures (4-6): At the conventional technique side the implant site was gradually enlarged with pilot and spiral drills according to the standard protocol as instructed by the manufacturer. Implants were inserted using torque wrench adjusted at 35 N/CM After implant placement at both sides primary wound closure was achieved with interrupted sutures.

Post-operative care and follow up:

Postoperative instructions:-

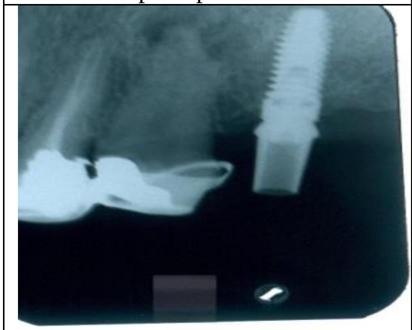
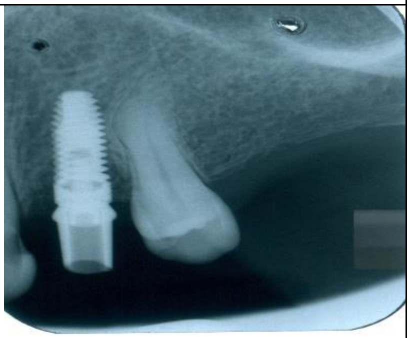
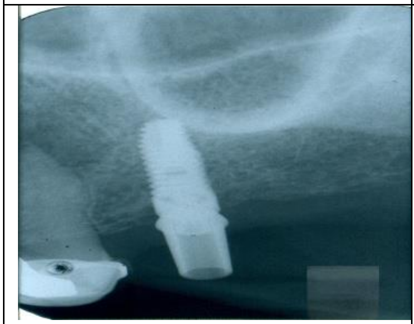
1. Intermittent cold application to minimize edema ten minutes / ½ hours.
2. Augmentin(Glaxo - Egypt) 625 mg tablets three times / day for five days.
3. Voltaren (Novartis) 50 mg tablet was prescribed as non-steroidal anti-inflammatory drugs three times /day for three days.
4. Chlorhexidine (Kahira-Egypt) mouth wash 0.1% three times/day started at the second postoperative day.

Clinical follow up: Patients were reviewed within two days to receive provisional crown free of occlusion and then they were assessed at one week, six weeks, twelve weeks and twenty four weeks for follow up.

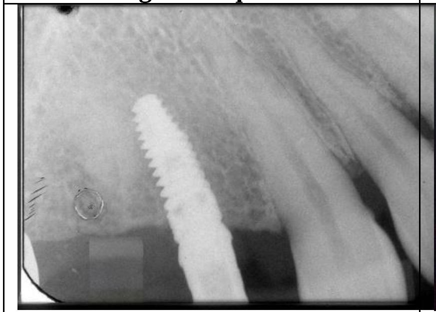
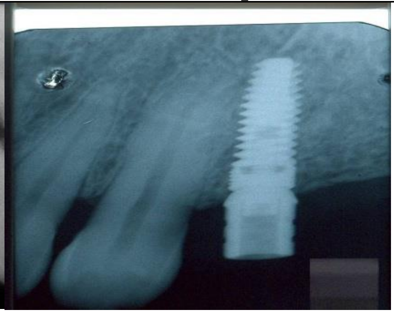
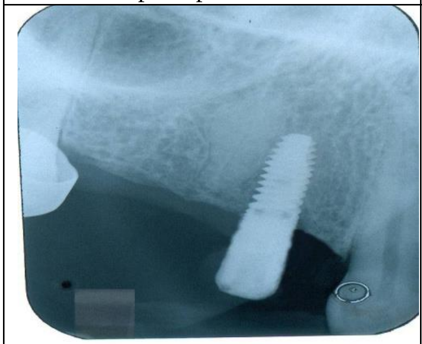
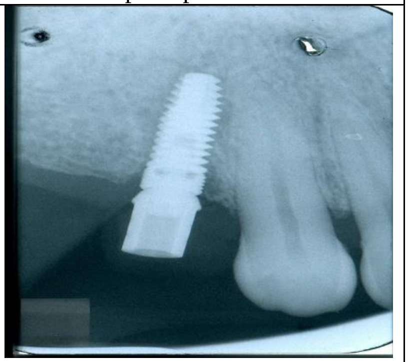
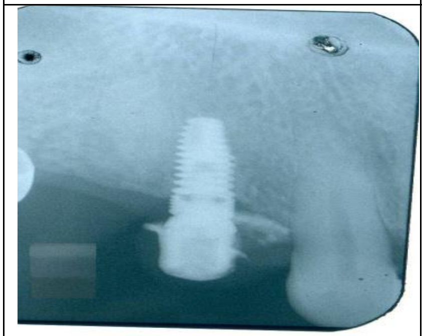
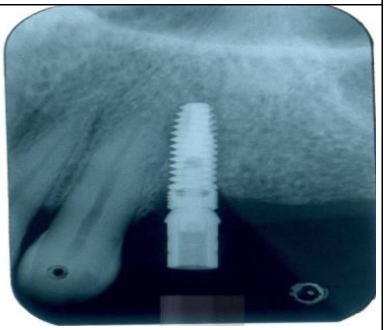
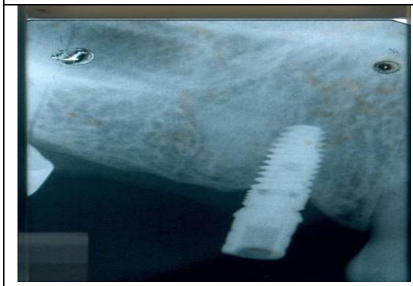
Immediate loading of implant with provisional crown was done forty eight hours postoperatively and was placed free of occlusion. Metal ceramic restoration was made six months postoperatively.

Radiographic follow up (case 1 and case 2): A standardized periapical radiograph was achieved and computer scanning for periapical radiographs was performed. Image readout was displayed on the computer screen, and then it was stored to be analyzed by Digora software.

Case: 1

Condensing technique	**Conventional technique**
 Immediate postoperative	 Immediate postoperative
 After six weeks	 After six weeks
 After twelve weeks	 After twelve weeks
 After twenty four weeks	 After twenty four weeks

Case: 2

Condensing technique	**Conventional technique**
 Immediate postoperative	 Immediate postoperative
 After six weeks	 After six weeks
 After twelve weeks	 After twelve weeks
 After twenty four weeks	 After twenty four weeks

RESULTS

In the present study, ten patients were recruited. They were seven females and three males with age ranging from 28-65 years. Each patient received two implants one on each side of maxilla. One implant failure occurred in the group of condensing technique 4 weeks postoperatively, so the success rate was 90% for condensing technique and 100% for drilling or conventional technique. All patients were followed according to postoperative assessment scheme.

A standardized periapical radiographs was achieved and computer scanning for periapical radiographs was performed immediately, after six weeks, after twelve weeks and after twenty four weeks. Image readout was displayed on the computer screen, and then it was stored to be analyzed by Digora software figure (7).

Radiometric Analysis: Linear measurements were carried out to assess the crestal bone loss in relation to implant length. The implant length was measured from the apex of the implant till the top of the implant and the bone height was measured as the tangential line to the implant thread from the level of implant apex till the bone crest. Linear measurements were calibrated and standardized according to the predetermined implant length.

Radiodensitometric Analysis: The optical density of the alveolar bone surrounding the implant was measured. This was carried out for the mesial and distal sites as far as 0.5mm from the implant thread and for the full implant length as mentioned above. The bone density was measured around the apex of the implant using the same protocol. The density measurements were calibrated by quantifying the image on gray scale and records were standardized according to step wedge records.

Statistical Analysis: All data were collected, tabulated and statistically analyzed. Descriptive statistics including mean, average, standard deviation, change and percentage of change were calculated for the bone density and crestal bone loss for the two groups. The following tests were used in the current study.

Paired t- test was used to determine the difference between study groups, as well as for bone density.

Friedman test was used to determine the difference between repeated measures in each group for crestal bone loss.

The level of significance was determined by P-value. P-values less than 0.01 ($p < 0.01$) were considered statistically significant.

Bone density: In condensing technique group the mean of bone density was (*98.9* ± 28.9 pixel) immediate postoperative. The density increased steadily to record (*108.4* ± 30.9 pixel) and (*112.0* ± 30.7 pixels) at six weeks and twelve weeks respectively. After twenty four weeks the mean was (*117.3* ± 22.4 pixels). (P- Value > 0.01)

In conventional technique group the mean of bone density was (*102.6* ± 23.8 pixel) immediate postoperative. The density increased steadily to record (*103.0* ± 27.1 pixel) and (*104.4* ± 23.3 pixels) at six weeks and twelve weeks respectively. After twenty four weeks the mean was (*106.8* ± 27 pixels). (P- Value > 0.01)

On comparing between both groups the records of bone density were higher in condensing technique group, however, there was no statistically significant difference in the change which occurred between both groups after twenty four weeks. **(Table 1 Fig.8)**

Crestal Bone Height: In condensing technique group the median of crestal bone loss increased steadily from the immediate postoperative (0 mm) to reach (0.97mm) and (1.22mm) at six weeks and twelve weeks respectively. After twenty four weeks the median bone loss was (1.59mm). (P-value 0.002)

In conventional technique group the median of crestal bone loss increased steadily from the immediate postoperative (0 mm) to reach (1.27mm) and (1.69mm) at six weeks and twelve weeks respectively. After twelve four weeks the median bone loss was (2.08mm). (P-value 0)

The crestal bone loss was less in condensing group. There was statistically significant difference between both groups after twenty four weeks. (P-value 0.009) (**Table 2 Fig.9**)

Fig. 1: A photograph showing expansion kit (screw expanders) used for bone condensing technique.

Fig. 2: A photograph showing the expander remained at the area of upper right second premolar.

Fig. 3: A photograph showing placement of the implant at the upper right second premolar using torque wrench adjusted at 35 N/cm.

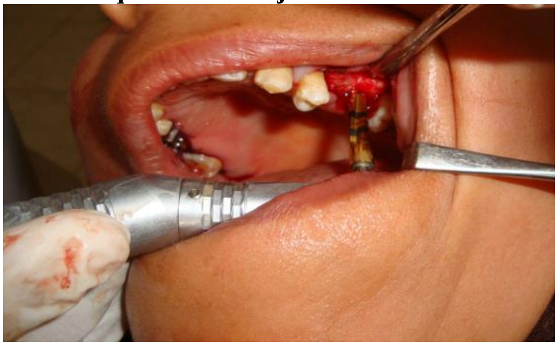


Fig. 4: A photograph showing the implant site at the upper left first molar enlarged with 3.5 mm diameter spiral drill.

Fig. 5: A photograph showing Implant after insertion at the upper left first molar.

Fig. 6: A photograph showing primary wound closure with interrupted suture at the upper right first premolar.

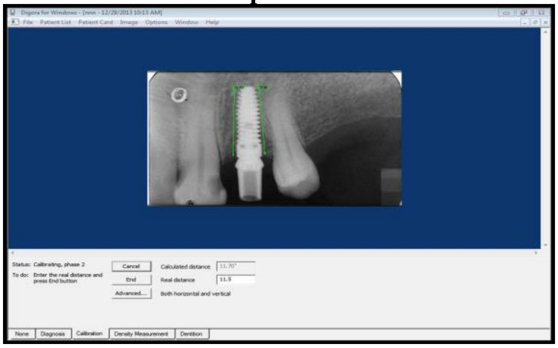


Fig. 7: A photograph showing linear measurements using digora software.

Table 1: Comparison in bone density at different follow up periods

BONE DENSITY	Condensing technique	Conventional technique	Paired Test	
	MEAN±SD	***MEAN±SD***	**t**	**P- value**
Immediate post-operative	98.9 ± 28.9	102.6 ± 23.8	-0.32	0.758
After 6 weeks	108.4 ± 30.9	103.0 ± 27.1	0.38	0.712
after 12 weeks	112.0 ± 30.7	104.4 ± 23.3	0.55	0.596
after 24 weeks	117.3 ± 22.4	106.8 ± 27	-0.81	0.436

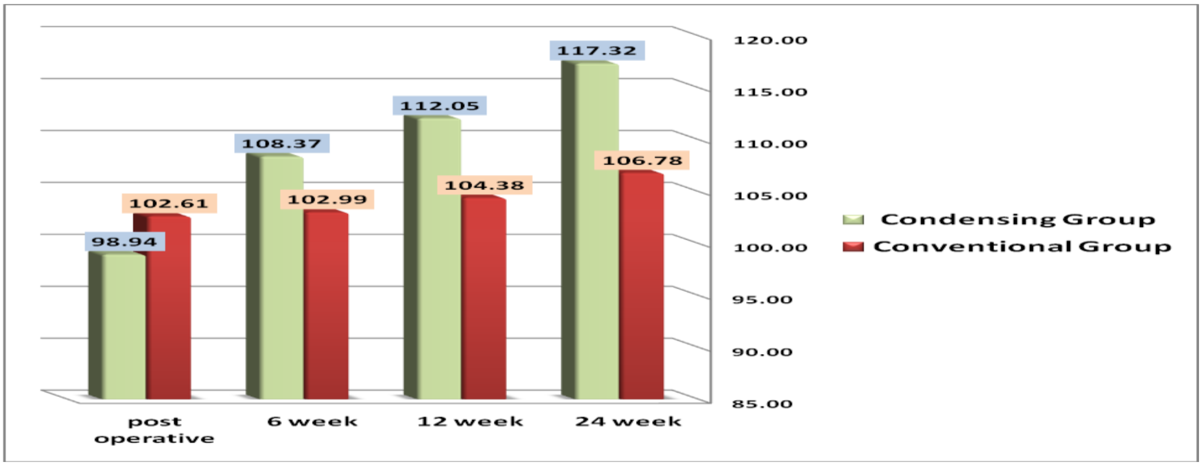


Fig. 8: Showing the changes in the bone density for both groups at different follow-up periods

Table 2: Comparison of the change in crestal bone loss for both groups throughout the study

CHANGE WITH POST OPERATIVE BONE LOSS	Condensing technique	Conventional technique	Paired Test	
	MEAN±SD	*MEAN±SD*	T	P- value
after 6 weeks	*1.2* ± 0.7	*1.3* ± 0.5	-0.44	0.669
after 12 weeks	*1.5* ± 0.6	*1.9* ± 0.6	5.31	0
after 24 weeks	*1.7*± 0.5	*2.1* ± 0.6	3.29	0.009

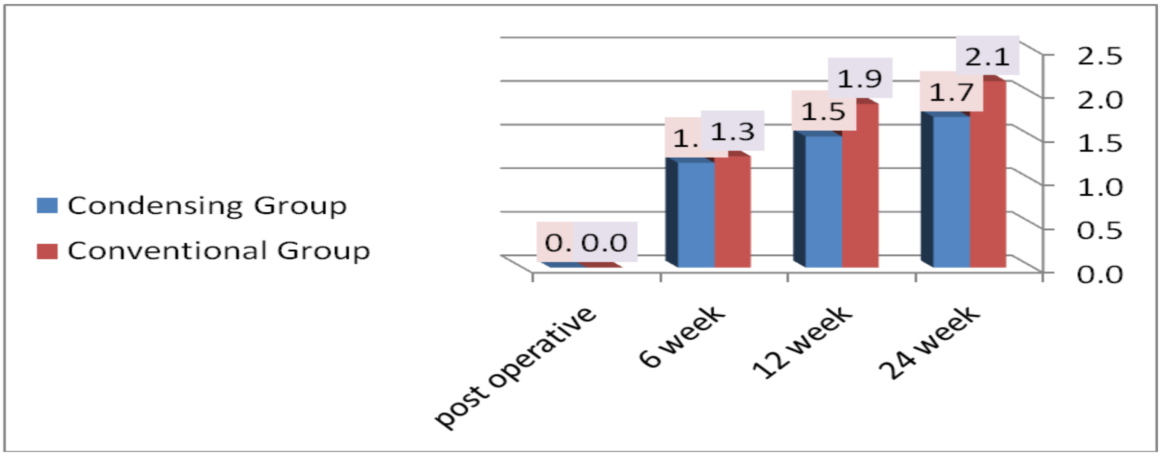


Fig. 9: Bar graph showing the changes in the crestal bone loss for both groups in the current study

DISCUSSION

The alveolar process is subjected to continuous remodeling. Loss of teeth leads to resorption of the alveolar ridge. When tooth loss occurs in the maxilla, it usually results in bone resorption both apically and palatally. In addition to the problem of a compromised alveolar ridge, the maxillary sinus can vary in size and shape, making implant placement impossible without surgical modification.(22) The bone condensing technique was introduced to increase the primary stability of dental implants in the posterior maxilla. The purpose of this technique was to improve bone quality.

In the current study, ten patients were selected with age ranged from 28 to 65 years. The patients were free from any systemic diseases that may compromise bone healing process. They had bilaterally missing teeth in the maxillary posterior region. This criterion was preferred to pursue standardization in the density and healing process. Standardized periapical radiographs were obtained by use of XCP film holding device and film positioning stent. An aluminum step wedge was incorporate into the device to minimize variation in radiographic film density caused by processing and to perform photodensitometric measurements for periapical radiographs.

Regional difference in Jaw anatomy and bone structure may explain some of the variation in the clinical success rate of implant therapy in the maxilla.[74]

In the present study, the success rate was 90% with the bone-condensing technique. Only few investigations have been published on the prognosis of implants inserted with that technique. The results of such investigations revealed higher success rates than those in the present study. Zitzmann and Scharer(23) compared three different methods for sinus elevation the lateral antrostomy as a two-step procedure, the lateral antrostomy as a one-step procedure, and the osteotome technique with a crestal approach. In 30 patients designated for implant treatment in the resorbed posterior maxilla, 79 implants were placed in combination with a bone-grafting material for sinus augmentation. The final bone heights were measured from panoramic radiographs or post-operative computed tomography scans. The success rate for the osteotome technique was 95% during the 30-month study period; no failures occurred in any site treated with a lateral antrostomy.

Strietzel et al. (24) showed success rate 91% in bone condensing technique, in his study, the peri-implant alveolar bone loss after use of the osteotome technique was evaluated radio graphically with respect to the bone quality in 22 patients with 22 implants. Differences between the alveolar crest and the implant shoulder in radiographs obtained immediately after implant insertion, after the end of unloaded healing period, and after different periods of functional loading were calculated. The osteotome technique was used in bone quality classes 2 and 3, respectively, according to the Lekholm and Zarb classification. Significant differences were found between the bone levels after implant insertion and at the end of the healing period as well as after functional loading.

In the present study we compared the crestal bone loss between both groups. It was less in condensing group in relation to conventional group with statical significance. In Strietzel[(24)] study three patients had labial cortical plate fractured during the technique two of them failed. Uncontrolled excessive loading with the bone condensing technique might have led to micro damage or even micro fractures of trabecular bone. In our study labial cortical plate cracks occurred with three patients one of them was the failure case. The failure of implant might have been due to labial cracks, besides mis-selection of the case. The patient had a large number of missing teeth that might have caused overloading on the implant and failure.

Ayşe Gulsahi et al.[(25)] Used dual energy x-ray absorptiometry (DEXA) and periapical radiography to assess bone density differences after conventional and bone-condensing dental implant techniques Single-tooth dental implants were placed by a conventional technique on one side and by a bone condensing technique on the other side, 28 implants were placed in 14 patients. The implants were loaded six months post operatively; with one implant placed with the conventional technique was mobile at the time of abutment placement and was removed. The success rate was 92.9% for the conventional technique. Four implants that had been placed with the bone condensing technique were not integrated and were removed. The final success rate was 71.5% with the bone-condensing technique, which might be the result of trabecular fracture associated with the bone-condensing technique. (DEXA) was used to calculate bone mineral density (BMD) and bone mineral content (BMC) before implant placement and then at 6 and 12 months postoperatively. The BMD was found to be significantly higher 6 months after implant placement and continued after 12 months in both groups. However, there was no significant difference in BMD between conventional and bone-condensing techniques. The BMC was significantly higher 6 months after implant placement but did not change between 6 and 12 months in both groups. However, there was no significant difference in BMC between the two implant techniques.

In the current study we made immediate loading free of occlusion after forty eight hours and we used digora system for comparison. We found that the bone density increased in both groups from the base line immediate post-operative records to the twenty four weeks records. Bone density was higher in condensing technique group, without any statistical significant difference between both groups.

Kamburoğlu K et al.[(26)] Examined the effect of conventional and bone- condensing techniques on levels of marginal bone surrounding implants and to assess the level of agreement between measurements ,they used digitized intraoral images. The study group consisted of 14 healthy patients with 28 single-tooth dental implants. In each patient, an implant was placed on one side using a conventional technique and on the opposite side using a bone-condensing technique. Film radiographs were taken at 6 and 12 months following implant placement and were digitized using a laser scanner. They found that the bone condensing technique resulted in greater marginal bone loss.

Padmanabhan et al.[(27)] Evaluated the crestal bone loss exhibited by the bone around early non-functionally loaded implants placed with conventional technique and condensing technique. 10 implants were placed in the maxillary anterior region of 5 patients. One implant site was prepared using the conventional technique with drills (control group A), and second site was prepared using the osteotome technique (experimental group B). The peri-implant alveolar bone loss was evaluated radio graphically. Differences between the alveolar crest and the implant shoulder in radiographs were obtained immediately after implant insertion and on the 180th day after implant placement A significant difference was found in the crestal bone levels after 180 days of surgery between two groups with less crestal bone loss with group A.

Koutouzis et al.[(28)] Evaluated the outcome of immediately loaded implants placed with the osteotome technique for single tooth replacement over a 12-month period in twenty patients. He observed that the mean marginal bone loss from the time of implant placement to the 6-month examination was 0.08 mm, while 0.19 mm loss was observed from the time of implant placement to the12-month examination. The amount of marginal bone loss reported in this study was smaller compared to immediate loaded single implants placed with a conventional site preparation by Glauser et al.[81] who recorded mean marginal bone loss after 1 year of loading those 1.2 +/- 0.9 mm. In our study there was statistical significant decrease in crestal bone loss in condensing group in relation to conventional group as recorded in the follow up.

Previous studies have shown that bone-condensing technique significantly improves the success rate of end osseous implants placed in bone type D4 compared with conventional technique. Nkenke et al.[(22)] Announced that the percentage of the bone-to-implant contact during the first 8 weeks of healing significantly increased after the application of bone condensation in relation to bone drilling. They have also shown that bone condensation leads to increased new bone formation and enhanced osseo integration of dental implants in spongy bone; Nkenke placed 104 implants into the distal femoral condyle of 52 New Zealand white rabbits. This region contains sufficient trabecular bone for implant placement. The implant site was prepared either by the osteotome technique or by conventional technique with drills as a control group. During the healing period polychromatic fluorescence labeling was performed with four different fluorescent dyes. After 2, 4 and 8 weeks, the implants were removed with the surrounding bone, Eight weeks after implant placement the bone-to-implant contact ratio was still better for the osteotome technique compared to the conventional implant placement.

However, it was no longer statistically significant. In the current study the records of mean bone density of condensing group were higher than that of conventional, but after twenty four weeks of follow up there was no statistical significant difference between both groups.

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