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ORIGINAL ARTICLE

Evaluation of Bone Density Around the Implants Placed Using Drilling Technique and Bone Expansion Technique: An In vivo Study

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Abstract Bone density is a key parameter in determining the surgical procedure of implant placement and for the predictability of successful implant treatment. Several clinical studies have shown lower survival rates of implants in maxilla which was attributed to poor bone quality. The present study compared the variations in the pre-operative and post-operative bone density values in Hounsfield units using CT between drilling technique and bone expansion technique at 0.25 and 1.0 mm sections at two sites which were selected in maxillary arch between the second premolar regions of either quadrants and results have shown bone expansion technique is superior to drilling technique in division III bone.

Keywords Bone density · Osteotomes · Bone expansion · Dental CT

Introduction

Implant treatment in maxillary ridge offers greater challenges and successful implant therapy depends on adequate bone quality and quantity. Clinical studies have shown lower survival rates of implants placed in maxilla [1, 2] which was attributed to poor bone quality or less dense bone available [3].

Bone quality [4] is a collective term referring to the mechanical properties, architecture, degree of mineralization of the bone matrix, chemistry and structure of the bone mineral crystals as well as the remodeling properties of bone. Bone quality and quantity are typically estimated from radiographs or at the time of implant site preparation. Computed tomography (CT) [5] is currently the only diagnostically justifiable imaging technique that allows at least rough conclusions about the structure and density of the jaw bones, of which CBCT and Dexa scan are the latest diagnostic imaging tools to acquire correct structure and density of the bone.

The objectives of the present study were:

1. Evaluation of bone density using computerized tomography in the pre-operatively assigned bone site for implant placement and bone around implants placed in the same designated site using drilling technique and bone expansion technique postoperatively.
2. To evaluate pre and postoperative bone density around implants in buccal and palatal aspects in 0.25 and 1.0 mm sections using CT scan in both drilling technique and bone expansion technique.
3. To compare the variation in pre and post-operative bone density values using computerized tomography between drilling technique and bone expansion technique.

Materials and Methodology

Before starting the study research committee and ethical committee clearance was obtained. Patient consent was

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also obtained for the study. A total of 10 implants (Indegenous single piece implants) were placed. Five patients aged between 25 and 60 years with two edentulous sites in maxillary arch who are eligible for implant placement were selected.

Inclusion Criteria

1. Patients aged between 25 and 60 years
2. Willingness to comply with the study requirements
3. Need for implant placement in the anterior maxillary site
4. Sufficient alveolar bone volume at the implant site with minimum 3.5 mm width labio-lingually and minimum of 12 mm height
5. Division III bone quality

Exclusion Criteria

1. Insufficient bone quantity of less than 3.5 mm width and 12 mm length
2. Severe inter maxillary skeletal discrepancy
3. Para functional habits
4. Patients who had already received or lost implants in the potential implantation site
5. Drugs or alcohol abuse
6. Smoking
7. Pregnant or lactating women
8. Patients who had undergone radiotherapy for malignancies of the head and neck region
9. Patients undergoing chemotherapy
10. Patients with systemic disorders including hypertension, bleeding disorders, metabolic bone disorders, liver disease and renal diseases
11. Immunocompromised patients

Laboratory Investigations

Blood analyses were done for each patient to assess the health status.

Diagnostic Casts and Wax-up

Two sets of diagnostic impressions were made using irreversible hydrocolloid (ZELGAN PLUS, DENTSPLY) with perforated stock impression trays. Inter-occlusal records were used to mount the models on mean value articulator and a diagnostic wax-up was done. Proposed site of implant placement was marked on the diagnostic wax-up in relation to the central fossa of the waxed up tooth.

Radiographic Stent

A radiographic stent was fabricated on the diagnostic wax-up using auto polymerizing acrylic resin to locate the site of implant placement intraorally for pre-operative radiographic evaluation using computed tomography. The stent was drilled corresponding to the central fossa of the waxed-up tooth just enough to let the initial no. 6 round bur to drill the bone with the stent in place and 2 mm diameter gutta-percha sticks were incorporated into the drilled holes.

Pre-operative Radiological Evaluation

A spiral CT machine (Siemens AR-SP 40, Munich, Germany), which is calibrated according to manufacturer's instructions, was used for the study. CT scanning of the maxilla is performed after positioning the radiographic surgical guide in the oral cavity with the following parameters: 130 kV, tube current 83 mA, slice thickness 1 mm, and slice intervals 1 mm. Trans-axial, Coronal and Sagittal sections were recorded. Coronal images are used for plotting the designated implant site with a tool incorporated in the CT software. The mean bone density of the pre-operative designated implant site at 1 and 0.25 mm was measured using pre incorporated software with in the CT at four different regions. Bone density was measured at the crest, 3 mm from crest, 6 mm from crest and at the apex, both on the buccal and palatal aspect for all the designated implant sites. The bone density values were recorded in Hounsfield units (HU) (Figs. 1, 2).

Implant Selection

Single stage, single piece root form titanium implants manufactured as single-piece were selected based on the available bone measurements.

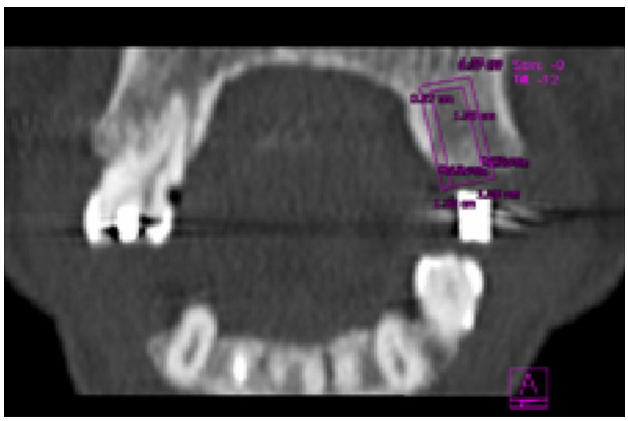

Fig. 1 Pre-operative CT in predicted sites at 0.25 mm

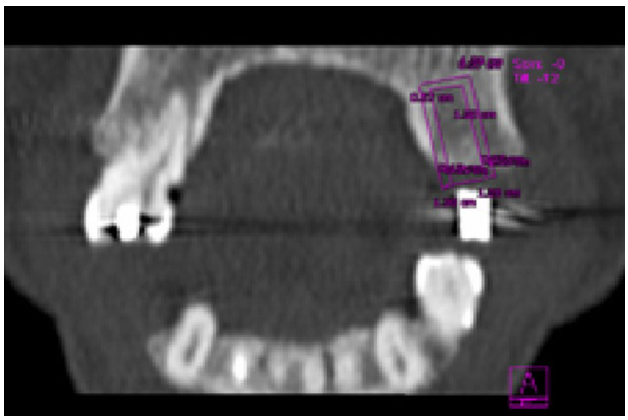

Fig. 2 Pre-operative CT in predicted sites at 1.0 mm

Implant Surgery

Routine pre-surgical protocol was followed for every patient (Fig. 3). Sterilization protocol was strictly followed during the entire process of surgery. The areas for implant placement were anesthetized by subperiosteal infiltration using 2 % lignocaine with 1:200,000 adrenalines. Osteotomy was accomplished by the same operator to eliminate operator variability.

The site for drilling technique for placement of fixture was selected based on the following criteria:

i. Minimum bone width of 4.5 mm and without undercuts of more than 15°
ii. Keratinized tissue of at least 5 mm must be present

After marking the site using surgical stent, initial penetration through cortical bone was achieved using no. 6 round bur. Incremental drilling was done using progressively larger drill sizes. Sequence of drill sizes (diameter) used was based on the diameter of the proposed implant and was as follows (Fig. 4):

i. 2.3 mm (Pilot drill)
ii. 2.8 mm
iii. 3.4 mm

Gradations corresponding to lengths of 8, 10, 11.5, 13 and 16 mm were present on each drill. A recommended drill speeds were used for all drills. The preparation was done carefully, progressing 1 mm every 5 s with a constant supply of copious amount of chilled normal saline at the rate of 50 ml/min.

A diagnostic radiograph was taken at each step starting with pilot drill to assure parallelism with adjacent teeth.

- Intermittent drilling with pumping (Up and Down) motion was used to allow the coolant to reach the site. The bone chips clogging the drill were removed frequently to reduce frictional heat buildup and to restore cutting efficiency. Thus, the site was prepared to the estimated length of the selected implant.
- Once the required depth of preparation was reached, the implant was driven to its final position using an appropriate wrench to deliver 25–30 N of force.
- Complete seating of the implant was ensured by close approximation of the crest module of the implant to the crestal bone. Radiographs were obtained to confirm the complete placement of the implants and their parallelism with adjacent teeth.
- In the other edentulous area, implant placement was done by bone expansion technique using osteotomes (Fig. 5). After osteotomy with pilot drill bone expansion was performed using 2.8 and 3.4 mm osteotomes.
- For every penetration of the osteotome with mallet, 5 s of waiting period time was maintained for alveolar bone to expand. Once the required depth had been tapped, the implant was mounted on a carrier and was

Fig. 3 Pre operative intraoral photograph

Fig. 4 Implant placement-drill technique

Fig. 5 Implant placement-bone expansion technique

slowly driven to its final position to deliver 25–30 N of force.

- Once the fixture was in position, the abutments were prepared and an impression was made with irreversible hydrocolloid for the fabrication of provisional restorations. Provisional restorations were cemented using IRM cement (DENTSPLY) and were kept under non-functional loading.

Loading of Abutment

All implants were restored for immediate nonfunctional loading by placement of provisional restorations and subsequently with permanent metal–ceramic restorations after 6 months. At 6 months (Fig. 6) the final modification of the abutment, if required, was carried out using sharp diamond points. The final impression was made in polyvinyl siloxane addition silicone (AQUASIL, DENTSPLY) using putty reline technique. The elastomeric impression was poured in type IV dental stone and the die preparation was done. The irreversible hydrocolloid impression was poured in type III dental stone. Both casts were mounted on the articulator using a wax inter occlusal record reinforced with zinc-oxide eugenol paste. Metal–ceramic crowns were fabricated following implant protective occlusion. The provisional and definitive restorations were cemented using IRM cement (Fig. 7).

Post-operative Radiological Evaluation of Bone Density in Hounsfield Units

After placement of implants in the designated implant locations post-operative CT scan was obtained at baseline under the similar pre-operative conditions i.e. 130 kV, tube current 83 mA, slice thickness 1 mm, and slice intervals 1 mm (Figs. 8, 9).

Fig. 6 Intra oral view after osseointegration

Fig. 7 Intra oral view after cementation of prosthesis

Results

The measurement values were subjected to statistical analyses using paired t test for any significant difference between the two parameters. The variation in bone density between two groups was compared pre-operatively and post-operatively on buccal as well as palatal aspect.

Mean and standard deviations were estimated from the samples for each study group. Mean values were compared between the groups by paired t test. In the present study, $P < 0.05$ was considered as the level of significance. The present study had shown the mean bone density values pre-operatively in buccal aspect in drilling and expansion site were 626.45 and 549.55 HU in 1.0 mm sections and 605.99 and 513.15 HU in 0.25 mm sections respectively

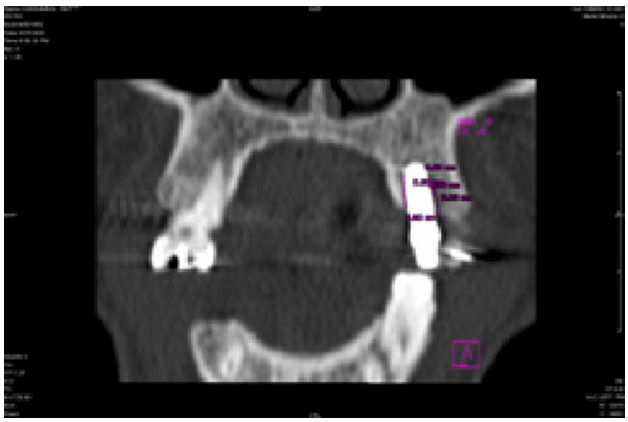

Fig. 8 Post-operative CT in predicted sites at 0.25 mm

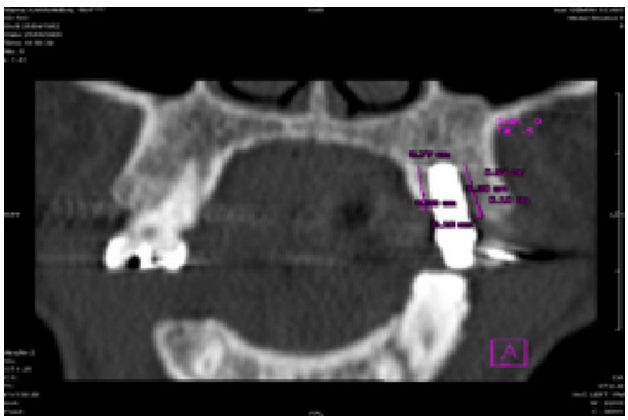

Fig. 9 Post-operative CT in predicted sites at 1.0 mm

and post-operatively 438.05 and 594.5 HU in 1.0 mm sections which was statistically significant (*P* value 0.05) and 468.5 and 597.15 HU in 0.25 mm sections respectively. In palatal aspect, bone density values pre-operatively were 574.15 and 521.45 HU in 1.0 mm section and 553.90 and 520.15 HU in 0.25 mm sections respectively. Post-operatively mean bone density values were 397.35 and 585.70 HU in 1.0 mm sections, which were statistically significant (*P* value 0.007) and 480.95 and 598.95 HU in 0.25 mm sections respectively, which were also statistically significant (*P* value 0.02) (Tables 1, 2, 3, 4).

Table 1 Comparison of mean values between two groups pre-operatively and post-operatively in 1.0 mm section on buccal and palatal surfaces

	Drilling		Expansion		Significance
	Mean	SD	Mean	SD	
Buccal					
Pre-operative	626.5	49.68	549.7	150.84	0.311(NS)
Post-operative	438.05	50.59	594.5	145.87	0.05
Palatal					
Pre-operative	574.15	48.11	521.45	106.95	0.34(NS)
Post-operative	397.35	36.92	585.70	112.69	0.007

Table 2 Comparison of mean values between buccal and palatal surfaces pre-operatively and post-operatively in 1.0 mm site using drilling technique and bone expansion techniques

	Pre-operative		Post-operative		Significance
	Mean	SD	Mean	SD	
Drilling technique					
Buccal	626.45	49.68	438.05	5.59	0.001
Palatal	574.15	48.11	397.35	36.92	0.001
Bone expansion technique					
Buccal	549.70	150.84	594.55	145.87	0.121(NS)
Palatal	521.45	106.96	585.70	112.69	0.02

Table 3 Comparison of mean values between two groups pre-operatively and post-operatively in 0.25 mm section on buccal and palatal surfaces

	Drilling		Expansion		Significance
	Mean	SD	Mean	SD	
Buccal					
Pre-operative	605.99	86.24	513.15	153.73	0.27(NS)
Post-operative	468.05	110.80	597.15	141.13	0.14(NS)
Palatal					
Pre-operative	553.90	95.14	520.15	96.68	0.59(NS)
Post-operative	408.90	110.72	598.95	101.17	0.02

Discussion

Placement of implants in poor quality sites led to decreased primary stability and consequently leading to failure of implant. Various investigations to classify bone quality were proposed [3].

The volume and quality of the bone are important factors determining the type of surgical procedure. Clinical studies have shown a higher survival rate for dental implants in the mandible [5] and more failures in maxilla [2]. It has been considered that the discrepancy in the survival rates of the implants placed in the maxilla and mandible arises from the bone conditions around the implants.

In our study, the bone density values obtained at the pre-operative designated implant site using computerized tomography in the maxilla region were comparable to the

Table 4 Comparison of mean values between buccal and palatal surfaces pre-operatively and post-operatively in 0.25 mm site using drilling and bone expansion techniques

	Pre-operative		Post-operative		Significance
	Mean	SD	Mean	SD	
Drilling technique					
Buccal	605.99	86.24	468.00	110.80	0.02
Palatal	553.90	95.14	408.90	110.72	0.01
Bone expansion technique					
Buccal	513.15	153.73	597.15	141.13	0.01
Palatal	520.15	96.68	598.95	101.17	0.03

data from previous studies [3, 5–8] ranging from 630 to 520 HU, demonstrating Type III bone quality.

The pre-operative bone density values helps in assessing the placement technique to be used. In regions of less bone density, bone expansion technique can be used to overcome excess removal of bone during osteotomy [8, 12]. Present study values ranged from 630–520 HU in two different sections of 1.0 and 0.25 mm around the designated site of implant. The site having considerably less amount of bone density is preferred for expansion as denser bone cannot be compacted with ease as the trabeculae are densely packed.

Post-operatively the drilling technique had shown significant decrease in bone density in 1.0 mm as well as 0.25 mm sections around the implants and bone expansion technique [7, 8–10] had shown significant increase in bone density values in both 1.0 and 0.25 mm sections. During the process of drilling, more amount of bone is removed due to incremental increase in drill size and hence creates more amount of separation between the trabecular spaces in Type III bone. But in bone expansion technique, only initial pilot drill is used to locate the implant location and subsequently osteotomes [9] or bone expanders are used sequentially. This technique helps in condensing the bone and compressing the trabecular spaces there by preserving the bone and consequently increasing the quality or density of bone. These results correlated with the studies conducted by Fanuscu et al. [11] in cadaver bone where expansion technique resulted in notable change in peri-implant bone architecture. Hence the increase in bone density will aid in better primary stability of the implant as the implant adheres to bone closely. The results between 0.25 and 1.0 mm sites around implant using bone expansion technique had shown significance increase in density post operatively compared to drilling technique in which there is significant decrease in bone density. The significant decrease in bone density can be attributed to amount of heat generation and more amount of bone removal using drills, compared to expansion technique. On comparing the buccal and palatal surfaces, the pre-operative and post-operative values in 1.0 and 0.25 mm sections around implants had shown significant differences stating more amount of bone loss using drills all around the implant. But in bone condensation technique, in 1.0 mm section there was only significant difference in density values in palatal aspect. The reasoning can be the thick configuration of bone usually present in the palatal aspect and more amount of compaction takes place in this region. In 0.25 mm sections, both the buccal and palatal aspects have shown significant increase in the density values. The technique of sequential use of osteotomes [8, 9, 11, 12, 13] to condense the bone may increase the success and survival rate of implant after complete healing period.

Summary and Conclusion:

Within the limitations of this study, the following conclusions were drawn after the analyses of results:

- In relation to implants placed using drilling technique, there was a significant reduction in bone density post-operatively at baseline compared to the pre-operative bone density values in Hounsfield units both in buccal as well as palatal sides in 0.25 and 1.0 mm sections.
- In relation to implants placed using bone expansion technique, there was a significant increase in bone density post-operatively at baseline compared to the pre-operative bone density values in Hounsfield units in palatal side, and no significant increase in buccal side in 0.25 and 1.0 mm sections.

The main limitation of the study was smaller sample size, hence difficulty in standardizing the selection of subjects. To obtain findings of more accuracy by comparing the two parameters designed for the study, the variables associated with patients like location, bone thickness, age and sex have to be standardized.

Future long-term studies with higher sample size and better standardization procedure for patient selection, is suggested.

References

1. Friberg B, Jemt T, Lekholm U (1991) Early failures in 4,641 consecutively placed Branemark dental implants. A study from stage I surgery to the connection of completed prosthesis. Int J Oral Maxillofac Implants 6:142–146
2. Jemt T, Lekholm U (1995) Implant treatment in edentulous maxilla: a 5-year follow-up report on patients with different degrees of jaw resorption. Int J Oral Maxillofac Implants 10:303–311
3. Norton MR, Gamble C (2001) Bone classification: an objective scale of bone density using the computerized tomography scan. Clin Oral Implants Res 12:79–84

4. Gomes Olieveira RC, Leles CR, Normanha LM, Lindh C, Ribeiro-Rotta RF (2008) Assessments of trabecular bone density at implant sites on CT images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 105(2):231–238
5. Tumer TI, Ozbek EN, Tozum TF (2007) Relations between the bone density from computerized tomography, and implant stability parameters: a clinical study of 230 regular platform implants. J Clin Periodontol 34:716–722
6. Beer A, Gahleitner A, Tschabitscher A, Homolka P (2003) Correlation of insertion torques with bone mineral density from dental quantitative CT in the mandible. Clin Oral Implants Res 14:616–620
7. Hanazawa T, Sano T, Seki K, Okano T (2004) Radiographic measurements of the mandible: a comparison between CT-reformatted and conventional tomographic images. Clin Oral Implants Res 15:226–232
8. Strietzel FP, Nowak M, Kuchler I, Friedmann A (2002) Peri-implant alveolar bone loss with respect to bone quality after use of osteotomes technique. Clin Oral Implants Res 13:508–513
9. Davapanah M, Martinez H, Tecucianu JF, Hage G, Lazzara R (2001) The modified osteotome technique. Int J Periodontics Restorative Dent 21:599–607
10. Shapurian T, Damoulis PD, Reiser GM, Griffin TJ, Rand WM (2006) Quantitative evaluation of bone density using the Hounsfield index. Int J Oral Maxillofac Implants 21:290–297
11. Fanascu MI, Chang T-L, Akca K (2007) Effect of surgical techniques on primary implant stability and peri-implant bone. J Oral Maxillofac Surg 65:2487–2491
12. Nocini PF, Albanese M, Fior A, De Santis D (2000) Implant placement in the maxillary tuberosity: the summer's technique performed with modified osteotomes. Clin Oral Implants Res 11:273–278
13. Albrektsson T, Zarb G, Worthington P, Eriksson AR (1986) The Long-Term efficacy of currently Used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants 1:11–25