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ORIGINAL RESEARCH

A Comparative Clinical And Radiological Analysis To Correlate The Bone Density And Primary Implant Stability Using Cone Beam Computerized Tomography And Insertion Torque

Shobha ES[1] | **Prashanth NT**[2] | **Vinod Rangan**[3] | **J Shirisha**[4] | **Anusha BL**[5] | **Alfred Joseph Ravikumar**[6]

1 Professor and Head of Department, Department of Oral Implantology, Dayananda Sagar College of Dental Sciences, Bengaluru, Karnataka, India.

2 Professor and Head of Department, Department of Oral and Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bengaluru, Karnataka, India.

3 Reader, Dayananda Sagar College of Dental Sciences, Bengaluru, Karnataka, India.

4,5 Post Graduate Student,Dayananda Sagar College of Dental Sciences, Bengaluru, Karnataka, India.

6 Maxillofacial Surgeon, Bengaluru, Karnataka, India.

Correspondence

Corresponding author Shobha ES

Email: shobhaes@dscds.edu.in

Present address

Department of Oral Implantology, Dayananda Sagar College of Dental Sciences, Shavige Malleshwara Hills, Kumaraswamy Layout, Bangalore 560 111; Karnataka; India.

Aim / objectives: The aim of this study was to assess the bone quality with density values obtained by cone beam computed tomography (CBCT) and to determine the correlation between bone density and primary stability of implants using insertion torque values.

Materials and methods: Twenty Root Form Implants were inserted into individuals with edentulous areas in upper and lower jaws in whom rehabilitation with implants was possible. The bone densities of implant recipient sites were preoperatively determined by the density value using CBCT. The maximum insertion torque value of each implant was recorded manually using a torque wrench with calibrations. Spearman's correlation coefficient was calculated to evaluate the correlations among density values and insertion torque values.

Results: The density values in Hounsfield units ranged from 209.91 to 667.13Hu. The mean density value and insertion torque of all implants were 464.69 + 135.74 Hu and 49.0 + 8.20 Ncm respectively. There was a highly significant correlation statistically between bone density and insertion torque (rs 0.89, P< 0.001).

Conclusion: The bone density evaluated by CBCT showed a high correlation with the primary stability of the implants (insertion torque). Therefore, the use of a CBCT pre-operatively may greatly help the implant surgeon in predicting the primary implant stability. Hence CBCT can be used as a predictor diagnostic tool for implant success.

KEYWORDS

Cone-Beam Computed Tomography, Dental Implants, Insertion Torque, Primary Stability

1 | INTRODUCTION

The success of a dental implant procedure depends on a series of patient related as well as procedure dependent parameters, including general health conditions, biocompatibility of the implant material, the feature of the implant surface, the surgical procedure and quality and quantity of the local bone.[1] Over the last 10 years, reconstruction with dental implants has changed considerably. Rather than merely focussing on the tooth to be replaced, today's implant practitioner considers a com-plex set of interwoven factors before formulating an implant treatment plan.[2] The success of a dental implant relies majorly on both the quality and quantity of the bone available for implant placement.[3] Bone density is a key factor to take into account the prediction of implant stability.[4]

Bone density plays a pivotal role, influencing implant stability, particularly in the mandible compared to the upper maxilla.[5] Misch (2008) used computed tomography (CT) to objectively classify bone density into 5 types based on Hounsefield units (HU). Various imaging tech-niques, including computed tomography (CT) and cone-beam computed tomography (CBCT), are employed for presurgical and postsurgical examinations, offering 3D perspectives crucial for assessing bone quality.[6] CBCTs are increasingly being considered essential for optimal implant placement, especially in the case of complex reconstructions.[7] The cone beam configuration is ideal for the maxillofacial region be-cause the dimensions of the beam allow for a panoramic view, sparing patients the radiation exposure of separate scans of the maxilla and mandible.[8] The past two decades have seen continual efforts by manu-facturers, researchers and clinicians to improve the success of implant treatment outcomes through evaluation in implant designs, materials and clinical procedures.[9] One such aspect is corelation of available bone density with primary implant stability.

Primary implant stability, referring to immediate stability post-implantation, is a critical factor in the osseointegration process. Evaluation methods like insertion torque tests and resonance frequency analysis provide non-invasive insights into local bone quality, guiding decisions on immediate loading with prosthetic reconstruction.

Several studies have explored the correlation between bone density, as assessed by CT or CBCT, and primary implant stability. Notably, a study by Isoda et al. demonstrated a strong correlation between specific CBCT-evaluated bone quality and primary implant stability.

This study aims to contribute to this body of knowledge by comparing CBCT-estimated bone density with primary implant stability, using insertion torque measurements. Understanding this relationship enhances the predictability of implant treatment outcomes, facilitating more informed decision-making in clinical practice.

2 | AIMS AND OBJECTIVES

To assess the bone quality with density values obtained by cone beam computed tomography (CBCT) and to determine the correlation between bone density and primary stability of implant by insertion torque value.

3 | MATERIALS METHODS

The study was done to compare and correlate clinically and radiologi-cally the bone density and primary implant stability using cone beam computerized tomography and insertion torque, on patients who visited the Department of Oral Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bangalore for implant supported prosthetic rehabili-tation. Twenty out- patients with missing single/ multiple teeth and who were suitable for implant rehabilitation were considered for the study.

INCLUSION CRITERIA:

• 20 healthy individuals with edentulous areas in upper and lower jaws in whom rehabilitation with implants was possible were taken up for the study. • Patients with missing single/ multiple teeth for implant replacement.

EXCLUSION CRITERIA:

• Patients with uncontrolled systemic/ psychiatric illness. • Patients with previous history of/ undergoing radiotherapy or chemotherapy • Pregnant patients • Clinical cases of post implant removal • Implants placed in sinus lift and immediate extraction sites.

PRE-OPERATIVE ASSESSMENT:

• Patients selected from the above criteria were evaluated and recorded on a custom made Case sheet. (Performa Attached)

• A written informed consent was obtained from all patients and a standardized pre-surgical and surgical protocol was followed for all the patients.

• Pre-operative bone density of implant sites was evaluated using cone beam computerized tomographic scans.

• Bone density measurements were derived using 3DiagnoSys version 4.1 Software It is a licensed product from 3DIEMME Bio imaging Technologies. 3DiagnoSys® is a diagnostic imaging, analyses and 3D simulation software, tailored for the Clinician. 3Diagnosys® software helps to interact with the 3D-model of the Patient, which is obtained by importing TC/CBCT/RM images in DICOM format, in a simple and intuitive way. The tools included in this software are not bound to a morphological reconstructions but are also able to extract from the DICOM data the densitometric values for a bone functional evaluation.)

• Pre-operative evaluation of bone height and bone width was done using Cone Beam Computed Tomographic scan and appropriate implants were selected to be placed.

• The bone height and width measurements were achieved using the "Carestream Dental Imaging Software v6.13.3.3 CS imaging software" (Fov-15x9cm)"

• All CBCT scans were obtained using the "KODAK 9500machine" (10ma 90 Kvp, 200-micron resolution, 10.9sec exposure, 605mgy per cm2).

SURGICAL PROCEDURE OF IMPLANT PLACEMENT:

1. In all instances, implants were placed under local anaesthesia using
2. 2 Different implant systems were used and all were root form implants.
3. Surgical preparation and isolation of surgical field was accomplished according to standard operative protocols.
4. Surgical template pre-pared on the model pre-operatively was used to identify the implant placement site.
5. A Crestal incision was placed with a No.15 BP blade.
6. Mucoperiosteal flap was reflected and alveolar bone was exposed, and the implant placement site was identified by the marking made with the aid of the surgical probe.
7. Osteotomy site preparation was done with a Reduction gear hand piece (1:16/64) with an external irrigation attached to the handpiece.
8. Implant osteotomy was performed using standard sequential drill bits as per the dimensions of the implant.
9. A speed of 800 RPM and torque of 25-30 ncm was standardized for the procedure.
10. The osteotomy was proceeded till the desired depth as per the selected implants.(Fig:15, 16, 17)
11. The orientation of the os-teotomy was verified using paralleling pins when placing two or more implants, using the long axis of the adjacent teeth as a reference plane.
12. The implant was inserted into the osteotomy site with the use of a manual torque wrench until the final depth was achieved(Fig 18,19, 20).
13. All Implants placed were of tapered design and their lengths ranging from8 to 16 mm and diameters from 3-5 mm.
14. Following the placement of the implant, its stability was assessed manually using the insertion torque test with a calibrated torque wrench.
15. The insertion torque reading was measured and recorded at the maximum torque re-sistance achieved.
16. The cover screw over the implant was then placed.
17. Flap closure was done using 3-0 vicryl.

RADIOLOGICAL ASSESSMENT:

Post-operative OPG and IOPA was taken.

POST OPERATIVE PROCEDURE:

1. Routine Antibiotics and anti-inflammatory drugs were prescribed along with oral hygiene maintenance instructions.
2. Patients were re-called for regular follow ups.
3. Permanent prosthesis was given after 3 month

Fig:1 Height Measurements Scale: 1-20; Slice Thickness – 0.2mm; Section Thickness – 1mm; Implant site: 9-12

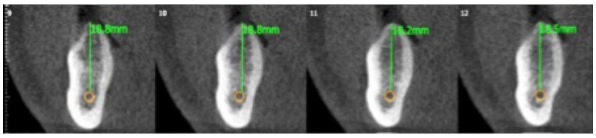


Fig: 2

Fig: 3: Width Measurements Scale: 1-20, Implant site:9-12

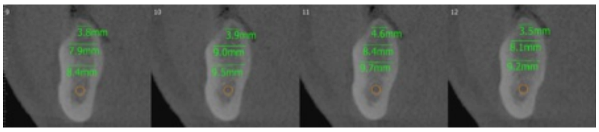


Fig:4

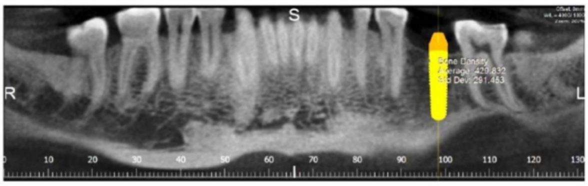


Fig:5: Pre-Operative Bone Density measurements taken using 3Diagnosis Software V4.1

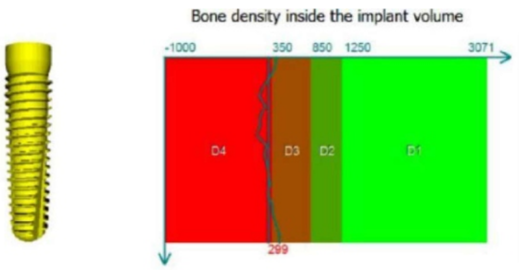


Fig:6

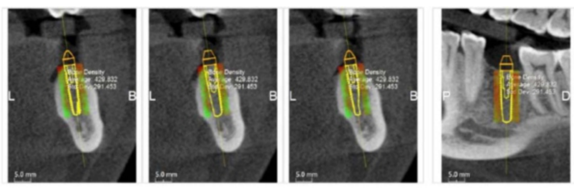
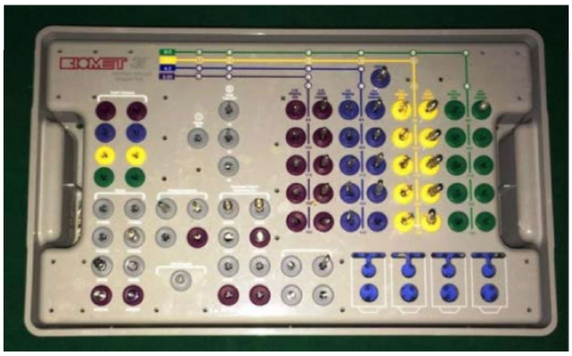


Fig:7



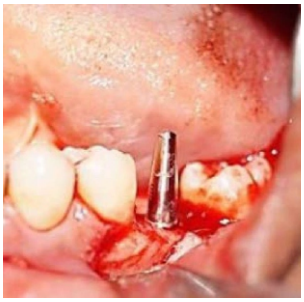


Table 2. Age distribution of study population

	Mean	Standard Deviation	Range
Age (years)	36.45	11.96	19-59

Table 3 . Gender distribution of study population

	Number	Percentage
Male	7	35
Female	13	65

Table 4. Mean values of bone density and insertion torque

	Mean	Standard Deviation	Range
Bone density (Hu)	464.69	135.74	209.91-667.13
Insertion torque (Ncm)	49.0	8.20	40-60

Table 5. Correlation between bone density and insertion torque

	Insertion torque (Ncm)	P value
Bone density (Hu)	0.89	<0.001 **

Spearmans correlation test

** P<0.001 highly significant

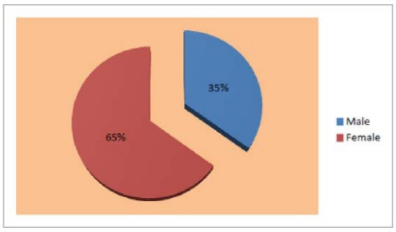


Fig 1. Gender distribution of study population

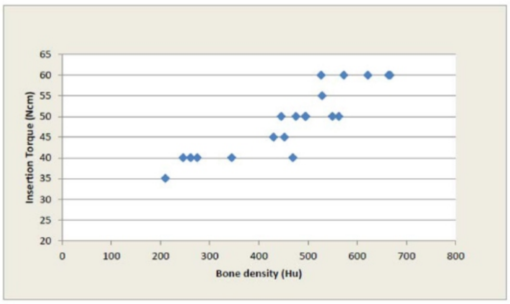


Fig 2. Scatter plot for correlation between bone density and insertion torque

4 | STATISTICS & RESULTS

The statistical analyses were performed using SPSS version 16.0 software (SPSS Inc., Tokyo, Japan). Spearman's correlation coefficient (rs) was calculated to evaluate the correlation among density values and insertion torques. A value of P <0.05 was considered to be statistically significant.

RESULTS

The density value ranged from 209.91 to 667.13 hU. The mean density value and insertion torque of all implants were 464.69 + 135.74 Hu and 49.0 + 8.20 respectively. There was highly significant correlation between bone density and insertion torque (rs 0.89, P< 0.001).

5 | DISCUSSION

Preoperative evaluation of the bone quality is important for the clinician to establish an optimum treatment plan for implant supported dental rehabilitation. Accurate information and assessment of the bone density will help the surgeon to identify suitable implant sites and determine accurate implant designs.1 A precise evaluation of the bone configuration is essential prior to implant placement.1 One of the most important factors in determining implant success is proper treatment planning and with the advent of advanced imaging technology, Cone Beam Computerized Tomography (CBCT) is increasingly being considered as an essential tool determining the bone quality and quantity thus helping for optimal implant planning and placement.[2]

Presurgical dental implant planning for Implant placement requires specific and accurate data to assess the implant site so that the dental implants placed has the greatest chance of success.[3] It has been proven that the success of an inserted implant strongly depends on the quality, beside the quantity, of the surrounding bone (Jaffin & Berman 1991; Jemt et al. 1992).[4]

Various bone classification systems have been proposed to assess bone quality. In 1985, Lekholm and Zarb introduced a system that uses radiographs to subjectively classify bone density into four types based on the proportions of cortical and trabecular bone. This classification has gained worldwide use due to its simplicity and minimal investment requirements. Misch (2008) developed a classification system using computed tomography (CT) to objectively categorize bone density into five types based on Hounsfield units (HU) (Hounsfield 1980). This method provides a precise and objective evaluation of bone quality.[1]

Lekholm and Zarb used radiographs to subjectively classify bone density into four types based on the amount of cortical and trabecular bone. This classification system has been utilized Worldwide because it is easy to use without considerable investment. Misch (2008) used computed tomography (CT) to objectively classify bone density into 5 types based on Hounsfield units (HU) (Hounsfield 1980). This method allows for a precise and objective assessment of bone quality.[1]

Significant correlations between the density values of CBCT and Hounsfield unit (HU) of multi slice CT were also reported in recent studies (Naitoh et al. 2009; Nomura et al. 2010). In a recent study, Pauwels et al. (2013) investigated the correlations between CBCT derived gray values and multi slice CT-derived gray values. The authors found controversial results showing good correlations between CBCT and CT but also large errors when using gray values in a quantitative way. Consequently, deriving bone density values from CBCT images seems controversial. In the literature, there are only limited number of studies about the correlation between bone density estimated by CBCT and primary implant stability.[6]

Primary stability is associated with the mechanical engagement of an implant with the surrounding bone. Whereas bone regeneration and remodelling phenomena determine the secondary (biological) stability to the implant. A secure primary stability is positively associated with a secondary stability.[7]

In the present study 20 healthy individuals, who visited the Department of Oral & Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bangalore for implant supported prosthetic rehabilitation were taken up.

Helical CT scans provide bone density measurements in HU. In contrast, CBCT lacks a standardized unit like HU because it has not been calibrated. Several studies have found a high correlation between CBCT density values and the HU of multi-slice CT (Aranyarachkul et al. 2005; Naitoh et al. 2009; Nomura et al. 2010). Radiographic examinations can offer preoperative bone density information. HU is a standardized scale used for reporting reconstructed CT values (Shapurian et al. 2006).

In a previous study, 32 helical CT scans of patients were examined, revealing mean bone density values ranging from 77 to 1421 (Norton & Gamble 2001). Bone density values from 20 patients evaluated via CBCT ranged from 238 to 777 (Song et al. 2009). Additionally, the bone density values of three human mandibles (dry bone) varied between 267 and 553 HU, with a mean of 113 HU (Turkyilmaz et al. 2009). The density values recorded in the present study are comparable to those reported in these studies and can be considered analogous to HU values assessed by helical CT. In our study, density values ranged from 209.91 to 667.13 HU, with a mean density value of 464.69 ± 135.74 HU for all implants.

The study reveals a robust correlation (0.89) between Cone Beam Computed Tomography (CBCT)-derived bone density and implant stability, endorsing CBCT as a valuable tool for preoperative assessment. Previous research also indicates correlations between bone density and implant stability. However, conflicting results exist, with some studies showing no correlations. The present clinical study emphasizes the importance of including cortical bone evaluation in preoperative bone density assessments. CBCT examinations before implant surgery prove instrumental in predicting primary stability, guiding optimal loading times for implants in prosthetic rehabilitation. While CBCT shows promise, further research is essential to explore correlations across diverse variables influencing implant stability.

5 | CONCLUSION

In the study conducted in the Department of Oral and Maxillofacial surgery, Dayananda Sagar College of Dental Sciences, we aimed to evaluate bone quality by using density values obtained from cone beam computed tomography (CBCT) pre-operatively and to determine their correlation with insertion torque values recorded during the implant placement procedure.

Based on the observations and results obtained, we can conclude that this study demonstrates the relationship between bone density values derived from Cone Beam Computed Tomography (Hu) in the maxilla and mandible and bone quality as classified by Lekholm & Zarb.

The primary implant stability measured with the insertion torque test (ITV) depends on bone density values, bone quality and implant location. Implants Placed in location with higher bone density have more stability, and we can probably predict the implant insertion torque based on the bone density values (Hu) and the implant location. Finally, with higher bone density values (Hu) and higher primary implant stability measured in ITV values; Hounsfield units can be used as a diagnostic parameter to predict possible implant stability.

CONFLICT OF INTEREST:

The authors declare no conflict of interest.

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