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ORIGINAL RESEARCH

Evaluation of Osseointegration by correlating Insertion Torque, Implant Stability, and Bone Density of Implant Site: An *in vivo* Study

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ABSTRACT

Aims and objectives: The aim of this study was to determine the bone density in the designated implant sites using cone beam computerized tomography (CBCT), the insertion torque value (ITV) of dental implants, and the implant stability quotient (ISQ) values using resonance frequency analysis (RFA). Further objective was to evaluate a possible correlation between bone densities, insertion torque, and implant stability.

Materials and methods: A total of 30 implants placed in 7 patients were included the study. Bone density values of the implant recipient sites were recorded using CBCT. The maximum ITV of the implants were recorded using a torque ratchet during surgery. Resonance frequency measurements were taken using the osstell mentor.

Results: Data were analyzed statistically. The mean bone density, ITV, and ISQ of all implants were 774.6 ± 102.88 RHU, 32.0 ± 6.103 Ncm and 61.5 ± 7.91 respectively. Statistically significant correlations were found between ITV and ISQ measurements, and positive correlations were found between bone density values from CBCT and ISQ measurements.

Conclusion: Bone density values from CBCT are significantly correlated with primary stability parameters derived from RFA in implants. Preoperative ITV are also correlated with ISQ measurements.

Keywords: Cone beam computerized tomography, Implant stability quotient, Insertion torque, Primary stability, Resonance frequency analysis.

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INTRODUCTION

The primary stability of an implant at the time of placement is considered as one of the key factors for clinical success of implant treatment.[1-6] Orenstein et al[7] reported that implants that were appropriately stabilized without any mobility at the time of placement had a significantly high survival rate compared with those that were not. The evaluation of the primary implant stability is usually performed after placement. Some of the main methods include mobility test, resonance frequency analysis (RFA), and the measurements of the removal torque values and the insertion torque values (ITVs). In particular, the measurement of the removal torque values is an objective evaluation method, but its clinical application is difficult because it is an irreversible and invasive method. Mobility test is useful for the evaluation of an implant whose osseointegration was surely obtained, but there is a possibility that the primary stability could decrease by the impact of the tapping head. On the contrary, the measurement of ITVs and the measurement of implant stability quotient (ISQ) values by using a resonance frequency analyzer are noninvasive, convenient, and objective evaluation methods. Therefore, these methods are used for evaluation in various researches investigating the primary stability.[8-11]

Numerous clinical studies with dental implants have revealed encouraging outcome, in a retrospective study by Turkyilmaz on influence of bone density on implant stability parameters and implant success, which indicated statistically significant correlations between bone density and ITVs, bone density and ISQ values, and insertion torque and ISQ values.

The purpose of this study is to assessment stability of implants by correlating insertion torque, RFA, and cone beam computerized tomography (CBCT) placed in bone tissue of different densities.

MATERIALS AND METHODS

Study Design

Thirty implants were placed in different sites of oral cavity among seven individuals of either sex, with mean age of 38.71, were included in the study. The patients were either fully or partially edentulous. The patients who had implant recipient sites that exhibited bone quality of type 1 to 3, according to Lekholm and Zarb, were included the study.[12]

The study was approved by the institutional ethical committee of DJ College of Dental Sciences and Research, Ghaziabad, Uttar Pradesh, India. The patients signed a written informed consent letter.

Radiographic assessment of bone density was done by CBCT (CARE STREAM CS 900) prior to the surgery Flow Chart 1. Prior to CBCT scan, previously fabricated surgical acrylic templates including 1-mm-diameter indicator metal rods, which were located in the center of the missing teeth, or the existing removable complete dentures attached with the same indicator rods for edentulous patients were placed in the mouth. The same scanning conditions (tube voltage 130 kV, tube current 83 mA, slice thickness 1 mm, and slice interval 1 mm) were provided for each CBCT scan. Cone beam computerized tomography revealed mesiodistal and apicocoronal dimensions of the available bone at the implant site as well as the trabecular pattern of the bone. This helps us to select the length and diameter of implant to be used.

The mean bone density of the implant recipient area was measured to a distance of 1 mm from the simulated implants using software (CS 3D on Demand, Germany) incorporated in the CBCT machine. The bone density measurements were recorded in relative Hounsfield units (RHU). Subsequently, the diagnostic wax up of the cast is done, and the surgical template was prepared to guide the implant location and angulations during placement.

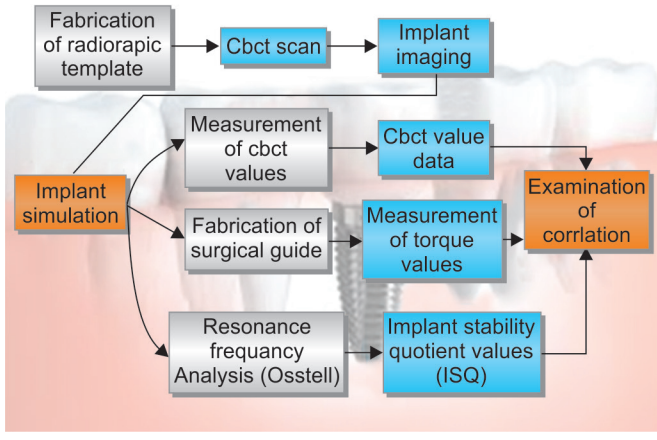
Insertion Torque Measurements

During the implant insertion, the maximum ITV was recorded by means of the torque ratchet. Starting from 20 Ncm, the placement torque was increased in steps of 5 Ncm, when the rotation stopped because of friction before the implant was fully inserted. The final maximum ITV of each implant was attained in 20, 30, and 40 Ncm.

Resonance Frequency Analysis

The RFA measurements were performed using the osstell instrument (Integration Diagnostics AB, Göteborg, Sweden). All RFA measurements were performed at implant level immediately after implant placement. The captured data (RFA values) are recorded in ISQ ranging from 1 to 100.[13] The measurements were taken with the transducer parallel to the bone crest and the cantilever in a distal position.[14] Implant stability quotient values are derived from the stiffness (n/μm) of the implant/bone system and the calibration parameters of the transducer. High ISQ value indicates high stability, whereas low value indicates low implant stability.

Flow Chart 1: A schematic diagram of the study design



Statistical Analysis

Statistical Package for the Social Sciences (SPSS) (version 21.0, SPSS Inc., Chicago, IL, USA) was used for all statistical analysis. Mann–Whitney U test was used to verify possible differences between groups in terms of the bone density, insertion torque, and resonance frequency values. Correlations between the bone density, insertion torque, and ISQ were determined by using Spearman's rho test, and $p < 0.05$ was considered statistically significant.

RESULTS

Thirty implants were inserted and healed uneventfully. Of these, two implants showed lack of osseointegration, hence considered as failures. It was observed that bone density in all patients ranged from 566 to 920 RHU in mean bone density value of all patients at base level was 774.6 ± 102.88 RHU while average maximum ITV was 32.0 ± 6.103 Ncm and ISQ value ranged from 45 to 76 whereas mean value (ISQ) was 61.5 ± 7.91 (Table 1).

Statistically significant correlations ($p < 0.005$) were found between ITV and ISQ measurements. There was no statistical significance seen ($p < 0.005$) between bone density values from CBCT and ISQ measurements though the values are positively correlated (Table 2; Graphs 1 and 2).

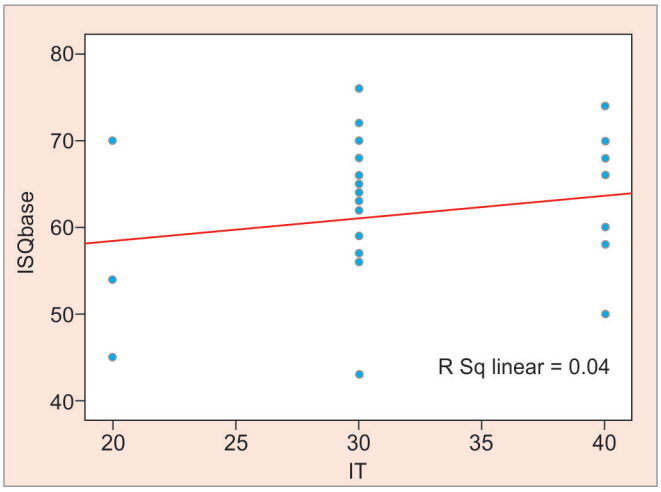
Table 1: Descriptive statistics of implant data in the study

Parameters	*N*	*Mean ± SD*
Density values (RHU^0)	30	774.6 ± 102.88
Insertion torque value (ITV)	30	32.0 ± 6.103
Implant stability quotient (ISQ^0)	30	61.5 ± 7.91

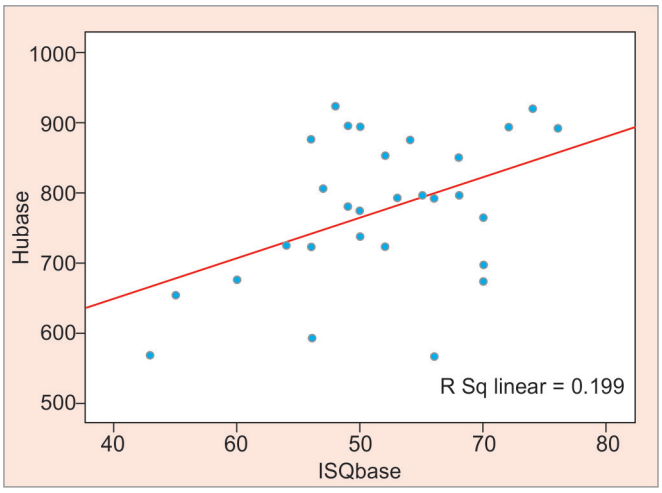
Table 2: Overall correlation between bone density values derived from CBCT and ITVs and ISQ values

Parameters	*r-value*	*p-value*	*Significance*
ISQ*IT	0.215	0.003	S
RHU*ISQ	0.346	0.061	Statistically not significant

S: Significant



Graph 1: Correlations between ISQ and ITV at placement



Graph 2: Correlations between bone density values derived from CBCT and ISQ° at placement

DISCUSSION

It is currently accepted that RFA is a noninvasive method and can be successfully used to monitor the stability of a newly placed implant and also stability changes over time with reliable outcomes in clinical practice.

Statistically significant correlations (p-value = 0.003, r = 0.255) were found between ISQ and insertion torque values.

Friberg et al[15] compared placement torque and resonance frequency measurements of maxillary implants. They reported on TiUnite MK II implants, an intermediary implant generation between the standard Brånemark system implants and the TiUnite MK III. A significant relationship was found between placement torque and resonance frequency at implant placement only in the upper/crestal third of the implants. However, Freiberg et al[15] final results also showed that there was no overall correlation between placement torque and ISQ.

In our study, positive correlation was found but not significant value (p = 0.061, r = 0.346) were found between bone density and ISQ. Which is in contrast with studies published earlier due to increasing the free length of implant resulted in decreasing the RFA of implant or In addition, the location and the size of soft tissue are two factors that influence the RFA of dental implant.

Tatli et al[16] found that statistically significant correlations were found between bone density and ISQ0 (r = 0.874, p < 0.001).

A clinical study by Song et al[17] showed that bone density obtained by CBCT showed strong correlation with ISQ.

Turkyilmaz et al[18] determined the relationship between bone density, insertion torque, and implant stability at implant placement. Statistically significant correlations were found between bone density and insertion torque values (p < 0.001); bone density and ISQ values (p < 0.001); and insertion torque and ISQ values (p < 0.001).

However, relationship and consistency between stability changes of implants and CBCT-derived preoperative bone density assessments have not been evaluated in the literature. The current study differed from previous studies with a special emphasis on the correlations among bone density values from CBCT and ISQ measurements to evaluate whether bone density from CBCT gives predictable data about stability changes of the implants during osseointegration and function period.

SUMMARY

The following conclusions can be withdrawn basing on our study:

Bone density values from CBCT are significantly correlated with primary stability parameters derived from RFA in implants. Preoperative ITV are also correlated with ISQ measurements.

The advantages of measuring implant stability are to make more accurate decisions about the time of crown loading or unloading, select the protocol of choice for implant loading, and increase trust between patient and practitioner.

However, more studies are necessary to explore the correlations among the corresponding parameters under different variables (bone tissue of different densities) that rule implant stability.

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