Determination Of Implant Primary Stability By Resonance Frequency Analysis- Co-Relation With Bone Density And Insertion Torque: An In-Vivo Study

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Abstract:

Background: Today in the field of science collaborative measures are being used to help patients for their well being. This article helps to integrate medical physics with the stability of dental implant for proper osseointergration measurement and also helps to gain thepsychological advantage to the patient.

Purpose: The study aims to determine implant primary stability by resonance frequencyanalysis and its co-relation with bone density and insertion torque

Methods: A total of 400 patients were selected for this study. Before implant placement, CBCT of the patient was done to evaluate the bone density, and implants were placed underaseptic condition. Immediately after implant placement insertion torque was measured withthe help of a physio dispenser and ISQ was measured using osstell mentor.

Results: According to the result derived from this a direct co-relation was seen in theHounsfield Unit i.e. bone density, insertion torque, and implant stability quotient.

Conclusion: 1. Maxillary anterior showed a significant and high positive (direct) correlation between all the parameters.
2. Maxillary posterior showed a significant and high positive (direct) correlation between allthe parameters.
3. Mandibular anterior showed a significant and high positive (direct) correlation between allthe parameters.
4. Mandibular posterior showed a significant and high positive (direct) correlation betweenall the parameters.

Keyword – CBCT(Cone Beam computed Tomography), Osstell Mentor, RFA(Resonance Frequency Analysis), Hounsfield unit(HU).

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Introduction

Osseo integrated dental implant has been used as a replacement of completely and partially edentulous patients over the last three decades as a major treatment modality.[1] Implantology is unique as it provides a range of additional abutments and also can convert a removable prosthesis into a fixed one. Osseointegration means the apposition of bone around the implant surface creating a bone-implant interface. Osseointegration is influenced by a number of parameters, and poor regulation of these factors affects theimplant's anchoring to the bone tissue. [2]

Osseointegration, or the direct structural and functional connection between bone and the surface of a load-bearing dental implant, is dependent on implant stability. [3,4] The stability of the implant must be achieved and maintained for a successful therapeutic outcome. As a result, measuring implant stability is crucial for determining implant success. [5,6]The main determinants of implant stability are the mechanical properties of the bone tissue at the implant site and how well the implant is engaged with that bone tissue. [7]

Misch (2008) divided bone density into five types using this classification approach, which iswidely used since it is simple to apply and require the use of computed tomography (CT) or Hounsfield units (HU) (Hounsfield 1980). This method enables a precise and objective evaluation of bone quality (D1 bone, >1250 HU; D2 bone, 850–1250 HU; D3 bone, 350–850 HU; D4 bone, 150–350 HU; D5 bone, 150 HU).

The mechanical behavior of bone appears to be a key element in determining osseointegration levels.[8]. Primary stability is usually measured by Resonance Frequency Analysis (RFA) using osstell mentor at the time of implant placement. RFA has now become very popular among implantologists as it is non-invasive. The measuring of the frequency with which a device vibrates is known as resonance frequency analysis (RFA). There are numerous methods for detecting the resonance frequency, one of which is to listen to the vibration frequency's audible sound. The stabilityof a dental implant can be assessed by comparing resonance frequencies, which alter with different stabilities. A sensor is put on top of the implant, and the sensor is gently moved using magnetic pulses to cause it to vibrate. The sensor will vibrate for a few seconds before stopping. The vibration frequency of the sensor will increase when implant stability (stiffness of the bone-implant contact) improves. The acronym ISQ stands for "Implant Stability Quotient." The ISQ scale ranges from 1 to100 and roughly correlates to the resonance frequency. The reason for utilizing ISQ rather than the resonance frequency given in Hz is that it is more straightforward to communicate. ISQ 1 corresponds to 1,000 Hz, whereas ISQ 100 corresponds to 10,000 Hz, according to the scale developed in 2003. Early scientific research were utilized to define how the ISQ scale should relate to Hz, and subsequent clinical investigations have placed the ISQ scale in a therapeutic context, relating to treatment and loading methods.

Materials And Methodology

A cone beam computerized tomography (CBCT) equipment was used to measure bone density at implant recipient locations. The CBCT machine was used to obtain cross-sectional, coronal, and axial images of each maxilla/mandible. Using cross-sectional pictures, the best implant for each previously identified implant recipient site was chosen. All of the patients had surgery in accordance with the normal procedure. RFA is a test that measures the frequency of implant oscillation inside the bone to determine implant stability. An electric or magnetic impulse is utilized to stimulate a transducer attached to the implant (depending on the type of transducer used). As a result, the implant is subjected to a little lateral force, which produces lateral displacement due to bone deformation. The stiffness of the bone-implant attachment determines the frequency of the registered oscillation: the stiffer the system, the greater the transducer's oscillation frequency. While most tests produce subjective outcomes, RFA enables for objective, noninvasive implant stability testing.

Sequential drilling was done as per manufacturer's protocol then implant ADIN TOUAREG™ -S/ GENESIS) were placed at equicrestal level using implant surgical kit and torque rachet, then by Smart Peg was screwed onto the implant to measure ISQ reading. After that cover screw was placed. Primary closure was done using Mersilk 3-0 suture.

The physio dispenser and torque ratchet were used to quantify insertion torque with calibrations of 15N/cm, 30N/cm, and 40N/cm, and the osstell mentor was used to calculate RFA.

osstell mentor has various versions of transducers and assessment equipment. An L-shaped metallic attachment composed of surgical stainless steel or titanium was connected to (screwed on) the implant or pillar in the first-generation transducers. The two ceramic pieces at the ends of this accessory were activated by a sinusoidal signal with a changeable frequency, which caused the implant to vibrate. The latter ceramic piece, on the other hand, measured the response to vibration and amplified the signal before comparing it to the original signal using a frequency analyzer.

Third-generation instruments (Osstell®) do not require a computer to do analysis and are light, tiny, rapid, and simple to use in daily clinic activities. Unlike prior versions, the transducer does not require instrument calibration. ISQ (Implant Stability Quotient) units are used to measure stability, and they range from 1(poor stability) to 100 (great stability) (high stability). Each type of implant has its own transducer, and the results obtained are independent of the transducer.

The transducer known as Smart-Peg is fastened on the implant in the last two types (Osstell Mentor®) and communicates with the equipment via electromagnetic waves. To compare measurements performed with the same equipment, it must be able to reproduce substantially similar values in multiple takes (i.e., the instrument is required to render a high degree of repeatability). Furthermore, the values recorded by different Smart-Pegs must be comparable (i.e., the instrument is required a high degree of reproducibility).

Few studies in the literature compare the results of several generations of RFA devices or analyze repeatability and reproducibility in registers taken with each of the current systems.

The goal of this study is to determine the Osstell Mentor® system's dependability(repeatability and reproducibility).

Result

Present *in-vivo* study determines implant primary stability by resonance frequency analysis and its correlation with bone density and insertion torque. A total of 400 (100 for each region i.e. 1. maxillary anterior, 2. maxillary posterior, 3. mandibular anterior, and 4. mandibular posterior) implants were selected and evaluated. The outcome measures of the study were implant stability quotient, bone density, and insertion torque.

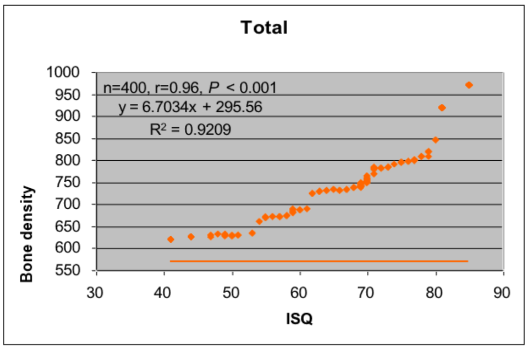
A. Overall

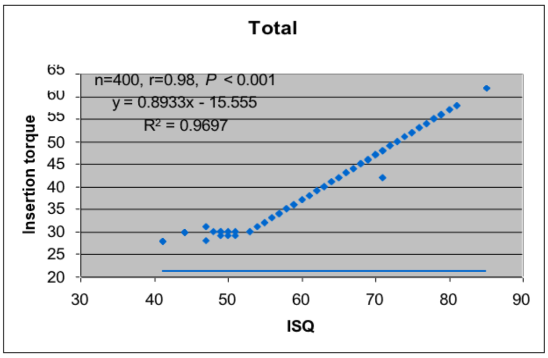
The inter-correlation of ISQ, bone density, and insertion torque values at the mandibular anterior are summarized in Table 1 and also shown in Fig. 1. The Pearson correlation analysisshowed a significant and high positive (direct) correlation between ISQ and bone density (r=0.96, $P < 0.001$), ISQ and insertion torque (r=0.98, $P < 0.001$), and bone density and insertion torque (r=0.96, $P < 0.001$) suggesting that increase in one may be directly associated to increase in other.

Table 1: Overall inter-correlation (R-value) of different assessed variables by Pearson correlation analysis (n=400)

Variable	***ISQ***	***Bone density***	***Insertion torque***
ISQ	1.00		
Bone density	0.96***	1.00	
Insertion torque	0.98***	0.86***	1.00

***$P < 0.001$





Graph 1. Overall inter-correlation of different assessed variables assessed by Pearsoncorrelation analysis.

Discussion

The goal of this study was to assess changes in bone quality in implant recipient sites using CBCT density values, insertion torque during implant placement, and RFanalysis shortly after implant placement, as well as to look for possible relationships between these three parameters. The Osstell methodology is a method of measuring osseointgration indirectly. It measures theattached Smart Peg's resonance frequency, which reflects the implant's micro mobility. When compared to direct procedures such as "knocking" (percussion-based techniques) on the implant, this method has various advantages. The implant's mass will have a minor impact, and the very low energy transferred to the implant will be non-invasive. The measurement is completely objective; regardless of who uses the device, the end result is always the same. The measurement is precise and reproducible, and it may be used to track osseointegration without interfering with the biological process. The strong correlations between bone density and insertion torque values, bone density and ISQ values, and insertion torque and ISQ values in the present study are consistent with a previous study by Turkyilmaz and co-workers [9]

In addition, Turkilmaz et al. [10] and Isoda et al. [11] reported statistically significant correlations between HU and the parameters of primary stability, IT, and RFA. These resultswere also found in this study. However, the findings of this study differed from those of earlier research, presumably due to differences in patient characteristics such as age and gender. However, in contrast to my results Andreaza Da Cunha et al[12]
undertook a study to evaluate the primary stability and placement torque with 2 implant types to determine if the evolution of the implant design has improved implant performance. It was discovered that there was no direct association between ISQ (primary stability) and placement torque in this study. Some implants showed higher placement torque but not greater primary stability.

The findings revealed that the aforementioned increase in implant stability during clinical function was also significantly correlated with preoperative CBCT and preoperative ITV bone density values, implying that patients with lower CBCT density values had lower stability increases up to 6 months after implant placement. After that, in patients with lower preoperative CBCT bone density readings, increasing stability takes longer. Additional predisposing clinical characteristics should be considered while deciding on a loading protocol for dental implants.

Conclusion

The overall or total (maxillary anterior + maxillary posterior + mandibular anterior + mandibular posterior) inter-correlation of ISQ, bone density, and insertion torque values showed a significant and high positive (direct) correlation between ISQ and bone density, ISQ and insertion torque, and bone density and insertion torque suggesting that increase in one may be directly associated to increase in other.

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