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REVIEW ARTICLE

Resonance Frequency Analysis: A Game Changer in Implant Stability Assessment- A Review

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ABSTRACT
Stability of implant is important element in determination of the accomplishment of implant placement. The definition of osseointegration is suggested by the concept of stability of implant, which is nothing but the lack of the clinical mobility.The type, quantity, and placement technique of the bone all affect the mechanical phenomenon known as primary dental implant stability. Secondary stability of dental implant meansthe rise in instability resulting from formation of bone and it's remodeling at the junction of the bone and the implant's tissue. Stability of implant can be evaluated, utilizing various invasive and/or noninvasive methods. Through this article light will be thrown on comprehensive overview of RFA and its role in determining implant stability, highlighting its importance in achieving successful osseointegration.
Keywords: Implant stability, Resonance frequency analysis, penguin RFA.

INTRODUCTION

Ever since the development of the Branemark's implant system in 1960's, dental implants are regarded as a dependable course of treatment for replacing lost teeth.[1] For the success of implants, osseointegration is among the most significant criteria.[2]Osseointegration is the direct, structurally and functionally compatible bond between the bone surface and the dental implant, avoiding any interface with connective tissue.[3]

Primary implant stability is crucial for the successful osseointegration process to occur[4]. Absence of clinical mobility is a sign of implant stability. Primary stability governs when implant's mechanical interaction in the cortical bone is there. Secondary implant stability obtains due to the regeneration followed by remodeling of bone as well as the tissue around the implant, which influences the primary stability of implant, maturation of the bone, bone remodeling, and density of bone with time.[5]

Atsumiet al[6] had given the subsequent elements that impact primary stability:

1. Quantity as well as the quality of bone
2. Technique of surgery, including the operator's skills
3. Geometry of implant, implant length, diameter, and also the surface characteristics of the implant.

Secondary implant stability influencing factors:

1. Primary stability of implant
2. Bone modeling as well as remodeling
3. Surface conditions of implant[6]

There are several methods by which Stability of implants can be quantified. [Figure 1]

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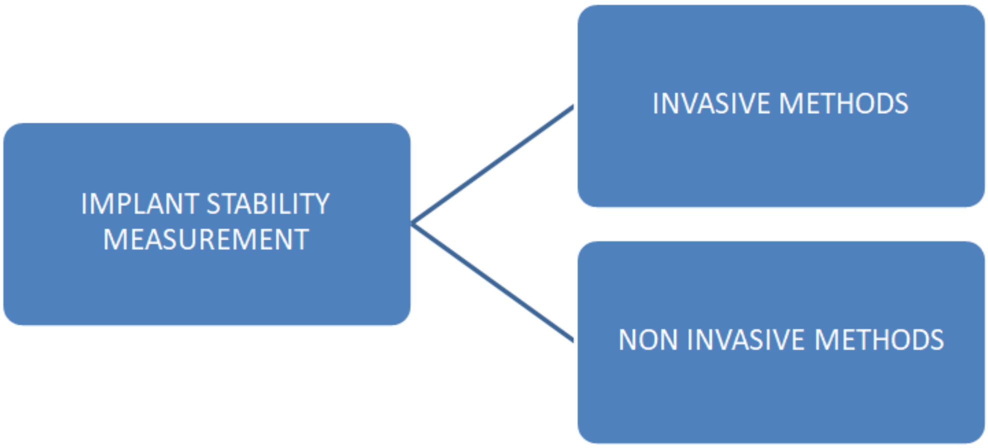

Figure 1 Methods to quantify Implant Stability

Figure 2 Penguin RFA Device

Various Invasive techniques are as follow:

- Histological or histomorphometric analysis,
- Tensional tests,
- Push-out/pull-out tests,
- Removal torque analysis.

Whereas noninvasive methods are:

- Insertion torque measurement,
- Percussion tests,
- Periotest,
- Resonance frequency analysis (RFA)

Most often, simple, non-invasive methods are used to measure implant stability and osseointegration[6].

RESONANCE FREQUENCY ANALYSIS

Development of one of the primary instruments for evaluating implant stability is RFA, which was developed approximately 30 years ago by Meredith and associates. Vibration and structural principles are used in this noninvasive type of diagnostic method to assess implant stability and bone density over time.[7]This technique measures the resonance frequency (RF) of the device by means of a transducer peg that is placed over the dental implant and stimulated by electromagnetic waves spanning multiple frequency ranges. Hertz is used to calculate RF values. Which, on a scale of 1 (lowest stability) to 100 ISQ units (Highest stability), are then translated into the implant stability quotient (ISQ)[8]

Thus far, four generations of RFA have been identified. The device's first iteration was built around a transducer with a measuring element that was wired to a measuring unit and placed on the implant or abutment.

A device of second-generation analyzes response of different frequencies by means of magnetic technology. The main goal of the device with third generation design was to address the shortcomings of the devices with first and second generation. A tiny battery-operated system found in the third-generation system allowed for rapid and easy measurements as well as chairside interpretation.[9]

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Penguin RFA Device

Integration Diagnostics Sweden AB, Gothenburg, Sweden, debuted Penguin RFA in 2015. The instrument uses a reusable transducer (MulTipeg) to measure ISQ.[10][Fig. 2]MulTipeg is composed of titanium and has a maximum autoclaving cycle of 20 cycles. Magnetic pulses are used to excite the MulTipeg when it is implanted.

The connected MulTipeg and the Penguin RFA are not in contact during the RF measurement process. The vibration frequency of device is detected and converted into an ISQ value between 1 and 99. The stability of the implant is improved with a higher ISQ value.[8]

Factors which determine RFA measurements

1. **Bone related factors-** Stability of dental implant is typically greater in the mandible because the mandibular bone is frequently denser than the maxillary bone.[11] Thickness of cortical bone and initial ISQ values have a strong, favorable relationship, according to Myiamoto et al.[12] In an in vitro study, Tozum and colleagues found that a decrease from 8 to 0 mm in buccolingual thickness was associated with a lower ISQ value.[13]
2. **Implant related factors- -** Implant stability rises with increasing implant diameter and falls with implant length, according to Ostman et al. and Miyamoto et al. This can be explained according to the fact that certain long designs have a smaller coronal part diameter in order to make one piece smaller and less heat-producing friction.[14] According to Bischof et al., the values of ISQ are unaffected by implant position, length, diameter, or vertical position.[15]
3. **Surgical technique-** Using a technique to increase lateral compression during insertion appears to increase stability.[16]
4. **Implant surface-** With an immediate loading protocol, Glauser et al. did the comparison between machined and the oxidized implants and discovered that machined implants had a greater decline in the stability during the first three months following loading. The primary stability of titanium implants that are machined or oxidized is not different, according to a clinical study conducted in the posterior mandible. After four months of loading, the oxidized implants maintained their stability while the machined implants lost it.[17]

Interpretations of RFA measurements

"Safe" implants with primary ISQ values of 70 and higher are found in the green zone. "Questionable" implants (ISQ value < 55) are there in the red zone. Implants having an ISQ value between 55 and 70 are represented by the yellow zone. [Figure 3]

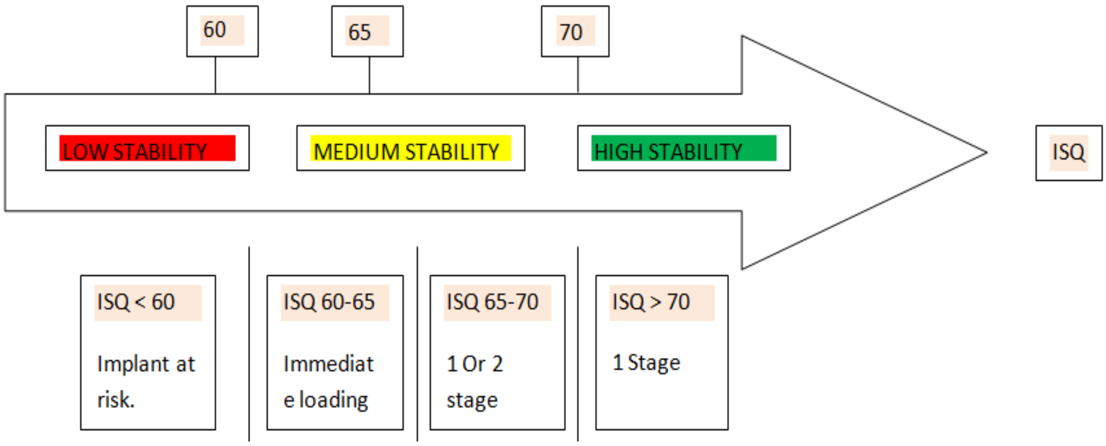

Figure 3 Interpretations of RFA measurements

Whereas implants in the yellow and red zones require a healing period, those in the green zone can undergo immediate loading protocols. After healing, a second measurement in the latter groups will verify that more stability (into the green zone) has been attained. If after the initial healing period low ISQ values are still obtained, then implant is left to heal.

Implants that have low or declining ISQ values fail more frequently than those that have rising or low values. In order to diagnose implant stability and make decisions regarding implant treatment and follow-up, ISQ measurements can be used as an additional parameter.[18]

CONCLUSION

While there are several techniques to assess implant stability, it is challenging to identify a critical value that can predict an implant's success, failure, or long-term prognosis due to the multitude of factors influencing the outcome.

At any point following implant implantation, the RFA technique provides clinically relevant information regarding the condition of the implant-bone interface. The micromobility of an implant under load is represented by its ISQ value, which is based on the bone quality -dental implant interface and the biomechanical characteristics of the surrounding bone tissue.

As of yet, no clear-cut technique is developed which can assess implant stability. While the theory

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underlying RFA is sound, the technology is unable to deliver a critical value that can predict an implant's success, failure, or long-term prognosis. Thus, the current conclusion drawn from this review is that, in order to ensure long-term implant stability, data should be gathered from numerous diagnostic tools. Undoubtedly, this field needs more research.

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