Resonance Frequency Analysis and Oral Implant Stability: A Long Term Relationship

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Abstract

For a desired osseointegration to take place, implant stability plays an expository role. Hence to achieve a functional dental implant, successful osseointegration is a necessity. The two major factors affect the survival of implants that is the stability of the implant during placement and the event of osseointegration. Two separate phases determine the stability of implant: Primary implant stability as well as secondary implant stability. Mechanical grip withthe cortical bone determines the primary stability whereas Secondary stability is due to regeneration as well asremodelling of the surrounding bone and surrounding tissue around the implant after loading. Implant stability is a mechanical phenomenon which is in association with local factors such as quality of bone, type of placement technique used, quantity and the type of implant used. It is considered highly advisable for implementation of a user-friendly, non-invasive, clinically reliable method to assess the stability of the implant and the osseointegration process. Resonance frequency analysis (RFA) is one of the method thats how almost perfect consistency after statistical analysis. Therefore, the focus of this currentre view article is particularly on presently used RFA method which are highly followed in the current times to elicit oral implant stability.

Keywords: *Resonance Frequency Analysis, Implant stability, Implant survival, Osseointegration.*

Introduction

Osseointegration is defined as "the direct, functional, and structural contact between live bone and the surface of a functionally loaded implant. This was evinced by Branmarket al. in 1969. Modern dentistry aims at restoring the function, comfort, and aesthetics of the missing tooth. The success of a dental implant depends on its ability to osseointegrate with surrounding bone[1]. Within the clinical perspective, quantification of successful osseointegration is based on the implant stability.[1-3] Stability of implants is of 2 various types: Primary implant stability and secondary implant stability.[4] Primary implant stability is a component of quality of nearby bone and amount, the morphology of an implant (i.e. length, width and sort), and the installation technique utilized (connection between drill size and implant estimate, whether a pre-taped or self-tapped implant is utilized[5]. Secondary implant stability is the eventual result of regeneration as well as remodelling of the tissue and bone surrounding the implant. Primary stability determines the secondary stability, which dictates the time of functional loading. Condition of the surrounding tissues also influences the extent of implant stability. Hence, it is necessary to be able to evaluate implant stability at different time intervals to reckon a long term prognosis.

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Method to assess oral implant stability: It is sometimes intricating to assess the stability of the implant because of the diverse nature of the implant's surrounding bone tissue and the phenomenon of osseointegration. In vivo, there are various method to gauge implant stability. However, for many surgeons, proprioception is the only thing they count on because of the difficulty to monitor in vivo healing of bone. To reduce the vulnerability of failure of the implant, precise quantitative measurements are needed to guide the operators.

Invasive/Destructive Method[4]

- Histologic/histomorphologic analysis
- Tensional test
- Push-out/pull-out test and
- Removal torque analysis

Non-invasive/non-destructive method[6]

- The surgeon's perception
- Radiographical analysis/imaging techniques
- Cutting torque resistance (for primary stability)
- Insertion torque measurement
- Reverse torque
- Seating torque test
- Modal analysis and Implatest
- Percussion test
- Pulsed oscillation waveform (POWF)
- Periotest
- Resonance frequency analysis (RFA): Electronic technology
- Magnetic technology

Resonance frequency analysis (RFA): Among all the method, RFA is one such method which is used most frequently. Meredith et al. in 1996 were the first to portray the RFA strategy, which is commercially available as Osstell, Implomates, and Penguin[4]. It is a diagnostic method which is nonintrusive while measuring bone density and implant stability at disparate time points using vibration and structural principle analysis[7].

To elicit implant stability two commercial devices have been generated. The original method i.e. electrical method utilizes direct wire connection betwixt the transducer as well as the resonance frequency analyzer. However, the second method used utilizes magnetic frequencies[7].

Within the electronic device, the transducer is anL shaped cantilever beam connecting like a screw attachment with the implant. The L beam has a vertical segment that posses a piezoelectrical crystal which lowers the implant/transducer complex. The opposite side, comparably has a piezoelectric crystal, similarly, on the opposite side of the beam second piezoelectric crystal discerns the beam's response.

Recently a new device with magnetic RFA has been introduced which has a metallic rod with a magnet on top, which is screwed onto an implant or abutment and a transducer. In this, magnetic pulse from a wireless probes stimulates the magnet. 1millisecond is the pulse duration. The peg vibrates unconfined after stimulation, and electric voltage present inthe probe coil is effectuated by the magnet. The voltage thus producedis the signal measured as well as sampled by the resonance frequency analyzer. Both the method that is electronic and magnetic method measure similar changes,but the magnetic device provides higher implant stability quotient (ISQ) value while measuring the stability of non-submerged dental implant[7].

Four generations of RFA have been introduced so far. The first-generation device was based on a measuring element transducer placed on implant/abutment and then connectedto a measuring unit with a wire. The second-generation device analyses frequency response utilizing the magnetic technology. The third-generation device was designed to overcome drawbacks of first- and second-generation. The third-generation system runs by a small battery system. This is helpful in swift as well as steady and chair side interpretation.[8, 9]

The first commercially available RFA equipment is Osstell™, followed by Osstell AB, then Osstell Mentor and Osstell ISQ, being the latest version, which utilizes a smart peg and a wireless probe attached to the device. A small magnet is attached at the top of the smart peg-top.To excite this, magnetic pulses are generated from a probe. The activated peg induces electric volt into a probe that is sampled by the magnetic RFA device[9]. Implant stability was determined under various surrounding bone conditions by Feng et al. and concluded that to elicit the implant stability during different healing phase,it can act as a non-invasive diagnostic tool.

For quantification of accuracy of prognosis of RFA measurements, clinical trials were carried out which determined the failure risk prediction's optimal threshold value. RFA value is just an indication that the implant inserted is stable clinically but may provide false assurance in considering immediate restoration of the implant. RFA as a prognostic tool, has a low sensitivity, before immediate loading,a combination of clinical parameters,radiographic evaluation should be taken into consideration.

Implant stability using Ostell: RFA evaluates the Stability of implant by quantifying the frequency of oscillations done by the implant on bone. Meredith et al. 1998 described the non-invasive method of assessing implant stability utilizing the RFA device OSSTELL. Sweden's Integration Diagnostics Ltd has been designing OSSTELL devices since the year 1999. These devices have developed with time with, improved generation of measuring the implant stability, these are, OSSTELL™, OSSTELL ISQ and OSSTELL Mentor[9].

This technique utilizes a piezoelectric transducer and is a diagnostic technique, which is non-invasive. It has sinusoidal signals which are projected in a limited frequency and the implant vibrates within this frequency. Resistance produced by the implant to this vibration is quantified and converted to ISQ values by this device. ISQis measured on a scale within 0–100, 100 being themaximum, and 0 lowest stability values[9].

OSSTELL ISQ is the recent generation of this device and was developed in the year 2009. It includes a newcontrol unit with a probe connected to it usinga cable. Its use is progressively extending to registerthe implant stability measurement due to the ability of

device to reproduce accurate values without intra andinter observer variability. The Osstell measurementsare highly reliable and are alone sufficient to assess the status of implant success[9].

When the ISQ is 47, Implant stability can be obtained. But, when the ISQ more than 49, it osseointegrated with healing period of 3 months. However, immediately loaded implants with an ISQ more than 54, osseointegrated easily. When ISQ value is low the implant stability depletes. In such cases, the operator should follow a tight recall schedule and should take point to point unloading measurements until implant stability is redeemed. When implants have high values of ISQ, the thing taken into consideration is the stability of the implant in the first twelve weeks of healing. This should not demand any changes in recall appointments. The downside of this system is that the measurement of the transducer is restricted to a set of 60, thus making the method much costlier. Implant has a fixed transducer in order execute RFA. This precludes observing the implants that support a cemented restoration[7].

Factors influencing resonance frequency analysis/ implant stability quotient values: It is revealed that ISQ is influenced by the diameter of the implant, form, surface, the ratio of contact to the bone,site where the implant is placed, system/type of implant used, the procedure of surgery, bone's height and bone quality. Stiffness of the interface affects the RFA along with 3 other aspects. At first healing of bone and remodelling of bone increases the stiffness of the interface of the surface of implant and bone. Secondly, bone stiffness and density along with cancellous and cortical bone ratioputs impact on RFA. Finally, interlocking parts of components of the implant can be a factor. Smaller drilldiameter final drill, varying surgical techniques e.g. self-tapping design implants, bone compaction technique, and wide tapered implants may also put impact on stiffness of the implant surface.

Application[10]

- It aids in making loading decisions.
- ISQ of 70 or more has reached–planning of the prosthetic phase can be done. Howbeit, since remodelling is always alternating, high Implant stability quotientdoes notalways state that there will be same the secondary stability will also be the same. Similarly, a when ISQ is low, it does not specify that there will beimplant failure because the contact between the bone and implant increases after the stand by interval of osseointegration.
- Alerts for hindering failure: An ISQ of 55 or progressive decline over period suggests of a hidden failure and notifies for necessary measures.
- Case documentation: Helps in maintaining records and hence communication is made easy as well as it is of great assistance in medico-legal cases.

Limitations[10]

- Comparatively expensive
- The smart pegs sum up the expense.
- Each implant system has a respective smart pegs.

- In case of single piece implant cannot record ISQ and requires an extra attachment.
- Cannot be utilized when the implant is placed subcrestally.

Conclusion

Clinically appurtenant information can be provided by resonance frequency analysis technique, regarding the state of the interface between bone and implant at any juncture of the treatment and follow-up. The inclemency of the interface of implant-bone is also based on implant stability and this particular technique quantifies it. Factors governing the above are such as the density of bone, time for healing of jawas well the implant that is exposed above the crest of alveolar bone. Research Studies specify that during recall examinations, successful osseointegration is elicited in implants with high values of ISQ. The opposite might signal in the direction of failure of implant or bone loss in the marginal area. To know clear specifications, for better implementation of the resonance frequency analysis technique, further clinical case reports are required.

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