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RESONANCE FREQUENCY ANALYSIS (RFA) IN IMPLANT DENTISTRY

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ABSTRACT

Implant stability and osseointegration have been the two major issues affecting long term implant survival since its advent. The osseointegration of implants is the growth of bone around the implant surface forming an interlocking with the surface roughness of the introduced fixture while the stability of an implant is a mechanical phenomenon that depends largely on the quality and amount of bone surrounding an implant, the type of implant and the placement technique used by the clinician. Various crude methods were used in the past in order to gauge the stability of an implant like percussion with dull instruments, initial torque values, radiographic analysis and the likes. These techniques however failed to provide the clinician with a standardized method to assess implant stability and thus led to poor judgment on part of the clinician regarding the loading time for that particular case. The advent of the Resonance frequency analysis, which is a non-invasive, cost effective and simple procedure, has greatly helped clinicians achieve a more reliable mode of judgment. As the use of immediate loading of implants has become increasingly popular with clinicians in order to reduce morbidity, patient discomfort and to ensure faster rehabilitation, the use of accessory methods to gauge implant stability have become a must. The Resonance frequency analysis has proven to be a novel method to achieve just that. This review is aimed at throwing light on the RFA technique used to assess implant stability, how RFA values can be used to improve outcomes in implant therapy and to explain how implant stability quotient data can be used to objectively determine dental implant loading and restorative protocols.

KEYWORDS: Implant stability, resonance frequency analysis (RFA), Implant stability quotient, Osseointegration.

1. INTRODUCTION

Since its advent, Implant dentistry has been on a constant path of evolution in order to include increasingly difficult cases involving patients with advanced conditions and risk factors that have the potential to sabotage dental rehabilitation. Simultaneously, the number of patients desiring rehabilitation using dental implants has been on a constant rise and increasing number of individuals are resorting to rehabilitation using implants in place of removable or fixed appliances. Bone anchored implants are now being used in dentistry for supporting intraoral and craniofacial prosthesis. The longevity, aesthetics and fulfillment of functional demand are properties that are drawing increasing number of patients to adapt to this mode of treatment. While a range of factors is known to influence implant survival, primary stability and osseointegration of the implant are the key determinants in successful implant therapy. Implant stability primarily depends on the new bone formation and remodeling termed as osseointegration which is accomplished in the initial period post placement in which implants remain non-loaded to secure undisturbed bone formation on the implant surface. This process increases the stiffness of bone around the implant and the bony interlock with the implant surface prevents micro-movement and the formation of fibrous scar tissue at the time of implant loading. However, the development of new advances and clinical techniques has led to a marked reduction in healing time and consequently loading time even to the point of immediate loading or early loading of implants. Although high success rates have been reported, a small number of implants may fail during the early healing phase or later in function. Currently available clinical methods to determine implant stability and osseointegration are relatively crude and may entail percussing a fixture with a blunt instrument like a mirror, using the insertion torque technique or radiographic analysis. Sometimes, reverse or unscrewing torque has also been used. However, a standardized system is mandatory in order to achieve good implant stability and long-term success. Resonance frequency analysis (RFA) provides a non-invasive, objective method of assessing implant stability over time.

2. MECHANISM AND TECHNOLOGY

The technology used in RFA has been studied and used in clinical practice for over 20 years and is defined as the measurement of frequency at which an object vibrates.[1] As osseointegration progresses and stability increases, the frequency of vibration also increases and this translates to an increased stiffness of bone-to-implant interface.[1] Studies have demonstrated a correlation between the FRA values and lateral movement or displacement of implants showing that higher RFA values indicate lesser lateral movement and more stability. In addition, higher bone density also corresponds to higher RFA values. The unit consists of a Sensor that is placed on top of the implant and a probe that brings the sensor into vibration by gently moving it with magnetic pulses. The sensor will vibrate for a short period and then stop. If the implant stability increases the vibration of the sensor will increase.[4] When performing RFA, measurements are normally assessed by placing the probe perpendicular to the sensor at four sites circumferentially around the implant, including the buccal, lingual, mesial and distal aspects.[1] Generally the highest and lowest values are recorded. The resonance frequency of the unit is dependent on three factors: the design of the transducer, the stiffness of the implant fixture and the interface with the tissue and surrounding bone and lastly the total effective length above the marginal bone level.[2] The effective length comprises the length of the transducer, which is fixed, the length of the abutment, which may vary but at fixed intervals, and the level between the top of the fixture and the surrounding bone.[2]

The RFA unit essentially measures the micro mobility of the sensor and so the implant when subjected to lateral load.[1] Lateral load is often equated to functional forces that may act on the implant when in function. Till date, four RFA devices have been introduced. Early RFA units were designed based on basic principles of physics, as a simple cantilevered bar that could be screwed to an implant fixture or abutment.[6] The bar was stimulated over a range of frequencies. The most recent version is wireless and less bulky.[6] The rod mounted on the implant has two fundamental resonance frequencies; it vibrates in two directions perpendicular to each other.[6] One of the vibrations is in the direction where the implant is most stable and the other where the implant is least stable.[6] Thus two ISQ values are provided.

Objective measurements of implant stability

1. Supports making good decisions about when to load.[6]
2. Allows advantageous protocol choice on a patient-to-patient basis.[6]
3. Indicates situations in which it is best to unload.[6]
4. Supports good communication and increased trust.[6]
5. Provides better case documentation.[6]

3. IMPLANT STABILITY QUOTIENT

The measurement unit for frequency is hertz, but when assessing implants, hertz are often converted to an Implant stability quotient (ISQ).[1] It Is an objective world standard for measuring implant stability. Although the ISQ scale ranges from 1 to 100, Implant ISQ is normally between 55-80.[5] Higher values are generally observed in the mandible than the maxilla due to increased amount of stable, cortical bone.[5] The ISQ scale has a non-linear correlation to micro-mobility. We now know that high stability means ISQ value > 70, medium between 60-69 and < 60 is regarded as low stability.[5]

If the initial ISQ value is high, a small drop may be noticed gradually over a period of time. A big drop in stability should be taken as a warning sign. Lower values are expected to rise slightly after the healing period.[5] The opposite could be a sign of a failing implant.[5] Clinical research has demonstrated the lowest values and most significant reductions in stability at sites with poor bone.[1] By comparison, implants placed in type 1 bone generally do not exhibit significant changes in stability throughout the 10 week observation period.[1]

Thus, ISQ values at the time of implant placement and at subsequent postoperative time points can guide clinical decision making regarding the surgical protocol and timing of restoration.[1]

4. USE IN HIGH RISK CASES

The use of this methodology of implant stability measurement can provide great benefits in high risk cases by providing objective measurements over time.[1] The patients that fall under this category are the ones with:

1. Bruxism
2. Type 3 and Type 4 bone
3. Implant placement with bone augmentation
4. Immediate implant placement.

Usually in such cases, delayed loading is advised with serial ISQ measurements in order to allow clinicians to objectively monitor stability and determine the time of loading and restoration. Serial or periodic measurement of ISQ values is recommended, as baseline ISQ values are not strongly correlated with failure. Multiple values over a longer period of time must be recorded and the decision should not be based on just one value recorded at the time of placement.

5. CONCLUSION

The level of predictability and high success rates has demanded reassessment of long adopted surgical and prosthetic guidelines. With the current trend of working towards shortening treatment time and quicker rehabilitation of patients, immediate implant placement is the preferred choice of treatment. Howevr, in order to adopt this newer method, certain rules and guidelines must be followed to avoid failure and ensure long term success. It has been established that primary stability and osseointegration of implants is the key factor in determining long term success rates after implant placement. So, there is a need for a non-invasive, standardized method to determine primary stability. RFA could serve as an appropriate tool in order to determine the implant stability and decide regarding immediate or delayed loading and as a follow up protocol. Though the RFA technique has been used in several clinical studies, further research regarding the feasibility and predictability of the procedure is required.

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