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RESEARCH ARTICLE

DIFFERENT METHODS INVOLVED IN ASSESING THE IMPLANT STABILITY-A REVIEW

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Abstract

In order for osseointegration to be effective, implant stability is essential. Functional dental implants require successful osseointegration. It's crucial to conduct ongoing, objective, and high-quality monitoring to assess the stability of the implant. At the primary and secondary stages, implant stability is assessed. The primary source of stability is mechanical contact with the cortical bone. After implant placement, the bone and tissue around the implant regenerate and undergo remodelling, which is influenced by the main stability, bone production, and remodelling. The implant's stability affects how long it takes to reach functional loading. Radiographs and microscopic or histologic analysis were historically the gold standard methods to assess stability. However, due to the invasiveness of these methods and associated ethical concerns, many other methods, such as cutting torque resistance, reverse torque analysis, model analysis, etc., have been proposed. In order to predict a long-term prognosis for effective therapy, it is crucial to be able to access implant stability at various time periods.

Introduction:-

Osteointegration is essential for implants to operate, and primary implant stability is essential for effective osseointegration. When an implant is stable, clinical movement is not present. Failure may come from fibrous encapsulation brought on by implant instability. Osseointegration, which can occur in primary and secondary phases, can be used to gauge implant stability[1]. Primary implant stability after implantation is a mechanical phenomena that is influenced by the type of implant used, the insertion technique, and the quantity and quality of the surrounding bone. Secondary stability, which involves bone remodelling and regeneration, provides biological stability. Primary stability has an influence on secondary stability [2].

Histologic or microscopic investigation was formerly the gold standard approach for determining the degree of osseointegration. [3] However, other methods of analysis have been suggested due to the invasiveness of this method and associated ethical concerns. These methods include using blunt-ended instruments to clinically check for mobility, radiographs, cutting torque resistance, reverse torque, and resonance frequency analysis (RFA).

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There are different methods to assess implant stability. They can be grouped as invasive/destructive methods and noninvasive/ nondestructive methods.

Invasive/destructive methods

Following methods were included:

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

Histomorphometric analysis

This is calculated from the amount of peri-implant bone and bone-implant contact (BIC) of an implant and peri-implant bone samples that has been coloured. It's a good idea to get a second opinion if you have any doubts about the accuracy of the information provided. It is utilised in nonclinical research and testing. It is evaluated before, during, and after surgery.

Tensional test

The implant plate was previously detached from the supporting bone to measure the tensional test. Later, Bränemark improved it by placing a lateral stress on the implant fixture. Nevertheless, they also addressed the challenges in extrapolating the test results to mechanical features that aren't specific to any one application.

Push-out/pull-out test

The push-out/pull-out test looks into how well the bone implant interface can heal. By applying force parallel to the implant-bone contact, interfacial shear strength is measured. A cylinder-type implant is often inserted transcortically or intramedullarily into bone structures and subsequently removed by exerting force parallel to the interface in a push-out or pull-out test. The greatest force on the force displacement plot is used to establish the maximum load capability (also known as the failure load), and the interfacial stiffness is represented by the slope of a tangent that roughly lies at the linear portion of the force displacement curve before the breakpoint. It is evaluated while it is healing. While the majority of clinically available fixtures are of threaded design and their interfacial failures are solely dependent on shear stress without any consideration for either tensile or compressive stresses, the push-out and pull-out tests are only applicable for nonthreaded cylinder type implants. It is also technique sensitive.

Removal torque analysis

If the reverse or unscrewing torque was greater than 20 Ncm, the removal torque analysis implant is regarded as stable. The drawback is that the implant surface, which is currently osseointegrating, may shatter under the imposed torque force at the time of abutment attachment.

Clinical Perception

The movement detected by blunt-ended tools is frequently the foundation for the clinical assessment of the main implant stability. This method is very subjective and highly unpredictable. Another way to do this is to introduce an implant and watch the cutting resistance. If there is a sense of a sudden stop at the implant's sitting, it is important to emphasise the feeling of "excellent" stability. The root shapes of tapered implants frequently have a geometry that will provide a solid stop and perhaps a misleading perception of great stability [4,5].

Noninvasive/nondestructive methods for assessing implant stability

Percussion test
Reverse torque test
Cutting torque resistance analysis
Periotest
Resonance frequency analysis

Percussion Test

The percussion test is intended to produce a ringing sound from the implant as an indication of Osseo integration or excellent stability and may involve tapping a mirror handle against the implant carrier. Percussion testing may provide more details about the tapping instrument, but they only provide low quality information at worst.

Reverse Torque Test

It has also been suggested to provide a reverse or unscrewing torque to gauge implant stability when the abutment is connected. [6] Implants that twist when the applied torque is applied are removed as failures. Yet, the implant surface may shatter under the applied torque stress as it progressively begins the Osseo integrating process. Moreover, the reverse torque testing has lost credibility as animal studies have shown that loosening and rotationally mobile implants can reintegrate [7].

Cutting Torque Resistance Analysis

A current-fed electric motor's energy requirement to remove a unit volume of bone during implant surgery is assessed. [8-10] One of the elements affecting the stability of implants is energy, which is correlated with bone density. The fact that the lower limit value has not been determined, however, might indicate implant failure in the future. Moreover, it can only be utilised during surgery and cannot be used as a diagnostic tool or measure secondary stability due to remodelling and new bone growth surrounding the implant. [11]

Periotest

Measures how the peri-implant tissues respond to a certain impact stress to calculate an implant's mobility. Schulte developed the Periotest to measure the damping properties of the periodontal ligament and evaluate the mobility of real teeth. [12,13] Periotest employs a handpiece with a metallic tapping rod that is electromagnetically propelled and electronically controlled. Range of the periotest is between 8 (poor mobility) and +50. (high mobility). It has the ability to gauge bone density both during and after surgical implant implantation. A tiny accelerometer built within the helmet tracks the response to hitting or "barking". This method's reliability is in doubt due to its weak sensitivity and susceptibility to several factors. [14]

In vitro analyses showed a good degree of reproducibility between various periotest units and no statistically significant differences in measuring periotest readings from one operator to the next. Dental implants that have been successfully integrated have shown a variety of stability readings using the periotest. It is thought that this range of numbers represents bone density at the implant interface, which is correlated with implant site. Excitation factors like direction and position have a big impact on the measurements.

Measurements need to be taken in the mid-bony area and must be parallel to implant axis [Figure 4]. By taking into account the intraoral environment, it is more simpler to measure anterior implants than molars due to the buccal mucosa. A "borderline" instance or "an implant in the process of osseointegration" cannot be diagnosed by the periotest. [15] It cannot replace radiography since it does not show the level of peri-implant bone.

Resonance Frequency Analysis

Using structural and vibration principle investigation, this non-invasive diagnostic method assesses bone density and implant stability at various time periods. Two commercially available instruments were created to assess implant stability. The resonance frequency analyzer and the transducer are connected directly in the original method. The resonance frequency analyzer and transducer are connected via magnetic frequencies in the second method. The transducer for the electronic tool is an L-shaped cantilever beam that connects to the implant through a screw connector.

On the vertical section of the L beam, a piezoelectric crystal is utilised to stimulate the transducer complex or implant; a second piezoelectric crystal is employed as a receiving component on the opposite side of the beam to detect the response of the beam. A metallic rod with a magnet on top that is fastened into an implant or abutment serves as the sensor in the novel magnetic RFA device [16,17]. A magnetic pulse activates the magnet from a wireless probe. The pulse lasts for roughly 1 ms. After excitation, the peg vibrates freely, and the magnet induces an electric voltage in the probe coil. The resonance frequency analyzer samples the voltage as a measuring signal.

Both the magnetic and electronic instruments can detect identical changes, however the magnetic instrument yields a better implant stability quotient value when detecting the stability of non-submerged dental implants. With this method, implant stability is assessed by selecting a resonance frequency.

For implants with an ISQ of 47, implant stability may be established. All implants with an ISQ greater than 49 Osseo integrated after three months of healing. When immediately loaded, all implants with an ISQ greater than 54 Osseo integrated. A decrease in implant stability for implants with low ISQ values should prompt the practitioner to

subject those implants to a more stringent follow-up schedule and to take additional precautionary measures, such as unloading the implant until implant stability is restored or, if the implant is not loaded, checking for mechanical trauma and/or infection. Reduced implant stability during the first 12 weeks of healing for implants with high ISQ values should be regarded as a frequent occurrence and shouldn't necessitate changing usual follow-up. [11]

The disadvantage of this technology is that the transducer can only take a set of 60 readings, which makes the technique relatively pricey. A transducer is attached to the implant in order to perform the RFA. This does not include keeping an eye on any implants that support cemented restorations.

Electronic Technology Resonance Frequency Analysis (OSSTELL™)
It was the first commercially viable implant stability measurement product. The excitation source, computerised analysis, and transducer are all combined into one device via electronic technology. The measuring scale employed is the implant stability quotient (ISQ), which ranges from 0 to 100. Utilized at the time of implant insertion, it gives a baseline reading for comparison and after implant location. A marketed device using the RFA principle called Osstell (Integration Diagnostic AB, Goteborg, Sweden) has translated the resonance frequency, which ranges from 3000 to 8500 Hz, into the ISQ of 0-100. [18]

Magnetic Technology Resonance Frequency Analysis (OSSTELL™ MENTOR)
The transducer has a magnetic peg on top and is fixed to implant or abutment [Figure 4]. On activation by magnetic resonance frequency probe the peg is activated, which vibrates and induces electric volt sampled by magnetic resonance frequency analyzer. Values are expressed as ISQ of 0 to 100. At the time of implant placement, it provides baseline reading for future comparison and postsurgical placement of the implant.

However, this method is expensive and technique sensitive as it requires respective transducer and magnetic peg. It should maintain a distance of 1–3 mm, angle of 90°, and should be 3 mm above the soft tissue otherwise the measured value will be affected. Valderrama et al. reported in a study experimenting Osstell and Osstell Mentor that the two devices had high significant correlation.[19,20]

Newer methods under research and development
Implatest conventional impulse testing
In order to do a traditional implant impulse test, an accelerometer with related cables and connections must be attached to the implant. The implant must then be struck with a calibrated hammer, and the data must be recorded and analysed. Testing implants using electrical impulse techniques aims to identify, examine, and keep an eye on their signatures.

Implatest (Q Laboratories Inc., Providence, R.I.) is a portable, self-contained probe that integrates all of the properties of a traditional impulse test. Data collection takes only a few seconds and is operator-independent (independent of the direction or position of test application on the implant). While attempting to test an implant with a multifixture prosthesis connected, complications might occur due to the splinting impact they have. The supportive impact of all implants or natural teeth or a combination of these at the specific testing location makes the dynamic signature of a multifixture prosthesis exceedingly complicated. [21]

Electro-mechanical impedance method
This test makes use of piezoelectric materials' electro-mechanical impedance, which is directly connected to the mechanical impedance of the host structure and may function as both sensors and actuators. The structure being monitored is connected to piezoelectric zirconatetitanate (PZT). The PZT begins to vibrate when a voltage of 1 V in the kHz range is applied, and any alteration in structural properties like stiffness, damping, or mass distribution would affect how the impedance analyzer reads the electrical admittance of the PZT.

Micro motion detecting device
To measure implant micromotion, a specialised loading device with a digital force gauge (Chatillon E-DFE-025, Chatillon Force Measurement Systems, Largo, FL, USA) and a digital micrometre (Mitutoyo Absolute Digimatic, Mitutoyo America Corporation, Aurora, IL, USA) (range of 10-2500 N, 0.25% resolution over range) was used. By rotating a dial, which set the force gauge's height, the forces were generated. The abutment was subjected to this dialed-in force using a lever. After applying the load, the displacement was measured using a digital micrometre that was tangent to the abutment's crown. [22]

Conclusion:-

Data from the literature that has been given suggests that, when compared to conventional procedures, modern testing and equipment may be more important in determining implant stability. A important diagnostic and therapeutic tool with broad implications for implant dentistry is the ability to track osseointegration and the lifespan of an implant. The use of RFA to evaluate the impact of early and delayed loading, evaluate stability over time, and provide an early diagnosis of implant failure has generated significant attention in science recently. To guarantee long-term implant stability, information should be gathered through a variety of diagnostic tools.

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