METHODS TO MEASURE THE IMPLANT STABILITY – A REVIEW

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ABSTRACT

Implant stability is the prerequisites for the success of dental implants. Implant stability can be defined as the absence of clinical mobility. Successful osseointegration plays a major role in attaining implant stability. Primary stability comes from mechanical engagement with cortical bone, that is related to the local bone quality and quantity, the type of implant, and placement technique used. Secondary stability is developed from regeneration and remodelling of the bone and tissue around the implant after insertion and affected by the primary stability, bone formation and remodelling. There are many ways in which the implant stability can be evaluated. Therefore this review focuses on the currently available methods for evaluation of implant stability.
Keywords: implant stability, implant stability quotient, periotest, resonance frequency analysis

INTRODUCTION

Osseointegration defined as "A direct connection between living bone and a load-carrying endosseous implant at the light microscopic level." By Branemark. In 1986, American Academy of Implant Dentistry defined osseointegration as "Contact established without the interposition of non-bone tissue between normal remodelled bone and an implant entailing a sustained transfer and distribution of load from the implant to and within the bone tissue." Implant stability can be defined as the absences of clinical mobility, which is also the suggested definition of osseointegration. The ability to withstand the axial, lateral, and rotational loads is known as primary

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stability,and it is dependent on the implant anchorage within the bone. Different implant designs and drilling protocols appear to have improve the primary stability within the bone. Patient-dependent factors that are affecting the implant stability includes bone quality and quantity. Greater implant stability will be achieved in more dense bone[9]. Secondary stability is provided through the bone regeneration and remodelling. Primary stability is primarily affected by the bone quality and quantity, surgical technique and implant dimensions (implant length, implant diameter and surface characteristics). Secondary stability is affected by the primary stability.[10]

Atsumi et al[1] proposed the factors that affect the primary implant stability:

1) Bone quantity and quality

2) Surgical technique, including the skill of the surgeon

3) Implant geometry (length, diameter, and surface characteristics)

METHODS TO MEASURE IMPLANT STABILITY

There are different methods to assess implant stability. They can be grouped as destructive methods and non-destructive methods:

DESTRUCTIVE METHODS

HISTOMORPHOMETRIC

This is determined from a dyed sample of the implant and surrounding bone by assessing the amount of peri-implant bone and bone-implant contact (BIC)[11]. It is a gold standard method, accurate measurement is an advantage, but the disadvantage is the invasiveness of this method and ethical issuses[6].

PULL-OUT, PUSH-OUT AND PUSH-IN TEST

Push-out/pull-out test investigates the healing capabilities at the bone to implant interface[2]. It measures interfacial shear strength by applying the load parallel to implant-bone interface. In push-out or pull-out test, a cylinder-type implant is placed transcortically in the bone structures and then removed by applying force parallel to the interface.

It is assessed during the healing period. The limitation for push-out and pull-out tests are only applicable for non-threaded cylinder type implants, whereas mostly threaded design implant fixtures are clinically used and their interfacial failures are dependent on shear stress without any consideration for either tensile or compressive stresses[2]. It is also technique sensitive.

REVERSE TORQUE TEST

The reverse torque test was proposed by Roberts et al in 1984. It is also called as removal torque test. Implant stability is assessed by reverse or unscrewing torque at the time of abutment connection. Removal torque analysis implant is considered stable if the reverse or unscrewing torque was >20 Ncm. Disadvantage is that the implant surface in the process of osseointegration may fracture under the applied torque stress. The clinical usage of destructive tests is limited due to ethical concerns associated with invasive nature of these methodologies.

NONDESTRUCTIVE METHODS

CLINICAL PRECEPTION

The clinical perception of primary implant stability is frequently based on the mobility detected by blunt ended instruments. It's a very unreliable and non-objective method. It is frequently depends on the implant's cutting resistance and seating torque during insertion. If there is a sense of an abrupt stop at the implant's seating, it shows the "good" implant stability. Tapered implant root forms frequently have a geometry that gives a firm stop and possibly gives a false perception of high implant[11]. One's personal perception is difficult to communicate to others. Most importantly, this type of measurement can only be made at the insertion stage, it cannot be used before loading the implant[10].

PERCUSSION TEST

The percussion test involves the tapping of mouth mirror handle against the implant healing abutment and is designed to elicit a "good tone" ringing sound from the implant as an indication of positive stability or osseointegration. Muddy or low pitch sound indicates poor integration. Percussion tests only provide less qualitative information and reveal more information about the tapping instrument[8]. It cannot be used experimentally as a standardized testing method.

IMAGING TECHNIQUES

Imaging methods are frequently employed to evaluate the availability of bone, both in terms of quantity and quality. Radiographic interpretation is a standard method used to evaluate the amount of available bone. As a longitudinal monitor, periapical and panoramic radiographs provide fairly accurate information about the bone levels around implants. Limitation would be radiographs are not taken in a standardized manner, that exactly duplicates the cone placement and angle. Since radiographs are two-dimensional interpretations of a three-dimensional structure, a false sense of security may be conveyed, as various osseous defects such as buccal dehiscences may not be fully visualized.

CUTTING TORQUE RESISTANCE ANALYSIS

This was developed by Johansson and Strid and later improved by Friberg[3]. Controlling the hand pressure while drilling at a low pace allows for the measurement of the amount of bone removed per unit volume by a current fed electric motor. It determines the areas of low density bone and quantifies bone hardness during implant osteotomy at the time of implant placement. Clinical research revealed that jaws with extensive resorption and low bone quality, primarily in the maxilla, where implant failures occurred most frequently. Values greater than 32 Ncm signify that the implant is mechanically stable and securely embedded in the bone. The primary drawback of the cutting torque resistance analysis (CRA) technique is that until the osteotomy site is prepared, it provides no information about the quality of the bone. It also does not give the lower “critical” limit of cutting torque value (value at which the implant would be at risk).

PERIOTEST

Periotest measures how the peri-implant tissues respond to a certain impact load in order to quantify the mobility of an implant. The instrument's handpiece features a translational hammer that is electronically controlled and carries an 8-gram rod with a sensor at the tip of it. When activated, the rod taps the implant abutment up to 16 times in four seconds. Periotest measures how long passes between the first point of contact and the first rebounce off the implant. The elapsed time decreases with increasing implant stability. Periotest usually provides a range score from -5 to +5.

–8 to 0 = Good osseointegration, implant can be loaded

+1 to +9= Clinical examination is required, in most cases loading is not possible

+10 to +50= Osseointegration is not sufficient, implant cannot be loaded[12].

RESONANCE FREQUENCY ANALYSIS

It is a noninvasive diagnostic method that measures implant stability and bone density at various time points using vibration and structural principle analysis. RFA uses a small L-shaped transducer that is screwed tightly to the implant or abutment. Two ceramic components make up the transducer, one of which is vibrated by a sinusoidal signal (5–15 kHz) and the other, which acts as a receptor. . The implant is shaken at a constant input and amplitude, initially at a low frequency, and then the pitch rises until the implant resonates. Stronger bone-implant contact is indicated by high frequency resonance.

Additionally, it offers a starting point for comparison in the future and implant placement following surgery. RFA has been widely employed for clinically evaluating osseointegration[10].

RFA's most recent design is a wireless device. The implant is connected to a metal rod by a screw connection. Magnetic pulses from a portable electronic device activate a small magnet that is affixed to the top of the rod. The rod positioned on the implant vibrates in two directions that are perpendicular to one another and has two fundamental resonance frequencies. One of the vibrations is in the implant's most stable direction, while the other is in its least stable direction.

The resonance frequency of the resonance frequency analysis system is dependent upon three main factors:

1. the design of the transducer itself;
2. the stiffness of the implant fixture and its interface with the tissues and surrounding bone;
3. the total effective length above the marginal bone level[7].

Two commercial systems based on RFA are clinically used namely:

ELECTRONIC TECHNOLOGY RESONANCE FREQUENCY ANALYSIS (OSSTELL™)

It was the first commercially available implant stability monitoring product. The electronic technology combines the excitation source, computerised analysis, and transducer into a single device. The measurement scale employed is the implant stability quotient (ISQ), which ranges from 0 to 100. When employed at the time of implant insertion, it gives a baseline reading for comparative purposes in the future and for the postoperative positioning of the implant. The ISQ of 0-100 has been converted into the resonance frequency range of 3000 to 8500 Hz by Osstell (Integration Diagnostic AB, Goteborg, Sweden), a commercial device utilising the concept of RFA[10].

MAGNETIC TECHNOLOGY RESONANCE FREQUENCY ANALYSIS (OSSTELL™ MENTOR)

The transducer is attached to the implant or abutment with a magnetic peg on top. The peg is activated by a magnetic resonance frequency probe, which causes it to vibrate and create an electric volt, which is then recorded by a magnetic resonance frequency analyzer. Values are presented as ISQs ranging from 0 to 100. It gives a baseline reading at the time of implant insertion for comparison and postoperative implant placement.

However, because it needs a specific transducer and magnetic peg, this method is expensive and technique-sensitive. In order to prevent this from affecting the measured value, it should maintain a distance of 1-3 mm, a 90° angle, and be 3 mm above the soft tissue. In a study testing Osstell and Osstell Mentor, Valderrama et al. observed that there was a strong correlation between the two devices[10].

NEWER METHODS

IMPLATEST CONVENTIONAL IMPULSE TESTING

In order to do a conventional implant impulse test, an accelerometer with corresponding cables and connectors must be attached to the implant. The implant must then be pounded with a calibrated hammer, and the data must be recorded and analysed. Testing of implants using electrical impulse techniques aims to identify, examine, and monitor their signatures.

Implatest (Q Labs 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 few seconds and is operator independent (independent of the direction or position of test application on the implant). Due to its splinting action, complications could occur while trying to test an implant with a multi fixture prosthesis attached. The dynamic signature of a multi fixture prosthesis is extremely complex owing to the supporting influence of all implants or natural teeth or a combination of these at the particular testing site[5].

Huang invented the Implomates. The resonance of the implant is excited by this device using the impact force from a transducer. A computer is used to analyse the frequency spectrum of the incoming signal (2–20 kHz). Wider frequency and a low peak indicate an unstable implant, while a higher frequency and sharp peak indicate an unsuccessful implant. The most surgical placement of the implant is at the moment of placement, providing a baseline reading for comparison in the future[10].

CONCLUSION

Evidence from the literature that has been suggested that, when compared to conventional procedures, modern tests 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 implant stability over time, and make an early diagnosis of implant failure has generated significant interest in science recently. To ensure long-term implant stability, information should be gathered from numerous diagnostic tools.

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