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Primary Implant Stability, a Factor for Successful Osseointegration

Authors

Dr. Abhishek N Zingade[1], Dr. Swati Pralhad[2]

[1]Reader, Department of Periodontology, KLE VK Institute of Dental Sciences, KLE University, Nehru Nagar, Belgaum
Email: *abhi.zing@gmail.com*
[2]Reader, Department of Periodontology, Manipal College of Dental Sciences, Manipal University, Mangalore – 575001
Email: swatipralhad@gmail.com
Corresponding Author
Dr. Swati Pralhad
Reader, Department of Periodontology, Manipal College of Dental Sciences, Manipal University, Mangalore – 575001
Email: swatipralhad@gmail.com

ABSTRACT

Dental implants are being routinely used to replace missing and compromised teeth, and are said to offer predictable, long lasting replacement outcomes while still preserving the natural tooth structure of the adjacent teeth. Primary stability achieved immediately after placement of the implant is considered to be an important requisite for successful osseointegration. The present review summarizes the factors affecting primary stability and the available methods to assess primary stability.

Endosseous dental implants are being routinely used to replace missing and compromised teeth, and are said to offer predictable, long lasting replacement outcomes while still preserving the natural tooth structure of the adjacent teeth. Since they are being widely place, clinicians are on a look out for better clinical outcomes vis- a vis the longetivity and stability of the implants placed.

This stability of dental implants is talked in terms of Osseointegration, which is defined as "a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant." This stability can be either primary or secondary. Engagement of implant into the bone determines primary stability and is seen after placement of the implant, whereas secondary stability offers for biologic stability associated with bone remodelling and regeneration.[1]

The key to secondary stability is a secure primary stability. It has been defined as “the biometric stability of the implant immediately after its placement within the bone”. This primary stability prevents micro motions between the surface of the implant and the bone and is often used as a predictor for osseointegration.[2]It also helps in decision making regarding the loading protocols.

Primary stability has been related to local factors, implant factors, patient characteristic and surgical technique.

Bone quality and quantity have been considered as the most important risk factors that determine implant failure.[3] Bone quality is different at different sites in the jaws. Posterior maxilla is seen to have thin cortical bone combined with thick trabecular bone when compared to the mandible. This difference in the bone qualities explains the higher rates of implant survivals in the mandible than those placed in the maxilla especially the posterior maxilla.[4, 5] It has been suggested that in areas of poor density, a drill smaller than the diameter of the implant can be chosen, which will optimize the bone density and consequently improves primary stability.[6]

Implant factors like the length of the implant, diameter of implant, the design, micromorphology and the surface of implant also influences the primary stability. These factors when individually considered do not seem to influence primary stability, however in stepwise multiple regression analysis, after eliminating confounding factors these implant related factors do influence primary stability.[7]

Implants of higher length are said to provide greater contact surface between the bone and implant when compared to those of a smaller length.[8]Tapered implants lead to better primary stability than cylindrical, and this improvement could be due to compression of bone trabeculae and increase in the bone stiffness.[9]Implants with threads or the threaded implants have higher primary bone to implant contact which is due to an increase in surface area available for contact with the adjacent bone. Presence of threads has also shown to decrease the compression of crestal bone, thereby reducing the amount of crestal bone loss.[10] Rough surfaces provide a larger surface area and allow for a firmer mechanical link to the surrounding tissues. The rough surfaces are considered to be osteophilic as the rate and degree of osseointegration is superior.[11]

Implant site preparation has also shown to affect the primary stability. A procedure known as the osteotome technique or bone condensing was introduced wherein the cancellous bone is pushed aside with osteotomes after the pilot drill is used. This technique is said to increase the density of the surrounding bone, however this technique is indicated in knife edged ridges and for bone with less density.[12]Undersized drilling technique has been introduced to optimize bone density, which involves the use of a final drill with a diameter smaller than the diameter of the implant to be placed. This under preparation of the osteotomy increases the moment of force needed to place the implant in position that is the insertion torque, increase in the insertion torque increases the primary stability.[13, 14, 15]

Various methods have been used to determine implant stability with varying degrees of success. The destructive methods include histomorphologic research, tensional test, push – out/ pull – out test and removal torque test. Percussion test, radiography, cutting torque test when placing implants, Periotest, and resonance frequency analysis are the non-destructive methods to assess primary implant stability.[16]

1. Tensional test: in this technique the interfacial tensile strength is measured while a lateral load is applied to the implant fixture. However, there is a difficulty in translating the test results.[17, 18]
2. Histomorphometric analysis: involves measuring or calculating the bone quantity and the bone implant contact from a dyed specimen. Though it has the advantage of being accurate, this method is very invasive and not appropriate for long term studies. It is the preferred in non-clinical and experimental studies. [19]
3. Push – out/ pull out test: in this, the implant placed is removed by applying a force parallel to the interface. The loading capacity is measured by the dividing the maximum force by the area of implant bone contact. This is suitable for non-threaded implants, hence not much in use.[20]
4. Surgeon's perception

   This is usually dependent on the cutting resistance of implant during insertion. A sudden stop when implant is seated gives an impression of good stability. Disadvantage being, this cannot be validated and the measurement can be made only when the implant is inserted and not later.
5. Removal torque: unscrewing torque has been used to assess stability. This is usually done at the time of abutment connection.[21]
6. Percussion testing: handle of an instrument is used to percuss the implant and the resultant sound is assessed. However, this is a subjective method and measurements obtained could be inaccurate because of the lack of periodontal ligament and high rigidity of implants.
7. Insertion torque measurements: these values are used to measure bone quality during implant placement. An increase in insertion torque suggests an increased primary stability.[22]
8. Radiography: It is by far the most common method that is used. However, difficulty of standardization, limitation in image resolution and the fact that over 30% bone loss should have occurred to appreciate changes in bone morphology at implant bone interface make it unreliable to use radiographs for assessing primary stability.[23]
9. Periotest: this is described as a reliable method to gauge primary stability. It consists of a metallic tapping rod in a headpiece. Signals produced by the taping

are read as the periotestvalues.Periotest values (PTV) of -8 to -6 suggests good implant stability.

10. Resonance frequency analysis (RFA).[24]

It an objective and reliable method to measure micro mobility at various stages of implant process.Osstell is one of the RFA machines that is in clinical use. Implant stability quotient (ISQ) is the scale of measurement developed by Osstell for use with RFA. Resonance frequency values of 3,500 – 8,500 are converted into an ISQ of 0 – 100. A higher ISQ value that is > 60 is an indication of greater implant stability. ISQ < 50 indicates increased risk of implant failure.[25]

Thus, though there are arrays of methods to evaluate primary stability, no one method is considered the gold standard, and research is directed in this area. Primary stability is hence consideredis a prerequisite for implant survival by preventing the formation of a connective tissue layer between implant and bone. Bone quality and quantity, implant geometry, and surgical technique adopted may significantly influence implant initial stability and overall success rate of dental implants.

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