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Original Research

A Brief Review on Contemporary Methods and Equipment Used for Implant Stability Assessments

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Abstract:
Primary implant stability is essential for successful osseointegration which is influenced by quality and quantity of the bone, implant design, drilling technique and etc. Quantitative measurement of bone quality is therefore an essential component of dental implantation planning. Many techniques have been suggested to assess initial implant stability, but most of them are no longer used due to their invasiveness and inaccuracy. Resonance frequency analysis, Periotest analysis, and insertion torque values are three common techniques which are recommended to assess implant stability. The aim of this review article is to screen the advantage and disadvantages of using that mentioned techniques, briefly.

Key Words: Dental implants, implant stability, insertion torque, resonance frequency analysis

Introduction

Since Branemark's innovation in dental implantology, using dental implants instead of missing teeth have become widespread around the world. Nowadays many patients want to use this technology. The term "functional ankylosis" was firstly used by Schroeder *et al.* after they notified that the new regenerated bone was directly deposited on the surface of atraumatic placed implant.[1] Several factors such as implants stability, general health status, biocompatibility of the implanted materials, both microscopic and macroscopic nature of implants' surfaces, and surgical procedures have been proved to play an important role in implant stability.[2,3]

Stability is one of those factors which plays a paramount role in implants survival rate. These factors include:

1. Mechanical stability (primary stability) which is as a result of compressed bone that fix the implant tightly in place. Having adequate primary stability is important in distributing occlusal functional stresses[4]
2. Biological stability (secondary stability) which is a result of generation and osseointegration of bone cells at the site of implant and it will become apparent during healing period.[4]

Surveying the quality and quantity of stiffness and density of surrounding bone before or after placement of implant is very important because further decisions about continuing procedure highly depend on implant stability. Moreover, peri-implant bone loss is a major cause of mobility which may lead to implant failure.[5]

Stability Test Assessments

Several tests are available to assess primary stability. Histology and histomorphometry,[6] insertion torque and removal torque,[7] push-through and pull-through test,[8] radiographic assessment,[9] Periotest, and resonance frequency analysis (RFA) are the most common methods. Among these methods, insertion torque, RFA and Periotest are the easiest, most accurate and non-invasive tests.[10] Insertion torque values (ITV) is one of the quantitative methods, based on the implants insertion torque forces. Low torque values during implant insertion will lead to an implant, named "spinner" due to lack of well osseointegration. ITV represents the quality of fitness between the placed implant and walls of surrounding bone, quality and quantity of the bone and therefore primary mechanical stability.[11] A high value of ITV indicates that the implant is stable at its site.[4] Although different methods are available to evaluate implants stability, it is so challenging to find the most appropriate and the least invasive method. Variation in measured values and numbers are extensive and may impose some difficulties for clinicians to make the best and precise decision, therefore successfully placed implant may be endangered as a consequence. In a recent study, Walker *et al.* placed 174 implants immediately into mandibular first or second molar socket after extraction, ITVs were gathered and their stability were evaluated 3 months later. They concluded that providing an appropriate ITVs made a meaningful healing-time feedback which helps surgeon's diagnose in implant survival and determination of unloaded healing time.[12]

Periotest

Periotest, which is designed by Schulte *et al*.[13] is an instrument which has the capability to evaluate the tooth mobility by measuring the damping capacity of periodontal ligaments. This instrument has a tapping head that percusses the implant or tooth 16 times. The head is sensitive to pressure and also able to record the duration of contact with the implant or tooth. Therefore, the absence of tooth or implant will make longer contact time, so higher the Periotest value will be shown. Its measuring unit provides a 58 unit scale with a range from 08 (low mobility) to +50 (high mobility).[14] The whole measuring procedure takes around four seconds. A correlation has been shown between the measured values and real mobility. For instance −6 represents 0.038 mm movement, +2 represents 0.113 mm movement which are determined by an axial movement testing device. However, for measuring dental implant's stability, the obtained data are mostly in a range of −5 to + 5 which is a narrower range for the implants than tooth.[15]

RFA

RFA has gained specific fame in implantology. In 1996s, Meredith *et al*. stated that implant stability can be evaluated by applying RFA and architectural engineering.[9] RFA involves resonating sine wave with a certain frequency width continuously from high to low or from low to high. So, RFA can reveal the effective length of implant out of bone and also the stiffness of bone-implant interface.[16]

Osstell is an instrument which analysis RFA and converts the Khz to implant stability quotient (ISQ) values. Its recent generation is Osstell Mentor which is a refined type of Osstell ISQ and produce magnetic resonance frequency. Its fork shape rod (probe) releases magnetic resonance frequency to a transducer (smartpeg) which is screwed to the implant or surrounding tissue of abutment with the mean force of 7 Ncm, so activated peg starts to vibrate and induce electric volts to probe coil and finally the device converts RFA to ISQ values that would be shown as numbers from 1 to 100.[11,16] A stable implant will have high value and a risky implant will show low ISQ values. In the Osstell Mentor kit, the testing place for positioning the measuring probe is marked with a red dot on the smartpeg. The measuring probe should be adjusted at a minimum distance of 8 mm to the implant-mounted smartpeg. So the measuring probe emits magnetic pulses as high as 20 Gauss and the obtained data are calibrated.[14]

Jaramillo *et al*. conducted a study to compare the reliability of Osstell Mentor and Osstell ISQ for implant stability measurement. They recorded the primary stability of 58 implants with both devices. At last they stated both devices showed almost precise reproducibility and repeatability with no significant differences at a confidence level of 95%.[17]

In an investigation, Turkyilmaz observed the stability of 60 one-stage implants and recorded ITVs simultaneously with evaluating ISQ values using Osstell Mentor. They indicated that there is a significant correlation between ISQ values and ITVs ($P < 0.001$).[18] Boronat-López *et al*. determined implant stability in 133 implant (62 in maxilla and 71 in mandible) on the day of surgery. They claimed that the ISQ values were greater in larger diameter implants, shorter implants, in mandibular placements and more compact bones.[19]

Which One is More Accurate?

In an *in vitro* study, Al-Jetaily and Al-Dosari investigated the sensitivity and reliability of the Osstell systems comparing to Periotest system. They indicated that ISQ values and PTVs showed a significant difference between a direct contact and soft interface. Another remarkable discrepancy was recognized in different horizontally exposed fixture groups which were strongly correlated with PTVs and strongly negative correlated with ISQ values.[20]

In a comparative study, Oh *et al*. examined the usefulness of Periotest and Osstell Mentor for determining implant stability. So, 48 pure titanium implant were placed in maxilla and mandible of four adult dogs and they finally stated that both Periotest and Osstell Mentor were useful and comparably reliable in assessing implant stability. They indicated that in 6 weeks after implantation, the Periotest value was lower and ISQ value was higher in comparison with data collected at 3 weeks. Also, the Periotest values in the maxilla were higher than the mandible in contrast to the ISQ values.[20] Jun *et al*. evaluated ITVs, ISQ values, Periotest values in three human fresh cadavers. 48 implants were placed in four maxillary and four mandibular sites. They found significant correlation among those three items but not a reliable parameter to predict the area of bone-to-implant contact.[21] Zix *et al*. evaluated the reliability of Osstell and Periotest systems on 213 Straumann tissue level implants. They revealed that the Periotest measurements manifested a range of atypical or extreme measures that did not appear in Osstell measurements. Their final conclusion reflected that Osstell devise is more precise.[22] Lachmann *et al*. compared reliability of both Osstell and Periotest in an *in vitro* study. The experiment was executed on eight implants in which the stability was measured in three different variation: Without withdrawing the transducer, after withdrawing transducer and manual torqueing, and after withdrawing transducer and mechanic torqueing with a 10 N control torque rotary unit. The final result reflected that Osstell system was more precise with a 95% confidence interval.[23] Although the Periotest have shown successful results in some cases, this technique has been suggested to be sensitive to a wide range of factors such as tip placement angle, pillar height and metallic tip-implant distance, as well as being scarcely sensitive to differentiate between osseointegrated and non-osseointegrated implants.[24]

Conclusion

It is somehow difficult to suggest the most precise and accurate equipment for implant stability[25] assessment as the literature show controversial results. But overally, it seems that Osttell system (especially Osstell Mentor) provides more accuracy and connivance due to its recent updates and developments.

References

1. Schroeder A, van der Zypen E, Stich H, Sutter F. The reactions of bone, connective tissue, and epithelium to endosteal implants with titanium-sprayed surfaces. J Maxillofac Surg 1981;9(1):15-25.
2. Bauer TL, Pandelidis SM, Rhoads JE Jr, Owens RS. Mammographically detected carcinoma of the breast. Surg Gynecol Obstet 1991;173(6):482-6.
3. Sennerby L, Meredith N. Implant stability measurements using resonance frequency analysis: Biological and biomechanical aspects and clinical implications. Periodontol 2000 2008;47:51-66.
4. González-García R, Monje F, Moreno-García C. Predictability of the resonance frequency analysis in the survival of dental implants placed in the anterior non-atrophied edentulous mandible. Med Oral Patol Oral Cir Bucal 2011;16(5):e664-9.
5. Gupta RK, Padmanabhan TV. Resonance frequency analysis. Indian J Dent Res 2011;22(4):567-73.
6. Ericsson I, Johansson CB, Bystedt H, Norton MR. A histomorphometric evaluation of bone-to-implant contact on machine-prepared and roughened titanium dental implants. A pilot study in the dog. Clin Oral Implants Res 1994;5(4):202-6.
7. Wennerberg A, Albrektsson T, Andersson B, Krol JJ. A histomorphometric and removal torque study of screw-shaped titanium implants with three different surface topographies. Clin Oral Implants Res 1995;6(1):24-30.
8. Dhert WJ, Verheyen CC, Braak LH, de Wijn JR, Klein CP, de Groot K, *et al.* A finite element analysis of the push-out test: Influence of test conditions. J Biomed Mater Res 1992;26(1):119-30.
9. Meredith N. Assessment of implant stability as a prognostic determinant. Int J Prosthodont 1998;11(5):491-501.
10. Oh JS, Kim SG, Lim SC, Ong JL. A comparative study of two noninvasive techniques to evaluate implant stability: Periotest and osstell mentor. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;107(4):513-8.
11. Quesada-García MP, Prados-Sánchez E, Olmedo-Gaya MV, Muñoz-Soto E, González-Rodríguez MP, Valllecillo-Capilla M. Measurement of dental implant stability by resonance frequency analysis: A review of the literature. Med Oral Patol Oral Cir Bucal 2009;14(10):e538-46.
12. Walker LR, Morris GA, Novotny PJ. Implant insertional torque values predict outcomes. J Oral Maxillofac Surg 2011;69(5):1344-9.
13. Schulte W. The periotest method. Bensheim: Siemens AG eLMEG, Dental Sector; 1995. p. 13-5.
14. Soicu S, Bratu E, Bratu D, Borsanu I. An evaluation of Timplant using Osstell: A device for non-invasive assessment of dental implants stability. Oral Health Dent Manage 2009;2009:6. Available from: http://www.oralhealth.ro/volumes/2009/volume-4/V4-09-5.pdf. [Last cited on 2009 Dec 29].
15. Aparicio C, Lang NP, Rangert B. Validity and clinical significance of biomechanical testing of implant/bone interface. Clin Oral Implants Res 2006;17 Suppl 2:2-7.
16. Turkyilmaz I. Implant Dentistry: A Rapidly Evolving Practice, 1st ed. Rijeka: InTech; 2011. p. 112-20.
17. Jaramillo R, Santos R, Lázaro P, Romero M, Rios-Santos JV, Bullón P, *et al.* Comparative analysis of 2 resonance frequency measurement devices: Osstell Mentor and Osstell ISQ. Implant Dent 2014;23(3):351-6.
18. Turkyilmaz I. A comparison between insertion torque and resonance frequency in the assessment of torque capacity and primary stability of Brånemark system implants. J Oral Rehabil 2006;33(10):754-9.
19. Boronat-López A, Peñarrocha-Diago M, Martínez-Cortissoz O, Mínguez-Martínez I. Resonance frequency analysis after the placement of 133 dental implants. Med Oral Patol Oral Cir Bucal 2006;11(3):E272-6.
20. Al-Jetaily S, Al-Dosari AA. Assessment of osstell™ and periotest® systems in measuring dental implant stability (*in vitro* study). Saudi Dent J 2011;23(1):17-21.
21. Jun SH, Chang BM, Weber HP, Kwon JJ. Comparison of initial stability parameters and histomorphometric analysis of implants inserted into extraction sockets: human fresh cadaver study. Int J Oral Maxillofac Implants 2010;25(5):985-90.
22. Zix J, Hug S, Kessler-Liechti G, Mericske-Stern R. Measurement of dental implant stability by resonance frequency analysis and damping capacity assessment: Comparison of both techniques in a clinical trial. Int J Oral Maxillofac Implants 2008;23(3):525-30.
23. Lachmann S, Jager B, Axmann D, Gomez-Roman G, Groten M, Weber H. Resonance frequency analysis and damping capacity assessment. Part I: An *in vitro* study on measurement reliability and a method of comparison in the determination of primary dental implant stability. Clin Oral Implant Res 2006;17(1):75-9.
24. Derhami K, Wolfaardt JF, Faulkner G, Grace M. Assessment of the periotest device in baseline mobility measurements of craniofacial implants. Int J Oral Maxillofac Implants 1995;10(2):221-9.
25. Kumar AN, Agrawal G, Agrawal A, Sreedevi B, Kakkad A. Journey from 2-D to 3-D: Implant imaging a review. Int J Contemp Dent Med Rev 2014;2014. Article ID 091114, 2014. doi: 10.15713/ins.ijcdmr.13.