International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Implant Stability' Is the Pivotal for the Success of Implant Treatment: A Narrative Review

Dr.B. LakshmanaRao[1], Dr. Dalsingh.V[2], Dr. Vaishnavidevi. M[3]

[1]Prof & HOD, Dept of Prosthodontics, Lenora Institute of Dental Sciences, Rajahmundry, Andhra radish, India,
[2]Prof & HOD, Dept of Oral and Maxillofacial Surgery, Lenora Institute of Dental Sciences, Rajahmundry, Andhra radish, India,
[3]Professor, Dept of Oral and Maxillofacial Surgery, Lenora Institute of Dental Sciences, Rajahmundry, Andhra radish, India.

ABSTRACT:
The capacity of a dental implant to stay firmly attached in the jawbone following placement is referred to as implant stability. Long-term functionality and the effectiveness of implant osseointegration—the process by which the implant fuses with the bone—rely on it. Dental implants can be tested for stability using a variety of diagnostic tools. These tools assist medical professionals in evaluating the primary stability of the implant—which occurs right after implantation—and secondary stability—which occurs during the healing phase and after osseointegration. Precise evaluation of stability is necessary to establish suitable loading procedures and guarantee the implant's success. This narrative review aims to discuss various stability testing methods using in implant practice, their advantages and different equipment/instruments using for the implant stability assessment.

KEY WORDS: Primary Implant Stability; Secondary Implant Stability; Implant stability quotient (ISQ); Analysis of Resonance Frequency (RFA).

INTRODUCTION:
Generally speaking, there are two kinds of implant stability, which are called primary stability and secondary stability:

Primary Stability
The mechanical stability that is attained right away following the implantation of the implant into the bone. It is contingent upon various parameters, including bone density, implant architecture, surgical methodology, and bone quality. bone density, surgical technique, implant design (such as thread form, length, and diameter), and the surgeon's experience. For early healing to be successful and to stop implant micromovements during the first healing phase, primary stability is essential. Numerous studies highlight that one of the main causes of early implant failure is a lack of primary stability. Higher primary stability is typically attained in denser bone regions, such as the mandible, as opposed to softer bone parts, such as the maxilla, according to Meredith N. [1]

Secondary Stability

stability that results in osseointegration and is developed over time as the bone heals and remodels around the implant. biological elements such as bone metabolism, the rate of osseointegration, and bone healing mechanisms. Because secondary stability creates a solid biological connection between the implant and the bone, it guarantees long-term success. As the implant fuses with the bone, it usually rises as primary stability falls.

According to the creation of secondary stability, which is normally attained 4-6 weeks following implant placement and is impacted by biological factors. Bone remodelling occurs gradually, and secondary stability depends on optimal bone-to-implant contact. [2]

Combined Stability

The transitional state where primary stability is declining but secondary stability has not yet reached its full potential is known as mixed stability in some literature. Since the first few weeks following implantation are the most susceptible to implant failure, it is crucial that physicians comprehend these possible risks.[3]

How to verify the stability of the implant:

One of the most important steps in guaranteeing the success of dental implants is to check implant stability. Clinicians can safely place a prosthesis onto an implant by using stability assessment to help them make this determination. It is usual practice to assess primary and secondary stability using a number of methods. These are the most trustworthy techniques:

1. Analysis of resonance frequency (RFA)

Osstell ISQ (Implant Stability Quotient) is the instrument. Measuring Implant Stability: A tiny transducer, or smart peg, that is fastened to the implant or abutment is used in the RFA approach. RFA is a popular non-invasive method for evaluating the vibration response of the implant-bone complex to determine how stable dental implants are. The implant or abutment has a tiny transducer attached to it that emits a frequency that makes the implant vibrate.

The device detects the resonance frequency of the implant-bone system based on vibrational frequencies emitted by the transducer. An implant stability quotient, or ISQ, is the value of the resonance frequency represented in terms of a range from 1 to 100. Strong primary stability appropriate for immediate loading is indicated by higher ISQ values (>65), whereas lower values (<55) imply that delayed loading is safer.

Clinical Application: It is perfect for both immediate post-surgical measures and long-term follow-up because it is non-invasive, simple to use, and repeatable over time.

Ranges of ISQ: Good primary stability (fit for early or immediate loading) is defined as 55–60 or higher. Less than 50: Suggests a lack of stability; further healing time may be needed.

Benefits: It offers a reliable, objective way to gauge implant stability at various intervals; it's particularly helpful for tracking osseointegration.

2. Torque wrench and Insertion Torque Measurement (ITM)

Instrument: Motorised devices or torque wrenches. A manual or motorised torque wrench is used to measure the insertion torque during implant implantation. Newton centimetres (Ncm) represent the force needed to bury the implant in the bone.

Greater torque readings (>35 Ncm) indicate good primary stability and are appropriate for loading right away.

Clinical Application: Especially during the surgical phase, the insertion torque offers quick input on the primary stability of the implant. This metric is used by clinicians to assess whether immediate loading is necessary.

Benefits: Easy to use and offers quick feedback on the implant's mechanical anchoring in the bone. [5]

When the implant is being placed, the insertion torque is measured, which provides a quick indication of primary stability. The torque needed to screw the implant into the bone is measured during implant insertion and is commonly expressed in Newton centimetres (Ncm). Greater primary stability is indicated by high torque values.

Recommended Torque Levels:

35 Ncm: Excellent primary stability, appropriate for loading right away.

20–30 Ncm: It is recommended to load carefully, slowly, or with moderate stability.

< 20 Ncm: Poor stability; usually not advised for quick loading.

Benefits: Offers immediate input regarding the density of the bone and the mechanical engagement of the implant during surgery.

3. Periotest

Instrument: Periotest M. Another non-invasive method for assessing the stability of dental implants is called Periotest. Using a handpiece to tap the implant or abutment and a sensor to evaluate the damping properties of the peri-implant tissues, the Periotest tool assesses implant stability. A Periotest Value (PTV), which spans from -8 to +50, is provided as the outcome. Higher stability is suggested by lower values. Applying a mechanical tapping force on the implant or abutment and then documenting the surrounding tissues' damping properties. Periotest Values (PTV), which vary from -8 (high stability) to +50 (poor stability), are used to express the results.

Clinical Application: This tool is utilised for both long-term assessment and the evaluation of the initial stability following implant implantation. Better stability is indicated by lower PTV values, and the device is helpful for tracking implants after loading.

Benefits: Offers information on the peri-implant tissues' damping impact, which aids in evaluating primary and secondary stability. [6]

Recommended PTV ranges:

Good main or secondary stability, ranging from -8 to 0.

1 to 9: Moderate stability; further healing time may be needed.

10. Lack of stability and failure risk.

Benefits: Good for evaluating the peri-implant tissues' dampening capabilities as well as mechanical stability.[7]

4.Push-Out/Pull-Out Test (Experimental)

By exerting a vertical force, this technique is usually applied in laboratory settings to evaluate the mechanical anchoring of an implant. One can measure the force needed to push or pull an implant out of the bone. This is mostly applied to experimental models or animal studies. [8]

5.Reverse Torque Test

In this test, the implant is subjected to a reverse torque, or unscrewing. Reverse torque resistance is a sign of mechanical stability for the implant. This technique is not commonly advised in clinical practice and has the potential to cause injury by disrupting the bone-implant interface. [9]

6.Combined Use of Methods

Many medical professionals combine methods to more accurately evaluate implant stability at various stages of healing:

While insertion torque aids in determining primary stability during initial placement, RFA is frequently utilised for long-term secondary stability monitoring. Periotest can be used as an additional metric to assess long-term success or stability following loading.

A more thorough understanding of implant stability can be attained by combining several methods, which lowers the possibility of implant failure. [8]

7. Digital Torque Gauges

OsseoTest is the tool. Digital torque gauges, which are comparable to conventional torque wrenches, offer an even more accurate digital measurement of the insertion or reverse torque delivered to the implant. To evaluate the mechanical stability of the implant after implantation, these gauges can also measure the reverse torque.

Clinical Application: Mainly used to assess initial mechanical stability by measuring insertion and reversal torque. It is especially helpful in scenarios requiring precise torque control, including those involving complex cases or fragile bones. [9]

8.Radiographs in testing the stability of implant

When evaluating implant stability over time, radiographs are helpful but crucial, especially when it comes to keeping an eye on the osseointegration and surrounding bone structure. Radiographs offer important information on bone loss, the interface between the implant and the bone, and the general health of the implant, even though they cannot quantify the mechanical stability of the device directly. The following are radiography' primary functions in assessing implant stability:

Radiographs' Crucial Functions in Evaluating Implant Stability

A) Assessing Osseointegration

Function: By demonstrating how the implant blends into the surrounding bone, radiographs serve to guarantee that there are no gaps or radiolucencies between the implant surface and the bone. Successful osseointegration implies a continuous bone-implant interface devoid of radiolucent zones, which obliquely implies implant stability.

Clinical Application: Radiographs are used by clinicians to confirm that the implant is in touch with bone and that osseointegration is happening as planned after the implant has been put. A successful osseointegration is essential to the implant's long-term durability. [10]

B) Finding the Marginal Bone Loss

Function: Determining the amount of marginal bone loss surrounding an implant over time is one of the main purposes of radiography. One important sign of instability and peri-implant disease is marginal bone loss. It is possible to assess whether an implant is stable or at risk of failing by keeping an eye on the bone levels surrounding the implant neck.

Clinical Application: Preventive radiography follow-ups help identify early indications of bone loss, which could be a sign of peri-implantitis, high occlusal loading, or issues with implant stability. After the first healing period, a good implant should show little to no bone loss. [11]

C) Evaluation of the Density and Quality of Bone

Radiographs can give some information regarding bone density even though they are not as accurate as methods like cone-beam computed tomography (CBCT). Using radiographs, physicians can evaluate the overall density of the surrounding bone around the implant, which is related to stability. Implant stability is usually better in dense, compact bone than in porous or less dense bone.

Clinical Application: Radiographs taken before and after surgery can be used to evaluate the quality of the bone at the implant site, which can help predict long-term success and primary stability. [12]

D) Monitoring Peri-Implantitis and Other Complications

Radiographs play a crucial role in the diagnosis of peri-implantitis, a disorder marked by inflammation and loss of bone surrounding the implant. Radiographs that show bone loss can be used by clinicians to detect peri-implantitis early on. Failure to do so may result in implant instability and ultimately failure.

Clinical Application: Peri-implant bone levels are tracked through routine radiographic monitoring, which aids in the early diagnosis of mechanical stress or infection. Early intervention to preserve the implant can be initiated upon detection of increasing bone loss.[12]

E) Confirmation of Implant Orientation and Placement

Radiographs play a vital role in confirming that implants are positioned and angled correctly, particularly right after implantation. Implants that are not positioned correctly can cause bone loss, impair occlusal function, and influence stability.

Clinical Application: Taking radiographs as soon as possible after surgery helps guarantee that the implant is positioned correctly and has enough bone support. Uneven stress distribution from misaligned implants might compromise stability and ultimately result in failure.

F) Assessment of Prosthetic Components

Radiographs are used to examine how well prosthetic components and abutments are seating into the implant, making sure there are no gaps or mismatches that could cause the implant to become unstable.

Clinical Use: Radiographs verify that the prosthetic parts fit well, especially the abutment connection. Micromovements caused by an incorrectly seated abutment can weaken stability and cause bone loss.

Types of Radiographs Commonly Used in Implant Stability Assessment

Periapical Radiographs

The most often utilised radiographs in implant dentistry are periapical ones. They are used to monitor marginal bone levels, identify peri-implantitis, and assess osseointegration. They also give comprehensive views of the bone surrounding the implant.

Clinical Application: To assess bone levels around the implant neck and identify any radiolucency or bone abnormalities, this technique is used for routine follow-up.

Panoramic Radiographs

A comprehensive image of the jaw, including the locations of several implants, can be obtained using panoramic radiography. Although they lack the complexity of periapical radiographs, they are nonetheless helpful for a preliminary evaluation of implant placement and overall bone health.

Clinical Application: Good for assessing how implants are positioned overall in respect to anatomical structures, but less useful for performing a thorough evaluation of the bone level surrounding specific implants.

Computed Tomography (CT) and Cone Beam CT (CBCT)

Cone Beam Computed Tomography (CBCT) Equipment. Extensive three-dimensional imaging of the implant interface is possible using CT and CBCT. They are used to evaluate the quality and density of the surrounding bone, which affects stability, even though they do not directly test implant stability.

When it comes to detail, CBCT is superior to traditional radiography. It is especially helpful in difficult instances since it makes accurate assessments of bone density and the interface between the implant and bone possible.

Clinical Application: Perfect for determining the implant's closeness to vital anatomical structures (such as nerves and sinuses), gauging the quality of the bone, and detecting any abnormalities in the bone that would jeopardise stability.[15]

Additionally helpful for post-operative assessments to guarantee appropriate osseointegration and preoperative planning to evaluate the quality of the bone. This is crucial in situations when bone quality could be affected, like in radiation or grafted areas. [16]

Ultrasound Devices (Experimental)

Ultrasound transducer is the instrument. Acoustic impedance variations can be measured with ultrasound to assess the interface between the implant and bone. Though still mostly experimental, this approach is becoming more and more popular as a non-invasive means of assessing osseointegration.

Clinical Application: Since this technique may provide a non-invasive, non-radiographic alternative to test implant stability, research is being done to make it more useful in standard clinical practice. [17]

DISCUSSION:

The usefulness and dependability of several techniques for assessing implant stability have been compared in a number of studies. These techniques include Cone Beam Computed Tomography (CBCT), Periotest M, Osstell ISQ (Resonance Frequency Analysis - RFA), Torque Wrench (Insertion Torque Measurement - ITM), Digital Torque Gauge, and experimental techniques like ultrasound. These studies usually concentrate on the link between various assessment methodologies and the stability of main and secondary implants.

A comparison between Periotest and Resonance Frequency Analysis (Osstell ISQ), two non-invasive techniques for evaluating implant stability. The two techniques assess stability without necessitating direct physical contact with the implant; nevertheless, they vary in the way they quantify vibration (RFA) and damping properties (Periotest). Many studies come to the conclusion that Osstell ISQ offers more accurate and consistent measurements for tracking osseointegration and forecasting how well early or immediate loading techniques would work. The Periotest method's results are more varied because it depends more on damping qualities and soft tissue conditions. [18]

A comparison between Insertion Torque Measurement (ITM) and Osstell ISQ. Primary stability, or the mechanical engagement of the implant with bone, particularly during placement, is commonly measured by ITM. Conversely, Osstell ISQ quantifies stability across time and is particularly significant when assessing secondary stability (osseointegration). Comparative studies generally agree that Osstell ISQ is a more trustworthy measure for evaluating secondary stability over time, while insertion torque is a good predictor of initial primary stability. High ISQ readings and high insertion torque may be correlated, yet soft or low-density bone may exhibit differences. [5]

examining the connection between Torque Wrench (ITM), Periotest M, and Osstell ISQ to ascertain which approach offers the most accurate evaluation of implant stability in various bone types. Research indicates that there is a strong correlation between Osstell ISQ and insertion torque values in dense bone. However, in low-density or grafted bone, the ISQ measurement is more accurate in determining long-term osseointegration. In low-density bone, periotest scores are more impacted by soft tissue healing and are less constant. [7]

contrasting Osstell ISQ with conventional manual torque wrenches and digital torque gauges, which offer accurate and repeatable measurements of insertion torque. Digital torque gauges offer a more consistent and accurate way to measure insertion torque than manual wrenches, but they only evaluate primary stability, similar to ITM. However, Osstell ISQ is still the most effective instrument for evaluating secondary stability over an extended period of time. [19]

Studies have compared the use of CBCT with Osstell ISQ and ITM for post-operative evaluation of implant stability, even though its primary application is evaluating bone quality and quantity prior to implant placement. While RFA or ITM directly measure mechanical stability, CBCT offers useful 3D imaging for evaluating bone density and quality, which are critical for forecasting implant stability. It works well in complicated circumstances or when evaluating the regeneration of bone following transplantation. [16]

While ultrasound testing for implant stability is still in its experimental stages, preliminary comparisons with other techniques such as Osstell ISQ and Periotest have been conducted. Findings: While ultrasound is not as clinically validated as Osstell ISQ or Periotest, it demonstrates potential as a non-invasive method for evaluating bone-implant contact and osseointegration. More study is required, however studies indicate that ultrasonography may be able to identify changes in the bone-implant contact with a similar level of precision. [20]

One of the most dependable and extensively used techniques for assessing primary and secondary stability, particularly with regard to osseointegration, is still Osstell ISQ. Though it is only available at the moment of implant placement, insertion torque is a reliable indicator of primary stability. While Periotest offers a non-invasive method of stability assessment, its reliability may be compromised in some clinical circumstances due to its reliance on soft tissue conditions. When comparing manual torque wrenches to digital torque meters, the latter provide more accurate measurements. Although it cannot detect implant stability directly, CBCT is a powerful tool for evaluating bone quality and density. Although it is still being studied, ultrasound appears to be a promising non-invasive assessment tool.

Resonance frequency analysis (RFA), more precisely using Osstell ISQ, has become the most dependable and generally recognised technique for evaluating implant stability among available approaches. Its non-invasive, objective, and reproducible character makes it particularly useful for primary and secondary stability assessments. Osstell ISQ differs from other approaches for the following reasons:

Why Osstell ISQ Is regarded as the Best Method

Repeatable and non-intrusive:

Resonance frequency analysis, or RFA, is used by Osstell ISQ to gauge how stiff the implant-bone interaction is. Without harming the implant or the surrounding bone, it offers a numerical Implant Stability Quotient (ISQ) value that can be used to monitor stability over time.

Because Periotest is affected by soft tissue abnormalities and other methods, like insertion torque, can only be assessed during surgery, its non-invasive nature is crucial. [4]

Measurable and Objective:

Implant stability can be measured with clarity and quantification using ISQ values, which span from 1 to

100. This is in contrast to the binary evaluation of torque (either steady or unstable) or the subjective character of Periotest values.

While low results (below 60) imply that the implant may be at danger of failure, high values (over 70) indicate robust stability. These thresholds can be used by clinicians to determine whether to load an implant immediately or early.[21]

Relationship to Clinical Achievement:

Comparative research has demonstrated a strong correlation between ISQ values and osseointegration and long-term implant success. Since implants with high ISQ values typically have greater survival rates, this approach is a great way to anticipate effective long-term results.

Moreover, by altering the treatment plan (e.g., postponing loading), doctors can prevent failure by using the Osstell ISQ system to detect possibly unstable implants early. [22]

Tracking Stability Through Time:

Osstell ISQ can be utilised during the entire healing process to monitor secondary stability as the bone remodels and integrates with the implant, as contrast to insertion torque, which can only detect primary stability at the moment of implant placement.

It can therefore be used to determine when an implant is stable enough for functional loading without running the risk of failure, which makes it particularly helpful for early loading procedures. [23]

Reduced Variability in Outcomes:

The Osstell ISQ system is mostly unaffected by variables like prosthesis fit and soft tissue thickness, whereas Periotest methods are more heavily impacted by similar parameters. As a result, ISQ values are less susceptible to operator-dependent fluctuation and are more dependable.

Research contrasting Periotest with Osstell ISQ frequently discover that Periotest results are less reliable and more variable, particularly when soft tissue healing is not fully completed. [24]

Clinical Flexibility:

The Osstell ISQ device is adaptable to a variety of clinical circumstances due to its versatility with regard to implant types, implant surfaces, and loading regimens. It works well in areas with grafted bone, soft bone, and dense bone where other techniques might not be as successful.

In dense bone, insertion torque is very important for determining primary stability; however, in softer bone or grafted locations, its reliability is compromised. Osstell ISQ, on the other hand, can offer trustworthy stability measures in both situations. [5]

CONCLUSION:

Osstell ISQ as the Best Method: Osstell ISQ (Resonance Frequency Analysis) is regarded as the gold standard for evaluating both primary and secondary stability in dental implants, based on the body of current research and comparative studies. It is better than other techniques like insertion torque, Periotest, or digital torque gauges because it can provide quantifiable, non-invasive, repeatable, and objective measurements. These other techniques have more restrictions on consistency, invasiveness, and application in different clinical scenarios.

REFERENCES:

1. Meredith N. Assessment of implant stability as a prognostic determinant. International Journal of Prosthodontics 1998; 11(5), 491-501.
2. Buser, D., Sennerby, L., De Bruyn, H. (2017). Modern implant dentistry based on osseointegration: 50

years of progress, current trends and open questions. Periodontology 2000, 73(1), 7-21.
3. Staedt H , Kämmerer PW, Goetze E , Thiem DGE , Al-Nawas B,Heimes D. Implant primary stability depending on protocol and insertion mode — an ex vivo study. Int J Implant Dent 2020; 3;6:49.
4. Sennerby, L., & Meredith, N. (2008). Implant stability measurements using resonance frequency analysis: biological and mechanical aspects and clinical implications. Periodontology 2000, 47(1), 51-66.
5. Trisi, P., et al. Implant micromotion is related to peak insertion torque and bone density. Clinical Oral Implants Research, 2011; 22(5), 469-475.
6. Atsumi, M., et al. Evaluating implant stability in clinical trials. Journal of Oral Implantology 2007; 33(4), 233-239.
7. Schulte, W., & Lukas, D. The Periotest method. International Dental Journal,1993; 43(5), 428-435.
8. Duyck, J., & Vandamme, K. (2014). The effect of loading on peri-implant bone: a critical review of the literature. Journal of Oral Rehabilitation, 41(10), 783-794.
9. Roberts, W. E., et al. (1984). Bone physiology and metabolism in dental implantology: risk factors for osteoporosis and implant failure. International Journal of Oral and Maxillofacial Implants, 4(3), 203-212.
10. Buser, D., et al. (1997). Interface shear strength of titanium implants in the maxilla. Annals of Periodontology, 2(1), 150-160.
11. Albrektsson, T., et al. (1986). The long-term efficacy of currently used dental implants: A review and proposed criteria of success. International Journal of Oral and Maxillofacial Implants, 1(1), 11-25.
12. Lang, N. P., et al. (2011). Consensus statements and recommended clinical procedures regarding implant survival and complications. International Journal of Oral & Maxillofacial Implants, 26(1), 39-49.
13. Misch, C. E., et al. (2008). Dental Implant Prosthetics. Elsevier Health Sciences, pp. 347-370.
14. Kourtis, S. G., et al. (2004). Radiographic evaluation of the marginal fit of different types of implant-abutment connections. International Journal of Prosthodontics, 17(2), 212-218.
15. Tyndall, D. A., & Brooks, S. L. (2000). Selection criteria for dental implant site imaging: a position paper of the American Academy of Oral and Maxillofacial Radiology. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 89(5), 630-637.
16. Kernen, F., et al. (2016). CBCT in implant dentistry: how useful is it? Oral and Maxillofacial Surgery Clinics of North America, 27(3), 529-548.
17. Al-Jewair, T., et al. (2015). The use of ultrasound imaging in evaluating bone healing after implant surgery: A pilot study. Journal of Oral and Maxillofacial Surgery, 73(7), 1382-1389.
18. Nedir, R., et al. (2004). Predicting osseointegration by means of implant primary stability: a resonance-frequency analysis study with delayed and immediately loaded ITI SLA implants. Clinical Oral Implants Research, 15(5), 520-528.
19. Friberg, B., et al. (1999). Evaluation of bone density using cutting resistance measurements and micro-CT scanning. Clinical Oral Implants Research, 10(1), 30-38.
20. Park, J. M., et al. (2017). Ultrasonic evaluation of bone-implant interface for dental implants: A pilot study. Journal of Clinical Periodontology, 44(10), 1055-1063.
21. O'Sullivan, D., et al. (2000). Primary implant stability and its relationship to osseointegration: Part I. Resonance frequency analysis measurements over time. Clinical Oral Implants Research, 11(3), 206-214.

22. Glauser, R., et al. (2004). Peri-implant stability and early loading by measuring with resonance frequency analysis: A comparison between implants with SLA and SLActive surfaces. Clinical Oral Implants Research, 15(5), 428-436.
23. Barewal, R. M., et al. (2003). Resonance frequency measurement of implant stability in vivo on implants with a sandblasted and acid-etched surface. International Journal of Oral & Maxillofacial Implants, 18(5), 641-651.
24. Lachmann, S., et al. (2006). Resonance frequency analysis and damping capacity assessment. Part 1: An in vitro study on measurement reliability and a method of comparison in the determination of primary implant stability. Clinical Oral Implants Research, 17(1), 75-79.