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Research Progress on the Methods for Evaluating Tooth Mobility

Kangjie Li[1,2], Yuxin Wang[1], Jinlin Huang[1], Chenghua Li[1], Jiangtao Miao[1], Wanqiao Zong[1], Qi Meng[1] and Jianfei Yan[2]*

[1]Department of Stomatology, Beidaihe Rest and Recuperation Center, PR China

[2]State Key Laboratory of Oral & Maxillofacial Reconstruction and Regeneration, National Clinical Research Center for Oral Diseases, Shaanxi Key Laboratory of Stomatology, Department of Prosthodontics, School of Stomatology, The Fourth Military Medical University, Xi'an, Shaanxi, 710032, PR China

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***Corresponding author:** Kangjie Li, Department of Stomatology, Beidaihe Rest and Recuperation Center, PR China, State Key Laboratory of Oral & Maxillofacial Reconstruction and Regeneration, National Clinical Research Center for Oral Diseases, Shaanxi Key Laboratory of Stomatology, Department of Prosthodontics, School of Stomatology, The Fourth Military Medical University, Xi'an, Shaanxi, 710032, PR China

Abstract

Tooth mobility is the degree of movement of a natural tooth or implant when subjected to stress and is an important parametric indicator for clinicians in the diagnosis and treatment of periodontal disease, as well as in the development of restorative treatment designs. Traditional measurement by clinicians using tweezers to wiggle the teeth can provide some convenient information, but it does not provide reliable data to measure periodontal disease and also depends on the clinician's personal judgement. Therefore, objective and accurate measurement of tooth and implant mobility is essential for the early detection and treatment of periodontal disease. In this paper, the development and application of dental actuators are reviewed in order to provide references for clinicians.

Keywords: Tooth mobility; Implant stability; Measurement methods

Abbreviations: PVT: Periotest value; IST: Implant Stability Test value; RFA: Resonance Frequency Analysis; QUS: Quantitative Ultrasound

Introduction

Tooth mobility refers to the degree of looseness between the tooth and the alveolar socket. Factors affecting tooth mobility include the height of the supporting alveolar bone, the width of the periodontal membrane, the presence of inflammation, the shapes of the tooth root, and the number of tooth roots [1]. Globally, severe periodontitis may affect about 11% of the world's population, which is approximately 743 million people [2]. Tooth mobility is commonly used as a key diagnostic indicator for periodontal diseases and is also frequently applied in evaluating the prognosis following periodontal therapy, restorative or implant treatments, and orthodontic treatment. Currently, the primary clinical method for assessing tooth mobility involves the clinician using dental forceps to gently manipulate the tooth, evaluating the degree and direction of displacement to determine mobility. This clinical assessment is typically combined with radiographic imaging findings to form a comprehensive diagnosis of periodontal conditions. While this method is simple and practical, it cannot provide an accurate quantitative assessment of the stability of teeth or implants and heavily relies on the clinician's subjective judgment and clinical experience. Therefore, objectively measuring the degree of tooth mobility is of significant importance for diagnosing periodontal diseases, evaluating the condition of the tooth-supporting tissues, and designing treatment plans and prognostic assessments for affected teeth. This article reviews the progress of tooth mobility meters as follows.

Displacement Measurement Method

Periodontometry

Periodontometry [3] is a tooth mobility measurement method developed by English scientists in 1951, accompanied by a dedicated measuring instrument designed for this purpose. The instrument features an adjustable force application mechanism, meaning it measures based on tooth displacement and can accurately reflect tooth mobility while enabling real-time monitoring of tooth movement. The device is primarily secured intraorally using a tray. However, due to its complex operation, poor patient experience, and limitations in measuring mobility of posterior teeth, it has not been widely adopted in clinical practice.

Holographic interferometry

Holographic interferometry [4] involves shining a laser on the teeth to capture their initial state and recording the interference pattern to create an initial hologram. Then, a static load is applied to the teeth, and the laser is directed at the teeth again to record the interference pattern and create a hologram of the deformed state after the load is applied. By comparing the initial hologram and the hologram of the deformed state, the differences in tooth movement are analyzed [5].

Impedance Measurement Method

Periotest

Periotest [6] was developed by German scientists, including Lukas et al., as a periodontal diagnostic device. Originally designed to assess tooth mobility, it has subsequently been adopted for measuring implant stability. The instrument resembles a dental straight handpiece in appearance and operates through an internal electromagnetic mechanism that drives a percussive rod to tap against the tooth surface. The deceleration of the percussive rod upon impact serves as the primary signal for quantitative evaluation.

Greater stability of the periodontal ligament corresponds to a higher damping effect, leading to faster deceleration of the percussive tip upon striking the tooth. An accelerometer mounted on the impact rod records the contact duration between the tooth and the tip. The signal is then processed by an integrated computer and converted into the Periotest value (PTV). For natural teeth, the PTV typically ranges from –8 to +50. The values are clinically categorized as follows:

PTV between –8 and +9: indicates no clinically detectable mobility.

PTV between +10 and +19: corresponds to Grade I mobility (slight horizontal movement).

PTV between +20 and +29: indicates Grade II mobility (moderate horizontal movement).

PTV between +30 and +50: represents Grade III mobility (severe horizontal and/or vertical movement).

A lower PTV reflects greater tooth stability [7]. The Periotest instrument offers advantages such as simple operation, objective measurement, and reliable repeatability. However, when a PTV of –7 is recorded, the force applied by the probe to the tooth reaches approximately 5 N — a level that significantly exceeds the tolerable load of the periodontal ligament in teeth affected by periodontal disease, thus compromising patient comfort [7].

Any Check

In 2017, building upon the Periotest principle, a research team led by Jeong Yol Lee in South Korea introduced a novel damping capacity analysis device named AnyCheck. This instrument measures the contact duration between the percussive rod and the tooth/implant. During operation, it delivers six consecutive impacts within 3 seconds and converts the recorded time parameters into an Implant Stability Test value (IST). The IST scale ranges from 1 to 99, with higher values indicating greater implant stability [8]. Compared with the Periotest, the AnyCheck device applies a lower impact force to the tooth/implant and incorporates an automatic stop feature when low stability is detected. These characteristics enhance protection for both natural teeth and dental implants while also reducing patient anxiety and discomfort [8]. In recent years, several studies have demonstrated that the AnyCheck device offers high test sensitivity and possesses notable clinical merits, including non-invasiveness, minimal patient discomfort, and straightforward operation [8-10].

Resonance Frequency Analysis (RFA)

In 1996, Meredith [11] first proposed the use of Resonance Frequency Analysis (RFA) for the quantitative measurement of periodontal mobility. Currently, the widely adopted clinical RFA device is the Osstell ISQ. Its working principle involves attaching a magnetic transducer to the implant or abutment. The transducer is excited by a pulse lasting approximately 1 ms, inducing free vibration. A magnetic probe placed near the transducer detects the resulting magnetic field variation, which generates a voltage in the detection coil. This voltage signal is transmitted to the analyzer's resonance frequency processing system and converted into the Implant Stability Quotient (ISQ) – a numerical value representing the degree of implant stability.

An ISQ above 70 indicates high stability; values between 60 and 69 represent moderate stability; and an ISQ below 60 suggests poor stability [12]. The primary strength of Resonance Frequency Analysis lies in its ability to quantitatively assess implant mobility within the alveolar bone, thereby reflecting the rigidity and stability of the implant bone interface. This allows for a comprehensive, accurate, and detailed evaluation of implant stability [11], However, RFA measurements are influenced by multiple clinical and biological factors [13], meaning that a single ISQ value cannot fully characterize the entire bone implant system. Furthermore, in restored implant patients, the suprastructure must be removed prior to testing. This requirement increases clinical workload, heightens patient discomfort, and reduces practical operability [8].

Quantitative Ultrasound (QUS)

Quantitative Ultrasound (QUS) was introduced as a method to assess the stability of the implant bone interface by analyzing the echo signals generated as ultrasonic waves propagate along the bone implant interface. A planar ultrasonic transducer is used for detection. The ultrasound probe is fixed onto a titanium healing abutment, which is then screwed into the dental implant. The probe is connected via a coaxial cable to a pulse receiver unit. Radio frequency signals are captured using a transient recorder with a sampling frequency of 100MHz[14]. A key strength of Quantitative Ultrasound (QUS) is its high sensitivity to the actual contact area

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between the implant and bone, enabling quantitative assessment of the degree of osseointegration and thereby reflecting implant stability. Research by Vayron et al.[15] demonstrated that QUS provides a more accurate evaluation of bone implant interface integration compared to Resonance Frequency Analysis (RFA).

Summary

An overview of the characteristics of the aforementioned dental mobility measurement methods reveals the following: Periodontometry represents an early objective and quantitative approach for assessing tooth mobility. However, due to its cumbersome operation and suboptimal patient experience, it remains primarily confined to laboratory based research. ②Holographic interferometric metrology is an application of laser technology that provides complex and comprehensive insights through non-contact and non-destructive means. Nevertheless, the complex nature of the procedure hinders its clinical implementation. ③The Periotest device can objectively measure both natural tooth mobility and implant stability. Nevertheless, its reliability is relatively low. ④AnyCheck addresses several limitations of the Periotest, demonstrating improved reliability and patient comfort. However, it has not yet been widely implemented clinically, and reported clinical usage remains sparse. ⑤Quantitative Ultrasound (QUS), while extensively applied in other medical fields, is still in the developmental stage for assessing implant stability in dentistry and holds promising future prospects. ⑥Resonance Frequency Analysis (RFA) exhibits good reliability and repeatability. Although influenced by various clinical and physiological factors, it remains the most widely accepted method for evaluating implant stability in current clinical practice.

An ideal dental mobility measurement method should exhibit the following features: non invasive or minimally invasive, high sensitivity, high reliability, excellent repeatability, capability for continuous monitoring, and rapid testing. To date, no single method or technology can comprehensively and accurately assess the mobility of both natural teeth and dental implants. Although the Any Check device was introduced relatively recently, it offers the dual capability of measuring tooth mobility as well as implant stability. Its advantages—non invasiveness, absence of patient discomfort, high sensitivity, and ease of operation—indicate broad application potential. Nevertheless, further clinical trials and validation studies are warranted to substantiate its efficacy and reliability.

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