Assessment of Tooth Mobility Change During Orthodontic Treatment: A Preliminary Study

Nicha ARCHARIT[1], *Boonsiva SUZUKI*[1*], *Eduardo Yugo SUZUKI*[1]
[1]*Department of Orthodontics, Faculty of Dentistry, Bangkokthonburi University, Thailand*

Corresponding Author: ***Boonsiva SUZUKI*** *(E-mail:* ***boonsiva.suz@bkkthon.ac.th****)*

Abstract

Background: Assessment of tooth mobility (TM) is an important clinical indicator of the periodontium condition. However, the measurement of all teeth during the active phase of orthodontic treatment has never been performed.

Objectives: To investigate the overall changes in TM during active orthodontic treatment.

Methods: The study included 52 female patients, all of who received non-extraction orthodontic treatment (mean age 23.6±6.6 years). Assessment of TM was performed at baseline (T0) and 12 months appointment visits (T1- T12) by using the damping capacity assessment device (IMT-100, DMS Co., LTD. Gangwon-do, Korea), which measures the time of the tapping rod contact the tooth. T0 values were used to determine the respective TM values in percentage.

Results: There was an increment of TM after orthodontic loading. The increase of TM was highest in the first month (T0-T1; 4.8±2.8%) then, it increased gradually until T8 (T1-T8). A plateau was observed in T8-T12. In 12 months during orthodontic treatment, the overall TM value increased 15.9±4.9% from baseline. A significant difference in TM between each month was found in T0-T8. From T8-T12, there was no significant difference.

Conclusions: Longitudinal change of TM could be divided into 3 phases according to average TM increment per month.

Keywords: Tooth mobility, Orthodontic treatment

Introduction

Orthodontic force application can initiate remodeling of the periodontium. When force was applied to the tooth, bone formation and resorption occurs on the tension side and pressure side, respectively.(1) The orthodontic force stimulates the synthesis of several molecules and biomarkers. Many studies have evaluated the underlying biological process following orthodontic loading using several procedures such as tissue biopsy of tissue, gingival crevicular fluid (GCF) or saliva. However, these methods were invasive and not suitable for routine clinical application.(2) Another method is to use the TM test. TM is influenced by the degree of periodontal support, anatomy and mechanical properties of periodontal ligament (PDL) and alveolar bone, and the thickness of PDL space.(3) Assessment of TM may be an important key to determine the biomechanical characteristic of the periodontium and provide an understanding of biomechanical change during orthodontic tooth movement.(4) A widely accepted method for measuring TM has been Miller's index(5), but this method is subjective, leading to the development of numerous measuring devices. A damping capacity assessment (DCA) device was developed to measure TM objectively. DCA systems are developed to measure the damping characteristics of teeth or implants based on the contact time. The Periotest M (Medizintechnik Gulden, Modautal, Germany) is a non-invasive electronic DCA device that provides a measurement from the response of a periodontal tissue to a defined load. This device has been reported as highly accurate and reproducible.(6) Recently, a new device called Anycheck (IMT-100, Neobiotech, Seoul, Korea), using DCA was developed.(7)

Several studies have measured TM during the initiation of orthodontic treatment and also at the retention period.(4,7-10) Tanne *et al*.(4) found that after applied force for canine retraction, TM was significantly higher. They suggested that the elasticity of PDL and alveolar bone decreased after tooth movement. Tanaka E *et al*.(9) found an increase in TM at the end of orthodontic treatment. They suggested using TM to indicate biomechanical properties of PDL during orthodontic treatment. The TM measurement of all teeth during the active orthodontic phase has never been performed. Therefore, in this study, we evaluated the longitudinal TM changes of all teeth during the orthodontic treatment.

Materials and Methods

The study included 52 female patients, at the post-graduate clinic, Department of Orthodontics, Faculty of Dentistry, Bangkok Thonburi University (mean age 23.6±6.6 years old). All patients received non-extraction orthodontic treatment, were in good general health, not taking any medications affecting tooth movement during the study, also no history of trauma or previous orthodontic treatment. Approval for research activities was received from the Human ethics committee of the Bangkok Thonburi University. Informed consent was obtained from all patients before the initiation of the study (Approval number: 26/2561). Assessment of TM was performed before treatment (T0) and during the appointment's visits (T1-T12). TM was measured using a stability-measuring device, IMT-100 (Anycheck, DMS Co., LTD.Gangwon-do, Korea). This device uses the tapping method to measure the time the tapping rod contacts the tooth. The measurements were taken two times for each tooth and the average values were used. T0 values were used to determine the respective TM values in percentage. TM value was the total tooth mobility percentage change from baseline, by considering baseline value as zero. TM increment was a change of TM value in each month in percentage. Descriptive statistic was performed to find means and standard deviation of TM change. Repeated ANOVA was used to determine the difference between TM at all time intervals.

Results

There was no significant difference between the left and right sides of all teeth ($p<0.05$), the average value of both sides was used for the analysis.

Figure 1 showed the longitudinal changes in TM throughout orthodontic treatment for all patients. There was an increment of TM after orthodontic loading. Most of the changes occurred in the first months (T0-T1; 4.5±2.6%). After that, the TM value increased gradually until T8 (T1-T8). The plateau was observed in T8-T12, no significant difference of TM value was found in this period ($p<0.05$). In 12 months, the TM value increased 15.7±5.0% from T0.

TM increment was highest in the first month; the T1-T8 average TM increment was 1.5% per month. During T8-T12 the average TM increment was 0.2% per month. According to TM increment, the change can be divided into 3 phases: Phase1 in T0-T1, Phase2 from T1-T8, and Phase 3 from T8-T12.

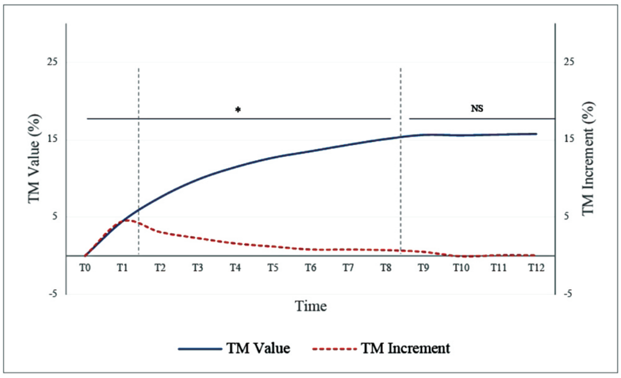

Figure 1: Overall TM Value and TM Increment.
*Significant difference between time interval at $p<0.05$

Discussion

In the present study, in order to reduce the confounding factors and provide more homogeneity to the sample, only female subjects were included. In a previous study, we had observed a significant lower TM in males compared to the female subjects.(11) For reliability of the measuring device, comparisons of the reliability of the Anycheck and Periotest M devices for the assessment of TM was performed in our previous study.(12) A strong correlation between the Periotest M and Anycheck values were observed. Moreover, the use of incisal edge for tooth stability measurements provided reliable and consistent tooth stability measurements.(12) Therefore, we performed the investigation of TM using Anycheck. Overall TM changes showed different increments and patterns during the different time intervals of orthodontic loading. The results observed in this study were in agreement with studies by Tanne *et al*.(4) and Nakago *et al*.(7), which found the increment of TM during the first month following orthodontic treatment. Tanne *et al*, suggested that the PDL and alveolar bone became more flexible after orthodontic tooth movement. In addition, Nakago *et al*. suggested that the elastic nature of the PDL and alveolar bone might decrease following the orthodontic force application.

The overall TM was divided into 3 phases according to the pattern of increments. In phase1 (T0-T1) or the first month following orthodontic loading, the highest TM increment was observed. This might be caused by both the immediate biomechanical and inflammatory cellular responses.(13) In agreement with Burstone's(14) evaluation of the biomechanics in orthodontic tooth movement, the tooth started moving after 20-30 days following orthodontic loading. The presence of acute inflammatory response is characterized by many cellular responses, which induce the bone remodeling process.(13) On the compression side, hyalinization of the compressed PDL and hyalinization occurs, as macrophages are responsible for the removal of the hyalinized tissues and alveolar bone resorption. On the tension side, osteoblasts stimulate bone formation.(2) Studies of PDL changes following the orthodontic loading also supported our results. Zimbran A *et al*.(15) observed an increase in the PDL width and Nakdilok K *et al*.(16) found a significant increase in PDL proliferation after 4 weeks of orthodontic loading.

In Phase 2 (T1-T8), a progressive increase of TM values was observed. However, the amounts of increments were lower than phase 1. No study has evaluated the longitudinal TM change during the active phase of orthodontic treatment before so, this is a new finding of this study. We assumed that the progressive increases in TM were due to the high alveolar bone remodeling. The bone remodeling initiates after the first month of orthodontic loading and continues until the PDL width returns to the normal limits.(17) Although bone formation and resorption occur simultaneously, the formation of a bone matrix with complete mineralization takes approximately 3 to 6 months.(18) This also corresponded with a study of Hsu JT *et al*.(19), which observed a 24% reduction in bone density after 7 months during orthodontic treatment. In phase 3 (T8-T12), no significant change in the overall TM values was observed. This phase may continue to the end of orthodontic treatment. In this phase, PDL and bone remodeling have reached homeostasis. The PDL and the alveolar bone have stromal cells, which is important in signaling and effector mechanisms to maintain the PDL width and preserve cell viability. The maintenance of a healthy and proliferative PDL is important to allow the rapid remodeling of alveolar bone when orthodontic loads are applied.(17) Moreover, Westover *et al*.(8) evaluated the longitudinal changes in PDL stiffness of the canines during orthodontic retraction by measuring TM. They observed an increase in the TM after orthodontic loading. In one year, PDL stiffness values were less than 50% of the pretreatment. For clinical importance, the TM can provide a tool to clinically monitor the periodontium condition of teeth that are undergoing orthodontic treatment. Optimal orthodontic treatment requires a mechanical input that leads to a maximum rate of tooth movement with minimum irreversible damage to the periodontium.

Discussion

The results obtained in the present study must be further investigated to obtain the maximum advantage on the biomechanics of tooth movement. The production of a biological archwire to deliver the corresponding loading values is desirable. A limitation of the present study is the use of overall values of TM. Therefore, the values of the maxillary and mandibular dentition, as well as the different groups of teeth were averaged to provide the value of TM. Further studies detailing the individual TM should be performed.

Conclusions

1. During orthodontic treatment, there is a significant increase in the TM values.
2. The TM changes exhibit a characteristic three-phase pattern.
3. Assessment of TM is a useful indicator of the underlying periodontal support during orthodontic treatment. Further studies are needed to evaluate the correlation between the rate of tooth movement and TM.

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