Original Article

Comparison Study of Periotest M and AnyCheck for Tooth Stability Measurement at the Incisal Edge of the Crown During Active Orthodontic Treatment: A Suggested Protocol

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Abstract

Assessment of tooth stability (TS) during orthodontic treatment provides relevant information regarding the biomechanical behavior of the periodontium. Therefore, the purpose of the present study was 1) to compare the performance of the Periotest M and the AnyCheck in assessing tooth stability, 2) to compare the measurement of TS values obtained from the middle and the incisal edges, and 3) to develop a protocol of tooth stability measurement during the active phase of orthodontic treatment. Comparison of reliability of the Periotest M (Medizintechnik Gulden, Modautal, Germany) and the AnyCheck (IMT-100, DMS Co., LTD. Gangwon-do, Korea) was performed on 20 participants. Both devices are designed to provide objective measurements by assessing the damping capacity. Since the periotest values are displayed in PTV values and AnyCheck displayed in the iST scale (Implant Stability Test), a conversion equation to convert PTV into IST values was developed. A comparison of tooth stability values obtained from the middle and the incisal edge was performed to allow measurements during the active orthodontic treatment. Data was collected and analyzed statistically. Significant differences in TS measurements between the middle and incisal sites were observed. The Periotest produced the largest discrepancies (42.2%, ± 22.2%) between the middle and incisal readings. (p<0.001) Measurements of the posterior teeth were not possible with the Periotest due to the bulky head size. The AnyCheck produced reduced discrepancies between the middle and incisal readings (6.8%, SD 1.9%) with no significant changes in the posterior teeth. Relatively simple measurements were possible with AnyCheck. The correlation coefficient between the mean Periotest M and AnyCheck values was 0.870 (P<0.01). A strong correlation between the Periotest M and AnyCheck values was observed. The use of incisal edge for tooth stability measurements provided reliable and consistent tooth stability measurements. Moreover, it allows measurement during the active phase of orthodontic treatment.

Keywords: AnyCheck, Orthodontic tooth movement, Periotest M, Tooth stability

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Introduction

Assessment of tooth stability has shown to be an important clinical indicator of the health status and biomechanical behavior of the periodontium during orthodontic tooth movement.[1,2] The continuous remodeling of the periodontal tissues during orthodontic tooth movement promotes the increase in tooth mobility.[1] Therefore, the assessment of tooth mobility changes can be used as an important evaluation tool for the evaluation of the biomechanical characteristics of the periodontium.[2] Consequently, the assessment of TS values can be used as a clinical indicator of the tooth movement and treatment duration. Moreover, it is commonly accepted that tooth mobility increases during orthodontic treatment and is gradually restored to baseline levels after completion of orthodontic treatment.[3,4] Therefore, the assessment of tooth stability changes during orthodontic treatment and at the retention period has been investigated.[1-5] Tanaka *et al.* had performed the longitudinal measurements of tooth mobility during orthodontic treatment using a Periotest.[4] However, measurements were performed only on the anterior teeth.

Several studies had been performed to assess the values of tooth stability in permanent dentition using different approaches.[6-10] However, their acceptance has been limited because of the subjectivity associated with their use.[6] The Periotest is a non-invasive, electronic device that provides an objective measurement of the reaction of the periodontium to a defined impact load applied to the tooth crown. Consequently, the assessment of tooth stability with the Periotest as a special test for assessing the periodontal status of teeth in children that have suffered trauma has been broadly used.[7-10]

This method has been described as an efficient and reliable method to assess tooth mobility.[11] The Periotest measures the mobility and damping of natural teeth by measuring the acceleration in response to an applied impact.[2-4] The periotest values are displayed in PTV values (-8 to +50), with a higher scale representing lower stability or higher mobility. The Periotest values are related to clinical tooth mobility through a simple correlation.[6]

Recently, a new measuring device, AnyCheck (IMT-100, DMS Co., LTD. Gangwon-do, Korea) has been introduced to assess the stability of dental implants.[12,13] This device uses the tapping method which measures the time the tapping rod of the device contacts the implant fixture. The result of measurement is displayed in the iST (Implant Stability Test) scale (1 to 99) with a higher scale representing greater stability or lower mobility.

Both the Periotest M and the AnyCheck devices are dynamic devices designed to provide objective measurement of tooth mobility and implant stability by assessing their damping characteristics. However, the AnyCheck device has not been tested for the measurement of tooth stability. Moreover, according to the manufacturer's instructions, the handpiece must be oriented perpendicular to the tooth's long axis with the tapping rod being placed towards the middle of the anatomical crown.[6-11] However, the middle of the anatomical crown is often the selected place for the orthodontic buccal brackets placement. Consequently, monitoring tooth stability with such devices during the active phase of orthodontic treatment is not possible.

To avoid these limitations, the authors propose an alternative measurement method by modifying the point of impact of the tapping rod to the incisal edge of the anatomical crown, consequently allowing the measurement of tooth mobility throughout the orthodontic treatment. However, the impact of these changes on the reliability of the measurements has not been investigated.

Therefore, the purpose of the present study was 1) to compare the performance of the Periotest M and the AnyCheck in assessing tooth stability, 2) to compare the measurement of TS values obtained from the middle and the incisal edge, and 3) to develop a protocol of tooth stability measurement during the active phase of orthodontic treatment.

Materials and Methods

Assessment of Tooth Mobility

Periotest M vs AnyCheck

In the first part of the study, the selection of the best equipment for tooth stability measurement was made. Therefore, the comparison of Periotest M (Medizintechnik Gulden, Modautal, Germany) and the AnyCheck (IMT-100, DMS Co., LTD. Gangwon-do, Korea) in assessing tooth stability was performed on 560 teeth of 20 volunteer participants. (Fig. 1 A-C) Measurements were performed of all maxillary and mandibular teeth.

Tooth stability assessment was performed following the instructions of the manufacturer. Measurements were performed with the participants seated in the dental chair in an upright position with a stable headrest. The tapping rod of the measurement device was placed in the middle of the anatomical crown. For the Periotest M device, the tapping rod was placed in a horizontal position 0.5–2 mm away from the tooth surface. Measurements are performed with the handpiece positioned perpendicular to the long axis of the tooth. (Fig. 1D-G) Measurements were performed by two trained examiners. Each measurement was performed twice for each tooth and was averaged for analysis.

Conversion Formulas

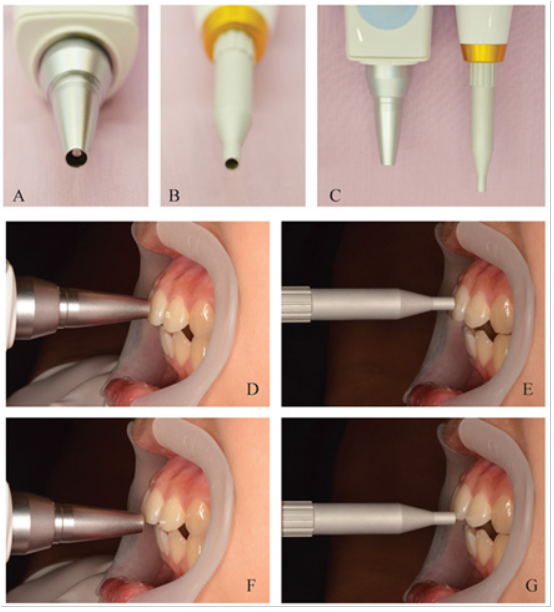

Figure 1 *Close-up pictures of the tips of the AnyCheck and Periotest M devices. Measurement devices were placed in the middle and the incisal edge of the tooth crown*

Both the Periotest M and the AnyCheck are dynamic devices designed to provide objective measurement of tooth stability by assessing damping characteristics of the periodontium. The periotest values are displayed in PTV values (-8 to +50), with a higher scale representing lower stability or higher mobility. In contrast, the AnyCheck values are displayed in iST (implant stability test) values (1 to 99) with a higher scale representing higher stability or lower mobility. Therefore, to allow the comparison of the standard deviations of the two devices, a conversion formula was created for both converting the PTV values into iST values. Moreover, since the Periotest M was designed to provide tooth stability values and the AnyCheck was designed to provide stability values, the conversion formula was proposed to represent the stability values.

The conversion of the PTV values into the iST values to assess stability was performed using the following equation: iST = 99 – ((PTV+8) * 99/58)

In this formula, the PTV values, which range from -8 to +50, thus containing a 58-unit scale, were converted into a 99-unit scale. The 0 to 99 scale is used for the iST assessment.

In this formula, the higher PTV scales represent the lower stability or higher mobility, while the higher iST scales represent higher stability and lower mobility.

Alternative Target Point for Tapping. (Middle versus Incisal edge)

In the second part of the study, the selection of an alternative target point for the tapping rod was performed to allow consistent and repeatable measurements during the active phase of orthodontic treatment.

For the conventional measurement for TM, the tapping rod of the measurement device is positioned at the middle of the anatomical crown perpendicular to the tooth's long axis. (Fig 2.) However, this position interferes with measurements during the active phase of orthodontic movement since this position coincides with the site where the orthodontic bracket is placed. Therefore, an alternative target point for the tapping rod was performed to allow

consistent and repeatable measurements during the active phase of orthodontic treatment.

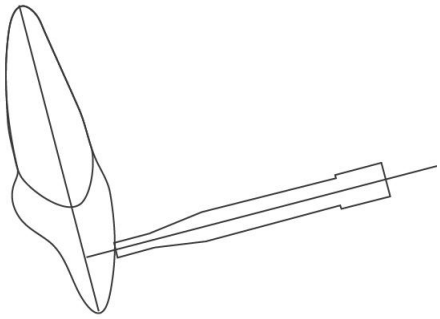

Figure 2 *Illustration of the tapping position perpendicular to the tooth's long axis*

All measurements were performed using the Periotest M and the AnyCheck device. The periotest values were converted into iST values using the proposed formula to allow comparison between devices.

Therefore, the selected point for the anterior incisors, canines, and premolars was the incisal edge perpendicular to the long tooth axis. For the molars, the selected point was the incisal edge of the mesial cusp. (Fig. 3)

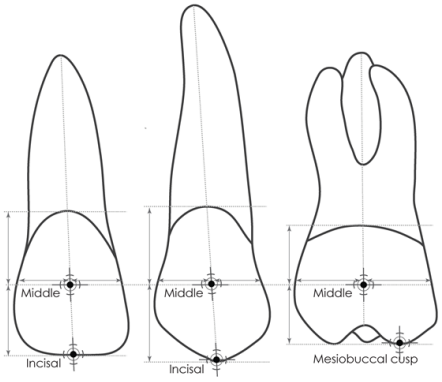

Figure 3 *Illustration of the middle and the incisal edge target sites for tapping*

The selected target point provides a reliable reference for tooth stability measurements during all phases of Orthodontic treatment, including at the baseline active and retention periods. (Fig. 4)

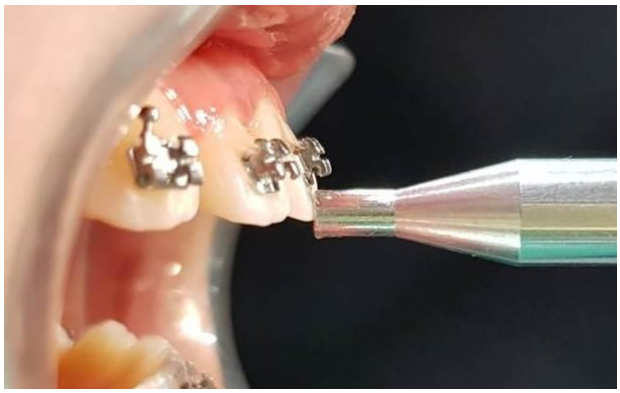

Figure 4 *Assessment of tooth stability during active orthodontic treatment*

Measurements performed at the middle and the incisal edge of the dental crown were performed to detect the differences between the different sites.

Participants

Assessment of tooth stability was performed on 560 teeth from 20 pre-orthodontic patients at the Graduate Clinic, Department of Orthodontics, Faculty of Dentistry, Bangkokthonbuti University between Jan 2018 – Jun 2018. This study was approved by the Human Experimentation Committee, Faculty of Dentistry, Bangkokthonburi University (Approval Number: 26/2561). Informed consent was obtained from all participants before the initiation of the study.

Inclusion and exclusion criteria

The overall inclusion criteria were; participants with good general health, excellent oral hygiene with sound teeth with normal shape and size, no periodontal disease nor bone loss visible on panoramic radiographs. Also, they should have no history of dental trauma nor previous orthodontic treatment with an absence of large restorative treatment such as large filling or crowns as well as no missing teeth except for the third molars.

Inter and intraindividual calibration

For the reproducibility and reliability of the measurements, inter-and intraindividual reliabilities were

performed using the intraclass correlation coefficients (ICC). Tooth stability was conducted twice at the incisal edge and the middle of the dental crown. For the middle of the dental crown measurements, the ICC was 0.850 and 0.915 for the inter-and intraindividual reliabilities, respectively. Whereas for the incisal edge of the dental crown measurements, the ICC was 0.801 and 0.844 for the inter-and intraindividual reliabilities, respectively.

Statistical Analysis

SPSS version 27.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis of the results. The paired *t*-test was used to compare the Periotest M and AnyCheck measurements at the middle and incisal edges. The agreement between the Periotest M and AnyCheck values measurements was evaluated with Pearson's correlation and coefficient and Bland-Altman analysis. The level of significance was set at 95% ($P<0.05$).

Results

Periotest M vs AnyCheck

Results of tooth stability measurements using the Periotest M (PTV values were converted in iST*) and AnyCheck values (iST) are shown in Table 1. There were no observed significant differences in the tooth stability values between both measurements. However, the Periotest M device could not perform measurements in the posterior molar area due to the large head. The Anychek device, presenting a longer and thinner tip for measurement, allowed simple measurement in both the anterior and the posterior teeth. The correlation coefficient between the mean Periotest M and AnyCheck values was 0.870 ($P<0.01$). Figure 5 Bland-Altman analysis demonstrated good agreement between the Periotest M and AnyCheck measurements. The results indicate that there is no consistent bias of one approach versus the other. (Fig. 6)

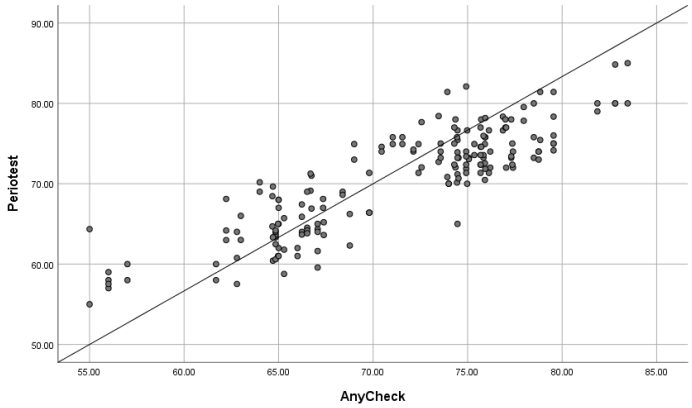

Figure 5 *Correlation of the Periotest M and AnyCheck values*

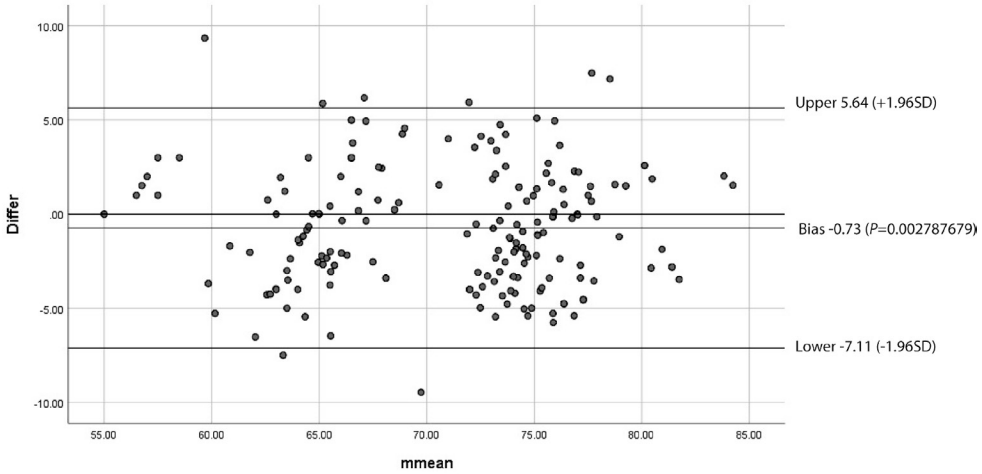

Figure 6 *Bland-Altman analysis to compare the reliability of the two measurements*

Table 1 *Assessment of tooth stability at the incisal edge using Periotest M and AnyCheck*

		Periotest M (PTV)				AnyCheck (iST)		*P* value
		PTV		iST*		iST		
		Mean	SD	Mean	SD	Mean	SD	
Maxilla	Central Incisor	14.2	2.3	61.1	5.9	66.2	4.7	0.335
	Lateral Incisor	12.5	2.2	64.0	4.7	64.7	4.3	0.464
	Canines	4.8	2.3	77.1	4.9	73.5	4.2	0.715
	First Premolar	9.5	2.2	69.1	4.0	72.6	4.0	0.468
	Second Premolar	5.7	3.7	75.6	5.9	71.5	4.2	0.406
	First Molar	4.1	5.3	78.3	5.1	76.2	3.9	0.626
	Second Molar	n/a				73.9	4.7	n/a
Mandible	Central Incisor	15.0	2.5	59.7	4.3	62.0	3.7	0.457
	Lateral Incisor	13.8	2.7	61.8	5.8	64.4	4.3	0.476
	Canines	7.7	3.0	72.1	5.1	73.1	5.0	0.696
	First Premolar	7.8	2.6	72.0	4.6	74.9	4.4	0.732
	Second Premolar	8.0	4.1	71.6	5.3	74.4	4.9	0.484
	First Molar	2.3	6.7	81.4	9.9	80.1	3.5	0.665
	Second Molar	n/a				76.2	3.9	n/a

PTV values were converted into iST values using the conversion equation*

Paired t-test, significant at P<0.05. n/a = Not applicable

Alternative Tapping Point (Middle versus Incisal)

Comparisons of tooth stability measurements between the middle and the incisal edge of the tooth's crown with Periotest M and AnyCheck are presented in Tables 2 and 3. Significant differences in tooth stability between both sites were observed.

For the Periotest M, a significant increase in the overall incisal readings (42.2%, SD 22.2%) was observed (p<0.001). The largest differences were observed in the anterior teeth. In Table 2, a moderate correlation (0.421) between the middle and incisal edge measurements was observed. (P<0.01) (Table 4)

For the AnyCheck, although an overall decrease in all incisal readings (6.8%, SD 1.9%) was observed, no significant changes in the tooth stability readings in the posterior teeth were observed. Table 3 A strong correlation (0.868) between the middle and incisal edge measurements was observed. (P<0.001) (Table 4)

Table 2 *Comparison of tooth stability values between middle and incisal sites using Periotest M*

		Periotest M (PTV)							
		Middle		Incisal		Diff		(%)	*P* value
		Mean	SD	Mean	SD	Mean	SD		
Maxilla	U1	7.37	2.73	14.2	2.3	6.8	-0.5	93.0 %	<0.001***
	U2	9.15	3.19	12.5	2.2	3.3	-1.0	36.4 %	<0.001***
	U3	4.01	2.50	4.8	2.3	0.8	-0.2	20.0 %	0.002**
	U4	5.72	1.79	9.5	2.2	3.8	0.4	66.7 %	<0.001***
	U5	4.41	1.00	5.7	3.7	1.3	2.7	29.5 %	0.002**
	U6	3.67	1.39	4.1	5.3	0.4	3.9	12.0 %	0.004**
	U7	n/a		n/a					

Table 2 *Comparison of tooth stability values between middle and incisal sites using Periotest M (cont.)*

		Periotest M (PTV)							
		Middle		Incisal		Diff		(%)	*P* value
		Mean	SD	Mean	SD	Mean	SD		
Mandible	L1	11.05	1.07	15.0	2.5	4.0	1.4	36.2 %	<0.001***
	L2	10.87	1.94	13.8	2.7	2.9	0.7	26.9 %	0.005**
	L3	5.91	1.32	7.7	3.0	1.8	1.7	31.0 %	0.006**
	L4	5.64	1.91	7.8	2.6	2.2	0.6	38.7 %	0.008**
	L5	5.43	2.34	8.0	4.1	2.6	1.7	48.3 %	<0.001***
	L6	1.47	0.91	2.3	6.7	0.8	5.8	56.1 %	0.004**
	L7	n/a		n/a					
	Mean	6.2	1.8	8.8	3.3	2.6	1.4	41.2 %	<0.001***

*Paired t-test, * P< 0.05, **P < 0.01, ***P < 0.001. n/a = not applicable*

Table 3 *Comparison of tooth stability values between middle and incisal sites using AnyCheck*

		AnyCheck (iST)							
		Middle		Incisal		Diff		(%)	*P* value
		Mean	SD	Mean	SD	Mean	SD		
Maxilla	U1	71.7	4.3	66.2	4.7	5.4	-0.4	7.6 %	0.042*
	U2	71.5	5.7	64.7	4.3	6.8	1.3	9.5 %	0.048*
	U3	78.4	5.5	73.5	4.2	4.9	1.3	6.2 %	0.025*
	U4	78.4	4.2	72.6	4.0	5.9	0.2	7.5 %	0.036*
	U5	76.2	4.2	71.5	4.2	4.6	0.0	6.1 %	0.124
	U6	81.4	4.4	76.2	3.9	5.2	0.6	6.4 %	0.126
	U7	77.1	5.5	73.9	4.7	3.2	0.8	4.2 %	0.133
Mandible	L1	68.6	6.1	62.0	3.7	6.6	2.4	9.6 %	0.048*
	L2	70.5	4.6	64.4	4.3	6.1	0.3	8.7 %	0.040*
	L3	79.8	3.7	73.1	5.0	6.6	-1.3	8.3 %	0.137
	L4	78.9	3.1	74.9	4.4	4.0	-1.3	5.1 %	0.234
	L5	79.4	3.2	74.4	4.9	5.0	-1.7	6.3 %	0.244
	L6	83.1	2.0	80.1	3.5	3.0	-1.5	3.6 %	0.246
	L7	80.2	4.7	76.2	3.9	4.0	0.7	5.0 %	0.181
	Mean	76.8	4.4	71.7	4.3	5.1	0.1	6.7 %	0.056

*Paired t-test, * P< 0.05, n/a = not applicable*

Table 4 *Correlation between measurements at the incisal edge and middle of the crown using Periotest M and AnyCheck*

	Incisal and Middle	*P*-value
Periotest M	0.421	0.007**
AnyCheck	0.868	<0.001***

Pearson correlation coefficient, significant at P< 0.01 and **P < 0.001*

Discussion

The orthodontic force applied to teeth generates specific compressive and tensile mechanical loading patterns that create complex biological responses in the periodontal tissues surrounding the loaded teeth.[14] As a result, the remodeling of the alveolar bone occurs accompanied by the widening of the periodontal ligament to allow the dental movement towards the compressive direction.[15,16] These sequential events play an important role in tooth stability. Therefore, the accurate determination of the tooth stability values at the baseline, and the changes during the active and retentive phases of orthodontic treatment provides relevant information regarding the biomechanical behavior of the periodontium.[1-6]

However, limited information is available regarding the tooth mobility at the baseline and the changes during the active orthodontic treatment. Since most of the measurement devices use the middle of the clinical anatomical crown, monitoring tooth stability with such devices during the active phase of orthodontic treatment with conventional buccal appliances is not possible.

In the present study, the authors describe a protocol for the measurement of tooth mobility and stability that can be applied during the active phase of the orthodontic treatment.

The Periotest M method has been described as an efficient and reliable method to assess tooth mobility.[11] Consequently, most studies involving assessment of tooth mobility utilize the Periotest M device to obtain reliable data. Recently, a new stability-measuring device, AnyCheck, has been introduced in the field of dental implantology. [12,13] Similar to the Periotest M device, the AnyCheck device measures fixture stability by using damping capacity analysis. Comparison of the sensitivity and reliability of the Periotest M and the AnyCheck for the assessment of the stability of dental implants have demonstrated a strong correlation between measurements.[12,13] Lee *et al.,* observed a strong correlation between Periotest M and AnyCheck values in an *in vitro* study.[12] Later, Lee *et al.* observed similar results in an *ex vivo* experiment.[13]

In the present study, the comparison of the sensitivity and reliability of the Periotest M and the AnyCheck for clinical assessment of tooth stability have demonstrated a strong correlation between measurements.

To the author's knowledge, the clinical use of the AnyCheck for assessing tooth stability values has not been performed. Moreover, to allow the comparison of tooth stability values obtained by both devices, a conversion formula was elaborated to convert PTV values into iST values.

In the present study, Bland-Altman analysis was performed to compare the reliability of the two measurements. No significant difference was found between the Periotest M and AnyCheck readings in the incisal sites. Moreover, a significantly strong correlation between both measurements was observed. The results are in agreement with previous studies that compared the Periotest M and AnyCheck values of implant stability.[12,13]

However, the Periotest M could not perform adequate and reliable measurements on posterior teeth. Repetition of several measurements was needed to obtain final tooth stability readings. This difficulty became more evident in the measurement of the posterior teeth. This difficulty was also reported by previous studies due to the difficulty of positioning the device as per the manufacturer's manual.[11]

Moreover, the Periotest M was hard to handle and measurements were time-consuming with several tooth measurements readings and the assessment of the second molars was not possible. The main reason for this difficulty was the large number of tapping times required for measurements, and relatively heavy tapping forces applied to the tooth. Moreover, the bulky size of Periotest M tips (large and short) and the need to maintain a constant clearance distance (0.5 to 2.0 mm) from the tooth surface to allow measurements, including difficult measurements with the Periotest M.

In contrast, the AnyCheck device was relatively simple and easy to handle. It allowed for relatively more simple and easy measurements of tooth stability in both

the anterior and posterior sites. Therefore, compared to the Periotest M, the AnyCheck device is more "user-friendly".

Comparison of different sites of tooth stability between the middle and incisal edge of the tooth's crown showed contrasting results between the Periotest M and the AnyCheck results.

For the Periotest M, a large discrepancy between the middle and incisal edge measurements was observed. The incisal edge site produced the largest tooth mobility values compared to the middle sites. The higher differences were observed more in the anterior teeth, in particular to the maxillary incisors. However, only a moderate correlation between reading between the middle and the incisal edge measurements was observed. Such discrepancies might be explained by the differences in the distances from the tooth's center of resistance, which is located in the middle third of the roots.

For the AnyCheck device, the significant differences between the middle and incisal edge readings were observed only with the anterior teeth. Moreover, the differences between the middle and incisal edge readings were eight times smaller than the differences observed with the Periotest M readings. In the posterior area, no significant differences in the middle and incisal edge readings were observed. This might be explained by the relatively short clinical crown observed in the posterior teeth and the relatively small distances between the middle and incisal edges observed in the posterior teeth.

Therefore, based on the results of this study, the AnyCheck device might be considered as an alternative equipment for evaluating the damping capacity of tooth stability.

A limitation of the present study might be the presence of inter-individual variation, such as the skeletal pattern, gender, and age. Therefore, further studies are necessary to assess factors related to the differences in tooth mobility.

In the present study, the authors had proposed an alternative measurement protocol for tooth stability by using the AnyCheck device and by modifying the point of impact of the tapping rod to the incisal edge of the tooth's anatomical crown. Such modifications have provided reliable and consistent tooth stability measurements. Consequently, the assessment of tooth stability throughout the active phase of the orthodontic treatment can be easily and consistently performed following this protocol.

Although it is generally known that an increase in tooth mobility occurs during orthodontic treatment, limited information regarding the amount of tooth mobility changes or the limits of safe tooth mobility values during active orthodontic treatment is available. Moreover, the possibility of using the tooth mobility analysis for predicting quantitatively the amounts of tooth movement might allow the construction of algorithms to precisely predict the overall optimum treatment duration. Therefore, further studies to assess the physiological values of the tooth mobility at the baseline, during the active and the retention phases of the orthodontic treatment, should be investigated in future studies.

Conclusions

1. A strong correlation between Periotest M and AnyCheck values in clinical measurements was observed.

2. The use of the incisal edge for tooth stability measurements provided reliable and consistent tooth stability measurements. Moreover, it allows for measurement during the active phase of orthodontic treatment.

3. The AnyCheck device allowed for relatively more simple and easy measurements of tooth stability in both anterior and posterior sites. Therefore, it might be considered as an alternative and reliable equipment for evaluating the damping capacity of tooth stability.

4. A protocol of tooth stability measurement using the incisal edge of the tooths' crown during the active orthodontic treatment with the AnyCheck device has been presented.

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