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Longitudinal Measurements of Tooth Mobility during Orthodontic Treatment Using a Periotest

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ABSTRACT

The present study was designed to investigate the alteration of tooth mobility through orthodontic treatment using a Periotest. Eighty-three crowding cases without severe skeletal discrepancies were used as subjects. For each subject, the mobility of the central and lateral incisors on both arches (U1, U2, L1, and L2) was measured immediately before and after orthodontic treatment (T1 and T2 stages) and after retention (T3 stage) by use of a Periotest. No significant differences of all the measurements were found between the left and right sides. At T1 stage, the mean values were 10.8, 10.4, 9.3, and 7.4 for U1, U2, L1, and L2, respectively. At T2 stage, the Periotest values for all the teeth increased in comparison with those at T1 stage, and significantly decreased at T3 stage compared with those at T2 stage. Negative correlations were found between the Periotest value and age, which imply that tooth mobility decreases with age. The durations of treatment and retention had low correlation with the change of tooth mobility for all the teeth. It is suggested that the tooth mobility before treatment and after retention may be one of the useful indicators for determination of the retention period.

KEY WORDS: Tooth mobility, Periotest, Orthodontic treatment.

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INTRODUCTION Return to TOC

When a force is applied to a tooth, bone resorption occurs on the compressive side and bone apposition also occurs on the tension side, followed by a widening of the periodontal ligament (PDL) space and tooth migration toward the compressive side. Histologically, the osteoclasts will attack the bone surface over a much wider area, provided the force is kept within certain limits.[1] Therefore, a widening of the PDL space is of great importance in the physiological extent of tooth movement.

In orthodontic tooth movement, the remodeling process in the PDL is repeated,[2,3] and tooth mobility is affected substantially by remodeling as well as by anatomical alterations in the PDL space and alveolar bone height.[4] Physiological tooth mobility is a product of the elastic attachment of the PDL between root and alveolar bone.[5] The duration of tooth movement is divided into initial and secondary phases, and direct bone resorption is found notably in the secondary period when the hyalinized tissue is lost after undermining bone resorption.[1] In the secondary period of tooth movement, the PDL is considerably widened, resulting in increased tooth mobility. It is generally recognized

that tooth mobility increases during orthodontic treatment and is gradually restored to standard levels after completion of orthodontic treatment.

Tooth mobility has been used as an important indicator in the assessment of biomechanical characteristics of the periodontium and the availability of periodontal support throughout orthodontic treatment.[4] An insight into the tooth mobility during orthodontic treatment, therefore, contributes to the risk detection and prevention of relapse after treatment. Thus far, however, relatively little information is available on the long-term follow-up of tooth mobility from the beginning of orthodontic treatment to the end of retention.

In this study, we measured the tooth mobility using a Periotest throughout orthodontic treatment. The aim was to investigate the alteration of the tooth mobility through the orthodontic treatment and to evaluate the influence of age, sex, treatment method, and treatment and retention durations on the tooth mobility.

MATERIALS AND METHODS Return to TOC

The invited participants were 168 patients with various malocclusions (48 male patients and 120 female patients ranging in age from 10 to 29 years). All patients appeared to be in good general health and had no obvious medical condition, which could affect the periodontal support of the tooth. In addition, they had no history of trauma, previous orthodontic treatment, or restorative treatment. From these patients, 83 crowding cases without severe skeletal discrepancies (23 male patients and 60 female patients ranging in age from 11 to 16 years) were selected. The treatment plan for each subject included the use of an edgewise appliance. As a result of diagnosis, 71 patients were treated as premolar extraction cases and 12 patients as nonextraction cases. Retention for all the patients was achieved with a canine-canine retainer made of flexible multistrand wire (0.0175 inch in diameter) bonded to all six anterior teeth. Informed consent was obtained from each subject before performing a serial examination.

Measurements of tooth mobility were carried out by four experts skilled in the use of the Periotest (Siemens Co., Bensheim, Germany). The Periotest is an electronic device that measures the damping characteristics of the periodontium. The apparatus consists of a microcomputerized measuring and steering device that connects to a handpiece with a tapping head (a built-in metal rod). The Periotest is designed to precisely calculate the tooth mobility from the state of the rebound of the tapping head. The tapping head in the handpiece beats the surface of the tooth at a rate of four times per second. The duration of the contact of the tapping head on the tooth surface is measured by the instrument that calculates the Periotest value to indicate tooth mobility.

Before the experiments, the interindividual and intraindividual variabilities were tested to determine the reproducibility of the Periotest measurement. Using a volunteer, Periotest measurements were conducted three times by four skilled experts to obtain the three Periotest readings for each expert. Thus, 10 of 12 readings had the same value, and the remaining two readings differed by only one. By means of Pearson's correlation coefficient, there was no evidence of a large random error between the readings with the reliability coefficient ranging from 0.93 to 0.96.

For each patient, the mobility of the central and lateral incisors on both the arches (U1, U2, L1, and L2) was measured immediately before and after orthodontic treatment (T1 and T2 stages) and after retention (T3 stage). The mean ages at T1, T2, and T3 stages were 12.2 (±1.8), 14.1 (±1.9), and 16.4 (±1.9) years, respectively. The mean duration of multibracket treatment was 21.5 (±5.9) months, and the retention period was 27.9 (±9.2) months. At each stage, the measurements were actually taken three times for each tooth and then the average values were used in the calculations. The device was used according to the manufacturer's instructions. The patient's head was placed against the headrest with the actual tooth perpendicular to the floor. The handpiece was held to the buccal surface of the tooth at the center of the anatomic crown with a distance of less than 4 mm from the buccal surface of the incisor. The height on which the rod of the handpiece was placed was measured as the distance from the edge of the tooth, and based on the height recorded, a serial examination for each patient was conducted in the same manner.

For evaluation of the measured tooth mobility, the means and standard deviations of the Periotest values were calculated for each tooth of each stage. The two subgroups classified by extraction case or not were subjected to statistical intergroup comparison with respect to the Periotest values. When a significant *f*-value was obtained, an independent Scheffé's test was performed for the comparison of the Periotest values for the two subgroups. With respect to the effect of age, and treatment and retention durations on the tooth mobility, correlation coefficients between Periotest value at T1 stage and age, between T2/T1 ratio and treatment period, and between T3/T2 ratio and retention period were calculated for all the teeth. Here, T2/T1 and T3/T2 ratios were calculated as mean Periotest values at T2 and T3 stages divided by those at T1 and T2 stages, respectively. Hereby, no change of Periotest values between the two stages would be expressed because the ratios are 1.00. Probabilities of less than 0.05 were considered to be significant.

RESULTS Return to TOC

For all the subjects, means and standard deviations of Periotest values are shown in Table 1. By use of a paired *t*-test, no significant differences of all the measurements were found between the left and right sides. Therefore, the means of both the sides were used for the following analysis. At T1 stage, the mean values were 10.8 ± 3.2 for U1, 10.4 ± 2.8 for U2, 9.3 ± 2.8 for L1, and 7.4 ± 2.4 for L2. The Periotest value for L2 was significantly ($P < .01$) smaller than those for the remaining teeth. The value for U1 was also significantly larger

than those for L1 ($P < .01$). At T2 stage, the Periotest values for all the teeth increased in comparison with those at T1 stage (Figure 1). The value for L1 was significantly larger than those for U1 ($P < .05$) and L2 ($P < .01$) (Table 1). The significant increases ($P < .01$) in the values were found for U2, L1, and L2. At T3 stage, the Periotest values significantly ($P < .01$) decreased compared with those at T2 stage (Figure 1). The mean value of L2 at T3 stage was significantly ($P < .01$) smaller than those of the remaining three teeth.

The mean Periotest values for the upper and lower incisors by sex were shown in Figure 2. The results show that the mean values were almost same in the male patients and female patients at T1 stage. At T2 and T3 stages, the mean values of the all teeth tended to be larger in female patients than those in male patients. Especially, L2 showed significantly larger values in female patients than in male patients at T2 stage ($P < .05$).

Comparing the extraction and nonextraction groups, the Periotest values at T3 stage were larger in the extraction group but not significantly more than in the nonextraction group. There were, however, no significant differences between the two subgroups at all the stages (Figure 3). Furthermore, the mean duration for treatment was longer in the extraction case (22.3 ± 6.0 months) than in the nonextraction case (19.8 ± 4.7 months).

Regarding the level of association between Periotest values at T1 stage and age, all the correlations for the teeth were negative, implying that the Periotest values decrease with age (Table 2). Especially the upper incisors showed significantly ($P < .01$) higher correlation coefficients with age. Regarding the durations of treatment and retention, a low level of correlation coefficients was detected for all the teeth implying no correlations between the change of tooth mobility and the durations of treatment and retention.

DISCUSSION Return to TOC

Various measuring devices with dial meters and strain gages have been used to investigate tooth mobility. In addition, techniques with laser holography and noncontact displacement sensors were developed.[4,6,7] These measuring systems enable us to obtain accurate values for tooth mobility by which the biomechanical properties of PDL can be calculated.[4] However, the systems involve a huge apparatus, and it is not easy for clinicians to apply them to many teeth of many patients. On the other hand, Periotest offers a simple and accurate method for clinically determining tooth mobility with a coefficient of variation of the measured value of 4.3% on average.[5] The measurements with the Periotest imply dynamic tooth mobility in nature, therefore, the quantity may be used for the evaluation of viscoelastic behavior of the periodontium.[8] Therefore, we performed the investigation of tooth mobility for orthodontic patients using the Periotest.

Even a healthy tooth with sufficient alveolar bone support and a tight PDL reveal proper tooth mobility. Such physiologic tooth mobility is a product of the elastic attachment of the PDL between root and alveolar bone.[5] According to previous reports,[9–12] the tooth mobility of incisors with healthy surrounding tissues ranged from 5 to 10 on average by use of Periotest. In this study, the mean values at T1 stage were 10.8 for the upper central incisor, 10.4 for the upper lateral incisor, 9.3 for the lower central incisor, and 7.4 for the lower lateral incisor, which were larger than the mean values in the healthy permanent incisors.[9,10,12] The possible explanation for this difference of tooth mobility is that abnormal occlusal contact associated with tooth crowding may gradually induce the loss of supporting tissues for teeth. In fact, each tooth shows a different degree of loss of supporting tissues, which results in a large variation of the Periotest values even in an individual.

Our results showed negative correlations between the Periotest value and age, implying that tooth mobility decreases with age. The upper incisors especially showed significantly high correlation coefficients with age. In younger patients, a decrease in the Periotest values with age could be expected, and this finding in our results are fully consistent with the results of Mackie et al[10] for healthy children. The decreased Periotest values with age could be caused by root development and periodontal maturation, which occur as more and more periodontal fibers become attached to the root and bony socket, and thus the periodontium becomes more resilient to external forces.[10]

It is generally known that root resorption occurs sometimes during orthodontic treatment. Furthermore, the relevance of root resorption becomes higher when the treatment duration becomes longer.[13,14] In this study, although severe apical root resorption could not be detected, slight or mild root resorption was found in a few patients through the treatment. External apical root resorption varies between patients and between different teeth in the same person. In our result, although there was an increase of 10–50% in the Periotest values from T1 to T2 stages, a significant correlation was not found between the change of the values and the treatment period. It is well known that the PDL is considerably widened in the secondary period of tooth movement, resulting in the increase of tooth mobility.[1] Considering the present results, it is demonstrated that the increase in tooth mobility occurs in the early stage of the secondary period, and the level of tooth mobility is kept constant through the orthodontic treatment because of bone remodeling and PDL regeneration.

In the orthodontic clinic, relapse after treatment is the most complicated problem encountered. Relapse can be defined as the general tendency of teeth to migrate back in the direction of their original position after orthodontic movement, and its cause is largely unknown.[15] In addition, the necessary period for retention is not clear, and we have not yet had any useful indicator to determine the retention period, as noted by Watted et al.[16] In the present results, the retention period was 27.9 months on average, and the Periotest values at T3 were smaller than those at T1 for all the teeth except for L1. In addition, there was no significant correlation coefficient between the changing ratio of tooth mobility during T2 to T3 and retention period. That is, the tooth mobility might reach a steady level by the T3 stage. In fact, almost all patients followed in this study maintained an acceptable occlusion without relapse after retention (data not shown).

CONCLUSIONS Return to TOC

These findings indicate that this retention period may be considered sufficient for the periodontal tissue to be restored to a physiologic state after orthodontic tooth movement and that to compare the Periotest values before treatment and after retention may be one useful indicator for determination of the duration of the retention period.

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TABLES Return to TOC

TABLE 1. Means and Standard Deviations of Periotest Values (n = 83)

Tooth	T1 Stage	T2 Stage	T3 Stage
U1			
Left	10.6 ± 3.3	11.5 ± 3.8	9.7 ± 3.5
Right	11.1 ± 3.5	11.5 ± 3.6	9.5 ± 3.8
Average[a]	10.8 ± 3.2	11.5 ± 3.4	9.6 ± 3.5
U2			
Left	10.5 ± 2.9	12.1 ± 4.3	9.3 ± 3.1
Right	10.3 ± 3.1	12.1 ± 3.5	8.6 ± 3.2
Average[a]	10.4 ± 2.8	12.1 ± 3.5	8.9 ± 2.9
L1			
Left	9.3 ± 3.1	12.6 ± 4.3	9.5 ± 3.9
Right	9.4 ± 3.6	13.6 ± 4.0	9.6 ± 3.7
Average[a]	9.3 ± 2.8	13.1 ± 3.8	9.6 ± 3.6
L2			
Left	7.5 ± 2.5	10.3 ± 4.2	7.0 ± 3.5
Right	7.3 ± 2.7	11.0 ± 3.2	7.3 ± 3.3
Average[a]	7.4 ± 2.4	10.6 ± 3.3	7.1 ± 3.1

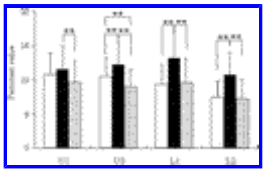
[a] Not significantly different between the means of the right and left sides.
* $P < .05$.
** $P < .01$.

TABLE 2. Correlation Coefficient between Periotest Values at T1 Stage vs Age, T2/T1 Ratio vs Treatment Duration, and T3/T2 Ratio vs Retention Duration

Tooth	Age	Treatment Duration	Retention Duration
U1	−.744**	−.097	.015
U2	−.619**	−.170	.108
L1	−.238	.024	.190
L2	−.316	.057	.084

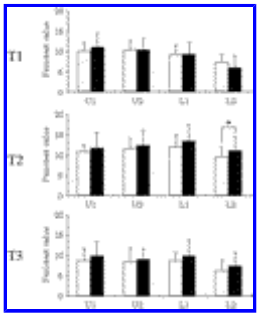
** $P < .01$.

FIGURES Return to TOC



Click on thumbnail for full-sized image.

FIGURE 1. Means and standard deviations of Periotest values at T1, T2, and T3 stages. Error bars indicate standard deviations. Asterisks: significance of differences between the stages (** $P < .01$) as tested with Scheffés test. □: T1 stage; ■: T2 stage; ▒: T3 stage



Click on thumbnail for full-sized image.

FIGURE 2. The Periotest values for all the upper and lower incisors by sex. Asterisk: significance of differences between the groups (* P

< .05) as tested with Scheffés test. □: Male patient; ■: Female patient

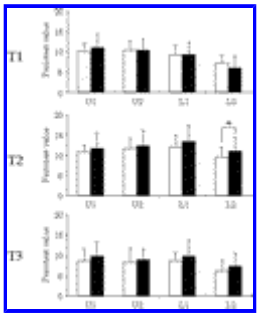


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FIGURE 3. Comparison between the Periotest values of extraction case and nonextraction case for all the upper and lower incisors. □: Extraction case; ■: Nonextraction case

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