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Relationship between initial crowding and interproximal force during retention phase

Kumiko Okazaki

Division of Applied Oral Sciences, Nihon University Graduate School of Dentistry, Tokyo, Japan

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Abstract: This study investigated the change in interproximal force (IPF) in mandibular anterior teeth during retention and the relationship between the irregularity index before orthodontic treatment and the IPF. The effect that an erupting third molar had on IPF was also examined. Forty treated patients (40 with extraction of four bicuspids) were followed for 18 months during the retention phase. The irregularity index was determined from initial plaster casts. The total IPF was determined by measuring the interdental frictional forces at the mandibular anterior teeth by withdrawing a metal strip. The total IPF increased during the retention phase until 18 months, and there was a positive correlation between the irregularity index and total IPF 6 to 18 months after active treatment. An erupting third molar did not affect the total IPF. An increase in the total IPF may be an indication of relapse in mandibular anterior crowding. In conclusion, orthodontists should pay special attention to potential relapse in the lower anterior teeth 6 months after active treatment in cases with severe anterior crowding before treatment. (J Oral Sci 52, 197-201, 2010)

Keywords: retention; irregularity index; interproximal force; crowding; stability.

Correspondence to Dr. Kumiko Okazaki, Department of Orthodontics, Nihon University School of Dentistry, 1-8-13 Kanda-Surugadai, Chiyoda-ku, Tokyo 101-8310, Japan
Tel: +81-3-3219-8105
Fax: +81-3-3219-8312
E-mail: ohashi-km@dent.nihon-u.ac.jp

Introduction

Long-term stability of tooth alignment is an important concern of orthodontists. However, Little (1) reported that only 10% of patients have clinically acceptable long-term results when the mandibular arch is expanded laterally. Kuijpers-Jagtman (2) investigated the long-term stability of orthodontic treatment for 10 years after the retention phase and showed that nearly 50% of the total relapse occurred within the first 2 years after retention.

Kahl-Nieke et al. (3) reported that, for mandibular anterior teeth exhibiting a large degree of crowding before orthodontic treatment, relapse readily occurred. Southard et al. (4) found that contact point displacement of the mandibular anterior teeth was related to the interproximal force (IPF) at the premolar, several years after finishing active treatment as well as with no orthodontic treatment. Furthermore, Southard et al. (5) suggested that IPF may help to explain crowding of the mandibular anterior teeth after the retention phase. Acar et al. (6) reported that the IPF during occlusion is related to the mandibular anterior irregularity index after retention. These studies indicate a clear relationship between the IPF and a lower anterior irregularity index or crowding. Although these studies describe the relationship between apparent mandibular anterior crowding and the IPF, they did not investigate when the risk for relapse increased. It is important to know when the risk for relapse of the crowding of mandibular anterior teeth increases.

Richardson et al. (7) suggested that the growth of third molars is the cause of late lower arch crowding. Conversely, Björk et al. (8) found no clear evidence that crowding was caused by the eruption of third molars. Consequently, it is controversial whether the third molar causes mandibular anterior crowding.

This study investigated the change in the IPF of mandibular anterior teeth during the retention phase, the relationship between the irregularity index before orthodontic treatment and the total IPF, and the effect of erupting third molars that do or do not touch the second molars on the total IPF.

Materials and Methods

The subjects were 40 patients (4 males and 36 females) who underwent orthodontic treatment with edgewise appliances at the Department of Orthodontics of Nihon University Dental Hospital, Tokyo, Japan. Subjects were selected using the following criteria. Subjects had overbite of 0.5 to 4.0 mm, overjet of 1.0 to 4.0 mm, or crowding of 0.5 to 10.0 mm in their lower anterior teeth before orthodontic treatment and had not undergone jaw surgery. After the active phase of orthodontic treatment, the subjects had a Frankfurt-mandibular plane angle (FMA) of 20-40°, an ANB angle of 0-6°, and no slendering or restoration of the lower anterior teeth. All subjects wore wrap around Hawley-type retainers. In 40 subjects, all four premolars were extracted (first and second premolar combinations). Their ages were 13 to 42 years (average age, 23.9) when the retention phase started. This study was approved by the ethics committee of Nihon University School of Dentistry.

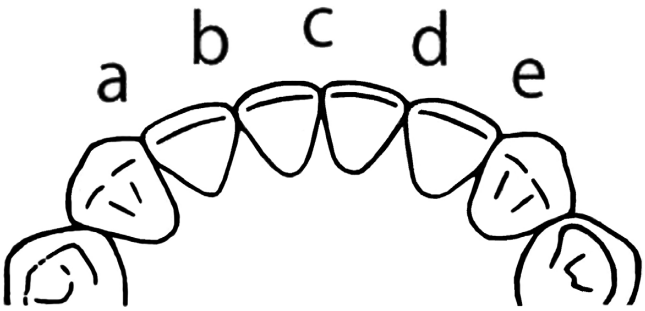

Fig. 1 The five contact points used for measuring the total interproximal force (IPF).

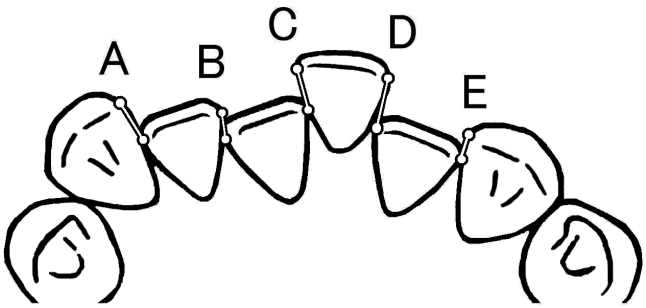

Fig. 2 The irregularity index was calculated by summing the liner distances between anatomic contact points of adjacent teeth at five mandibular anterior contact points on plaster casts made before orthodontic treatment. Irregularity Index = A + B + C + D + E.

The IPF was measured using the method described by Southard et al. (5) with minor changes. Thirty-μm-thick titanium strips (3 × 25 mm; Takeuchi Metal Foil and Powder, Tokyo, Japan) were used instead of the 50-μm-thick strips used by Southard et al. (5), because IPF measurement using a 30-μm-thick titanium strip was found to be the most stable (least variability in three times measurement) with less patient pain in a pilot study that compared 5-, 10-, 20-, 30-, 40-, and 50-μm-thick titanium strips. For the measurement, the patient sat in an upright position in a chair, with his or her head resting on the back of the chair and the mouth open with the mandibular occlusal plane parallel to the floor. A 30-μm-thick titanium strip was placed in the interproximal space of the mandibular anterior teeth and was withdrawn using the hook of a digital force gauge (DPS-5; Imada, Tokyo, Japan) at 10 mm/second. Five contact points (a to e) in the mandibular anterior teeth were measured (Fig. 1).

Each measurement was taken three times and averaged. The average values for all five contact points (a, b, c, d, and e) were added, and the sum was defined as the total IPF for each subject. The force was measured during each visit to the hospital until 18 months after active treatment.

The deviations of the anatomic contact points between adjacent teeth (A to E) were measured on plaster casts at the initial visit, and their sum was defined as the irregularity index (Fig. 2).

To determine whether a lower wisdom tooth influenced the withdrawal force, the total IPF during the period from 6 to 12 months after active treatment was compared between subjects with mandibular impacted third molars that had incomplete tooth roots in contact with the second molar (contact group) and other subjects (with complete tooth roots with or without contact with second molar and with no third molars) (no-contact group). These positions were confirmed by panoramic and lateral cephalometric radiography.

The total IPF was analyzed for the periods 0-3, 3-6, 6-12, and 12-18 months after beginning the retention phase. One-way analysis of variance (ANOVA) was used to evaluate the change in total IPF. Intergroup comparisons of total IPF were performed using the Tukey-Kramer honestly significant difference test. The level of significance was set at 5%. Correlation analysis was used to assess the relationship between the total IPF and the irregularity index. An unpaired *t*-test was used to evaluate differences

between the contact and no-contact groups.

Results

The total IPF in each period is shown in Fig. 3. The total IPF increased until 18 months after active treatment, in a time-dependent manner ($P < 0.05$ by one-way ANOVA; Fig. 3). The total IPF at 0-3 months was significantly lower than the values at 6-12 ($P < 0.05$) and 12-18 ($P < 0.01$) months. The total IPF at 3-6 months was significantly lower than that at 12-18 months ($P < 0.05$). No significant differences in the total IPF were found between 0-3 and 3-6 months or between 6-12 and 12-18 months.

A mean value of the irregularity index was 8.21 mm (SD 4.46, minimum 0.44, maximum 19.32). The correlations between the irregularity index and the total IPF are shown in Fig. 4 and Table 1. There was a positive correlation between the total IPF and the irregularity index in the retention phase at 6-12 (r = 0.40, $P < 0.05$) and 12-18 (r

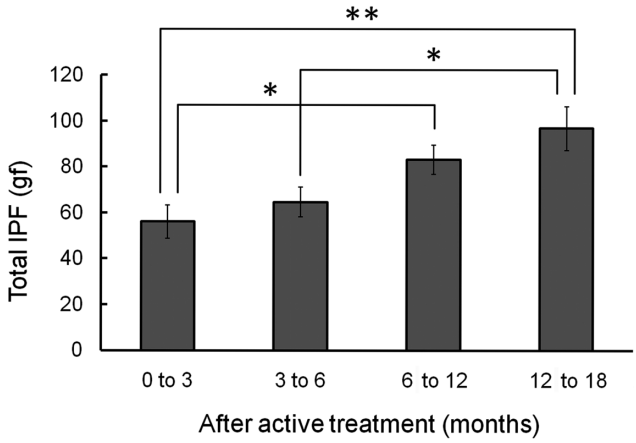

Fig. 3 The mean change in the total interproximal force (total IPF) during the retention phase, with standard error bars (40 patients).
The total IPF was assessed for four periods: 0 to 3, 3 to 6, 6 to 12 and 12 to 18 months after beginning retention. gf: gram force, * $P < 0.05$, ** $P < 0.01$.

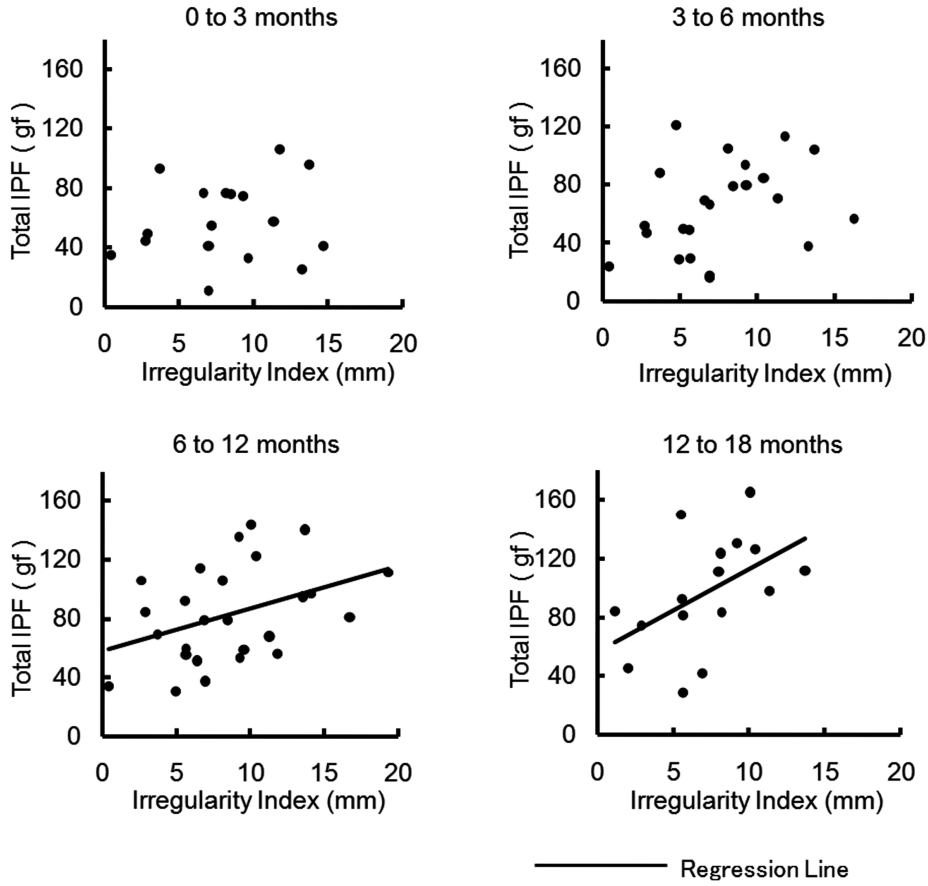

Fig. 4 Correlations between the irregularity index and the total interproximal force (total IPF). gf: gram force
The total IPF was assessed for four periods: 0 to 3, 3 to 6, 6 to 12 and 12 to 18 months after beginning retention. The horizontal axis is the irregularity index before orthodontic treatment, and the vertical axis is the total IPF during the retention phase.

Table 1 Correlations between the irregularity index before orthodontic treatment and the total interproximal force during retention

retention	*r*	*P* value	*n*
0 to 3 months	0.16	0.539	17
3 to 6 months	0.33	0.126	23
6 to 12 months	0.40	0.045 *	26
12 to 18 months	0.50	0.049 *	16

r: correlation coefficients * : $P < 0.05$

Table 2 Effect of the lower third molar completion rate on the total interproximal force (total IPF) during retention from 6 to 12 months

total IPF	condition of the lower third molar		*P* value
	contact group	no-contact group	
	n = 5	*n* = 21	
mean (gf)	91	81	0.928
SD	36.1	33.6	

= 0.50, $P < 0.05$) months.

The total IPF of subjects with a third molar having incomplete roots in contact with the second molar ranged from 50 to 143 gram force (gf) (mean, 91 gf), and the total IPF of the other subjects with complete tooth roots and missing the third molar ranged from 30 to 136 gf (mean, 81 gf); the difference was not significant (Table 2).

Discussion

Regarding the IPF, Southard et al. (9) reported that the IPF of subjects who had no orthodontic treatment was approximately 990 gf, measured using 38.1-μm metal strips. By contrast, the maximum total IPF during retention in this study was much less, 170 gf as measured using 30-μm metal strips. In this pilot study, the strip thickness and IPF were positively correlated for metal strips of 30-, 40-, and 50-μm thickness, with a three-fold increase of IPF when the strip thickness was changed from 30 to 40 μm (data not shown), which is similar to the four-fold increase found by Southard et al. (9) when the strip thickness was changed from 30 to 40 μm. Thus, strip thickness greatly influenced the value of IPF. When using 40- or 50-μm strips for the measurement, most subjects complained of discomfort; therefore, 30-μm metal strips were used for the measurement. Furthermore, because the subjects were being maintained with retainers and those of Southard et al. (9) were not undergoing orthodontic treatment, the total IPF in this study would be expected to be much less than that reported by Southard et al.

The total IPF increased in a time-dependent manner during the retention phase, from approximately 60 gf at the beginning of retention to approximately 100 gf 18 months later (Fig. 3). This increase was considered to be caused by the remodeling of alveolar bone and periodontal ligament. Tanaka et al. (10) stated that although tooth mobility increased during orthodontic treatment, there was no significant difference in tooth mobility between before orthodontic treatment and after 27.9 months of retention, because bone remodeling and periodontal ligament regeneration were completed post-retention. Thus in this study, the total IPF might have continued to increase for a further 10 months after this final total IPF measurement at 18 months.

The principal findings in this study were a positive correlation between the irregularity index and the total IPF during the retention phase, from 6 to 18 months. However, there was no correlation between the two parameters during the first 6 months of the retention phase. In previous studies of the relationship between the IPF and irregularity index, Southard et al. (4) found a positive correlation between the discrepancy of mesial contact points of the lower central incisors and the IPF in subjects several years after retention and in subjects who had no orthodontic treatment; Acar et al. (6) found a positive correlation between the lower anterior irregularity index and the IPF at the canine and first premolar contact points in subjects who had been out of retention for an average of 3.5 years. However, neither study determined the irregularity index before orthodontic treatment. This study focused on the anterior irregularity index at the initial visit and examined the relationship between the total IPF and the irregularity index to determine when the risk for relapse began to increase. Many studies have shown a strong correlation between initial lower anterior crowding and post-treatment relapse. For example, Kahl-Nieke et al. (3) found that in cases of marked mandibular anterior crowding before orthodontic treatment, mandibular anterior relapse readily occurred after retention. In addition, Canut et al. (11) reported that 83% of the subjects in a group with Class II division 2 malocclusions and initial severe crowding developed unacceptable lower irregularity after retention. O'Neill (12) reviewed many articles that indicated the reoccurrence of mandibular crowding of the lower anterior teeth after retention, despite initial successful dental alignment of the crowded teeth. Although the studies showed high risk for lower anterior relapse in the cases with severe initial crowding, they did not specify when the risk started. In the present study, patients who had a large

irregularity index before orthodontic treatment had greater total IPF during retention, from 6 to 18 months. Based on these results, it is likely that the risk for relapse of lower anterior crowding is higher when the total IPF is greater, i.e., an acute increase in the total IPF during the retention phase results in relapse of the lower anterior teeth. The correlation between the total IPF and the irregularity index was significant 6 to 18 months after active treatment. Therefore, it is important to closely assess retention after 6 months or more in cases with initial mandibular anterior crowding; in patients who do not comply with wearing a retainer, it is better to use a fixed retainer instead of a removable retainer.

Regarding the effect of the third molar on the lower anterior teeth, Vego (13) reported that the degree of crowding was significantly greater in patients with lower third molars than in those without lower third molars; they concluded that the erupting lower third molar exerts a force on adjacent teeth. There was no significant difference in the total IPF between contact group versus no-contact group. Southard et al. (14) measured the IPF of the sides on which third molars were extracted and were not extracted, concluding that there was no significant difference between them; there was also no correlation between the IPF and the stage of root development or length of third molars. Ades et al. (15) reported no significant difference in the crowding of mandibular incisors after retention among groups of subjects with erupted third molars, third molar agenesis, third molar impaction, and third molar extraction. The results in this study are consistent with these previous results, suggesting that the status of the lower third molar does not directly influence the total IPF.

In conclusion, these results demonstrated that an increase in the total IPF may indicate relapse in lower anterior crowding in the present study. And orthodontists should pay special attention to the possibility of relapse in the lower anterior teeth at 6 or more months after beginning the retention phase in cases with severe anterior crowding before treatment.

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