Original Article

A comparison of second premolar extraction and mini-implant total arch distalization with interproximal stripping

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ABSTRACT

Objective: The effect of total arch distalization using orthodontic mini-implants (OMIs) combined with interproximal stripping (IPS) and second premolar extraction was investigated in Class I malocclusion patients.

Materials and Methods: A total of 66 consecutively treated Class I malocclusion (Class I molar relationship; 0 mm $<$ overbite and overjet $<$ 4.5 mm) patients ranging in age from 17 to 44 years who received single-phase treatment were included in this study. Pre- and posttreatment lateral cephalograms and dental casts were measured and compared statistically.

Results: In the distalization with IPS group, 3.6 mm and 3.8 mm of crowding in the upper and lower arches, respectively, were resolved, and 3.8 mm and 3.2 mm of upper and lower incisor retraction, respectively, were achieved simultaneously by the treatment. As a result of the second premolar extraction treatment, 3.9 mm and 3.6 mm of crowding in the upper and lower arches, respectively, were resolved, and 3.3 mm and 3.2 mm of incisor retraction, respectively, were achieved during treatment. There was no statistically significant difference in the amount of crowding and incisor retraction between the two groups.

Conclusions: Total arch distalization using an OMI with IPS did not yield a significantly different treatment result compared to second premolar extraction treatment. (*Angle Orthod.* 2013;83:680–685.)

KEY WORDS: Orthodontic mini-implant; Stripping; Incisor retraction

INTRODUCTION

Although extractions have been used for a long time in orthodontic treatment, the extraction decision is still the most critical decision made by orthodontists when they are planning treatment.[1] In terms of orthodontic purposes, premolars are the most commonly extracted teeth.[2] Conveniently located between the anterior and posterior segments, premolar extractions would seem to allow for the most straightforward relief of crowding, the improvement of soft tissue profile, or the correction of an unacceptable interincisor relationship.[3,4]

It is generally accepted that there is a close relationship between the sum of the root surface area and the degree of anchorage. Therefore, the choice of teeth to be extracted would have a direct influence on the amount of incisor retraction. For instance, Creekmore[5] reported that when second premolars are extracted, one can expect the posterior teeth to move forward approximately half the extraction space, leaving the other half of the space for the relief of crowding and anterior teeth retraction. In Class I malocclusion patients, second premolar extraction is frequently used when there is mild to moderate crowding and/or mild protrusion.[6,7]

Orthodontic mini-implants (OMIs) are being used increasingly as an orthodontic anchorage source. The distal retraction of the entire dentition using OMIs was recently introduced and yielded good treatment results.[8,9] Distal force is usually applied to the canines or anterior hooks are attached to the main archwire by OMIs placed in the posterior region of the buccal alveolar bone. Recent research[10] showed that total arch distalization can simultaneously retract the upper incisor 2.62 mm and resolve up to 2.06 mm in arch length discrepancy (ALD) in the maxilla.

Interproximal stripping (IPS) consists of the removal of interproximal enamel to correct crowding. Studies have shown that a minimum of 7 mm of space can be

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Table 1. Comparison of Age, Irregularity Index (II), Arch Length Discrepancy (ALD), and Treatment Time Between Groups[a]

	Group 1		Group 2		
Parameters	Mean	SD	Mean	SD	Significance
Age, y	28.3	8.4	24.4	5.6	*
II Mx, mm	4.0	2.1	4.9	3.1	NS
II Mn, mm	4.2	2.9	4.2	2.3	NS
ALD Mx, mm	3.6	1.3	3.9	2.1	NS
ALD Mn, mm	3.8	2.1	3.6	1.7	NS
Treatment time, mo	20.5	4.5	24.0	6.7	*

SD, standard deviation. II, irregularity index; ALD, arch length discrepancy; [a] Independent *t*-test between groups 1 and 2; Mx, maxilla; Mn, mandible; NS indicates not significant; * $P < .05$.

created with a 50% reduction in the enamel thickness of the premolars and the first molars,[11] with an additional gain of 2.5 mm if the anterior dentition is also included.[12]

Total arch distalization performed using OMIs and IPS together to treat patients with crowding and protrusion appears to extend the limit of nonextraction treatment. This study was undertaken to determine and compare the anterior-posterior dental changes in a group of patients with mild to moderate crowding and an Angle Class I relationship treated with second premolar extraction and total arch distalization with IPS.

MATERIALS AND METHODS

This prospective clinical trial was approved by the Seoul National University Dental Hospital Institutional Review Board. Class I malocclusion patients (Class I molar relationship, 0 mm < overbite and overjet < 4.5 mm) who showed a mild to moderate degree of ALD and/or mild dental protrusion and who started treatment in 2009 were used in this study (Tables 1 and 2).

Table 2. Comparison of Pretreatment Cephalometric Variables of Groups 1 and 2[a]

	Group 1		Group 2		
	Mean	SD	Mean	SD	Significance
Björk Sum, °	393.6	7.5	398.7	5.0	NS
Facial height ratio, %	64.8	4.5	61.5	3.8	NS
ANB, °	3.4	2.2	2.6	1.9	NS
A to N perp, mm	0.3	2.7	−1.1	3.6	NS
Pog to N perp, mm	−4.0	6.6	−5.8	7.0	NS
U1 to FH, °	119.3	6.4	116.4	5.6	NS
L1 to Apog, °	5.7	2.6	7.2	1.8	*
IMPA, °	96.8	7.0	93.8	6.2	NS
Interincisal angle, °	117.4	9.3	119.9	5.7	NS
Nasolabial angle, °	95.9	6.6	95.4	10.0	NS
Upper lip to EL, mm	−0.2	2.0	0.1	1.6	NS
Lower lip to EL, mm	1.3	2.1	2.1	1.9	NS

[a] Independent *t*-test between groups 1 and 2; NS indicates not significant; * $P < .05$. perp indicates perpendicular; EL, esthetic line; and SD, standard deviation.

Before starting this clinical trial, 20 previously treated cases using total arch distalization with IPS and second premolar extraction (10 cases each from two orthodontic clinics, which will be described later) that showed a moderate degree of ALD (3 mm << 5 mm) were evaluated cephalometrically. The size of the samples for the study was estimated on the basis of the standard deviations (SDs) of the changes in maxillary and mandibular incisor position from this pilot study. This calculation showed that 23 patients in each group were needed, with a power of 80%, based on an α significance level of .05 and a β significance level of .1.

Records of 34 consecutively treated patients (seven males and 27 females) who started their treatment with total arch distalization with IPS by an experienced orthodontist with preadjusted edgewise appliances were included as group 1. During that period, no patient was treated by second premolar extraction in this clinic.

Thirty-two second premolar extraction cases (group 2: six males and 26 females) consecutively treated by another experienced orthodontist with preadjusted appliances were also included. During this period, no patient was treated by total arch distalization with IPS in this clinic.

Since the two practitioners were located in the same geographic area, the cost of treatment was similar. Both practitioners obtained their orthodontic training at the same university hospital, both use 0.022-inch slot edgewise brackets from the same company with MBT prescription, both prefer to use sliding mechanics, and the entry diagnostic criteria were similar.

The inclusion criteria were as follows:

- Patients underwent single-phase treatment with fixed appliances. All patients had erupted second molars in both arches, and brackets were bonded to them at the beginning of treatment. They did not show a severe degree of ALD (>6.0 mm) or severe lip protrusion (upper lip to esthetic line > 3.5 mm or lower lip to esthetic line > 5 mm; greater than 2 SD of Korean norm[13]), which requires first premolar extraction treatment.
- Patients with impacted canines, supernumerary or missing teeth, facial asymmetry, craniofacial anomalies, or interdental spacing were excluded. Males under 18 years of age and females under the age of 17 years were also excluded to minimize the effect of jaw growth on dental change.
- Those patients who had any adjunctive appliances, such as headgear, transpalatal arch, functional appliance, or rapid palatal expander, were also excluded. Interarch elastics were used as necessary. In the extraction group, no OMI was used.

The age at commencement, the duration of active treatment, Little's irregularity index, and the ALD (Hays-Nance analysis) for each group are shown in Table 1. The patients in group 2 were younger, but the irregularity index and ALD did not show significant difference between groups. All of the posttreatment dental casts showed good alignment (irregularity index $<$ 1.0 mm). Initial ALD was considered as the improved amount of crowding during treatment.

In group 1, all of the OMIs (Mplant U1 and U2, Biomaterials Korea Inc, Seoul, Korea) were placed by one operator, and most of the OMIs were placed between the root of the second premolar and the first molar with a 30–45° insertion angle to maximize the amount of distalization during the initial leveling stage. The patients who required OMIs in one jaw only or in another region, such as the anterior alveolar bone for intrusion, were excluded.

Four patients experienced loosening of one OMI within the first 2 months, and replacements were made after 6 weeks. The Mplant U1 (diameter of 1.5 mm, length of 6.1 mm) was used in the lower arch, and the Mplant U2 (diameter of 1.5 mm, length of 7.1 mm) was used in the upper arch. Distal movement procedures were performed as described previously.[10] The working archwire used during total arch distalization was made of 0.019 $\times$ 0.025–inch stainless steel.

IPS was usually performed during the initial leveling stage. A rubber separation ring was placed for 2 weeks before IPS. After removal of the separation ring, a new diamond-coated stripping disk (Komet 6911H, Brasseler, Lemgo, Germany; Superflex 355-514-160, Edenta, Austenau, Austria) was mounted on a straight-angle handpiece, and the enamel reduction was done. A diamond-coated strip (Steelcarbo Strip, Hopf, Ringleb & Co, Berlin, Germany) was also used when needed. Cone-shaped triangular diamond burs (Komet 8833, Brasseler) and Sof-Lex disks (3M, St Paul, Minn) were used for rounding off the corners and polishing. The amount of IPS was usually 0.2–0.3 mm per tooth surface, but in some patients additional IPS was done because of the patient's original Bolton ratio discrepancy, abnormal shape or size of a specific tooth, or difficulties in acquiring an adequate amount of distalization. Topical fluoride treatment was applied after the IPS procedure. In group 2, anterior teeth were retracted en masse with sliding mechanics using elastomeric chains. The working wire used during retraction was made of 0.019 $\times$ 0.025–inch stainless steel.

All cephalograms were traced and digitized by one investigator, and cephalometric values were calculated using the V-ceph program (Cybermed, Seoul, Korea). The extent of incisor and molar movement was determined by measuring the perpendicular distance from the Frankfort horizontal plane (Figure 1).[15] The angulation of the upper incisor (U1 to FH plane) and lower incisor (IMPA) was also measured.

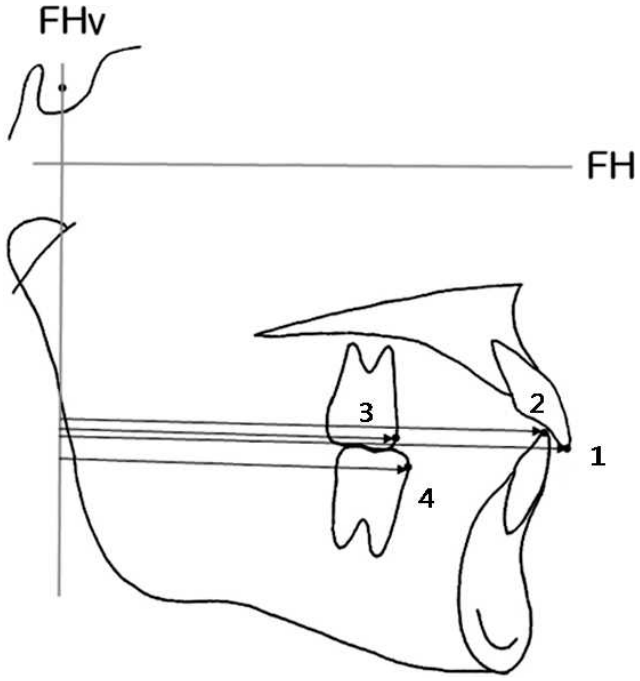

Figure 1. Cephalometric reference lines and measurements used for evaluating anterior-posterior dental changes. FH indicates Frankfort horizontal plane; FHv, vertical reference plane on the sella vertical to the FH plane: 1, FHv to the upper incisal tip; 2, FHv to the lower incisal tip; 3, FHv to the upper molar; and 4, FHv to the lower molar.

Before the data analysis, 30 randomly selected cephalograms were retraced and measured twice 2 weeks apart, and the measurement error was calculated by Dahlberg's formula.[16] The error ranged between 0.2 mm and 0.6 mm for the linear measurements and between 0.4° and 1.0° for the angular measurements. Pretreatment cephalometric variables and the extent of treatment changes were compared between the two groups. Although the lateral cephalograms of two groups were taken using different imaging systems, the magnification values were the same: 10% enlargement factor.

All statistical analyses were conducted with SPSS software (version 17.0, SPSS, Chicago, Ill). The Shapiro-Wilk test confirmed that all of the variables followed a normal distribution, so the variables were compared using independent *t*-tests. The level of significance for all tests was set at $\alpha = .05$.

RESULTS

Evaluation of pretreatment cephalometric variables showed that there was no significant difference in skeletal or dental measurements except for the lower incisor to A Pogonion (Table 2). The treatment changes are shown in Tables 3 and 4.

Table 3. Treatment Changes of the Cephalometric Variables[a]

	Group 1		Group 2		
	Mean	SD	Mean	SD	Significance
Björk Sum, °	−0.6	1.1	−0.3	1.3	NS
Facial height ratio, %	0.4	0.8	0.3	0.8	NS
ANB, °	−0.5	1.0	−0.6	1.0	NS
A to N perp, mm	−0.9	2.0	−0.9	1.6	NS
Pog to N perp, mm	0.2	2.4	−0.1	2.0	NS
U1 to FH, °	−6.9	4.7	−4.8	5.0	NS
L1 to Apog, °	−2.4	1.7	−2.8	2.0	NS
IMPA, °	−4.8	3.5	−3.6	5.6	NS
Interincisal angle, °	10.3	7.1	8.0	7.0	NS
Nasolabial angle, °	5.2	3.2	6.0	6.5	NS
Upper lip to EL, mm	−1.7	0.9	−1.9	1.0	NS
Lower lip to EL, mm	−2.0	1.3	−2.8	1.1	NS

[a] Independent *t*-test between groups 1 and 2; NS indicates not significant; perp, perpendicular; EL, esthetic line; and SD, standard deviation.

In group 1, 3.6 mm and 3.8 mm of crowding in the upper and lower arches, respectively, were resolved, and 3.8 mm and 3.2 mm of upper and lower incisor retraction, respectively, were achieved simultaneously by the treatment. The upper incisal angulation (U1 to FH) decreased by 6.9°. The first molar was retracted 2.2 mm in the upper arch and 2.1 mm in the lower arch.

The second premolar extraction treatment yielded 3.9 mm and 3.6 mm of crowding resolution in the upper and lower arches, respectively, in addition to 3.3 mm and 3.2 mm of upper and lower incisor retraction, respectively. The upper and lower first molars moved forward 3.2 mm and 3.3 mm, respectively. The skeletal and dental treatment changes did not differ significantly between groups except in terms of the amount of molar movement.

DISCUSSION

The amount of crowding and protrusion are major factors influencing the decision of whether to extract teeth as part of orthodontic treatment,[16,17] and the decision to extract four second premolars was often made in cases involving mild crowding and mild dental protrusion.[18,19] However, there is little scientific information available to facilitate an accurate prediction of extraction space distribution, and controversy surrounds the distances of incisor and molar movement in second premolar extraction treatment. Some authors[14] reported little incisor change and that nearly the entire extraction space was taken up by molars, while others[20] found that the incisors were retracted remarkably, by even as much as 4.2 mm. Underlying these inconsistent data are considerable differences in pretreatment characteristics, including crowding severity, skeletal pattern, and age, that can result in a wide range of variation in the extent of tooth movement. In cases with severe crowding, most of the extraction space would be used to resolve crowding, and then the extent of incisor retraction would be affected by the amount of residual space. Moreover, the anterior-posterior movement of dentition differs in Class I cases compared to Class II or Class III malocclusion cases. In addition to affecting cephalometric measurements through jaw growth, age is also related to the availability of the second molar as an anchorage mechanism. Most studies[14,18,20] of second premolar extraction included patients who were 11–13 years of age, and it would be difficult to use second molars for anchorage during retraction in patients within this age range.

Table 4. Incisor and Molar Change by the Treatment[a]

	Group 1		Group 2		
	Mean	SD	Mean	SD	Significance
FHv to U1, mm	−3.8	2.1	−3.3	2.0	NS
FHv to L1, mm	−3.2	1.8	−3.2	1.8	NS
FHv to U6, mm	−2.2	1.2	3.2	1.3	**
FHv to L6, mm	−2.1	1.4	3.3	1.3	**

[a] Independent *t*-test between groups 1 and 2; NS indicates not significant; ** $P < .01$.

The mean changes in the anteroposterior position of the incisors in both groups in this study were similar to or greater than the second premolar extraction treatment in previous studies.[18–21] In the present sample, there was a mean maxillary incisor retraction of 3.8 ± 2.1 mm in group 1 and of 3.3 ± 2.0 mm in group 2, with 3.6 mm and 3.9 mm relief of crowding, respectively. The greater change in incisor position as a result of second premolar extraction treatment in this study seems to be related to the inclusion of second molars as anchorage sites during space closure.

The distalization and IPS treatment seems to offer a good alternative to second premolar extraction treatment for several reasons. First, patients or parents usually feel more comfortable with the IPS and OMI option because it does not require extraction, and the distalization with IPS approach facilitates easy adjustment of the extent of incisor retraction during treatment. If the patient's profile still shows lip protrusion after a certain period of treatment and if there is still room for distalization or more IPS, further incisor retraction can be achieved. Thus, the extent of incisor retraction reported in this study likely does not represent the maximum overall change that can be accomplished via total distalization with IPS treatment.

Additionally, the distalization treatment is advantageous compared to extraction therapy in that treatment time is often reduced, since the space gained by enamel removal and molar movement corresponds exactly to the extent of crowding and required incisor retraction. In this study, treatment time in the distalization group was shorter (20.5 months) than that in the second premolar extraction group (24.0 months).

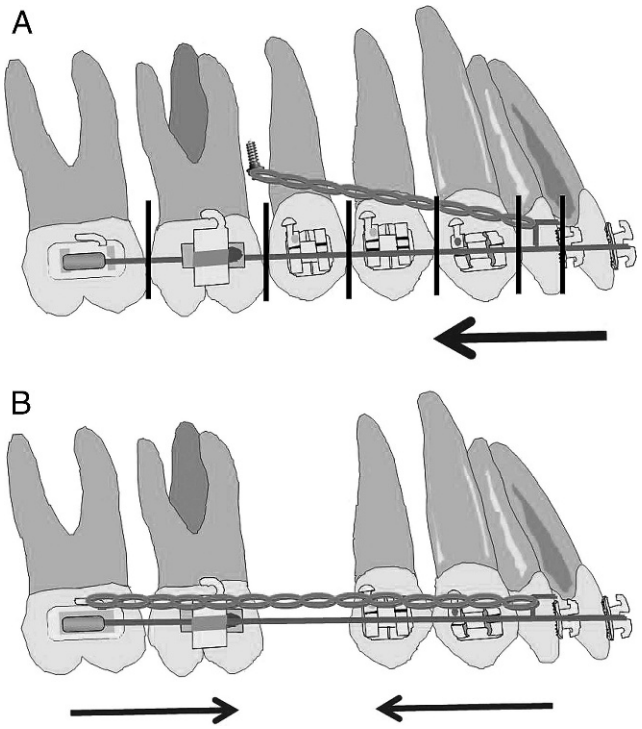

Figure 2. Schematics showing different types of space closure in this study. (A) In group 1, the effects of IPS and total arch distalization using OMIs were synergistic in incisor positional change. (B) In group 2, the anterior and posterior teeth moved reciprocally during the space closure.

The main purpose of IPS is relief of crowding. If OMIs are used with IPS, the space made by IPS can be used more effectively for incisor retraction, as shown in Figure 2. The average amount of upper molar distalization in group 1 was 2.2 mm, and the average amount of upper incisor retraction was 3.8 mm. That means that after resolving the 3.3 mm of crowding, the space gained by IPS enabled the upper incisor to move posteriorly. Thus, the effect of OMI and IPS can be synergistic in cases of mild to moderate arch length discrepancy with protrusion.

At present, most authors suggest that the maximum amount of IPS without jeopardizing health is generally about 0.3 to 0.5 mm per tooth surface,[22] or up to 50% of the enamel thickness,[12] and some researchers[23] have even demonstrated that, using the proper technique, the entire enamel layer can be ground down without side effects. However, such extensive IPS requires a great deal of experience. The typical amount of IPS in this study was 0.2 to 0.3 mm per tooth surface, and IPS was performed from the incisors to the first molars. IPS of 0.2 mm per tooth surface in the incisor surface and 0.3 mm per tooth surface in the canine and premolars would produce 5.2 mm of space, which would be sufficient to relieve a mild to moderate degree of crowding. Previous research[24] showed that 5.0 mm (maxilla) and 5.9 mm (mandible) of crowding was relieved with 0.7 mm (maxilla) and 1.4 mm (mandible) of incisor protrusion, respectively, in IPS treatment.

In recent computed tomography imaging studies,[25,26] the average amount of mesiodistal bone between adjacent roots buccally was found to be less than 3.3 mm between the first molar and second premolar, which was the largest average interradicular space, when the OMI was placed 5–7 mm from the crestal bone or cementoenamel junction (CEJ). Thus, if we consider that the typical diameter of an OMI is approximately 1.2–2.0 mm, the potential extent of molar distalization is minimal, even if tipping and occlusal plane rotation contribute to the need for additional distalization of the upper dentition.[9] To maximize the amount of distalization, the OMIs were inserted at the angle of 30–45° to the alveolar bone in this study. IPS or total arch distalization using OMI is less effective than premolar extraction treatment in crowding and protrusion relief, but it seems that their effect can be synergistic when they are used together.

CONCLUSIONS

- There was a mean maxillary incisor retraction of 3.8 mm in the distalization with IPS group and 3.3 mm in the second premolar extraction group, with 3.6 mm and 3.9 mm relief of the maxillary arch length discrepancy, respectively. The mean mandibular incisor retraction was 3.2 mm, and the amount of crowding relief in the mandible was 4.2 mm in both groups.
- There was no significant difference in the treatment result between the total arch distalization using OMI with IPS and second premolar extraction treatment.

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