Original Article

Periodontal consequences of mandibular incisor proclination during presurgical orthodontic treatment in Class III malocclusion patients

Yoon Jeong Choi[a]; Chooryung J. Chung[b]; Kyung-Ho Kim[c]

ABSTRACT

Objective: To test the hypothesis that periodontal changes are similar between proclined and minimal-changed mandibular incisor position groups during presurgical orthodontic treatment for Class III orthognathic surgery.

Materials and Methods: The following measurements were performed before and after presurgical orthodontic treatment of 75 patients (proclination group, 39 subjects; minimal-change group, 36 subjects): clinical crown length, sulcus and bone probing depths, and width of attached gingiva from clinical examination; infradentale-to-MP (perpendicular distance of infradentale to mandibular plane) from examination of lateral cephalograms; and the distance between the cementoenamel junction and alveolar crest from examination of periapical radiographs. Data were compared between the two groups, and a regression analysis was performed to investigate factors affecting the periodontal changes.

Results: In both groups, clinical crown length and bone probing depth increased during presurgical orthodontics ($P < .05$). Infradentale-to-MP and the width of attached gingiva decreased more in the proclination group than in the minimal-change group ($P < .05$). Proclination and protrusion of the mandibular incisors, and treatment duration affected the periodontal changes.

Conclusions: The null hypothesis was rejected. Proclination of the mandibular incisors for decompensation in Class III surgery patients seems to result in labial alveolar bone recession and a decrease in width of attached gingiva. However, the amount of the periodontal recession appeared to be clinically insignificant. (*Angle Orthod.* 2015;85:427–433.)

KEY WORDS: Periodontal tissue change; Class III malocclusion; Orthodontic treatment; Mandibular incisor proclination

INTRODUCTION

In skeletal Class III cases in which orthognathic surgery is planned, presurgical orthodontic treatment is necessary for dental decompensation and arch coordination. Mandibular incisors that are tipped lingually due to dental compensation need to be flared labially, which may lead to periodontal recession. Although the precise mechanism by which orthodontic treatment affects the occurrence of recession remains unclear, it has been assumed that lower incisor proclination contributes to the development of bone dehiscences and subsequent gingival recession.[1–3]

On the contrary, some studies have demonstrated the lack of such an association between orthodontic labial movement and periodontal recession[4–6]; the clinical relevance of the relationship was negligible[4] or there was no relationship between the amount of incisor proclination and gingival recession.[6] As documented in previous studies, reports on periodontal tissue response following lower incisor proclination are conflicting, possibly due to the variety of orthodontic mechanics used, differences in postoperative follow-up, total amounts of proclination, and differences in final inclination of the mandibular incisors.[7]

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Table 1. Demographic Description of Subjects[a]

	Proclination (n = 39)		Minimal Change (n = 36)		
	Mean	SD	Mean	SD	*P* Value
Age, y	22.1	4.2	21.3	2.9	.357
Duration, mo	13.6	6.8	13.1	6.4	.741
SNA, degrees	81.1	3.3	81.1	4.1	.988
SNB, degrees	84.2	4.2	83.0	4.1	.234
ANB, degrees	−3.1	3.4	−1.9	2.9	.110
SN-GoMe, degrees	35.3	5.6	35.7	6.3	.745
Gonial angle, degrees	125.3	6.6	126.4	7.2	.524
IMPA, degrees	74.3	6.0	86.7	7.8	.000**
L1FP, mm	3.3	2.5	5.7	2.8	.000**
L1MP, mm	43.1	4.0	45.4	3.5	.012*
Infradentale-to-MP, mm	32.8	3.4	34.5	3.3	.032*
CEJ-AC, mm	1.7	0.6	1.5	0.5	.496
Clinical crown length, mm	8.4	0.8	8.5	0.8	.548
Sulcus probing depth, mm	1.7	0.6	1.7	0.4	.621
Bone probing depth, mm	2.9	0.6	3.0	0.5	.266
Width of attached gingiva, mm	3.1	1.4	2.7	0.8	.187

[a] IMPA indicates angle of mandibular incisor long axis to the mandibular plane; L1FP, horizontal perpendicular distance of the mandibular incisor tip to the facial plane; L1MP, vertical perpendicular distance of the mandibular incisor tip to the mandibular plane; infradentale-to-MP, perpendicular distance from infradentale to the mandibular plane; CEJ, cementoenamel junction; and AC, alveolar crest.

* $P < .05$; ** $P < .01$.

However, previous studies were mostly performed in skeletal Class II subjects or under conditions in which the mandibular incisors were proclined to improve the incisal relationship for dental compensation. The periodontal tissue response of Class III patients, which has been hardly reported, may be different from that of Class II patients in that the lingually tipped incisors move to the normal range in Class III patients, while the incisors move labially past the normal range in Class II patients. In a study regarding Class III patients, gingival recession seemed to be inevitable, especially in patients with thin alveolar housing.[8] As Class III patients with normodivergent or hyperdivergent profiles tend to have thinner mandibular anterior alveolar bone than Class I or II patients with similar vertical patterns,[9] recession is likely to occur more frequently in Class III patients with normodivergent or hyperdivergent profiles. Because the previous study examined gingival recession before and after orthodontic treatment,[8] it is uncertain how alveolar bone changed and whether the recession occurred during presurgical orthodontic treatment (in which proclination of the mandibular incisors takes place) or throughout orthodontic treatment (which includes orthognathic surgery and the postsurgical period).

Therefore, the purpose of this study was to evaluate the following null hypothesis: periodontal tissue changes (including gingival recession, alveolar bone resorption, and width of the attached gingiva) are similar between proclined and minimal-changed mandibular incisor position groups during presurgical orthodontic treatment. This study was also performed to investigate factors affecting changes to the periodontal tissues.

MATERIALS AND METHODS

Subjects

This retrospective study included a proclination group (n = 39, 15 male and 24 female) and a minimal-change group (n = 36, 19 male and 17 female) (Table 1). From 267 patients who had visited the Department of Orthodontics, Gangnam Severance Hospital from January 2008 to February 2010 and were diagnosed with skeletal Class III malocclusion and scheduled for orthognathic surgery, 82 patients were excluded based on the following exclusion criteria: systemic disease, craniofacial syndrome, missing tooth/teeth excluding the third molars, gingival recession with root exposure before treatment, sulcus probing depth ≥3 mm in the mandibular anterior teeth, a gingival index (GI) score of 2 or 3,[10] and orthodontic extraction of mandibular teeth other than the third molars. This study was approved by the Gangnam Severance Hospital Institutional Review Board (3-2014-0090).

According to change in the angle of the mandibular incisor long axis to the mandibular plane (IMPA) during presurgical orthodontic treatment, 110 patients who showed an IMPA change ≥2° and ≤10° were excluded additionally, and 75 consecutively treated patients were finally selected. Thirty-six patients who

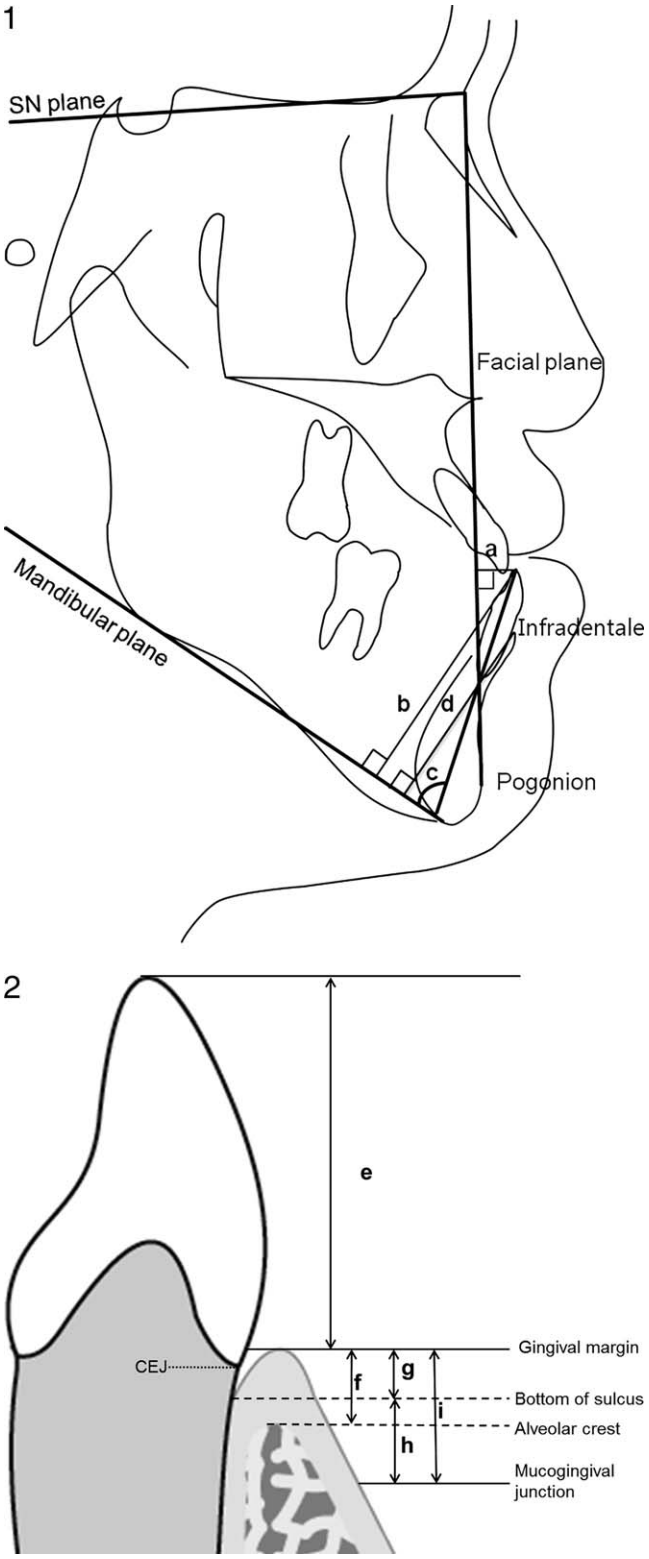

Figure 1. Cephalometric and periodontal tissue measurements. (a) Horizontal perpendicular distance of the mandibular incisor tip to the facial plane. (b) Vertical perpendicular distance of the mandibular incisor tip to the mandibular plane. (c) IMPA (incisor mandibular plane angle). (d) Infradentale-to-MP (perpendicular distance of infradentale to the mandibular plane). (e) Clinical crown length. (f) Bone probing depth. (g) Sulcus probing depth. (h) Width of attached gingiva. (i) Width of keratinized gingiva. CEJ indicates cementoenamel junction.

showed an IMPA change of less than 2° were assigned to the minimal-change group, while 39 patients with an IMPA change of greater than 10° were assigned to the proclination group.[8] The mean (SD) age was 21.7 (3.7) years, and mean (SD) duration of presurgical orthodontic treatment was 13.3 (6.6) months (Table 1).

Methods

Lateral cephalograms and periapical radiographs of the mandibular incisors were taken, and clinical examinations were performed before (T0) and after (T1) presurgical orthodontic treatment. T1 data were obtained approximately 2 weeks before surgery.

Cephalometric Measurements

Measurements from lateral cephalograms included (Figure 1): (1) the mandibular incisor position (L1FP and L1MP, the horizontal and vertical perpendicular distances of the mandibular incisor tip to the facial plane [nasion-pogonion line] and the mandibular plane [gonion-menton line], respectively); (2) infradentale-to-MP (the perpendicular distance from infradentale to the mandibular plane); and (3) IMPA.

Clinical Examinations

Periodontal examination included GI, clinical crown length (CCL), sulcus probing depth (SPD), bone probing depth (BPD), and width of the attached gingiva (AGW), which had been performed to all surgical patients based on clinical protocol of the hospital. Examination was performed on the four mandibular incisors, and the mean value of the four incisors was used. Plaque control was performed with scaling before and during orthodontic treatment. Oral hygiene and gingival condition were scored according to the GI,[10] and patients who exhibited an index of 2 or 3 were excluded to prevent possible harms of gingival inflammation to the periodontal tissue.

CCL was measured from the incisal edge to the deepest point on the curvature of the vestibulo-gingival margin. SPD and BPD were measured at the midlabial surface. When the BPD was recorded under local anesthesia, the tip of the probe (N22T, devemed GmbH, Tuttlingen, Germany) was forced through the connective tissue from the base of the pocket until definite resistance was met.[11] AGW was calculated by subtracting the SPD from the width of the keratinized

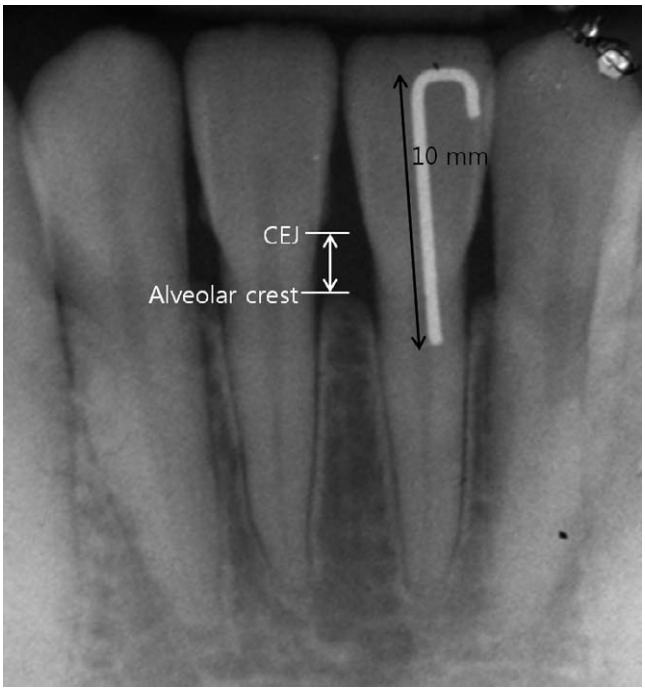

Figure 2. Periapical measurements. Arrow indicates the distance from the cementoenamel junction to the alveolar crest. A 0.016 × 0.022-inch stainless-steel guide wire 10 mm in length was fixed with wax on the labial surface of the tooth to compensate for the distortion resulting from the axis change of the x-ray beam.

gingiva, which was measured from the gingival margin to the mucogingival junction (Figure 1).

Measurements on Periapical Radiographs

To investigate whether proclination of the anterior teeth affected alveolar bone level on the lateral sides, changes in the alveolar bone level were measured on the periapical radiographs. When taking periapical radiographs, a 0.016 × 0.022-inch stainless-steel guide wire 10 mm in length was fixed with wax on the labial surface of the lower central incisor to compensate for the distortion resulting from axis change of the x-ray beam (Figure 2). Radiographic films were processed manually and converted into digital images by scanning. The length of the guide wire was corrected to 10 mm, and the distances from the cementoenamel junction (CEJ) to the alveolar crest (AC) were measured (CEJ-AC) on the mesial and distal surfaces of the two central incisors using an image measuring program (ImageJ, National Institutes of Health, Bethesda, Md). The mean value of the two mesial and two distal surfaces was calculated.

Statistical Analysis

Statistical analysis of the data was performed using SAS 8.02 software (SAS Institute Inc, Cary, NC). Paired *t*-test was used to compare the data recorded between T0 and T1 in each group, and independent *t*-test was performed to compare the proclination group to the minimal-change group. Simple and multiple regression analyses were conducted to determine if age, sex, treatment duration, or changes in mandibular incisor position (Δ IMPA, Δ L1MP, and Δ L1FP) were related to the periodontal changes (Δ infradentale-to-MP, Δ CEJ-AC, Δ CCL, Δ SPD, Δ BPD, and Δ AGW). The variance inflation factor revealed that there was no multi-collinearity with covariates.

One examiner performed all measurements. To evaluate intraexaminer reliability, the same examiner reanalyzed 20 randomly selected cephalometric and periapical measurements within a 2-week interval. Intraclass correlation coefficient (ICC) showed high reliability (ICC $>$ 0.95). A P value of less than .05 was considered statistically significant.

RESULTS

Before presurgical orthodontic treatment, the proclination group had smaller IMPA, L1FP, and L1MP values, and lower infradentale positioning when compared to the minimal-change group ($P < .05$, Table 1). During presurgical orthodontic treatment, the mandibular incisor was proclined with subsequent periodontal changes (Table 2). In the proclination group, IMPA increased 14.18°, and the mandibular incisor tip moved 2.65 mm forward and 1.12 mm upward ($P < .05$). CCL and BPD showed significant increases of 0.37 mm and 0.41 mm, respectively, while infradentale-to-MP and AGW decreased by 1.09 mm and 0.75 mm, respectively ($P < .05$). The minimal-change group also showed significant changes in some measurements during the presurgical treatment ($P < .05$; Δ L1MP, 0.59 mm; Δ CCL, 0.30 mm; Δ BPD, 0.47 mm). When the two groups were compared, the proclination group showed significantly larger changes in IMPA, L1FP, infradentale-to-MP, and AGW with the infradentale-to-MP and AGW decreasing to a greater degree than the minimal-change group ($P < .05$).

Simple regression analysis (Table 3) revealed significant relationships between duration and Δ BPD, duration and Δ AGW, Δ IMPA and Δ infradentale-to-MP, and Δ L1FP and Δ AGW ($P < .05$). Multiple regression analysis (Table 4) showed that age, sex, and Δ L1MP were not related to the periodontal changes ($P > .05$). Duration and Δ IMPA affected Δ BPD and Δ infradentale-to-MP, respectively; Δ L1FP affected Δ infradentale-to-MP and Δ AGW ($P < .05$).

DISCUSSION

The mandibular incisors, which are tipped lingually in skeletal Class III patients, are more susceptible to labial

Table 2. Periodontal Tissue Changes (T1-T0) During Presurgical Orthodontic Treatment and Comparison Between the Proclination and Control Groups[a]

	Proclination (n = 39)		Minimal Change (n = 36)		
	Mean	SD	Mean	SD	*P* Value
Δ IMPA, degrees	14.18†††	3.57	0.09	1.65	<.001***
Δ L1FP, mm	2.65†††	1.56	0.10	1.40	<.001***
Δ L1MP, mm	1.12†††	1.58	0.59††	1.30	.119
Δ Infradentale-to-MP, mm	−1.09†††	1.30	−0.33	1.23	.011*
Δ CEJ-AC, mm	0.17	0.50	0.30	0.64	.224
Δ Clinical crown length, mm	0.37†	0.91	0.30†	0.70	.690
Δ Sulcus probing depth, mm	0.14	0.56	0.13	0.50	.916
Δ Bone probing depth, mm	0.41††	0.88	0.47†††	0.76	.760
Δ Width of attached gingiva, mm	−0.75†††	1.09	−0.27	0.88	.040*

[a] T1 and T0 indicates after and before presurgical orthodontic treatment, respectively; IMPA, angle of mandibular incisor long axis to the mandibular plane; L1FP, horizontal perpendicular distance of the mandibular incisor tip to the facial plane; L1MP, vertical perpendicular distance of the mandibular incisor tip to the mandibular plane; infradentale-to-MP, perpendicular distance from infradentale to the mandibular plane; and CEJ-AC, distance from the cementoenamel junction to the alveolar crest.

† Paired *t*-test analysis between before and after the presurgical orthodontic treatment; † $P < .05$; †† $P < .01$; ††† $P < .001$.

* Independent *t*-test analysis between the proclination and control groups; * $P < .05$; *** $P < .001$.

gingival recession and alveolar bone loss because labial gingival recession of the mandibular incisors is related to linguoversion (less than 85° of IMPA).[12] Moreover, a narrow alveolus, which is frequently noted around the mandibular incisors in patients with long lower face height and skeletal Class III malocclusions,[13,14] increases the development of bone dehiscences and gingival recession.[1,15] Therefore, orthodontic tooth movement challenging the alveolar housing in skeletal Class III patients may aggravate the periodontal support of the mandibular incisors.

This study shows that while clinical crown length and bone probing depth increased 0.30–0.37 mm and 0.41–0.47 mm, respectively ($P < .05$), sulcus probing depth and CEJ-AC distance showed no significant changes during the presurgical orthodontic treatment ($P > .05$) in both groups. The changes in these four measurements during the presurgical orthodontic period were not significantly different between the two groups ($P > .05$). These observations indicate gingival recession with attachment loss and, more specifically, a 0.30–0.37 mm apical movement of the free gingival margin and sulcus base, regardless of the amount of labioversion of the mandibular incisors. The 0.41–0.47 mm increase of bone probing depth indicates that the alveolar crest on the labial side moved 0.77–0.78 mm apically, with consideration to the 0.30–0.37 mm apical movement of the free gingival margin. In other words, the apical movement of gingival tissue, including the free gingival margin and the gingival attachment to the tooth, is less than the apical migration of alveolar bone. This means that more gingival recession is likely to occur in

Table 3. Standardized Coefficients by Simple Linear Regression Analysis for Factors Affecting Changes to the Periodontal Tissues During Presurgical Orthodontic Treatment[a]

	Δ Infrad	Δ CEJ-AC	Δ CCL	Δ SPD	Δ BPD	Δ AGW
Age	−0.078	0.205	0.196	0.077	0.065	0.115
Sex	0.098	−0.064	−0.150	−0.005	−0.215	−0.121
Duration	0.067	−0.146	0.190	0.032	−0.295*	−0.235*
Δ IMPA	−0.335**	−0.139	0.057	0.049	0.089	−0.214
Δ L1MP	0.121	0.050	0.157	0.023	0.007	−0.141
Δ L1FP	0.054	0.013	0.148	−0.007	0.094	−0.307**

[a] Infrad indicates perpendicular distance from infradentale to the mandibular plane; CEJ, cementoenamel junction; AC, alveolar crest; CCL, clinical crown length; SPD, sulcus probing depth; BPD, bone probing depth; AGW, width of attached gingiva; Symphysis, thickness of symphysis at the level of B point; IMPA, angle of mandibular incisor long axis to the mandibular plane; and L1MP and L1FP, horizontal and vertical perpendicular distances of the mandibular incisor tip to the mandibular plane and facial plane, respectively.

* $P < .05$; ** $P < .01$.

Table 4. Standardized Coefficients by Multiple Regression Analysis for Factors Affecting Changes to the Periodontal Tissues During Presurgical Orthodontic Treatment

	Δ Infrad	Δ CEJ-AC	Δ CCL	Δ SPD	Δ BPD	Δ AGW
Age	−0.144	0.199	0.195	0.104	0.018	0.200
Sex	0.066	−0.054	−0.155	−0.003	−0.166	−0.146
Duration	0.016	−0.139	0.209	0.044	−0.281*	−0.181
Δ IMPA	−0.634***	−0.231	−0.025	0.112	0.011	−0.035
Δ L1MP	0.055	0.062	0.146	0.047	−0.017	−0.038
Δ L1FP	0.496**	0.090	0.027	−0.127	0.085	−0.339*

[a] Infrad indicates perpendicular distance from infradentale to the mandibular plane; CEJ, cementoenamel junction; AC, alveolar crest; CCL, clinical crown length; SPD, sulcus probing depth; BPD, bone probing depth; AGW, width of attached gingiva; Symphysis, thickness of symphysis at the level of B point; IMPA, angle of mandibular incisor long axis to the mandibular plane; and L1MP and L1FP, horizontal and vertical perpendicular distances of the mandibular incisor tip to the mandibular plane and facial plane, respectively.

* $P < .05$; ** $P < .01$; *** $P < .001$.

further postsurgical orthodontic treatment because it has been assumed that the presence of bony dehiscences is a prerequisite for the development of gingival recession.[16] According to Artun and Krogstad,[8] clinical crown height increased 0.76 and 0.31 mm from before treatment to removal of appliances in the proclination and minimal-change groups, respectively. The larger increase in the proclination group than in this study may also indicate the possibility of further recession after orthognathic surgery. However, such recession seems to be limited to the labial surfaces because the periapical measurements showed no significant difference of the distance from CEJ to the lateral alveolar crest.

Two periodontal measurements, the width of the attached gingiva and infradentale-to-MP, showed significantly different changes between the two groups: the proclination group showed a larger decrease than the minimal-change group ($P < .05$). The width of the attached gingiva decreased 0.75 mm during presurgical treatment in the proclination group. This decrease exceeds the calculated amount of the apical movement of the sulcus base, which indicates coronal movement of the mucogingival junction. Previous studies demonstrated that the gingival margin and mucogingival junction moved in the same direction as the teeth.[17,18] Even though the mandibular incisors moved coronally in this study, it seems that the free gingival margin and the labial alveolar crest were influenced more by the labial movement of the teeth than by the coronal movement, resulting in a decrease in width of the attached gingiva. The multiple regression analysis also shows that Δ AGW was affected by Δ L1FP ($\beta = -0.339$, $P < .05$), which means that as the mandibular incisor tip moves forward, the width of the attached gingiva decreases.

Infradentale-to-MP decreased more in the proclination group than in the minimal-change group ($P < .05$). In the former group, infradentale moved 1.09 mm inferiorly, which was greater than measurements of the labial alveolar crest by bone probing. This may be because the most superior point was marked among several labial alveolar crests on lateral cephalogram or because the gingival recession occurred simultaneously with the apical movement of the labial alveolar crest. The multiple regression analysis revealed that Δ infradentale-to-MP was influenced by Δ IMPA ($\beta = -0.634$, $P < .001$) and Δ L1FP ($\beta = 0.496$, $P < .01$). This result indicates that as IMPA increases and the mandibular incisor tip moves anteriorly, infradentale moves inferiorly. Based on standardized coefficients, infradentale-to-MP was influenced more by Δ IMPA than by Δ L1FP. The regression analysis also showed that as treatment duration increased, bone probing depth increased ($\beta = -0.281$, $P < .05$) and that age, sex, and Δ L1MP did not affect the results.

This study confirms the previous hypothesis that gingival recession, with underlying bone resorption, occurs during presurgical orthodontic treatment.[8,19] However, the amount of gingival and alveolar bone recession during this particular period, which was less than 1 mm, is similar to that occurring during routine orthodontic treatment.[5,20] In addition, an average width of the attached gingiva of greater than 2 mm after the presurgical treatment is sufficient in preserving periodontal conditions.[21] Alveolar bone loss was greater than gingival recession; however, additional gingival recession can occur, and the widths of the keratinized and attached gingiva can also decrease after orthognathic surgery.[22] Moreover, although periodontal recession occurred irrespective of labioversion of the mandibular incisors, the larger decreases in the attached gingiva and infradentale-to-MP in the proclination group indicate the possibility for further periodontal problems. Because Artun and Krogstad[8] also reported more gingival recession in the proclination group when compared to the minimal-change group during active treatment on the whole, patients whose mandibular incisors will be flared labially during treatment should be informed of the potential for periodontal recession before treatment.

Melsen and Allais[23] reported that baseline recession, gingival biotype, and gingival inflammation are possible predictors of recession. To control the effect of these possible predictors in the present study, we excluded subjects who exhibited severe gingival inflammation and root exposure before treatment. Even though plaque control was performed at every visit, individual anatomic variation as well as gingival biotype may have affected periodontal recession.

Gingiva grafts or bone augmentation can be recommended before treatment in patients with extremely shallow gingiva and alveolar bone because the thickness of the soft and hard tissues is more important than its quality.[24,25] In addition, careful monitoring and meticulous oral hygiene control are essential. Furthermore, additional research should be performed to investigate the effect of orthognathic surgery and postsurgical orthodontic treatment on the periodontal tissues.

CONCLUSIONS

- The null hypothesis was rejected. Infradentale-to-MP and width of the attached gingiva decreased more in patients with mandibular incisor proclination when compared to patients with minimal changes to the incisors during presurgical orthodontic treatment. The two parameters were affected by changes in IMPA and antero-posterior position of the mandibular incisor tip to the facial plane.

- Presurgical orthodontic treatment appeared to result in statistically significant, but clinically insignificant, gingival recession and labial alveolar bone resorption, regardless of the amount of proclination.

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