Original Article

Correlation Between Mandibular Central Incisor Proclination and Gingival Recession During Fixed Appliance Therapy

Garret Djeu, DMD[a]; Catherine Hayes, DMD, DMSc[b]; Samer Zawaideh, BDS, DMSc[c]

Abstract: The purpose of this study was to determine whether proclination of mandibular central incisors during fixed appliance therapy results in gingival recession. Complete records of 67 patients (39 female and 28 male patients; mean age, 16.4 years; age range, 10–45 years) were used in this retrospective case-control study. Using pretreatment and posttreatment lateral cephalograms, the change in mandibular central incisor inclination was measured to divide the patients into an experimental group (proclination) and a control group (no proclination). Changes in clinical crown length were determined from pretreatment and posttreatment study models, and changes in gingival recession were determined from intraoral slides. Eight of the 67 patients exhibited a measurable increase in gingival recession of at least 0.5 mm, and 27 patients had an increase in clinical crown length of at least 0.5 mm. Statistical analyses showed no correlation between mandibular central incisor proclination and gingival recession or clinical crown length. A *t*-test analysis showed no statistically significant difference in gingival recession or change in clinical crown length between patients whose mandibular central incisors were proclined and those whose incisors were not proclined. Multiple regression analysis demonstrated that age, sex, race, treatment duration, extraction, treatment type, Angle classification, and proclination were not related to gingival recession or change in clinical crown length of mandibular central incisors. We conclude that the degree of proclination of mandibular central incisors during fixed appliance therapy was not correlated to gingival recession in this sample. (*Angle Orthod* 2002;72:238–245.)

Key Words: Tipping; Inclination; Cephalometric; Orthodontics; Periodontics

INTRODUCTION

Fixed appliance orthodontic therapy has been shown to produce deleterious effects on the periodontium, ranging from gingivitis to bone loss.[1] Many of these sequelae can be attributed to plaque accumulation due to the difficulty of maintaining adequate oral hygiene in the presence of bands and brackets. Accordingly, once the fixed appliances are removed after treatment, the inflammation can be expected to resolve.[2–4]

One long-term complication of orthodontic treatment, however, is gingival recession. Numerous studies have shown that irreversible recession can be caused by fixed appliance therapy in 1.3% to 10% of treated cases.[5,6] It is believed that during orthodontic movement, soft tissue attachment moves with the tooth.[4] Dorfman[6] showed that 1.3% of 1150 patients exhibited a decrease in the width of keratinized gingiva with either minimal movement or some labial movement of the mandibular incisors, whereas 0.69% of the patients had an increase in keratinized gingiva associated with significant lingual positioning of the lower incisors. It is widely accepted that 2 mm of keratinized gingiva is enough to withstand orthodontic forces and prevent recession, but preexisting mucogingival defects can be exacerbated during tooth movement.[7] Therefore, it is important to recognize and correct areas of actual or potential stress before orthodontic therapy.[7]

Dorfman[6] suggested that mandibular incisors would be most likely to exhibit this type of pathologic recession because the tooth-arch relationship results in labially prominent teeth covered with a thin or nonexistent labial plate of bone and inadequate or absent keratinized gingiva. Consequently, much research has been directed at this region of the oral cavity.

Previous studies have focused on determining the incidence and predisposing factors for recession, such as oral

[a] Harvard School of Dental Medicine, Boston, Mass.

[b] Assistant Professor of Oral Health Policy and Epidemiology, Department of Oral Health Policy and Epidemiology, Harvard Medical School, Boston, Mass.

[c] Director of Graduate Orthodontics, Department of Growth and Development, Harvard School of Dental Medicine, Boston, Mass.

Corresponding author: Samer Zawaideh, BDS, DMSc, Director of Graduate Orthodontics, Department of Growth and Development, Harvard School of Dental Medicine, 188 Longwood Ave, Boston, MA 02115.

(e-mail: samer_zawaideh@hsdm.harvard.edu).

Accepted: December 2001. Submitted: May 2001.

hygiene and quality and amount of keratinized gingiva. Coatoam et al[7] showed that a change in tooth position can be directly related to dimensional changes in the keratinized gingiva but bemoaned the need for a more detailed cephalometric analysis to measure the degree of proclination. Ruf et al,[8] using a cephalometric analysis, showed that only 3% of mandibular incisors developed recession after the use of Herbst appliance. They concluded that no interrelationship was found between the amount of incisor proclination and gingival recession.

Many factors have been shown to contribute to or predispose to gingival recession during orthodontic treatment. For instance, Wennstrom et al[9] used fixed appliance therapy on monkeys to show that plaque-induced inflammation and the thickness (volume) of the marginal soft tissue, rather than the apicocoronal height of the keratinized and attached gingiva, are determining factors for the development of gingival recession. Wennstrom also concluded that as long as the tooth can be moved within the envelope of the alveolar process, the risk of harmful side effects on the gingival tissue is minimal, regardless of the dimensions of the soft tissues. Wennstrom[10] argued that the thickness of the soft tissue is more important than its quality (gingiva vs alveolar mucosa). The clinical implication of these findings is that tooth movement—especially in the faciolingual direction—should be preceded by careful examination of the dimensions of the tissues covering the ''pressure side'' of the teeth to be moved.[10]

Trossello et al[11] stressed that the effects of orthodontic treatment on the periodontium are relatively modest. However, gingival recession is an important complication because it can lead to poor esthetics, root sensitivity, loss of periodontal support, difficult maintenance of oral hygiene, difficulty of successful periodontal repair and increased susceptibility to caries.[6] Consequently, it is important to determine the amount of tipping that can be achieved with fixed appliance therapy before recession begins.

Artun and Grobety[12] previously showed that pronounced advancement of mandibular incisors may be performed in patients with dentoalveolar retrusion without increasing the risk of recession. Their study focused on bodily movement of the teeth rather than changes in angulation. Therefore, the goal of the present study was to quantify the relationship between gingival recession and the degree of proclination of mandibular incisors. Using study casts, lateral cephalograms, and clinical intraoral slides, we took measurements of clinical crown length, gingival recession, and angulation and position of lower incisors before and after fixed appliance therapy. Trentini et al[1] have commented on the validity of using these orthodontic records to measure the width of keratinized tissue.

MATERIALS AND METHODS

Subjects

Records were selected from the pool of records of patients who have completed fixed appliance therapy with postdoctoral orthodontic students at Harvard School of Dental Medicine within the past 5 years. From the collection of 158 records, 67 were found to possess complete sets of pretreatment and posttreatment study casts, lateral cephalograms, and clinical intraoral slides. Because of the paucity of complete records available, no exclusion criteria were used, and all 67 cases were included in the study without regard to the patient's age, sex, or race. All patients had fixed appliance treatment on both arches. Fifteen of the patients were 18 years or older. None of the patient charts noted preexisting systemic diseases or medications associated with gingival changes. Unfortunately, histories of smoking and oral hygiene were not consistently reported in the records, so these variables were not incorporated. Patients with proclined mandibular central incisors were included in the experimental group, and patients whose mandibular central incisors were not proclined were included in the control group. The Harvard Medical School/Harvard School of Dental Medicine Committee on Human Studies approved the use of human subject records. Written consent was not obtained, but patient confidentiality and rights were protected.

Of the 67 patients, 39 were female and 28 were male. The average age of all patients at the beginning of treatment was 16.4 years, with a range of 10 to 45 years. The average duration of treatment with fixed appliance therapy was 33.2 months, ranging from 8 to 71 months. Seven patients were African Americans, 4 patients were Asian Americans, and 56 patients were white. Fifty patients started with an Angle Class I molar relationship, 11 patients began with an Angle Class II molar relationship, and 6 patients started with an Angle Class III molar relationship. Twenty-seven patients had standard edgewise treatment, 34 patients had straight wire treatment, and 6 patients had tip edge treatment. Fifty-two patients had no extractions, 12 patients had all four first premolars extracted, and 3 patients had all four second premolars extracted.

Analysis of lateral cephalometric radiographs

Using the DigiPlan orthodontic treatment planning computer program (version 2.2.5, Pacific Coast Software, Inc, Moreno Valley, CA), we measured sagittal changes in mandibular central incisor inclination and position that occurred during fixed appliance therapy from lateral cephalometric radiographs taken before and after treatment. Posttreatment radiographs were taken immediately after removal of bands and brackets. Central incisors were used in this study because only these teeth are distinctly visible as the most anterior teeth in the arch on lateral cephalograms. No correction was made for radiographic enlargement. Measurements were made to the nearest degree or 0.5 mm.

To provide a variety of data, four different measurements from three cephalometric analyses were used to determine tooth angulation and position. The mandibular teeth and alveolar process, as independent functional units, can be

displaced relative to the plane of the mandible.[13] To quantify this displacement, the angle between the long axis of the mandibular central incisors and the mandibular plane was measured using Downs Analysis.

To establish the relative protrusion of the dentition, the angle between the long axis of the mandibular central incisors and the nasion/B-point line was measured in degrees, along with the distance between the mandibular central incisor tip and the nasion/B-point line in millimeters. These measurements were taken from Steiner Analysis. The millimeter distance establishes how prominent the incisors are relative to the supporting bone, while the inclination indicates whether the teeth have been tipped to their position or have moved there bodily.[13]

To provide yet another way to determine the amount of bodily tooth movement relative to the amount of tipping, the distance between mandibular central incisors to the A-point/pogonion line was measured in millimeters, using Ricketts Analysis.

Analysis of dental casts

Measurements were made as described by Ruf et al.[8] Crown height was assessed separately for the mandibular central incisors by measuring from the deepest point of the curvature of the vestibulogingival margin to the incisal edge. These measurements were made to the nearest 0.5 mm using a Boley gauge (GAC International Inc., Islandia, NY) accurate to 0.05 mm.

Analysis of intraoral photographs

Measurements were made as described by Coatoam et al.[7] Intraoral photographic slides were projected onto a sheet of white construction paper measuring 9 × 11 inches. All measurements were made from the deepest point of the curvature of the gingival margin to the cementoenamel junction to the nearest 0.5 mm. When a slide was projected, all data were obtained at the same magnification. After collection of these data, a multiplication factor was established to calculate the actual height of the gingival recession. This step was necessary because the measurement of gingival recession from the projected slide would be meaningless unless the actual height could be calculated. The extrapolation of the actual recession height was performed using the following equation:

actual recession
= photographic measured recession
× (actual cast crown length
÷ photographic measured crown length)

Statistical analysis

Data were analyzed using Statistical Package for the Health Sciences SPSS 10.0/PC (SPSS Inc., Chicago, IL). Correlation analysis was used to determine a correlation coefficient and *P* value between each of the four measures of mandibular central incisor proclination and both clinical crown length changes and gingival recession changes. Furthermore, two-sample *t*-test analyses were performed using each of the four measures of mandibular central incisor proclination to determine whether there was a difference between the groups with and without proclination regarding both clinical crown length changes and gingival recession changes. Finally, a multiple regression analysis was used to determine if age, sex, race, treatment duration, extraction, treatment type, or Angle classification were linked to gingival recession or increase in clinical crown length. *P* values of .05 or less were considered to be statistically significant.

RESULTS

Examiner reliability

To verify examiner reliability, all measurements were repeated on 10 randomly selected records 1 month after the original measurements. Paired *t*-test analysis was used to compare the original and repeated data. None of the six measurements (recession, clinical crown length, the angle between the incisor and the mandibular plane [Inc-MP angle], the distance between the incisor and point A–pogonion [Inc–A-Pog distance], the angle between the incisor and nasion–point B [Inc–N-B angle], and the distance between the incisor and nasion–point B [Inc–N-B distance]) showed any statistical difference ($P < .05$) between the original and repeated values.

Incidence of mandibular central incisor proclination

Average measurements of mandibular central incisor inclination for all patients, patients with proclination, and patients without proclination using each of the four different analyses are shown in Table 1. For the Inc-MP angle, the average change in inclination was 1.04° for all patients, 5.03° for patients with proclination, and −4.37° for patients without proclination. For the Inc–A-Pog distance, the average change in inclination was 0.30 mm for all patients, 0.90 mm for patients with proclination, and −0.41 mm for patients without proclination. For the Inc–N-B angle, the average change in inclination was 1.44° for all patients, 5.17° for patients with proclination, and −3.12° for patients without proclination. For the Inc–N-B distance, the average change in inclination was 0.25 mm for all patients, 0.87 mm for patients with proclination, and −0.41 mm for patients without proclination.

Incidence of gingival recession and increased clinical crown length

The average amounts of gingival recession and average clinical crown lengths for all 67 patients are shown in Table

TABLE 1. Mandibular Central Incisor Inclination[a]

	Inc-MP Angle, Degrees (Normal = 91°)	Inc–A-Pog Distance, mm (Normal = 2.3 mm)	Inc–N-B Angle, Degrees (Normal = 25°)	Inc–N-B Distance, mm (Normal = 4 mm)
All patients				
Initial	96.05 ± 7.10[b]	1.64 ± 1.72	28.10 ± 6.50[b]	3.42 ± 1.84
Final	97.09 ± 7.50[b]	1.94 ± 1.38	29.54 ± 5.67[b]	3.67 ± 1.86
Change	1.04 ± 6.62	0.30 ± 1.41	1.44 ± 6.52	0.25 ± 1.38
Patients with proclination				
Initial	94.37 ± 7.41[b]	1.11 ± 1.55	25.81 ± 6.33[b]	3.03 ± 1.88
Final	99.40 ± 7.33[b]	2.01 ± 1.49	30.98 ± 6.02[b]	3.90 ± 2.08
Change	5.03 ± 6.37	0.90 ± 1.48	5.17 ± 6.27	0.87 ± 1.54
Patients without proclination				
Initial	99.17 ± 5.07[b]	2.46 ± 1.59[b]	31.43 ± 4.78[b]	3.86 ± 1.57
Final	94.70 ± 6.66[b]	2.05 ± 1.34	28.31 ± 5.08[b]	3.45 ± 1.36
Change	−4.37 ± 6.21	−0.41 ± 1.44	−3.12 ± 4.63	−0.41 ± 1.27

[a] Values are expressed as mean ± SD. Inc, indicates mandibular incisor; MP, mandibular plane; A, point A; Pog, pogonion; N, nasion; and B, point B.

[b] Measurements indicating a proclined position relative to the normative value.

TABLE 2. Clinical Crown Length and Gingival Recession[a]

	31 Crown Length, mm	41 Crown Length, mm	31 Recession, mm	41 Recession, mm
All patients				
Initial	7.98 ± 0.91	8.00 ± 0.89	0.02 ± 0.13	0.05 ± 0.27
Final	8.02 ± 0.99	8.06 ± 1.01	0.05 ± 0.23	0.13 ± 0.50
Change	0.04 ± 0.62	0.06 ± 0.61	0.03 ± 0.15	0.08 ± 0.29
Patients with proclination				
Initial	7.85 ± 0.93	7.70 ± 1.37	0.03 ± 0.17	0.08 ± 0.37
Final	7.91 ± 1.00	7.99 ± 1.00	0.07 ± 0.27	0.18 ± 0.60
Change	0.06 ± 0.62	0.29 ± 1.43	0.04 ± 0.17	0.10 ± 0.32
Patients without proclination				
Initial	8.12 ± 0.80	8.09 ± 0.82	0.00 ± 0.00	0.05 ± 0.26
Final	8.08 ± 1.01	8.19 ± 0.99	0.02 ± 0.11	0.12 ± 0.49
Change	−0.04 ± 0.68	0.10 ± 0.64	0.02 ± 0.11	0.07 ± 0.28

[a] Values are expressed as mean ± SD.

2. The average increase in clinical crown length was 0.04 mm for tooth 31 and 0.06 mm for tooth 41. The average increase in gingival recession was 0.03 mm for tooth 31 and 0.08 mm for tooth 41.

Eight of the 67 total patients (12%) exhibited an increase in gingival recession as measured from the pretreatment and posttreatment intraoral slides. Of these patients, six had their mandibular central incisors proclined during treatment, and two had their mandibular centrals retroclined during treatment. Twenty-seven patients (40%) had an increase in clinical crown length of at least 0.5 mm as measured from the pretreatment and posttreatment study models. Of these patients, 17 had their mandibular central incisors proclined and 10 had their mandibular centrals retroclined during treatment.

Table 3 shows the initial and final measurements of mandibular central incisor inclination for each of the eight patients in whom gingival recession occurred. Table 4 shows the initial and final measurements of mandibular central incisor inclination for each of the 27 patients who had an increase in clinical crown length.

Correlation analysis

Correlation analysis was performed to determine whether a relationship existed between each of the five measurements of mandibular central incisor proclination and increases in clinical crown length or gingival recession for teeth 31 and 41. The correlation coefficient ranged between 0.156 and −0.109 and did not reveal any statistically significant associations.

Two-sample *t*-tests

Using each of the four measurements of mandibular central incisor proclination, we divided the 67 total patients into an experimental group (proclined) and a control group (not proclined). Proclination was defined as a positive difference between the final angle/distance and the beginning

TABLE 3. Mandibular Central Incisor Inclination of Patients With Increased Gingival Recession[a]

	Patient No.	32 Recession, mm	41 Recession, mm	Inc-MP Angle, Degrees (Normal = 91°)		Inc–A-Pog Distance, mm (Normal = 2.3 mm)		Inc–N-B Angle, Degrees (Normal = 25°)		Inc–N-B Distance, mm (Normal = 4 mm)	
				Initial	Change	Initial	Change	Initial	Change	Initial	Change
Patients with proclination	7	0	1.2	86	+10[b]	0.0	+0.3	20	+5	1.8	−0.4
	15	0	1.2	101[b]	+4[b]	1.2	+0.3	25	+6[b]	2.2	+0.7
	20	0	1.1	99[b]	+5[b]	1.2	+1.0	31[b]	+2[b]	2.6	+0.5
	34	0.7	0	82	+4	−1.9	+2.3	14	+6	−0.5	+1.7
	43	0.8	0	83	+4	−1.1	+1.2	16	+5	0.2	+1.5
	49	0.4	0.7	86	+4	2.8[b]	−0.3[b]	26[b]	+6[b]	6.8[b]	+1.2[b]
	Mean	0.3	0.7	90	+5[b]	0.4	+0.8	22	+5[b]	2.2	+0.9
Patients without proclination	19	0.6	0	95[b]	−2[b]	1.7	−1.2	31[b]	−3[b]	2.7	−0.8
	53	0	1.1	84	−8	3.0[b]	−0.8	32[b]	−8	4	−1.1
	Mean	0.3	0.6	90	−5[b]	2.4[b]	−1.0	32[b]	−6[b]	3.4	−1.0

[a] Inc, indicates mandibular incisor; MP, mandibular plane; A, point A; Pog, pogonion; N, nasion; and B, point B.
[b] Measurements indicating a proclined position relative to the normative value.

TABLE 4. Mandibular Central Incisor Inclination of Patients With Increased (>0.5 mm) Clinical Crown Length[a]

	Patient No.	31 Crown Length, mm	41 Crown Length, mm	Inc–MP Angle, Degrees (Normal = 91°)		Inc–A-Pog Distance, mm (Normal = 2.3 mm)		Inc–N-B Angle, Degrees (Normal = 25°)		Inc–N-B Distance, mm (Normal = 4 mm)	
				Initial	Change	Initial	Change	Initial	Change	Initial	Change
Patients with proclination	1	−0.5	0.5	90	+1	2.1	−0.5	26[b]	+1[b]	3.2	−0.5
	7	0.6	0.5	86	+10[b]	0.0	+0.3	20	+5	1.8	0.0
	12	0.5	1.0	91	+1[b]	0.4	+0.7	22	+7[b]	2.0	+1.0
	14	0.7	0.2	82	+6	0.5	0.0	19	+6	1.1	+1.3
	15	0.2	0.7	101[b]	+4[b]	1.2	+0.3	25	+6[b]	2.2	+0.7
	18	0.6	0.5	99[b]	+3[b]	0.1	+1.3	26[b]	+2[b]	2.2	+0.8
	27	0.3	1.0	100[b]	+6[b]	3.1[b]	+0.8[b]	37[b]	+4[b]	6	+1.5[b]
	32	0.6	0.4	95[b]	+7[b]	0.5	+4.1[b]	31[b]	+7[b]	7.8[b]	+2.2[b]
	35	1.4	0.4	80	+16[b]	0.8	+1.2	17	+14[b]	1.7	+2.1
	41	0.9	1.0	97[b]	+6[b]	0.1	+0.1	23	+4[b]	1.6	+0.5
	45	0.8	0.5	106[b]	+2[b]	0.1	+0.2	30[b]	+3[b]	2.4	−0.4
	46	−0.3	0.6	90	+2[b]	1.1	+2.7[b]	23	+3[b]	4.3[b]	+3.1[b]
	48	0.7	0.8	100[b]	0[b]	1.1	+0.5	28[b]	+3[b]	2.8	+0.6
	54	0.9	−0.8	99[b]	+6[b]	0.8	+2.1[b]	26[b]	+2[b]	2.4	0.0
	56	0.7	0.8	83	+1	−0.3	−0.4	17	0	1	−0.1
	62	0.6	−0.2	95[b]	+3[b]	2.3	0.0	31[b]	+2[b]	5[b]	−0.3[b]
	63	0.6	0.1	87	+8[b]	1.6	+2.0	27[b]	+4[b]	2.9	+1.9
	Mean	0.6	0.4	88	+5[b]	0.9	+0.9	25	+4[b]	3.0	+0.8
Patients without proclination	3	−0.2	0.5	103[b]	−11[b]	1.6	+0.1	36[b]	−10[b]	3.7	0.0
	4	0.9	−0.1	99[b]	−6[b]	2.4[b]	+0.4[b]	34[b]	−6[b]	4.2[b]	−0.8
	6	0.8	1.0	96[b]	−1[b]	3.6[b]	0.0[b]	32[b]	−2[b]	4.4[b]	−0.9[b]
	19	−0.7	0.6	95[b]	−2[b]	1.7	−1.2	31[b]	−3[b]	2.7	−0.8
	25	0.3	0.5	98[b]	−1[b]	1	−0.1	29[b]	−1[b]	2.3	−0.4
	33	0.6	0.6	99[b]	−6[b]	4[b]	+0.4[b]	32[b]	−7	8.4[b]	−1.3[b]
	42	0.8	0.5	100[b]	−7[b]	2.5[b]	−0.7	34[b]	−7[b]	4.8[b]	−0.9
	53	0.7	1.9	84	−8	3[b]	−0.8	32[b]	−8	4	−1.1
	55	0.8	0.1	92[b]	−9	3[b]	−2.2	25	−6	3.1	−1.4
	57	0.7	0.7	93	−6	3.1	−1.3	24	−5	3	−0.3
	Mean	0.5	0.6	96[b]	−6	2.6[b]	−0.5	31[b]	−6	4.1[b]	−0.8

[a] Inc, indicates mandibular incisor; MP, mandibular plane; A, point A; Pog, pogonion; N, nasion; and B, point B.

angle/distance. A negative difference or no difference was considered not proclined. A two-sample *t*-test was performed for each of the four measurements of mandibular central incisor proclination to determine if there was a statistically significant difference between the proclined group and not proclined group in regard to increase in clinical crown length or gingival recession of teeth 31 and 41. None of the four *t*-tests showed a statistically significant difference between the experimental group and the control group (Table 5).

TABLE 5. Two-Sample *t*-Test Results

	Proclination Status	No. of Patients	Mean, mm	SD, mm	*t*	*P* Value
Inc-MP angle						
31 Crown length	Not proclined	27	0.022	0.625	−0.226	.822
	Proclined	40	0.058	0.630	−0.226	.822
41 Crown length	Not proclined	27	0.096	0.671	−0.586	.560
	Proclined	40	0.275	1.48	−0.668	.507
31 Recession	Not proclined	27	0.022	0.116	−0.658	.513
	Proclined	40	0.048	0.175	−0.711	.479
41 Recession	Not proclined	27	0.041	0.212	−0.903	.370
	Proclined	40	0.105	0.326	−0.978	.331
Inc–A-Pog distance						
31 Crown length	Not proclined	26	0.054	0.636	0.064	.950
	Proclined	41	0.044	0.638	0.064	.950
41 Crown length	Not proclined	24	0.131	0.638	−0.391	.697
	Proclined	41	0.254	1.52	−0.451	.654
31 Recession	Not proclined	26	0.038	0.139	0	1.00
	Proclined	41	0.038	0.168	0	1.00
41 Recession	Not proclined	26	0.069	0.251	−0.278	.782
	Proclined	41	0.090	0.315	−0.291	.772
Inc–N-B angle						
31 Crown length	Not proclined	26	0.027	0.638	−0.170	.866
	Proclined	41	0.054	0.621	−0.169	.867
41 Crown length	Not proclined	26	0.073	0.680	−0.692	.491
	Proclined	41	0.285	1.46	−0.802	.426
31 Recession	Not proclined	26	0.023	0.118	−0.601	.550
	Proclined	41	0.046	0.173	−0.654	.515
41 Recession	Not proclined	26	0.042	0.216	−0.839	.405
	Proclined	41	0.102	0.322	−0.915	.364
Inc–N-B distance						
31 Crown length	Not proclined	30	0.080	0.654	0.423	.674
	Proclined	37	0.014	0.614	0.421	.676
41 Crown length	Not proclined	30	0.057	0.635	−0.920	.361
	Proclined	37	0.336	1.56	−0.983	.331
31 Recession	Not proclined	30	0.020	0.110	−0.855	.396
	Proclined	37	0.053	0.184	−0.894	.375
41 Recession	Not proclined	30	0.077	0.292	−0.093	.926
	Proclined	37	0.083	0.287	−0.093	.926

[a] Inc, indicates mandibular incisor; MP, mandibular plane; A, point A; Pog, pogonion; N, nasion; and B, point B.

Multiple regression analyses

Multiple regression analysis was performed to determine whether age, sex, race, treatment duration, extraction, treatment type, Angle classification, or the four measurements of mandibular central incisor proclination were correlated with increases in clinical crown length or gingival recession for teeth 31 and 41. None of these variables had a statistically significant correlation to either increases in clinical crown length (Table 6) or gingival recession (Table 7).

DISCUSSION

Previous research has shown that gingival recession can be caused by fixed appliance therapy in 1.3% to 10% of treated cases.[5,6] In this study, gingival recession as measured from intraoral slides occurred in eight of 67 patients (12%) and, therefore, these findings are consistent with the literature. Furthermore, 27 of 67 patients (40%) had an increase in clinical crown length of at least 0.5 mm as measured from study models, which was considered to be clinically significant. Teeth that are associated with gingival recession generally have an increase in clinical crown length because of the accompanying decrease in vertical height of the attached gingiva. However, clinical crown length is not necessarily an accurate indicator of gingival recession because teeth can be extruded without any damage to the gingiva, but these teeth still exhibit an increase in crown height. Nonetheless, clinical crown length was included in this study to provide a secondary measure of gingival recession.

It has been postulated that excessive proclination of mandibular central incisors may contribute to gingival recession because the tooth-arch relationship results in labially prominent teeth covered with a thin or nonexistent labial plate of bone and inadequate or absent keratinized gingiva.[2] One weakness of previous studies has been their failure to quantify this relationship between tooth movement and gingival recession. Therefore, it was the goal of this study to measure the effect of mandibular central incisor proclination on gingival recession.

TABLE 6. Multiple Regressions for Crown Length

	31 Crown Length			41 Crown Length		
Variable	Standardized Coefficient β	*t*	*P* Value	Standardized Coefficient β	*t*	*P* Value
Age	.244	1.61	.114	.006	0.038	.969
Sex	.027	0.193	.848	−.100	−0.720	.475
Race	.182	1.30	.200	.132	0.959	.342
Treatment duration	.071	0.447	.657	.086	0.554	.582
Extraction	−.090	−0.620	.538	−.239	−1.69	.097
Treatment type	−.077	−0.523	.604	−.044	−0.308	.760
Angle classification	.014	0.100	.921	−.146	−0.106	.296
Inc-MP angle	.027	0.100	.920	−.089	−0.344	.732
Inc–A-Pog distance	.058	0.299	.766	−.043	−0.225	.823
Inc–N-B angle	−.016	−0.055	.957	.023	0.083	.934
Inc–N-B distance	−.026	−0.135	.893	.140	0.731	.468

[a] Inc, indicates mandibular incisor; MP, mandibular plane; A, point A; Pog, pogonion; N, nasion; and B, point B.

TABLE 7. Multiple Regressions for Gingival Recession

	31 Recession			41 Recession		
Variable	Standardized Coefficient β	*t*	*P* Value	Standardized Coefficient β	*t*	*P* Value
Age	−.136	−0.938	.353	−.091	−0.602	.550
Sex	.067	0.493	.624	−.039	−0.279	.781
Race	−.133	−0.989	.327	.107	0.768	.446
Treatment duration	−.286	−1.88	.066	.089	0.565	.574
Extraction	−.068	−0.489	.627	−.010	−0.071	.943
Treatment type	.169	1.20	2.36	.188	1.29	.205
Angle classification	−.037	−0.271	.788	−.126	−0.896	.375
Inc-MP angle	.100	0.394	.695	.150	0.567	.574
Inc–A-Pog distance	−.064	−0.342	.733	.021	0.106	.916
Inc–N-B angle	.056	0.201	.841	.067	0.234	.816
Inc–N-B distance	−.009	−0.050	.960	−.057	−0.295	.769

[a] Inc, indicates mandibular incisor; MP, mandibular plane; A, point A; Pog, pogonion; N, nasion; and B, point B.

The results of this study showed that there was no statistically significant relationship between mandibular central incisor proclination and increases in gingival recession or clinical crown length. Although 12% of all patients exhibited gingival recession and 40% of all patients had an increase in clinical crown length, correlation analysis showed that neither of these outcomes was related to any of the four measurements of mandibular incisor proclination. In fact, two of the patients who experienced gingival recession had their mandibular central incisors retroclined.

Furthermore, the *t*-test analyses demonstrated that there was no statistically significant difference between the experimental group (proclination) and the control group (no proclination) in the development of gingival recession or increased clinical crown length. Table 5 shows that the proclined teeth generally had slightly more gingival recession and increased clinical crown length on average relative to the nonproclined teeth, but these differences were so slight (<0.1 mm) that they were neither clinically nor statistically significant.

Finally, the multiple regression analyses showed that neither age, sex, race, treatment duration, extraction, treatment type, or Angle classification were related to increases in gingival recession or clinical crown length.

Several explanations may account for the lack of a statistically significant relationship between mandibular central incisor proclination during fixed appliance therapy and gingival recession. Primarily, the patients in general had minimal proclination during treatment. On average, the 67 patients had their mandibular central incisors proclined approximately only 1° by the end of treatment (Table 1). Even those patients who exhibited gingival recession averaged only 2° of proclination (Table 3). This lack of excessive proclination may be explained by the idealized treatment performed in an academic setting, in which the faculty closely monitors patient progress to prevent iatrogenic adverse outcomes.

In addition, it must be stressed that the measurements in this study were only made at two time points—initial and final tooth position. The data therefore account for proclination at the end of treatment but neglect proclination during treatment. Thus, it is possible that some patients may have had their mandibular central incisors excessively proclined (causing gingival recession) and then retroclined be-

fore the end of treatment, thereby skewing the data. Consequently, one of the major limitations of this study is that it relied on pretreatment and posttreatment measurements without analyzing tooth movement during treatment. Future studies should include progress records to better assess the entire range of movement. Furthermore, no follow-up data was available to see if gingival recession developed after fixed appliances were removed. Steiner[14] indicated that thinning of the gingiva during orthodontic therapy could create a long-term risk for recession. This study could have been improved with records taken at several time points after fixed appliance treatment.

In this sample, it is clear that gingival recession could not be explained by excessive mandibular central incisor proclination at the end of treatment. Instead, it is possible that gingival recession in the eight patients may be explained by inflammation due to poor oral hygiene. Unfortunately, another limitation of this study is the lack of hygiene records, making it impossible to include this important variable. It might be revealing to know the oral hygiene status of patients with recession relative to those without recession.

Another limitation is the use of records for data collection rather than clinical examinations of patients. Trentini[1] showed that there is no statistically significant difference between measurements from carefully taken intraoral slides and study models and measurements taken from patients. However, it could still be argued that the slides and models are inconsistent records because they were each taken by different orthodontic residents. A second important problem with using records is the inability to determine the buccolingual thickness of the gingiva. Wennstrom[15] has recently claimed that it is the thickness, not the height, of the covering gingiva that is the most important factor for the development of recession. However, this is a clinical parameter that is impossible to measure from study casts.

Finally, the small sample size is a limitation of this study. Only 67 complete patient records were available for use, and it is difficult to make broad conclusions without a much larger pool of data. Furthermore, the paucity of available records for this study made it impossible to be selective in choosing the patient pool. Therefore, another significant weakness of this study is the heterogeneity of the sample with regard to factors such as age, malocclusion type, fixed appliance type, treatment duration, and extraction/nonextraction treatment, which could each feasibly contribute to gingival recession.

Consequently, the clinical recommendations from this study would be to proceed cautiously when excessively proclining mandibular central incisors, especially if there is preexisting gingival recession. However, it appears that proclination of only a few degrees does not result in recession.

CONCLUSION

We conclude that the degree of proclination of mandibular central incisors during fixed appliance therapy was not correlated to gingival recession in this patient sample.

ACKNOWLEDGMENTS

This study was funded by a grant from the Harvard Medical School Academic Societies' Committee for Student Research and the NIH/NIDR Grant DE 07268 Short-term ''Training for Minority & Women Dental Student.''

REFERENCES

1. Trentini C, Moriarty J, Phillips C, Camilla J. Evaluation of the use of orthodontic records to measure the width of keratinized tissue. *J Periodontol.* 1995;66:438–441.
2. Hamp S, Lundstrom F, Nyman S. Periodontal conditions in adolescents subjected to multiband orthodontic treatment with controlled oral hygiene. *Eur J Orthod.* 1982;4:77–86.
3. Kloehn J, Pfeifer J. The effect of orthodontic treatment on the periodontium. *Angle Orthod.* 1974;44:127–134.
4. Zachrisson S, Zachrisson B. Gingival condition associated with orthodontic treatment. *Angle Orthod.* 1972;42:26–34.
5. Alstad S, Zachrisson B. Longitudinal study of periodontal condition associated with orthodontic treatment in adolescents. *Am J Orthod.* 1979;76:277–285.
6. Dorfman H. Mucogingival changes resulting from mandibular tooth movement. *Am J Orthod.* 1978;74:286–297.
7. Coatoam G, Behrents R, Bissada N. The width of keratinized gingiva during orthodontic treatment: Its significance and impact on periodontal status. *J Periodontol.* 1981;52:307–313.
8. Ruf S, Hansen K, Pancherz H. Does orthodontic proclination of lower incisors in children and adolescents cause gingival recession? *Am J Orthod Dentofacial Orthop.* 1998;114:100–106.
9. Wennstrom J, Lindhe J, Sinclair F, Thilander B. Some periodontal tissue reactions to orthodontic tooth movement in monkeys. *J Clin Periodontol.* 1987;14:121–129.
10. Wennstrom J. The significance of the width and thickness of the gingival in orthodontic treatment. *Dtsch Zahnarztl.* 1990;45:136–141.
11. Trossello V, Gianelly A. Orthodontic treatment and periodontal status. *J Periodontol.* 1979;50:665–670.
12. Artun J, Grobety D. Periodontal status of mandibular incisors after pronounced orthodontic advancement during adolescence: a follow-up evaluation. *Am J Orthod Dentofacial Orthop.* 2001;119:2–10.
13. Proffit W. *Contemporary Orthodontics.* St Louis, Mo: CV Mosby Company; 1986:121–129.
14. Steiner GG. Changes of the marginal periodontium as a result of labial tooth movement in monkeys. *J Periodontol.* 1981;52:314–320.
15. Wennstrom JL. Mucogingival considerations in orthodontic treatment. *Semin Orthod.* 1996;2:46–54.