Periodontal changes in supra-erupted maxillary molars after orthodontic intrusion using mini-screws

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June 2025

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교정의사의 길로 이끌어주시고, 미흡한 제자에게 한결같은 지도와 격려를 보내주신 김경호 교수님께 깊이 머리 숙여 감사드립니다. 또한 바쁘신 와중에도 논문을 살펴주시고 세심한 지도를 베풀어주신 유형석 교수님과 이기준 교수님, 정주령 교수님, 이지현 교수님께 진심으로 감사드립니다. 그리고 교정학에 대해 많은 가르침과 도움을 주신 차정열 교수님, 최윤정 교수님, 최성환 교수님, 박선형 교수님, 최재훈 교수님, 김하림 교수님께도 감사의 마음을 드립니다.

의국 생활을 하며 많이 부족한 저를 이끌어 준 장호식, 황우찬, 김지훈, 오채희, 김한결, 이현아 선배님과, 수련 기간 동안 항상 든든한 보탬이 되어준 동기 조병수 선생, 모자란 선배를 잘 따라준 김연희, 조신영, 임재현, 주희돈 선생에게 감사의 인사를 전합니다.

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2025년 6월

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ABSTRACT IN ENGLISH

Periodontal changes in supra-erupted maxillary molars after orthodontic intrusion using mini-screws

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(Directed by Prof. Kyung-Ho Kim, D.D.S., M.S., PhD)

This study aimed to analyze periodontal changes in supra-erupted maxillary molars that underwent orthodontic intrusion with mini-screws during the treatment and the postretention period.

40 supra-erupted maxillary molars were treated with buccal and palatal mini-screws and power chain loading of 100 g for orthodontic intrusion. Clinical examinations and periapical radiography were performed pretreatment (T0), posttreatment (T1), 6 months posttreatment (T2), and 2 years posttreatment (T3) to measure the following parameters: clinical crown length (CCL), sulcus probing depth (SPD), bone probing depth (BPD), attached gingiva width (AGW), root length (RL), alveolar crest level (ACL), and bone support (BS). The extent of intrusion and relapse was measured by superimposing the dental casts. Periodontal care was performed regularly during and after treatment for all patients, and the gingival indices were maintained below 1.

Immediately after treatment, CCL decreased, and SPD and BPD increased compared with the baseline; however, 6 months posttreatment, they returned to the baseline levels, except for palatal BPD. The AGW remained unchanged at all time points. Root length significantly decreased between T0 and T1, but as the amount was less than 1 mm, it was considered clinically insignificant. Six months after the treatment, ACL and BS showed significant improvements compared with the baseline. All periodontal parameters showed no statistically significant differences between T2 and T3, indicating stability after 6 months posttreatment.

Orthodontic intrusion of supra-erupted maxillary molars can enhance the periodontium in the long term.

Key words : maxillary molar intrusion, orthodontic miniscrew, periodontal change, long-term follow-up

1. Introduction

Supra-eruption of the molars is a common problem in adults, typically resulting from the early loss of opposing teeth. Several dental problems may arise from supra-erupted molars, such as inefficiency in the masticatory function, occlusal interference, periodontal diseases, and lack of space for prosthetic restoration[1]. Crown reduction is the most frequently used treatment for supra-erupted molars. However, this procedure is invasive and may require root canal, periodontal, and prosthetic treatments[2]. Other options include considering surgical impaction, or even extraction, in cases of severe supra-eruption. In contrast, orthodontic intrusion is a more conservative option that is usually completed within a few months, making it a viable alternative for the treatment of supra-erupted teeth.

Historically, achieving absolute orthodontic intrusion involves methods such as splinting adjacent teeth for anchorage, intrusion springs, or high-pull headgears, which often lead to reactive extrusion of neighboring teeth or require patient compliance[3,4]. The advent of skeletal anchorage systems, including orthodontic mini-screws and mini-plates, has made absolute orthodontic intrusion more achievable[5].

However, the effect of orthodontic intrusion on the periodontium remains unclear. Most existing studies have either focused on incisal intrusion[6-8] or are limited to case reports[9,10] and animal experiments[11-13]. Few retrospective studies have utilized less accurate radiographic techniques, such as panoramic or lateral cephalometric images[14,15]; however, conflicting findings due to small sample sizes[16,17] or methodological differences[18,19] are often noted. Many studies on similar topics have been conducted, but there is no well-controlled study that fulfills all the conditions mentioned above, such as investigating the changes in multiple periodontal parameters for the maxillary molars with a sufficient sample size, proper hygiene control, and over the course of initial treatment, posttreatment, and follow-up.

Additionally, it has been noted in a few animal or human studies that significant changes in some periodontal measurements occur within 6 months posttreatment[13,16]; however, long-term follow-up data on when these changes stabilize are lacking.

This study aimed to analyze periodontal changes in supra-erupted maxillary molars that underwent orthodontic intrusion with mini-screws, as well as assess the patterns of these changes during the follow-up period.

2. Material and Methods

This study was approved by the Institutional Review Board of the Gangnam Severance Hospital (No. 3-2023-0370).

The subjects were collected from 90 Asian patients who underwent adjunctive orthodontic intrusion using mini-screws between July 2008 and December 2023 at the Department of Orthodontics at Gangnam Severance Hospital, Seoul, South Korea. Eligible patients had maxillary molars with a marginal discrepancy of at least 1 mm compared with the adjacent teeth, exceeding the normal occlusal plane level. The exclusion criteria were as follows: (1) gingival index (Löe and Silness) of 2–3 at initial treatment which indicates moderate to severe inflammation; (2) systemic diseases affecting periodontal tissue; (3) previous orthodontic treatment; (4) age < 16 years with incomplete second molar root maturation; (5) change of treatment plan to full orthodontic treatment; (6) root proximity to the maxillary sinus wall throughout all time points; and (7) insufficient data or poor-quality radiographic images that made measurement unfeasible.

Ultimately, 40 maxillary molars of 29 patients (11 men, 18 women; mean age, 39.05 years) were included in the study (Table I). There were a total of 28 second molars and 12 first molars. Two teeth were included from 8 participants (some from the left and right sides, and some from the same quadrant with two teeth). One participant had 4 teeth included (all first and second molars from both quadrants).

Table 1. Demographic description of subjects

Characteristic	Mean ± SD or n (%)
Age, yr	39.05 ± 14.23
Sex	
Male	11 (37.9)
Female	18 (62.1)
Average time interval, yr	
T0-1	0.90 ±0.37
T1-2	0.67 ±0.22
T1-3	2.78 ±0.58

* SD indicates standard deviation

Two mini-screws , with a diameter of 1.8 mm and a length of 7 mm, were inserted into the mesio-buccal and mesio-palatal sides of the supra-erupted tooth. The mini-screws were inserted using a hand driver with a self-drilling technique, without irrigation. Orthodontic brackets or buttons were attached to the buccal and palatal surfaces. Mini-screw stability is known to decrease immediately after insertion, reaching the lowest stability at 2 weeks[20]. In this study, stability was evaluated at 3 weeks after insertion. In some cases of failure (failure rate: 5.17%), re-implantation was performed after a necessary healing period when required. Once the mini-screws were set, separate orthodontic power chains of 50 g were engaged from the tooth to the screw on each side, totaling 100 g (Figure 1). Power chains were replaced monthly, and scaling and oral hygiene instructions were provided at each clinic visit to eliminate the possibility of periodontal changes due to gingivitis or periodontitis. At the end of the treatment, alignment and occlusal settling with the adjacent teeth were performed briefly, if necessary. After orthodontic treatment, the appliances were de-bonded and fixed retainers (0.45mm diameter, stainless steel, super spring hard, 3-strand twisted; Dentaurum) connecting the intruded teeth and their adjacent teeth were placed for retention. The clinical photographs at pretreatment and posttreatment are shown in Figure 2A and 2B, and the corresponding periapical radiographs are shown in Figure 2C and 2D. Patients were scheduled for follow-up every 6 months for periodic scaling and oral hygiene instructions. All procedures were performed by a single orthodontist (K.K.).

Figure 1. Clinical photo of the appliance design. Two miniscrews were inserted on the mesio-buccal and the mesio-palatal sides of the supra-erupted tooth.

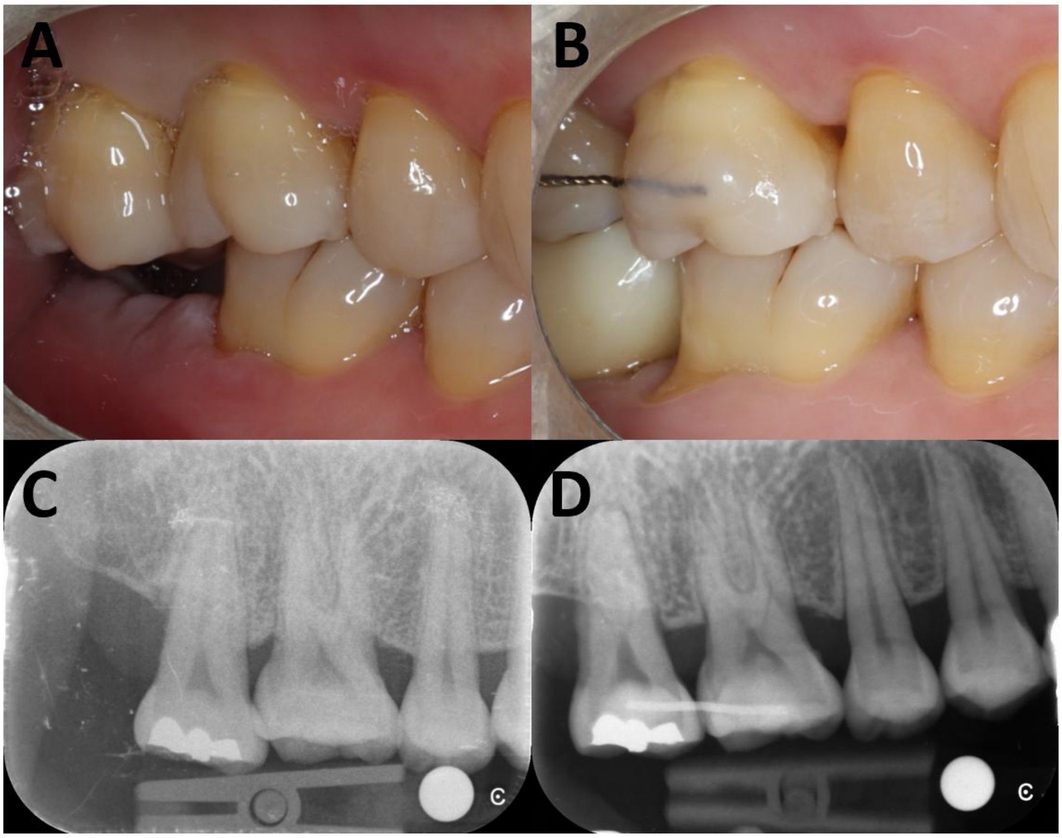

Figure 2. Clinical photos of (A) pretreatment and (B) posttreatment, and periapical radiographs of (C) pretreatment and (D) posttreatment.

Clinical measurement of periodontal variables and acquisition of periapical radiography and plaster models were performed at four intervals: pretreatment (T0), posttreatment (T1), 6 months posttreatment (T2), and 2 years posttreatment (T3); however, plaster models were not obtained at T2, and were available at T3 only in 5 samples. The average time differences for each interval are listed in Table I. The clinical measurements were taken twice at each time point by a single orthodontist (K.K.) for the purpose of evaluating periodontal tissue during treatment. The radiographic measurements and cast superimposition measurements were performed retrospectively, with each measurement taken once by two different orthodontists (K.K. & H.L.).

Plaster models were scanned using a 3D scanner accuracy: ± 20 μm, mode: high-resolution, optical scanning with laser slit at a 1:1 ratio. The maxillary digital models were aligned with the use of the occlusal plane as the horizontal reference plane using 3D Slicer (version 5.6.2; Slicer Community, Boston, MA, USA, https://www.slicer.org). The occlusal plane was determined by 5 points (the midpoint of the buccal and palatal cusps of the right and left first and second premolars and the contact point of the right and left central incisal edges). The x-axis was set as the line connecting the midpoint of the buccal and palatal cusps of the right and left first and second premolars. The z-axis was set perpendicular to the x-axis and passed through the contact point of the right and left central incisal edges. The y-axis was set perpendicular to both the x-axis and z-axis. As a result, the x-, y-, and z-axes were set as the transverse, vertical, and sagittal axes, respectively. Then, the models were superimposed with the anterior third rugae on both sides serving as a stable reference for superimposition[21] (Figure 3). The superimposed digital models before and after molar intrusion are presented from the occlusal (A), buccal (B), and palatal (C) views, with yellow indicating the pre-treatment model and green indicating the post-treatment model. After registration, the mesio-buccal, disto-buccal, mesio-palatal, and disto-palatal cusp tips were marked as landmarks in the models at each timepoint. Y-axis distances between the landmarks were measured. The extent of buccal, palatal, mesial, and distal vertical displacement was determined by averaging the vertical displacement of the adjacent cusps. Changes in the extent of intrusion throughout the treatment (T0-T1) and post-retention periods (T1-T3) are presented in Table II.

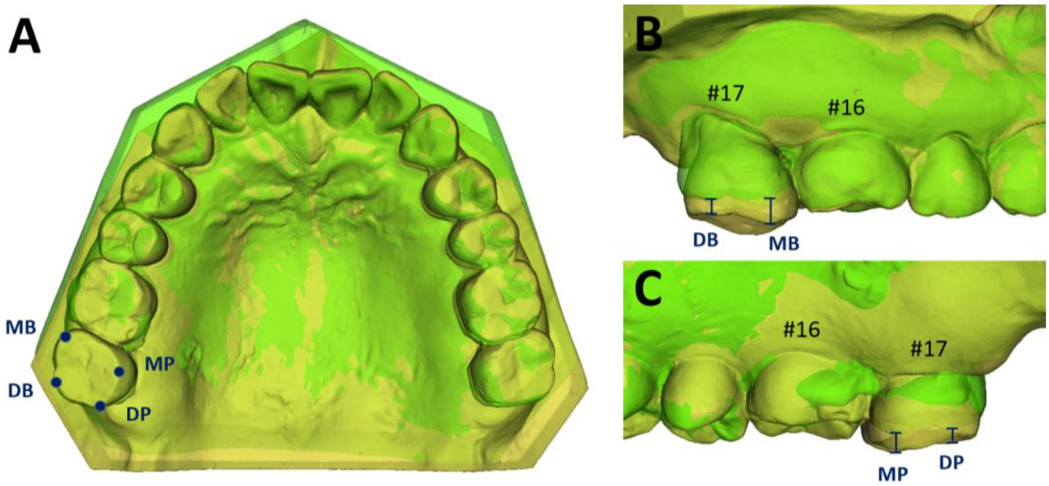

Figure 3. Superimposition of the digital models before and after molar intrusion. Yellow, before treatment; green, after treatment. (A) Occlusal surface; (B) Buccal surface; (C) Palatal surface. The maxillary right second molar was intruded. MB, mesio-buccal; DB, disto-buccal; MP, mesio-palatal; DP, disto-palatal. Straight-line distances between the same landmarks of before and after treatment were measured.

Table II. The extent of intrusion during the treatment (ΔT0–1) and post-retention (ΔT1–3) periods on each surface (mm)

Surface	Time interval	
	ΔT0–1	**ΔT1–3**
Buccal	2.20 ± 1.00 p<.0001****	0.04 ± 0.27 p =0.8125
Palatal	3.19 ± 1.38 p<.0001****	0.03 ± 0.37 p=1.0000
Mesial	2.36 ± 1.07 p<.0001****	-0.04 ± 0.22 p=0.6250
Distal	2.57 ± 1.27 p<.0001****	0.11 ± 0.80 p=0.3125

* Paired t-test analysis was conducted for ΔT0–1.

* Wilcoxon signed-rank test analysis for ΔT1–3; based on data from 5 samples.

* P < .05; ** P < .01; *** P < .001; **** P < .0001

The following clinical parameters were measured: clinical crown length (CCL), bone probing depth (BPD), sulcus probing depth (SPD), attached gingival width (AGW), and gingival index (GI) (Figure 4). All measurements were performed using a Williams-marked periodontal probe (Reicodent, Tuttlingen, Germany).

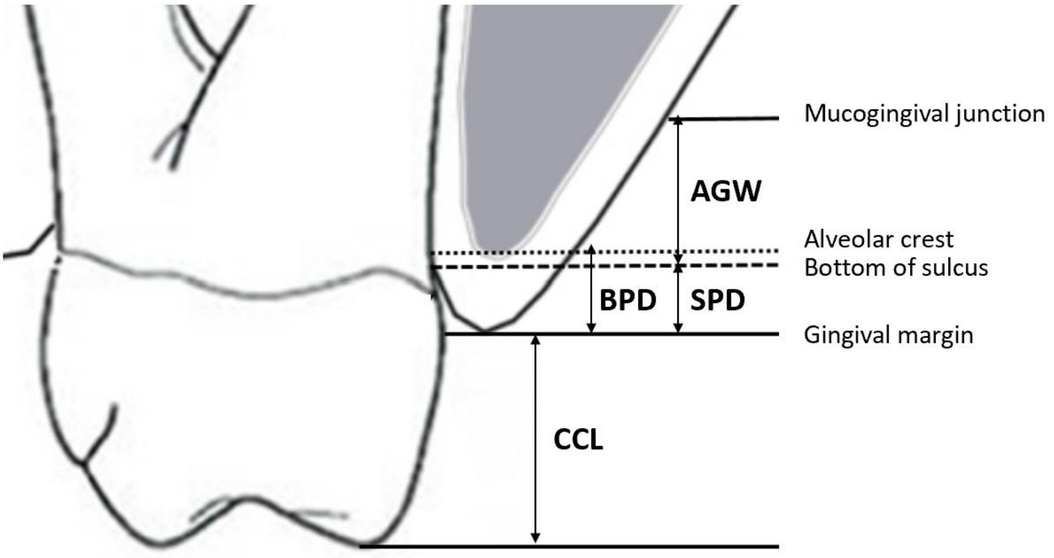

Figure 4. Clinical measurements of periodontal tissue. CCL indicates clinical crown length; BPD indicates bone probing depth; SPD indicates sulcus probing depth; AGW indicates attached gingiva width.

CCL was measured on the buccal and palatal surfaces from the highest point of the occlusal surface of the molar to the deepest point on the curvature of the vestibular gingival margin parallel to the long axis of the tooth. SPD was measured as the distance from the gingival margin to the sulcus bottom, and BPD was measured as the distance from the gingival margin to the alveolar crest. For SPD measurement, a consistent force of approximately 0.3N was applied during probing. For BPD measurement, the probe tip was forced through the connective tissue under local anesthesia until definite resistance was obtained[22]. To ensure consistent probing force, one orthodontist performed multiple practice sessions before the study to standardize the measurements. SPD and BPD were measured in the mesiobuccal, midbuccal, distobuccal, mesiopalatal, and distopalatal gingiva of the supra-erupted tooth. The average values from the mesiobuccal, midbuccal, and distobuccal areas were considered the buccal SPD or BPD, and the averages of the mesiopalatal and distopalatal areas were considered the palatal SPD or BPD. AGW was calculated by subtracting the SPD from the keratinized gingival width (length from the gingival margin to the mucogingival junction) on the mid-buccal surface. GI was assessed in both the buccal and palatal gingiva. Orthodontic treatment was initiated in patients with an initial GI score of 0 or 1. The GI remained < 1 throughout the follow-up period.

Periapical radiographs were obtained to assess alveolar crest level (ACL) and root length (RL) over time. The films were standardized using a 4 mm-diameter spherical metal ball bearing or a 10 mm-long stainless-steel guide bar fixed with wax on the Universal Measurement and Calibration Protocol (XCP), ensuring that the images were captured using the parallel technique. The films were scanned at a resolution of 2400 dpi on a 256 scale.

The cemento-enamel junction (CEJ), mesial and distal alveolar crests, and mesiobuccal, distobuccal, and palatal root apices of the molars were identified using ImageJ software (ImageJ, National Institutes of Health, Bethesda, MD, USA). After standardization, the perpendicular distance from the CEJ to each alveolar crest was measured to calculate the ACL, and the distance from the CEJ to each root apex was measured to determine the RL (Figure 5). The index of bone support (BS) on the mesial and distal sides of the supra-erupted tooth was calculated as (RL - ACL) / RL.

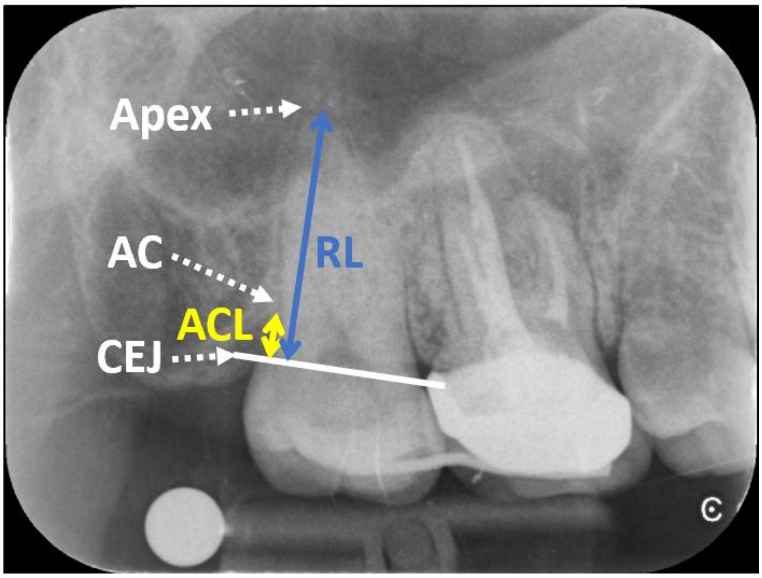

Figure 5. Periapical x-ray measurements of periodontal tissue. ACL indicates alveolar crest level (CEJ-AC); RL indicates root length (CEJ-Apex); CEJ indicates cementoenamel junction.

Statistical analyses were performed using SAS (version 9.4, SAS Inc., Cary, NC, USA); the significance level was set at 5%. All clinical measurements were performed twice by a single examiner (K.K.), yielding an intraclass correlation coefficient (ICC) of 0.90 or higher. In addition, all radiographic and model superimposition measurements were performed by two examiners (K.K. & H.L.), with each examiner conducting the measurements twice. A Bland-Altman analysis was conducted to assess the agreement between measurements, and the results indicated that the mean differences were close to zero and were between the 95% confidence intervals, supporting the consistency of the measurements. Furthermore, a high interclass correlation coefficient (ICC > 0.90) was observed. Linear mixed models and post-hoc analyses based on the same model were conducted to compare the clinical and periapical measurements across time points (T0–T3). Univariable linear regression analysis was performed to assess the effect of the extent of intrusion during the T0–T1 period on each periodontal parameter. Power analysis determined a sample size of 24 (α = 0.05, medium effect size = 0.6, power = 80%), adjusted to 29 to account for a 20% drop-out rate, indicating that the sample size was sufficient for this study.

3. Results

Table III summarizes the changes in the periodontal parameters at each time point. To account for the cluster effects arising from the inclusion of multiple teeth per patient, a linear mixed-effects model was employed to adjust for repeated measurements within subjects. Figure 6 graphically depicts the data presented in Table III.

Table III. Time-dependent changes in the periodontal parameters (mm; % for BS)

Outcome		Time	Estimated mean(SE)	95% CI	Time post-hoc	Diff(SE)	95% CI	p-value†
Clinical crown length	Buccal	1	7.27(0.33)	(6.62, 7.93)	T0 vs T1	1.04(0.23)	(0.59, 1.50)	<.0001****
		2	6.23(0.34)	(5.55, 6.90)	T0 vs T2	0.15(0.24)	(-0.33, 0.63)	0.5398
		3	7.13(0.34)	(6.44, 7.81)	T1 vs T2	-0.90(0.25)	(-1.39, -0.41)	0.0006***
		4	7.34(0.37)	(6.59, 8.09)	T2 vs T3	-0.22(0.30)	(-0.81, 0.38)	0.4703
	Palatal	1	6.70(0.30)	(6.10, 7.30)	T0 vs T1	0.98(0.18)	(0.62, 1.34)	<.0001****
		2	5.73(0.31)	(5.11, 6.34)	T0 vs T2	0.48(0.19)	(0.10, 0.85)	0.0142*
		3	6.23(0.31)	(5.60, 6.85)	T1 vs T2	-0.50(0.19)	(-0.89, -0.11)	0.0123*
		4	6.55(0.33)	(5.89, 7.22)	T2 vs T3	-0.33(0.23)	(-0.79, 0.14)	0.1665

(Continue)

Outcome		Time	Estimated mean(SE)	95% CI	Time post-hoc	Diff(SE)	95% CI	p-value†
Sulcus probing depth	Buccal	1	2.89(0.16)	(2.57, 3.21)	T0 vs T1	-0.58(0.15)	(-0.88, -0.27)	0.0003***
		2	3.47(0.17)	(3.13, 3.80)	T0 vs T2	-0.03(0.16)	(-0.35, 0.29)	0.851
		3	2.92(0.18)	(2.57, 3.27)	T1 vs T2	0.55(0.16)	(0.22, 0.87)	0.0014**
		4	2.91(0.20)	(2.50, 3.31)	T2 vs T3	0.01(0.20)	(-0.38, 0.41)	0.9446
	Palatal	1	3.17(0.23)	(2.71, 3.63)	T0 vs T1	-0.85(0.21)	(-1.28, -0.42)	0.0002***
		2	4.02(0.24)	(3.54, 4.50)	T0 vs T2	-0.13(0.22)	(-0.58, 0.32)	0.5597
		3	3.30(0.25)	(2.80, 3.80)	T1 vs T2	0.72(0.23)	(0.26, 1.18)	0.0028***
		4	3.62(0.29)	(3.05, 4.19)	T2 vs T3	-0.32(0.28)	(-0.88, 0.23)	0.2523
Bone probing depth	Buccal	1	4.51(0.24)	(4.04, 4.99)	T0 vs T1	-1.04(0.21)	(-1.46, -0.61)	<.0001****
		2	5.55(0.25)	(5.06, 6.05)	T0 vs T2	-0.26(0.22)	(-0.71, 0.19)	0.247
		3	4.78(0.26)	(4.26, 5.29)	T1 vs T2	0.78(0.23)	(0.32, 1.24)	0.0013**
		4	4.36(0.29)	(3.77, 4.94)	T2 vs T3	0.42(0.28)	(-0.14, 0.97)	0.1359
	Palatal	1	5.21(0.28)	(4.64, 5.78)	T0 vs T1	-0.99(0.26)	(-1.51, -0.47)	0.0004***
		2	6.20(0.30)	(5.60, 6.79)	T0 vs T2	-0.62(0.27)	(-1.17, -0.07)	0.028*
		3	5.83(0.31)	(5.21, 6.45)	T1 vs T2	0.37(0.28)	(-0.19, 0.93)	0.1948
		4	5.95(0.35)	(5.24, 6.66)	T2 vs T3	-0.12(0.34)	(-0.80, 0.56)	0.7237
Attached gingiva width	Buccal	1	5.10(0.46)	(4.18, 6.02)	T0 vs T1	0.49(0.32)	(-0.15, 1.12)	0.1287
		2	4.61(0.47)	(3.67, 5.55)	T0 vs T2	0.36(0.33)	(-0.31, 1.02)	0.2838
		3	4.74(0.48)	(3.77, 5.70)	T1 vs T2	-0.13(0.34)	(-0.81, 0.55)	0.7087
		4	4.45(0.53)	(3.40, 5.51)	T2 vs T3	0.29(0.41)	(-0.54, 1.11)	0.4883

(Continue)

Outcome		Time	Estimated mean(SE)	95% CI	Time post-hoc	Diff(SE)	95% CI	p-value†
Root length	Mesio-buccal	1	11.12(0.33)	(10.47, 11.77)	T0 vs T1	0.58(0.13)	(0.32, 0.85)	<.0001****
		2	10.54(0.33)	(9.89, 11.19)	T0 vs T2	0.82(0.15)	(0.53, 1.11)	<.0001****
		3	10.30(0.33)	(9.64, 10.96)	T1 vs T2	0.24(0.15)	(-0.06, 0.54)	0.114
		4	10.28(0.34)	(9.61, 10.95)	T2 vs T3	0.02(0.17)	(-0.31, 0.36)	0.8959
	Disto-buccal	1	10.82(0.32)	(10.19, 11.45)	T0 vs T1	0.63(0.10)	(0.43, 0.84)	<.0001****
		2	10.19(0.32)	(9.56, 10.82)	T0 vs T2	0.85(0.11)	(0.63, 1.07)	<.0001****
		3	9.98(0.32)	(9.34, 10.61)	T1 vs T2	0.21(0.11)	(-0.01, 0.44)	0.0609
		4	9.95(0.32)	(9.30, 10.59)	T2 vs T3	0.03(0.13)	(-0.22, 0.28)	0.8234
	Palatal	1	12.87(0.30)	(12.28, 13.46)	T0 vs T1	0.69(0.19)	(0.31, 1.06)	0.0005***
		2	12.18(0.30)	(11.58, 12.77)	T0 vs T2	0.94(0.21)	(0.53, 1.35)	<.0001****
		3	11.93(0.31)	(11.31, 12.55)	T1 vs T2	0.25(0.21)	(-0.17, 0.67)	0.2403
		4	11.89(0.32)	(11.25, 12.52)	T2 vs T3	0.04(0.24)	(-0.43, 0.51)	0.851
Alveolar crest level	Mesial	1	3.36(0.20)	(2.96, 3.77)	T0 vs T1	1.28(0.12)	(1.04, 1.53)	<.0001****
		2	2.08(0.20)	(1.67, 2.48)	T0 vs T2	0.64(0.13)	(0.37, 0.90)	<.0001****
		3	2.73(0.21)	(2.31, 3.15)	T1 vs T2	-0.65(0.14)	(-0.92, -0.38)	<.0001****
		4	2.85(0.22)	(2.41, 3.28)	T2 vs T3	-0.12(0.15)	(-0.42, 0.18)	0.4365
	Distal	1	3.34(0.21)	(2.92, 3.77)	T0 vs T1	1.53(0.08)	(1.36, 1.69)	<.0001****
		2	1.82(0.21)	(1.39, 2.24)	T0 vs T2	0.80(0.09)	(0.61, 0.98)	<.0001****
		3	2.55(0.22)	(2.12, 2.98)	T1 vs T2	-0.73(0.09)	(-0.92, -0.55)	<.0001****
		4	2.67(0.22)	(2.23, 3.11)	T2 vs T3	-0.12(0.11)	(-0.34, 0.09)	0.2553

(Continue)

Outcome		Time	Estimated mean(SE)	95% CI	Time post-hoc	Diff(SE)	95% CI	p-value†
Bone support	Mesial	1	69.4(2.0)	(0.65, 0.73)	T0 vs T1	-9.8(0.9)	(-0.12, -0.08)	<.0001****
		2	79.1(2.0)	(0.75, 0.83)	T0 vs T2	-3.9(1.0)	(-0.06, -0.02)	0.0003***
		3	73.3(2.1)	(0.69, 0.77)	T1 vs T2	5.8(1.1)	(0.04, 0.08)	<.0001****
		4	71.8(2.1)	(0.68, 0.76)	T2 vs T3	1.6(1.2)	(-0.01, 0.04)	0.2102
	Distal	1	74.0(1.8)	(0.70, 0.78)	T0 vs T1	-10.6(1.1)	(-0.13, -0.08)	<.0001****
		2	84.6(1.8)	(0.81, 0.88)	T0 vs T2	-5.0(1.2)	(-0.07, -0.03)	<.0001****
		3	79.0(1.9)	(0.75, 0.83)	T1 vs T2	5.6(1.2)	(0.03, 0.08)	<.0001****
		4	79.8(2.0)	(0.76, 0.84)	T2 vs T3	-0.8(1.4)	(-0.04, 0.02)	0.5516

* SE indicates standard error; Diff indicates difference

† Paired *t*-test analysis between each time interval;

* P < .05; ** P < .01; *** P < .001; **** P < .0001

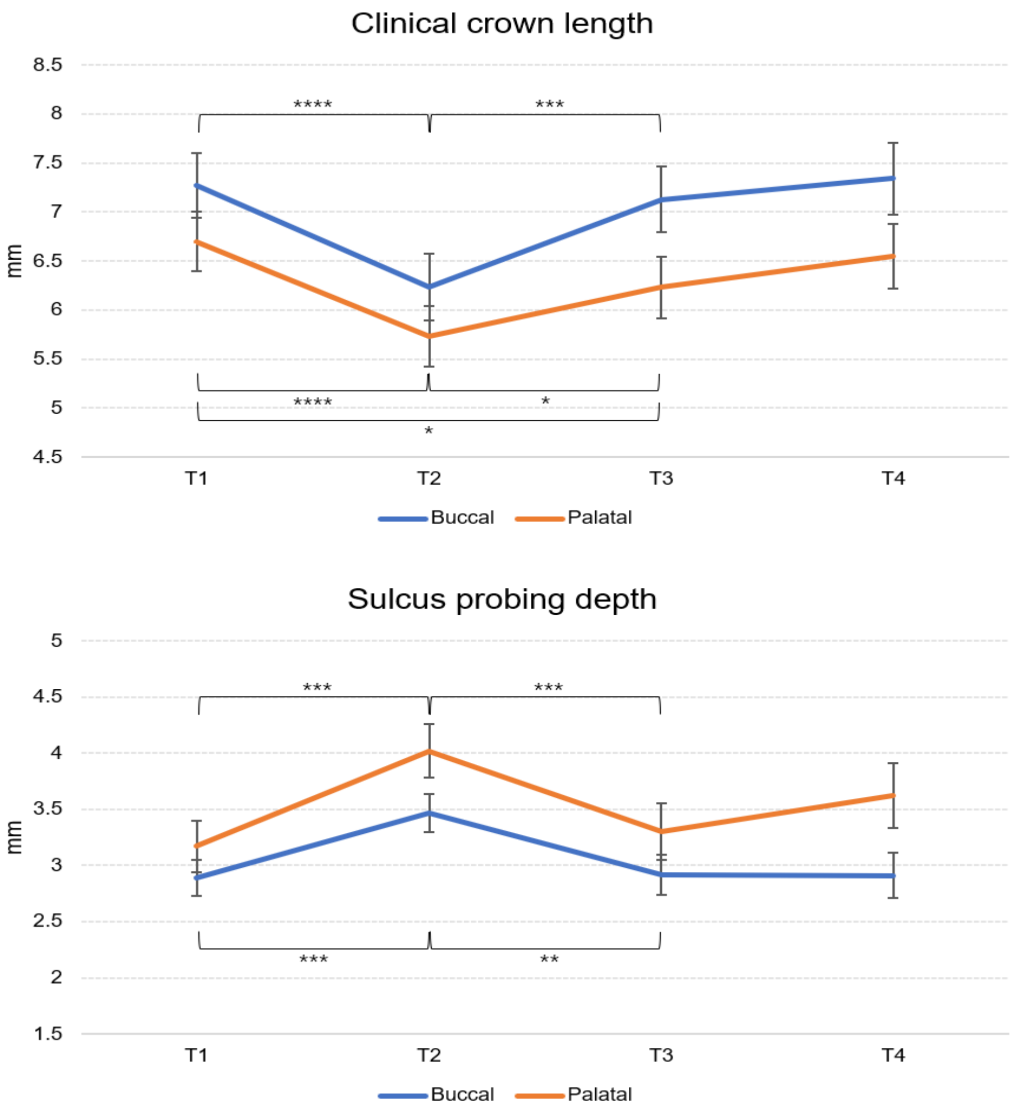

Figure 6. Time-dependent changes in the periodontal parameters. T0, pretreatment; T1, posttreatment; T2, 6 months posttreatment; T3, 2 years posttreatment. The vertical bars indicate standard errors. * $p < .05$; ** $p < .01$; *** $p < .001$; **** $p < .0001$.

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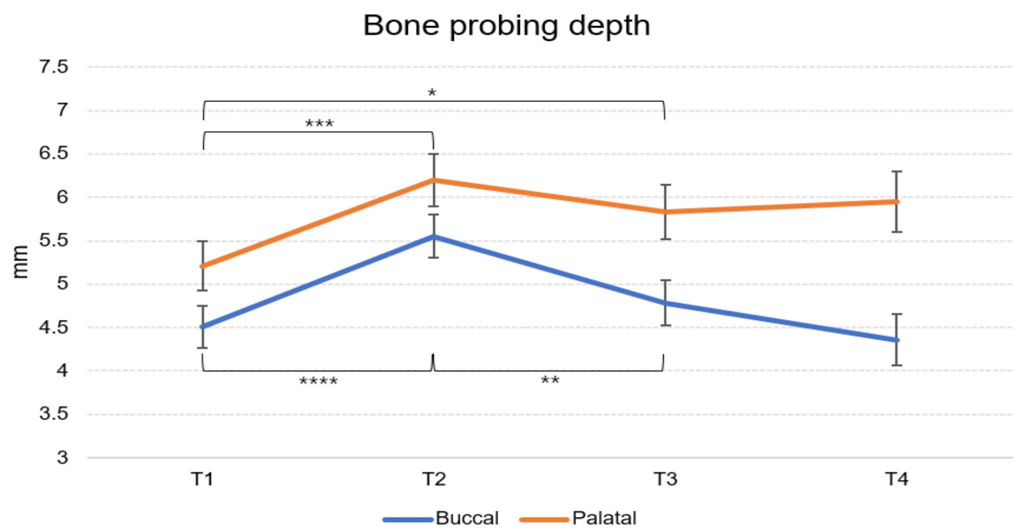
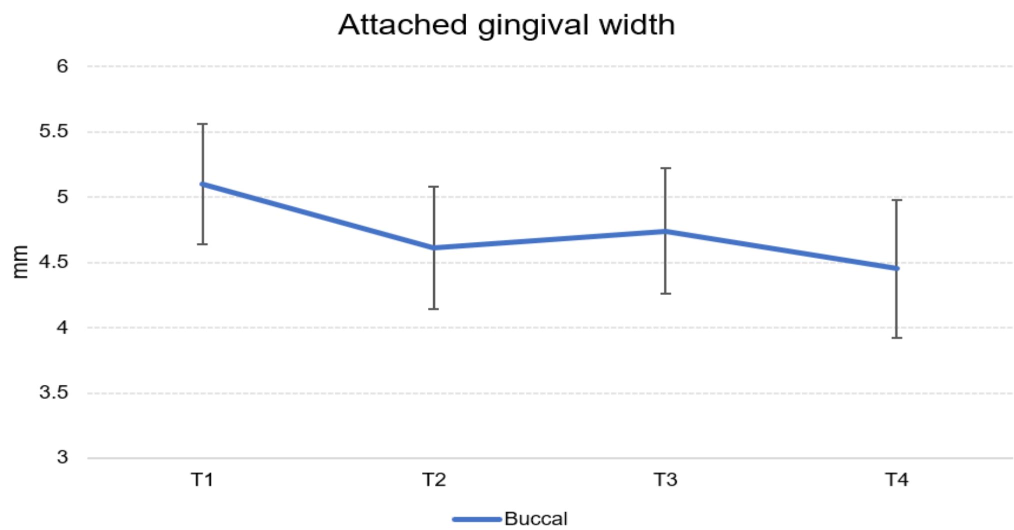
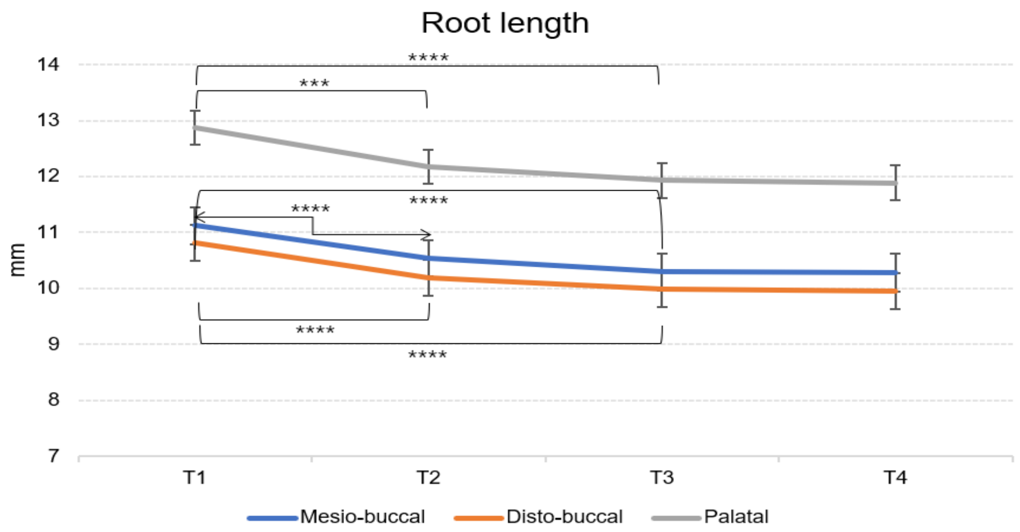
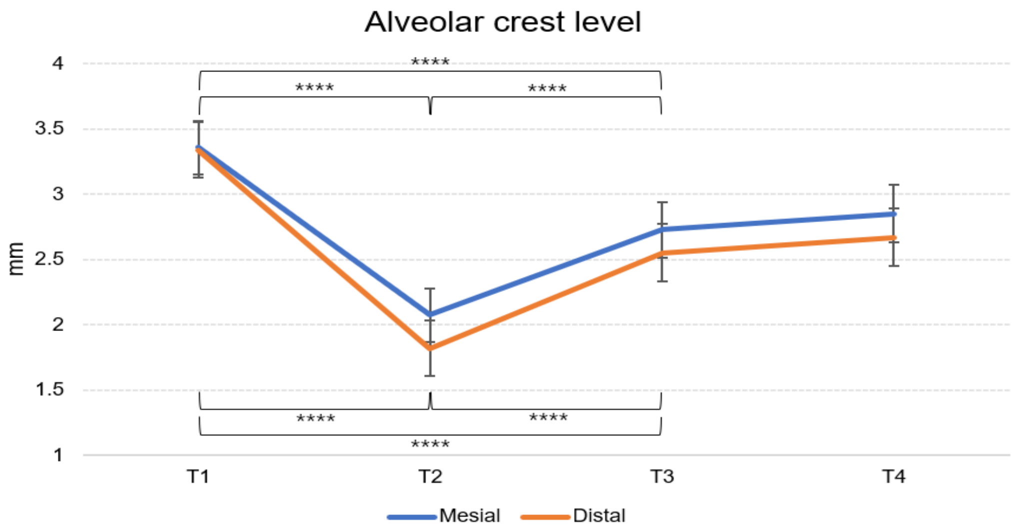

Bone probing depth
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
mm
*
***
****
**
T1
T2
T3
T4
Buccal
Palatal

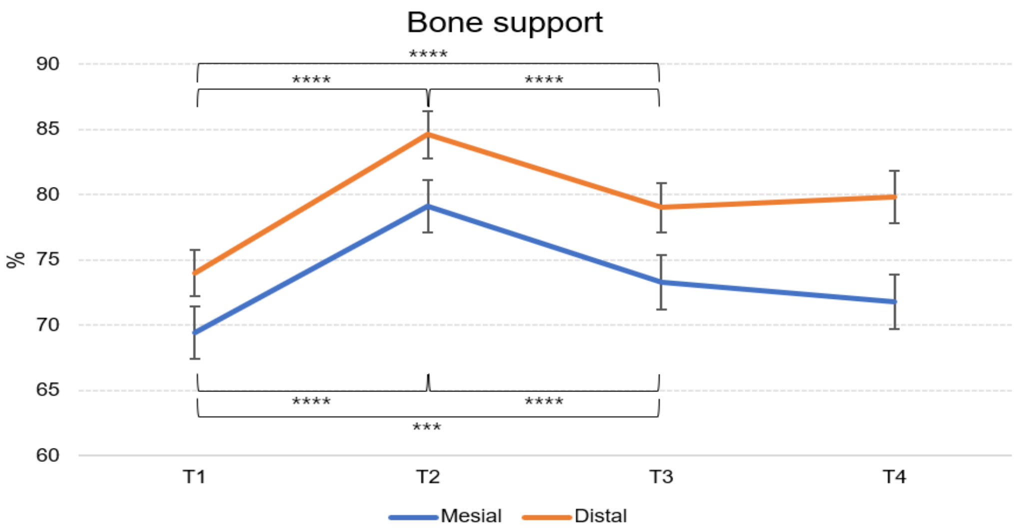

Attached gingival width
6
5.5
5
4.5
4
3.5
3
mm
T1
T2
T3
T4
Buccal

(Continue)


Root length
mm
14
13
12
11
10
9
8
7
T1
T2
T3
T4
****
***
****
****
****
****
Mesio-buccal
Disto-buccal
Palatal


Alveolar crest level
mm
4
3.5
3
2.5
2
1.5
1
T1
T2
T3
T4
****
****
****
****
****
****
Mesial
Distal

(Continue)



Buccal and palatal CCLs decreased by 1.04 ± 0.23 mm and 0.98 ± 0.18 mm respectively, from T0 to T1, followed by increases of 0.90 ± 0.25 mm and 0.50 ± 0.19 mm, respectively, from T1 to T2 ($P < .05$). At T2, the buccal CCL returned to the T0 level ($P > .05$), whereas the palatal CCL remained significantly lower than that at T0 ($P < .05$).

Buccal and palatal SPDs increased by 0.58 ± 0.15 mm and 0.85 ± 0.21 mm, respectively, from T0 to T1, then decreased by 0.55 ± 0.16 mm and 0.72 ± 0.23 mm, respectively, from T1 to T2 ($P < .05$). Both variables returned to T0 levels by T2 ($P > .05$).

Buccal and palatal BPDs increased by 1.04 ± 0.21 mm and 0.99 ± 0.26 mm, respectively, from T0 to T1 ($P < .05$), followed by decreases of 0.78 ± 0.23 mm ($P < .05$) and 0.37 ± 0.28 mm ($P > .05$), respectively, from T1 to T2. At T2, the buccal BPD showed no significant difference from that at T0 ($P > .05$), whereas the palatal BPD was significantly larger than that at T0 ($P < .05$).

No significant differences in AGWs were observed between time intervals ($P > .05$).

Mesiobuccal, distobuccal, and palatal RLs decreased by 0.58 ± 0.13 mm, 0.63 ± 0.10 mm, and 0.69 ± 0.19 mm, respectively from T0 to T1 ($P < .05$). Additional absorption from T1 to T2 was observed; however, it was not statistically significant ($P > .05$).

Mesial and distal ACLs decreased by 1.28 ± 0.12 mm and 1.53 ± 0.08 mm, respectively, from T0 to T1, followed by increases of 0.65 ± 0.14 mm and 0.73 ± 0.09 mm, respectively, from T1 to T2, ($P < .05$). At T2, both mesial and distal ACL were significantly lower than those at T0 ($P < .05$), indicating relative improvement at T1 but resorption at T2; however, overall improvement compared with T0 was noted.

Mesial and distal BS increased by 9.8 ± 0.9% and 10.6 ± 1.1%, respectively, from T0 to T1, followed by decreases of 5.8 ± 1.1% and 5.6 ± 1.2%, respectively, from T1 to T2 ($P < .05$). At T2, both values were significantly higher than those at T0 ($P < .05$).

No statistically significant differences were observed between T2 and T3 for any of the parameters ($P > .05$).

Table IV summarizes the outcomes of the univariable linear regression analysis assessing the effect of the extent of intrusion during the T0–T1 period on each periodontal parameter. While the majority of periodontal parameters did not demonstrate statistically significant associations with the extent of intrusion during this period, significant associations were identified for buccal and palatal clinical crown length, buccal sulcus probing depth, and mesial and distal alveolar crest level ($P < .05$).

Table IV. Standardized coefficients (β) and Pearson's correlation coefficients (r) from the univariable linear regression analysis assessing the effect of the extent of intrusion on each periodontal parameter during T0-T1

Outcome		β(SE)	p-value†	r(95% CI)
Clinical crown length	Buccal	-0.770(0.233)	0.003**	-0.559(-0.773, -0.208)
	Palatal	-0.357(0.156)	0.0312*	-0.423(-0.692, -0.034)
Sulcus probing depth	Buccal	0.319(0.146)	0.039*	0.407(0.015, 0.682)
	Palatal	0.326(0.172)	0.0695	0.362(-0.037, 0.653)
Bone probing depth	Buccal	0.194(0.316)	0.5458	0.124(-0.279, 0.486)
	Palatal	0.227(0.224)	0.3211	0.203(-0.204, 0.544)
Attached gingiva width	Buccal	-0.440(0.257)	0.1002	-0.330(-0.632, 0.073)
Root length	Mesio-buccal	-0.003(0.038)	0.9314	-0.016(-0.374, 0.346)
	Disto-buccal	-0.006(0.025)	0.8182	-0.044(-0.397, 0.322)
	Palatal	-0.010(0.025)	0.6778	-0.082(-0.440, 0.302)
Alveolar crest level	Mesial	-0.302(0.086)	0.0015**	-0.553(-0.758, -0.232)
	Distal	-0.282(0.070)	0.0004***	-0.606(-0.789, -0.305)
Bone support	Mesial	0.008(0.006)	0.1957	0.243(-0.133, 0.552)
	Distal	0.009(0.005)	0.0969	0.309(-0.063, 0.599)

(Continue)

* For the extent of intrusion, the corresponding value was used for each outcome. For example, buccal extent of intrusion was used for buccal outcomes, whereas palatal extent of intrusion was used for palatal outcomes.

* SE indicates standard error

† * P < .05; ** P < .01; *** P < .001

4. Discussion

First, periodontal care was performed regularly during and after treatment for all patients, and since the GI was maintained below 1, the possibility of bias due to periodontitis was excluded.

In contrast to a previous study that reported a 0.4 mm relapse of intrusion without fixed retention[16], in this study, which implemented fixed retention, observed approximately 0.1 mm relapse on model superimposition during the post-retention period, which was not statistically significant according to the Wilcoxon signed-rank test. The consistent absence of extrusive relapse as observed on periapical radiographs throughout the post-retention period also lends support to the clinical relevance of this trend, indicating that extrusive relapse can be disregarded. Nevertheless, the limited number of available plaster models during the post-retention period should be taken into consideration when interpreting these results.

Herein, decreases of 47.23% and 30.71% in the buccal and palatal CCLs, respectively, were observed immediately after treatment compared with the extent of intrusion. This indicates that the gingival margin moved apically by 52.77% in the buccal area and 69.29% in the palatal area relative to the extent of intrusion. Previous studies have reported that the percentage of gingival margin movement during intrusion varies from 21% to 100%[6,7,23,24]. Additionally, the CCL increased again 6 months after treatment completion. Maintenance of the cusp level indicated that the gingival margin moved further apically during the postretention period. Although the buccal CCL fully recovered to its initial clinical crown level, the palatal CCL did not. This phenomenon can be interpreted in terms of the gingival biotype, suggesting that a thicker palatal gingiva results in less gingival recession[25].

In our study, SPD increased after the treatment, which aligns with previous studies[7,13,23], and then returned to the baseline value 6 months posttreatment. Similar tendencies were observed for BPD; however, the decrease 6 months posttreatment was insignificant in the palatal area. The lesser recession of the palatal gingival margin, as demonstrated above, or additional palatal alveolar bone resorption might have contributed to this. Additional resorption of the palatal alveolar bone could be inferred from the fact that while palatal SPD decreased significantly during the postretention period, no significant change in palatal BPD was observed. In addition, the insignificant changes in AGW observed in this study are consistent with most previous studies[5,26].

Herein, less than 1 mm of root resorption occurred up to 6 months posttreatment, which is similar to that observed in previous studies[7,27]. Typically, root resorption within 2 mm is considered clinically insignificant, suggesting that the extent of root resorption observed in this study was clinically acceptable[28].

Many previous studies have reported that orthodontic intrusion exerts compressive forces on the root apex, leading to root resorption[29,30], and that excessive intrusion forces may exacerbate this resorption[30,31]. However, the exact amount of force considered appropriate has yet to be clearly established. Previous studies have utilized a range of forces between 100g and 500g[18]. In this study, the lowest force of 100g was employed, suggesting that the likelihood of increased root resorption due to excessive orthodontic force is low.

The ACL temporarily decreased immediately after treatment in both the mesial and distal regions but increased again 6 months posttreatment. In comparison to the extent of intrusion, the alveolar crest moved apically by 45.77% mesially and 40.47% distally immediately after the treatment and moved further apically during the posttreatment period. Regardless, these values reflected improvement compared with the baseline, indicating an increase in coronal bone support. In addition, the BS ratio showed significant improvement 6 months posttreatment compared with the baseline.

In this study, no statistically significant differences were observed between the measurements taken 6 months and 2 years posttreatment, suggesting that the treatment results remained stable up to 2 years posttreatment. Previous studies have reported relapse rates of 10.36-18.1% at 1–3 years[32-34] in intrusion cases of open bite. These studies targeted comprehensive treatments that may have introduced additional factors that contributed to the relapse and used removable retainers; in contrast, this study employed fixed retainers for more secure retention, potentially explaining the observed differences.

In addition, according to the univariable regression analysis, buccal and palatal clinical crown length, buccal sulcus probing depth, and mesial and distal alveolar crest level showed statistically significant associations with the extent of intrusion. Nonetheless, the absolute values of Pearson's correlation coefficients for these significant parameters ranged from 0.407 to 0.606, reflecting moderate correlations. Thus, although statistically significant, the strength of the associations may be considered limited. These findings are based on the range of intrusion (1.20–4.57 mm) observed in the present study, and caution is warranted when generalizing beyond this range.

Meanwhile, a few previous studies have reported on the relationship between the extent of intrusion and root resorption. Conflicting findings have been reported: while some studies on molars found no significant correlation between the extent of intrusion and root resorption[16,27], one study on anterior teeth reported a positive correlation between the extent of vertical apical displacement and root resorption[29]. This discrepancy may be due to the concentration of force in single-rooted teeth, potentially leading to more pronounced resorption. In contrast, another study reported no significant relationship between the extent of intrusion and either changes in alveolar crest level or root resorption[35].

The limitation of this study is the absence of a control group. The fundamental element that needed to be controlled in this study was the physiological periodontal changes in untreated teeth. A split-mouth design using untreated teeth from the same patient as the control group would have been the best option, as it could also control individual variability. However, since this was a retrospective study, there were no clinical or radiographic data for the teeth that did not undergo intrusion, making retrospective application impractical. Using different intrusion methods as control groups were also considered[36], but following the invention of TADs, it was extremely difficult to find samples using other intrusion methods. Even in the few cases that existed, they were either full orthodontic cases or had very small amounts of intrusion, making them unsuitable for use as a sample. Additionally, this method could not overcome the limitation of not being able to control physiological periodontal changes.

Meanwhile, numerous cross-sectional and longitudinal studies have reported that in patients with a healthy periodontium who did not undergo orthodontic treatment, the average periodontal measurements per year tend to either remain unchanged or show minimal negative change, with the largest reported change being around 0.1 mm[37-41]. Despite this physiological tendency for recession, the fact that the measurements in this study were either maintained or even improved can be interpreted as indicating that the results of this study are more reliable. Further studies are needed to control for individual variability.

Also, the results of this study are believed to be applicable only to supra-erupted maxillary molars. This is because physiologically supra-erupted teeth tend to have their periodontal tissues move along with the tooth during eruption, thus becoming "stretched"[42], which makes them different from the periodontal tissues of normal teeth. For example, it is known that supra-alveolar fibers begin to detach from the cementum starting from the coronal aspect along with tooth intrusion. According to a previous study, it was suggested that if intrusion exceeds 5 mm, the change of the periodontium might be different — no additional gingival fibers would remain, leading to an increase in sulcus depth without alveolar crest resorption[23]. In the case of supra-erupted teeth, detachment of supra-alveolar fibers is not likely to occur until the tooth reaches the occlusal plane level. While it is possible that the results of this study may apply to unextruded teeth within a limited range, it is difficult to conclusively apply the findings of this study to this category. Therefore, it is not feasible to universally generalize the results of this study.

5. Conclusions

Immediately after treatment, CCL, SPD, and BPD either increased or decreased compared with the baseline; however, 6 months posttreatment, they returned to levels similar to those at the baseline, except for palatal BPD. The AGW remained unchanged across all time points. Although root resorption was observed, it was clinically insignificant. Six months after treatment, ACL and BS showed significant improvements compared with the baseline values (Figure 7). The aforementioned periodontal parameters were stable 6 months posttreatment, indicating that orthodontic intrusion of supra-erupted molars might enhance the periodontium.

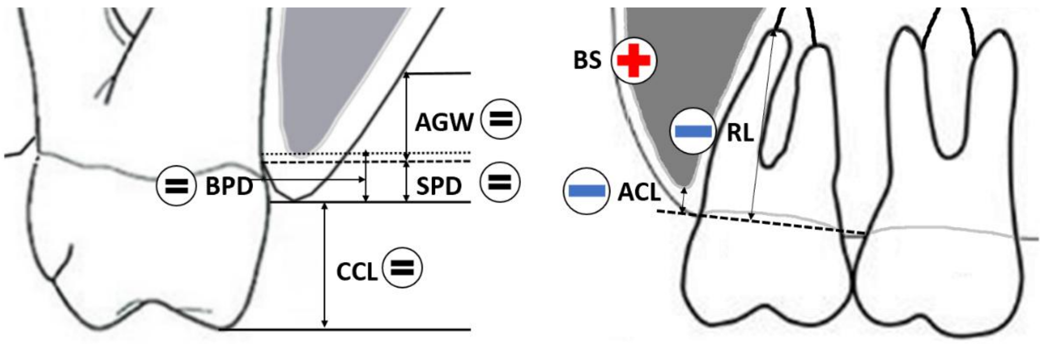


Figure 7. A schematic diagram of changes in parameters 6 months posttreatment compared with those of pretreatment. The black equal sign indicates maintenance; The red plus sign indicates an increase; The blue minus sign indicates a decrease. CCL, clinical crown length; SPD, sulcus probing depth; BPD, bone probing depth; AGW, attached gingiva width; RL, root length; ACL, alveolar crest level; BS, bone support.

Reference

1. Mahoorkar S, Shivakumar.N.Puranik, Moldi A, Chowdhary R, Majge B. Management of Supra-erupted Posterior Teeth- A Review. *INTERNATIONAL JOURNAL OF DENTAL CLINICS*. 2010;2(3):27-30.
2. Chun Y-S, Row J, Yang S-J, Cha H-S, Han J-S. Management of extruded maxillary molars to accommodate a mandibular restoration: A clinical report. *THE JOURNAL OF PROSTHETIC DENTISTRY*. 2000;83(6):604-606.
3. Hakami Z. Molar Intrusion Techniques in Orthodontics: A Review. *Journal of International Oral Health*. 2016;8(2):302-306.
4. Kim YH. Anterior openbite and its treatment with multiloop edgewise archwire *Angle Orthod*. 1987;57(4):290-321.
5. Umemori M, Sugawara J, Mitani H, Nagasaka H, Kawamura H. Skeletal anchorage system for open-bite correction. *Am J Orthod Dentofacial Orthop*. 1999;115(2):166-74.
6. Erkan M, Pikdoken L, Usumez S. Gingival response to mandibular incisor intrusion. *Am J Orthod Dentofacial Orthop*. Aug 2007;132(2):143 e9-13. doi:10.1016/j.ajodo.2006.10.015
7. Melsen B, Agerbaek N, Markenstam G. Intrusion of incisors in adult patients with marginal bone loss. *Am J Orthod Dentofacial Orthop*. 1989;96(3):232-41.
8. Re S, Cardaropoli D, Abundo R, Corrente G. Reduction of gingival recession following orthodontic intrusion in periodontally compromised patients. *Orthod Craniofac Res*. Feb 2004;7(1):35-9. doi:10.1111/j.1601-6343.2004.00277.x
9. Tsai HC, Chang JY, Tu CC, Jane Yao CC. Histological analysis on tissues around orthodontically intruded maxillary molars using temporary anchorage devices: A case report. *Korean J Orthod*. Mar 25 2023;53(2):125-136. doi:10.4041/kjod22.150
10. Park YC, Lee SY, Kim DH, Jee SH. Intrusion of posterior teeth using mini-

screw implants. *Am J Orthod Dentofacial Orthop*. Jun 2003;123(6):690-4. doi:10.1016/s0889-5406(03)00047-7

11. Embery G, Picton DC, Stanbury JB. Biochemical changes in periodontal ligament ground substance associated with short-term intrusive loadings in adult monkeys (Macaca Fascicularis). *Am J Orthod Dentofacial Orthop*. 1987;32(8):545-549.

12. Choi YJ, Kim KH, Lee KJ, Chung CJ, Park YC. Histomorphometric evaluation of maxillary molar roots and surrounding periodontium following molar intrusion in rats. *Orthod Craniofac Res*. Feb 2015;18(1):12-20. doi:10.1111/ocr.12054

13. Choi YJ, Kim KH, Lee KJ, Chung CJ, Park YC. Radiographic evaluations of molar intrusion and changes with or without retention in rats. *Angle Orthod*. May 2011;81(3):389-96. doi:10.2319/060510-307.1

14. Xun CL, Zhao H, Zeng XL, Wang X. Intrusion of overerupted maxillary molars with miniscrew implant anchorage: a radiographic evaluation. *J Huazhong Univ Sci Technolog Med Sci*. Oct 2013;33(5):780-785. doi:10.1007/s11596-013-1197-5

15. Ari-Demirkaya A, Masry MA, Erverdi N. Apical Root Resorption of Maxillary First Molars after Intrusion with Zygomatic Skeletal Anchorage. *Angle Orthod*. 2005;75:761-767.

16. Heravi F, Bayani S, Madani AS, Radvar M, Anbiaee N. Intrusion of supra-erupted molars using miniscrews: clinical success and root resorption. *Am J Orthod Dentofacial Orthop*. Apr 2011;139(4 Suppl):S170-5. doi:10.1016/j.ajodo.2009.06.032

17. Bayani S, Heravi F, Radvar M, Anbiaee N, Madani AS. Periodontal changes following molar intrusion with miniscrews. *Dent Res J (Isfahan)*. 2015;12(4):379-85.

18. Manea A, Dinu C, Baciut M, Buduru S, Almasan O. Intrusion of Maxillary Posterior Teeth by Skeletal Anchorage: A Systematic Review and Case Report with

Thin Alveolar Biotype. *J Clin Med*. Jun 30 2022;11(13)doi:10.3390/jcm11133787

19. Yen C-C, Dung TS-Z, Shih H-M, Lu H-K. Periodontal Considerations of Orthodontic Molar Intrusion: A Review of Traditional Orthodontic Methods and Temporary Anchorage Devices. *J Taiwan Periodontol*. 2011;16(1)

20. Proffit WR, Henry W. Fields J, Larson BE, Sarver DM. Contemporary Orthodontics, Sixth Edition. *Elsevier*. 2019:345.

21. Jang W, Choi YJ, Hwang S, Chung CJ, Kim K-H. Anchorage loss assessment of the indirect anchor tooth during adjunctive orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 2019;155:347-54.

22. Greenberg J, Laster L, Listgarten MA. Transgingival probing as a potential estimator of alveolar bone level. Article. *J Periodontol*. 1976;47(9):514-517. doi:10.1902/jop.1976.47.9.514

23. Murakami T, Yokota S, Takahama T. Periodontal changes after experimentally induced intrusion of the upper incisors in Macaca fuscata monkeys. *Am J Orthod Dentofacial Orthop*. 1989;1989(95):2.

24. Abdel-Kader HM. Clinical crown length and reduction in overjet, overbite, and dental height with orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 1986;89:246-250.

25. Olsson M, Lindhe J. Periodontal characteristics in individuals with varying form of the upper central incisors. *J Clin Periodontol*. 1991/01// 1991;18(1):78-82. doi:10.1111/j.1600-051x.1991.tb01124.x

26. Busschop JL, Vllerberghe MV, Boever JD, Dermaut L. The width of the attached gingiva during orthodontic treatment: A clinical study in human patients. *American Journal of Orthodontics*. 1985;87(3):224-229.

27. Bellini-Pereira SA, Almeida J, Castillo AA-D, Santos CCOd, Henriques JFC, Janson G. Evaluation of root resorption following orthodontic intrusion: a systematic review and meta-analysis. *European Journal of Orthodontics*. 2021;43(4):432-441.

28. Sameshima GT, Iglesias-Linares A. Orthodontic root resorption. *Journal of*

the World Federation of Orthodontists. 2021;10:135-143.

29. Kim KW, Kim SJ, Lee JY, et al. Apical root displacement is a critical risk factor for apical root resorption after orthodontic treatment. *Angle Orthod*. Nov 2018;88(6):740-747. doi:10.2319/111417-777.1

30. Roscoe MG, Meira JBC, Cattaneo PM. Association of orthodontic force system and root resorption: A systematic review. *Am J Orthod Dentofacial Orthop*. 2015;147:610-26.

31. Currell SD, Liaw A, Grant PDB, Esterman A, Nimmo A. Orthodontic mechanotherapies and their influence on external root resorption: A systematic review. *Am J Orthod Dentofacial Orthop*. 2019;155:313-29.

32. Espinosa DG, Moreira PEdO, Sousa ASd, Flores-Mir C, Normando D. Stability of anterior open bite treatment with molar intrusion using skeletal anchorage: a systematic review and metaanalysis. *Progress in Orthodontics*. 2020;21:35.

33. Lee HA, Park YC. Treatment and posttreatment changes following intrusion of maxillary posterior teeth with miniscrew implants for open bite correction. *Korean J Orthod*. 38(1):31-40.

34. Baek MS, Choi YJ, Yu HS, Lee KJ, Kwak J, Park YC. Long-term stability of anterior open-bite treatment by intrusion of maxillary posterior teeth. *Am J Orthod Dentofacial Orthop*. Oct 2010;138(4):396 e1-396 e9. doi:10.1016/j.ajodo.2010.04.023

35. Bellamy LJ, Kokich VG, Weissman JA. Using orthodontic intrusion of abraded incisors to facilitate restoration. *J American Dental Association*. 2008;139(6):725-733.

36. Liu J, Wei T, Zhao Y, Jiang C. Efficacy of maxillary molar intrusion and quantification of related external apical root resorption – A comparison of two approaches. *Orthod Craniofac Res* 2024;27:733–739.

37. Ship JA, Beck JD, Arbor A. Ten-year longitudinal study of periodontal

attachment loss in healthy adults. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1996;81(3):281-290.

38. Machtei EE, Hausmann E, Dunford R, et al. Longitudinal study of predictive factors for periodontal disease and tooth loss. *J Clin Periodontol*. Jun 1999;26(6):374-80. doi:10.1034/j.1600-051x.1999.260607.x

39. Lindhe J, Okamoto H, Yoneyama T, Haffajee A, Socransky SS. Longitudinal changes in periodontal disease in untreated subjects. *J Clin Periodontol*. Nov 1989;16(10):662-70. doi:10.1111/j.1600-051x.1989.tb01037.x

40. Ship JA, Wolff A. Gingival and Periodontal Parameters in a Population of Healthy Adults, 22-90 Years of Age. *Gerodontology*. 1988;7(2):55-60.

41. Needleman I, Garcia R, Gkranias N, et al. Mean annual attachment, bone level, and tooth loss: A systematic review. *J Periodontol*. Jun 2018;89 Suppl 1:S120-S139. doi:10.1002/JPER.17-0062

42. Antonarakis GS, Zekerido A, Kiliaridis S, Giannopoulou C. Periodontal considerations during orthodontic intrusion and extrusion in healthy and reduced periodontium. *Periodontology 2000*. 2024;00:1-25.

국문 요약

교정용 미니스크류를 이용한 정출된 상악 대구치의 압하 후 치주 변화

(지도 교수: 김 경 호, D.D.S., M.S., Ph.D.)

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이 현 지

본 연구는 교정용 미니스크류를 이용한 정출된 상악 대구치의 압하 치료 동안 및 유지 이후의 치주 조직 변화를 분석하는 것을 목적으로 하였다.
총 40개의 정출된 상악 대구치를 대상으로 협측 및 구개측에 미니스크류를 식립하고, 100g의 교정용 탄성체를 이용해 압하력을 가하였다. 임상 검진 및 치근단 방사선 촬영은 치료 전(T0), 치료 직후(T1), 치료 후 6개월(T2), 치료 후 2년(T3)에 시행되었으며, 임상 치관 길이(CCL), 치조골 탐침 깊이(SPD), 치주낭 탐침 깊이(BPD), 부착 치은 폭경(AGW), 치근 길이(RL), 치조정 높이(ACL), 골 지지도(BS) 등의 변수를 측정하였다. 압하 및 재발의 정도는 석고 모형 중첩을 통해 평가하였다. 모든 환자에게 치료 중 및 치료 후 정기적인 치주 관리가 시행되었으며, 치은지수는 1 미만으로 유지되었다.

치료 직후에는 CCL이 감소하고 SPD 및 BPD가 증가하였으나, 치료 후 6개월 시점에는 구개측 BPD를 제외한 모든 항목이 기저 수준으로 회복되었다.

AGW는 모든 시점에서 유의한 변화 없이 유지되었다. 치근 길이(RL)는 T0에서 T1 사이 유의하게 감소하였으나, 감소량이 1 mm 미만으로 임상적으로는 유의하지 않은 수준이었다. 치료 후 6개월 시점에서 ACL과 BS는 치료 전보다 유의하게 향상되었으며, T2와 T3 사이에는 모든 치주 지표에서 유의한 차이가 없어 치료 후 6개월 이후 안정성이 유지됨을 시사하였다.

결론적으로, 정출된 상악 대구치의 교정적 압하는 장기적으로 치주 상태를 개선할 수 있다.

핵심되는 말 : 상악 대구치 압하, 교정용 미니스크류, 치주 변화, 장기 추적 관찰