Original Article

Evaluation of dentoalveolar changes following maxillary incisor intrusion with one vs two anterior miniscrews in subjects with gummy smile: a randomized clinical trial

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ABSTRACT

Objectives: To examine dentoalveolar changes following intrusion of maxillary incisors with one or two anterior miniscrews in subjects with gummy smile and deep bite.

Materials and Methods: Forty-three subjects were selected and divided into two groups: group I (22 subjects: 15 women, 7 men; mean age 30 $\pm$ 10 years) received one miniscrew between the upper central incisors, and group II (21 subjects: 16 women, 5 men; mean age 30 $\pm$ 10 years) received two miniscrews between the canines and lateral incisors. Dentoalveolar parameters, including amount of intrusion, root resorption, incisor inclination, alveolar bone thickness, and buccal alveolar crest height (cementoenamel junction to labial alveolar crest), were evaluated using cone-beam computed tomography scans obtained before and after intrusion. The intergroup comparison was analyzed using a paired *t*-test and unpaired *t*-test to determine significant changes within and between groups.

Results: The amount of intrusion was significantly greater in group II than in group I ($P < .05$). No statistically significant differences were found between groups I and II for changes in incisor inclination, labial bone thickness, and buccal alveolar crest height ($P > .05$).

Conclusions: Maxillary central and lateral incisor intrusion was significantly greater in subjects treated with two miniscrews. Root resorption of the maxillary central incisors was notably greater in subjects with one miniscrew, while maxillary lateral incisor resorption was greater in subjects treated with two miniscrews. (*Angle Orthod*. 2024;94:522–531.)

KEY WORDS: Randomized clinical trial; Microimplant; Miniscrew; 3-dimensional diagnosis and treatment planning; Intrusion

INTRODUCTION

Orthodontists commonly encounter anterior deep bite, which affects 21% to 26% of the population.[1] It adversely affects periodontal health, the temporomandibular joint, and esthetics. Conventional incisor intrusion techniques lead to undesirable effects such as posterior tooth extrusion or anterior proclination, compromising treatment efficacy.[2,3] Miniscrews (MS) can facilitate intrusion with less proclination by applying force closer to the center of resistance (CR).[2–7]

There is no standardized protocol regarding the number and location of MS placement for anterior intrusion. Some investigators[4,5] have used a single MS between the central incisors (CI), while others used two. Placement strategies differ further, with some using two MS between the central and lateral incisors (LI)[1,6] and others favoring placement between canines and LI.[3,7–11] Inadequate interradicular bone and proximity to the periodontal ligament (PDL; <0.5 mm) increase the risk of MS failure.[12] Limited

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interradicular bone between CI and LI favors the region between LI and canines.[13] Limited literature compares single- vs dual-MS scenarios. Vela-Hernandez et al.[11] assessed the effects of one vs two anterior MS for maxillary intrusion through lateral cephalograms.

Intrusion often results in unwanted root resorption (RR).[14,15] Most research on upper incisor intrusion used lateral cephalograms,[3,6,7,11,16] while few studies used cone-beam computed tomography (CBCT) to evaluate RR.[8,17]

Lateral cephalograms offer a two-dimensional view, while CBCT provides 3D insight into dentoalveolar structures. There are no 3D comparative studies on the impact of one vs two MS in incisor intrusion. Therefore, this CBCT study aimed to evaluate the dentoalveolar variation associated with maxillary incisor intrusion using a single midline vs two bilateral MS (between the canine and LI). The null hypothesis was that there would be no significant dentoalveolar difference between single and bilateral MS-assisted intrusion mechanics.

MATERIALS AND METHODS

The research was conducted in the Department of Orthodontics (September 2021 to December 2022) after receipt of Institutional Ethical Committee approval (IEC/SCB Dental College and Hospital, Cuttack, Odisha, India/102/2021) and enrollment in the Clinical Trial Registry (CTRI/2022/09/045583).

Using G*POWER-3.1.9.7, it was calculated that 21 subjects per group were necessary for the study, based on a significance level of .05, a power of .80, and an assumed effect size of .9. Considering attrition, 45 eligible subjects (men = 13, women = 32) were selected. After two dropouts, 43 subjects were enrolled with informed consent, following the Consolidated Standards of Reporting Trials guidelines (Figure 1).

The participants were selected from patients undergoing treatment in the Department of Orthodontics, SCB Dental College and Hospital. For homogeneity, the inclusion criteria were (1) nongrowing subjects (mean age 30 $\pm$ 10 years) needing extraction of the maxillary first premolars as part of their treatment plan, (2) subjects in the postalignment and leveling stage, (3) gingival display $>$3 mm on posed smile and overbite $>$4 mm (deep bite), (4) maxillary incisor inclination (U1-SN) $>$104°, and (5) maxillary anterior dentoalveolar height (upper incisor to nasal floor) $>$32.6 mm for men and 29.2 mm for women. Exclusion criteria were (1) subjects with a prior history of trauma or orthodontic and endodontic treatment of the maxillary incisors, (2) pregnancy or systemic disease/under long-term medication, and (3) skeletal deep bite requiring surgery.

The participants were randomly allocated into two groups using computer-generated number sequences. The group I subjects received one midline MS, whereas the subjects in group II received bilateral MS (between LI and canine). Blinding was impractical for patients, the investigator who placed the MS (Dr Das), and the data calibration examiner (Dr M) due to the inherent study characteristics. Only the statistician was blinded.

Orthodontic Preparation

Following extraction, MBT brackets (Leone, Italy) and molar tubes (0.018 $\times$ 0.025 inches) were used for all patients. Alignment and leveling were achieved with 0.012, 0.014, 0.016, and 0.016 $\times$ 0.022-inch NiTi and with 0.016 $\times$ 0.022-inch stainless steel (SS) archwires. The final archwire was cinched distal to the second molar. The second premolar, first molar, and second molars were consolidated by figure-eight ligation and a transpalatal arch for anchorage reinforcement.

Study Intervention

After alignment and leveling in group I subjects, a single MS (1.4 $\times$ 8 mm; FavAnchor, India) was placed $\geq$6 mm above the alveolar crest in the labial interradicular area between CI. In cases with low frenal attachment, the MS was placed by displacing the frenum and attaching an S-shaped hook (0.018-inch SS) to the MS to avoid difficulty in changing the elastic chain (e-chain) due to soft tissue growth. In group II, the MS were placed bilaterally using the same protocol. A pointer (Figure 2), made by trimming the base of the lingual button, was used as a guide for implant positioning. After topical anesthesia, the pointed end of the button was pressed into the interradicular area, and a periapical radiograph was taken to confirm the site of MS placement (Figure 3).

Intraoral photographs, CBCT, and clinical measurements were taken after implant placement and before intrusion (T0). For anterior intrusion in group I, 100 gf was applied with an e-chain from the MS or attached hook to the archwire, while in group II, 50 gf was loaded from each MS (Figures 4 and 5). E-chains were replaced (reactivated) every 4 weeks over 3 months, followed by CBCT (T1) for postintrusion assessment.

Radiological Assessment

Imaging characteristics. CBCT scans were obtained using a NewTomGiANO machine with a 0.3-mm voxel size. Automatic X-ray parameter selection was based on scout views for an 8 $\times$ 8-cm field of view. The 2D and 3D images were generated in 16-bit grayscale using NewTom NNT software.

CBCT orientation. For image acquisition, the head was oriented and multiplanar reconstruction was

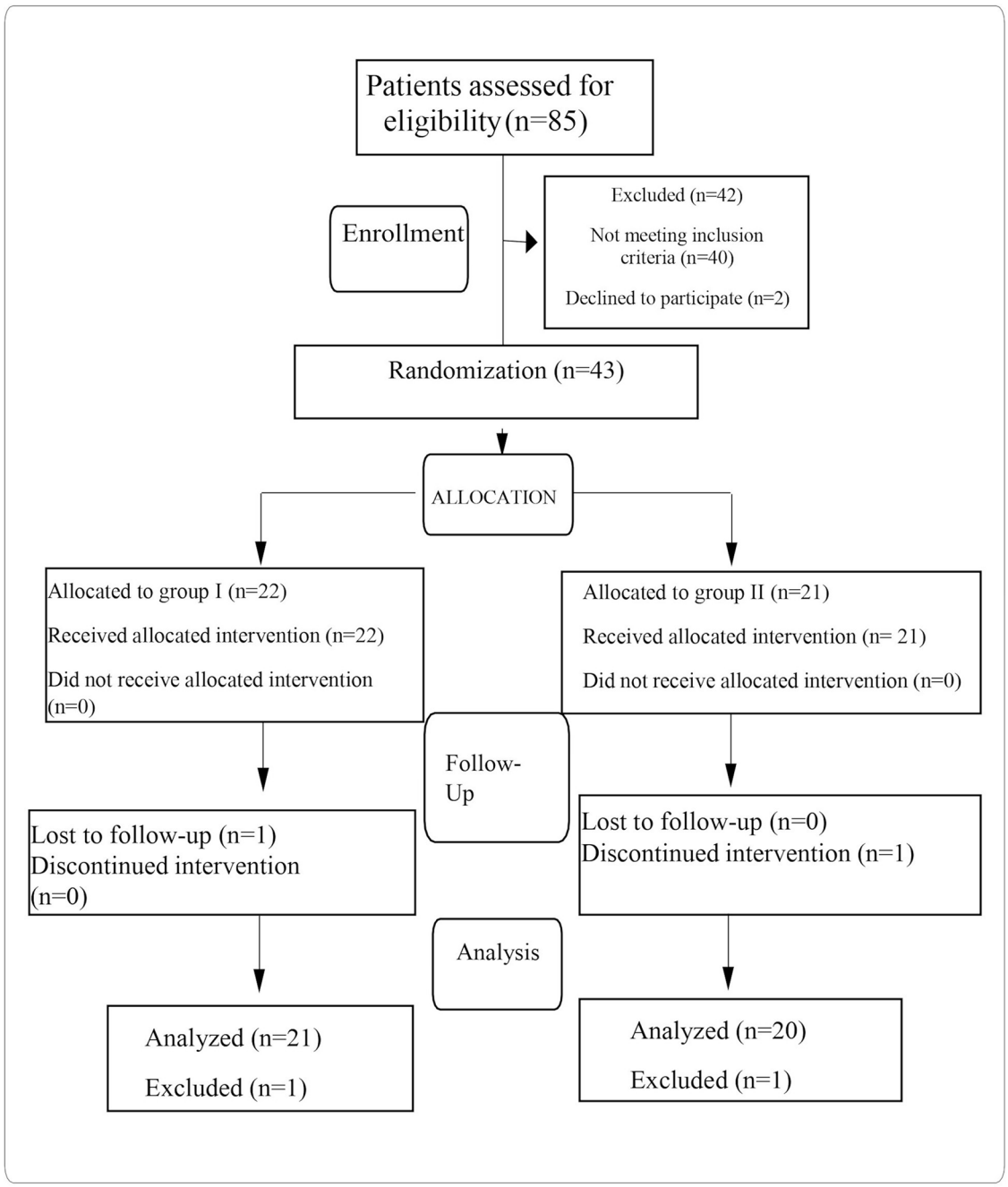

Figure 1. CONSORT flow diagram.

selected (Figure 6). In the axial plane, the desired tooth was aligned along its long axis in both the coronal and sagittal sections. In the corrected sagittal view, the palatal plane (PP) was marked using a line tool from the anterior to posterior nasal spine.

CBCT examination. Using an NNT viewer, evaluations were performed for maxillary incisor intrusion, inclination, alveolar bone thickness, buccal alveolar crest height (BACH), and RR.

Dental Changes

In the corrected midsagittal view:

1. Maxillary incisor intrusion was recorded from the PP to the incisal edges (incisor [U1/U2]–PP linear distance in millimeters). The difference between pre- and postvalues was the amount of intrusion (Figure 7A).
2. Maxillary incisor inclination was the angulation between the incisor long axis and the PP (incisor [U1/U2]–PP angle) in degrees. The change in

Figure 2. Guiding pointer used for correct miniscrew placement.

inclination was calculated from pre- and postvalues (Figure 7B).
3. Incisor length was recorded from the distance between the root apex to the incisal edges. The change in length determined the amount of RR (Figure 7C).

Sagittal changes of the molar were assessed clinically by measuring the horizontal distance from the maxillary first molar tube slot mesial aspect to the maxillary canine distal aspect using a digital vernier calliper.

Alveolar Bone Changes

1. Labial and palatal alveolar bone thickness (LBT and PBT) were measured for incisors in three slices separated by 3 mm (ie, 3 mm, 6 mm, and 9 mm) from the alveolar crest at the greatest diameter of the teeth in the axial section (Figure 7D).
2. BACH was recorded from the cementoenamel junction to the labial alveolar crest (LAC) in the midsagittal view.

The principal investigator performed all measurements at three equal intervals on the same day, and average values were used for statistical analysis.

Statistical Analysis

SPSS v23.0 was used for analysis. Descriptive statistics included mean values and standard deviations. Shapiro-Wilk normality test was used to determine

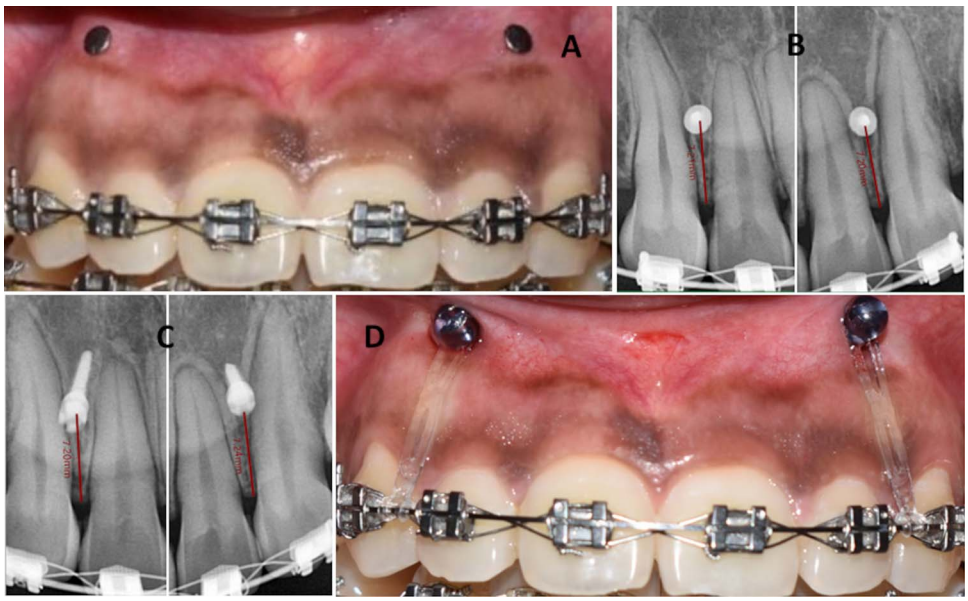

Figure 3. Use of guiding pointer in group II. (A) Guiding pointers. (B) Periapical radiograph with guiding pointers. (C) Periapical radiograph with miniscrews. (D) Two miniscrews loaded for intrusion with elastic chain.

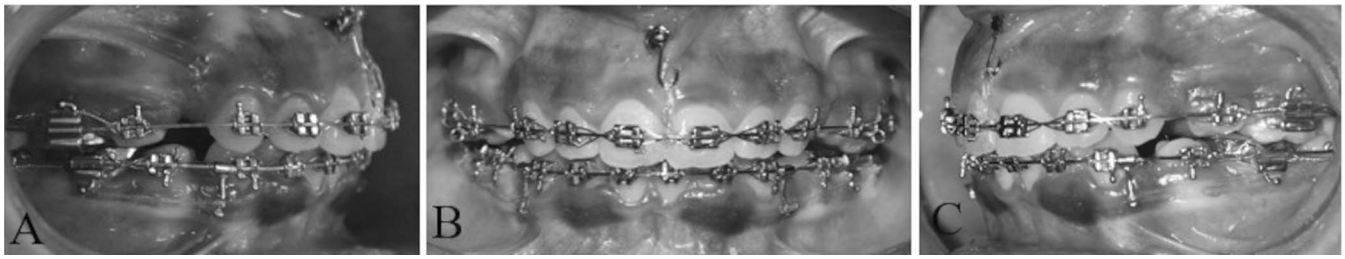

Figure 4. Preintrusion (T0) intraoral photographs, group I. (A) Right buccal. (B) Frontal. (C) Left buccal.

the normal distribution of parameters. Based on test outcome, a paired *t*-test or Wilcoxon signed-rank test was used to assess treatment changes within groups, depending on data normality. Similarly, an independent *t*-test or Kolmogorov-Smirnov test was used for intergroup comparisons. The significance level was $P < .05$.

RESULTS

Forty-three patients underwent intrusion using MS. Two patients were excluded due to irregular follow-up and MS failure, leaving 41 subjects. At baseline (T0), both groups were generally similar without any statistically significant differences (Table 1). Following intrusion, a reduction in gingival show on smile was clinically significant in both groups (Figure 8).

Pre (T0) and post (T1) intrusion data showed a normal distribution for all parameters. Therefore, paired Student *t*-test was used for intragroup comparison and unpaired *t*-test for intergroup comparison.

Dental Changes

Intragroup assessment. From T0 to T1, statistically significant intrusion was observed in both groups with an increase in incisor inclination and RR ($P < .001$). For CI, the intrusion rate was 0.52 mm/mo for group I and 0.71 mm/mo for group II. LI showed rates of 0.45 mm/mo for group I and 0.69 mm/mo for group II (Table 2).

Intergroup comparison. When the mean changes (T1–T0) were compared, significant differences were observed for the amount of intrusion ($P < .001$) and RR ($P < .05$). The amount of intrusion in group II was significantly greater (0.54 ± 0.14 mm for CI and 0.72 ± 0.13 mm for LI) than in group I. Group I exhibited more RR in CI (0.73 ± 0.27 mm), while group II demonstrated more resorption in LI (0.89 ± 0.31 mm). No significant differences ($P > .05$) were observed for the change in incisor inclination (Table 3).

Sagittal Changes of the First Molar

The intragroup and intergroup comparisons revealed no statistically significant decrease in the horizontal distance from canine to first molar (Tables 2 and 3).

Alveolar Bone Changes

Change in alveolar bone heights: intragroup assessment. In both groups, a statistically significant increase ($P < .001$) in BACH was observed after 3 months of intrusion (Table 2).

Change in alveolar bone heights: intergroup comparison. When the mean changes were compared, no significant differences ($P > .05$) were observed for the change in BACH (Table 3).

Change in alveolar thickness: intragroup assessment. Statistically significant decreases in LBT at 3 mm and 6 mm were found in both groups. However, a significant increase was noted at 9 mm from T0 to T1. Both groups exhibited a statistically significant increase in PBT at 3 mm and 6 mm postintrusion. However, a significant decrease was observed at 9 mm ($P < .05$; Table 4).

Figure 5. Preintrusion (T0) intraoral photographs, group II. (A) Right buccal. (B) Frontal. (C) Left buccal.

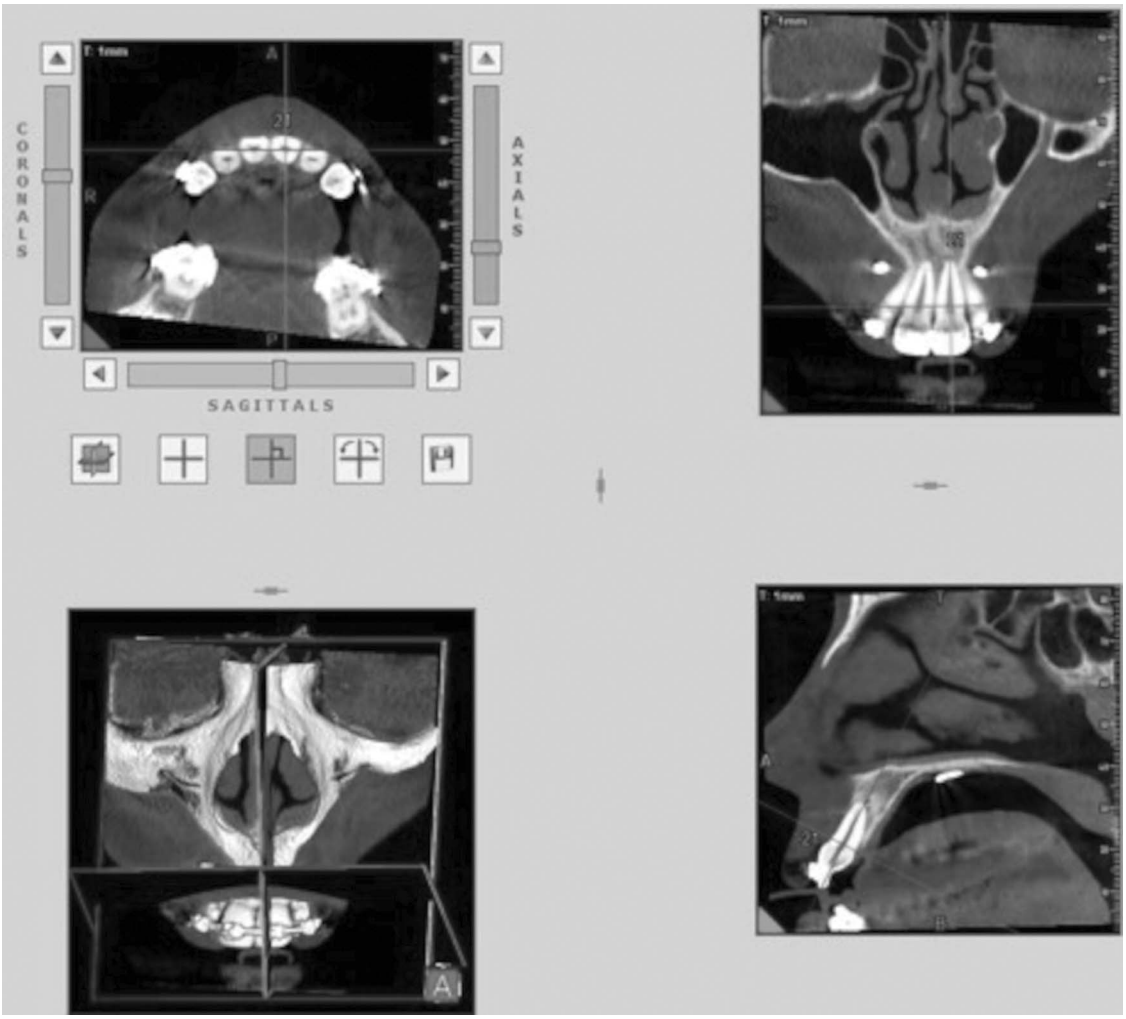

Figure 6. CBCT orientation of three planes of space.

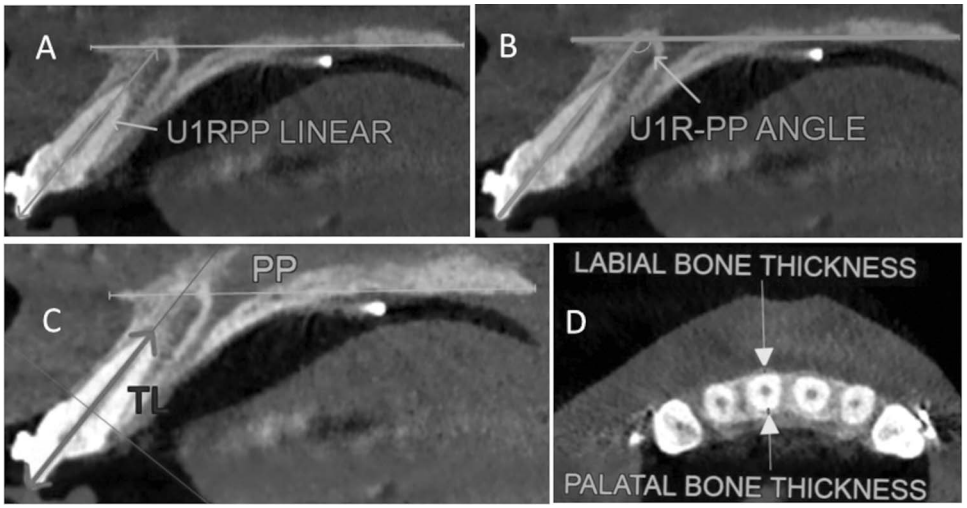

Figure 7. CBCT measurements: (A) vertical incisor position, (B) incisor inclination, (C) incisor total length, (D) labial and palatal bone thickness.

Table 1. Comparison of Initial Incisor Length, Inclination, and Vertical Incisor Position Between the Groups[a]

Variable	Tooth	Group I	Group II	*P* Value
Incisor length, mm	U1R	22.41 ± 2.07	21.74 ± 2.25	.83
	U1L	22.70 ± 1.88	21.88 ± 2.24	.49
	U2R	20.13 ± 2.13	20.53 ± 2.33	.57
	U2L	20.23 ± 2.07	21.07 ± 1.95	.62
Incisor inclination, °	U1R-PP	108.40 ± 2.95	119.69 ± 4.41	.27
	U1L-PP	109.10 ± 3.61	119.59 ± 4.39	.77
	U2R-PP	105.26 ± 3.49	118.98 ± 5.00	.36
	U2L-PP	104.19 ± 4.42	117.88 ± 5.34	.44
Vertical incisor position, mm	U1R-PP	31.21 ± 1.33	31.97 ± 2.16	.17
	U1L-PP	31.47 ± 1.63	32.34 ± 1.88	.92
	U2R-PP	30.54 ± 1.36	30.90 ± 2.10	.053
	U2L-PP	30.15 ± 1.69	31.20 ± 1.71	.83

[a] Group I, intrusion with a single miniscrew; group II, intrusion with two miniscrews; PP, palatal plane; U1R, right upper central incisor; U1L, left upper central incisor; U2R, right upper lateral incisor; U2L, left upper lateral incisor. Values are presented as mean ± standard deviation. Units are given in millimeters. Comparison of pretreatment measurements between the groups carried out using independent *t*-test; the significance level was $P < .05$.

Change in alveolar thickness: intergroup comparison. When comparing the mean changes, no statistically significant differences ($P > .05$) were found for the change in LBT at 3, 6, or 9 mm. Group I showed a significantly greater increase in PBT at 3 and 6 mm ($P < .05$) compared with group II. In addition, group I exhibited a significantly greater decrease in PBT at 9 mm (Table 5).

DISCUSSION

MS-assisted incisor intrusion simplifies gummy smile treatment, offering precise overbite reduction without conventional complications.[8] The site and number of MS used for incisor intrusion are not standardized in the literature as some clinicians use one midline MS[4,5] and others use two between central and LI[1,6] or LI and canines.[3,7–11] This CBCT study compared dentoalveolar changes in maxillary incisors with one vs two anterior MS-assisted intrusion.

Location of the CR is crucial for achieving true intrusion with minimal force and avoiding unintended tooth movement. Jeong et al.,[18] in a finite element method (FEM) study, found that the CR for the anterior maxillary teeth was 26.5 mm posterior and 11 mm apical to the CI edges on a line perpendicular to the occlusal plane distal to the first premolar.

In the present study, when the same total 100 gf was applied, the degree of intrusion was greater in dual MS subjects than in those with a single MS, probably due to distinct MS placement strategies. In group II, the point of force application was closer to the CR than in group I. Consequently, more favorable MS placement in group II led to increased intrusion with the same force.

The current study showed that the intrusion rate of CI was 0.52 mm/mo for the single-MS group and 0.71 mm/mo for subjects with dual MS. In a similar study conducted by Vela-Hernandez et al.,[11] the authors reported higher intrusion values in the two-MS group compared with the single-MS system. However, the intrusion rate in their study was nearly double that of the present study (8.19 ± 3.66 mm in the two-MS group and 5.69 ± 2.66 mm in the single-MS group for 6.1 ± 1.2 months). They applied 180 gf for the two-MS group and 90 gf for the single-MS group and used Tip-Edge Plus brackets. In their lateral cephalogram study, they found the RR of CI to be 2.20 ± 0.88 mm for single-MS and 2.11 ± 0.82 mm for the dual-MS group. This increased RR could be attributed to a higher intrusion rate and longer duration.

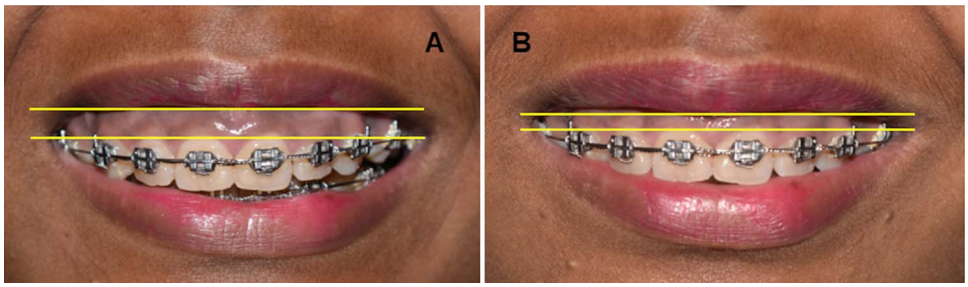

Figure 8. Clinical assessment of gummy smile correction following intrusion. (A) Preintrusion. (B) Postintrusion.

Table 2. Intragroup Comparison of Pre- and Postdentoalveolar Parameters[a]

Variable	Group	Tooth Number	Preintrusion T0, Mean ± SD	Postintrusion T1, Mean ± SD	T1–T0		P
					Mean Difference	SD	
Vertical incisor position, mm	Group I	U1	31.34 ± 1.48	29.79 ± 1.41	−1.55	0.37	<.001*
		U2	30.35 ± 1.53	29.01 ± 1.51	−1.34	0.38	<.001*
	Group II	U1	32.16 ± 2.02	30.07 ± 2.10	−2.09	0.50	<.001*
		U2	31.05 ± 1.91	28.99 ± 2.06	−2.06	0.41	<.001*
Incisor inclination, °	Group I	U1	108.75 ± 3.28	113.01 ± 3.75	4.26	1.70	<.001*
		U2	104.73 ± 3.96	109.45 ± 3.83	4.72	1.44	<.001*
	Group II	U1	119.64 ± 4.40	123.28 ± 4.38	3.64	1.16	<.001*
		U2	118.43 ± 5.17	123.27 ± 4.60	4.84	1.55	<.001*
Incisor length, mm	Group I	U1	22.56 ± 1.98	21.83 ± 1.89	−0.73	0.27	<.001*
		U2	20.12 ± 2.10	19.43 ± 2.07	−0.69	0.45	<.001*
	Group II	U1	21.81 ± 2.25	21.26 ± 2.18	−0.55	0.20	<.001*
		U2	20.80 ± 2.14	19.91 ± 2.13	−0.89	0.31	<.001*
Buccal alveolar crest height, mm	Group I	U1	1.10 ± 0.51	3.11 ± 0.75	2.01	0.73	<.001*
		U2	1.23 ± 0.58	3.65 ± 1.64	2.42	1.54	<.001*
	Group II	U1	1.64 ± 0.64	3.51 ± 0.94	1.87	0.84	<.001*
		U2	1.92 ± 0.52	3.73 ± 0.77	1.81	0.72	<.001*
Horizontal distance from molar to canine, mm	Group I		21.38 ± 0.49	20.41 ± 0.32	−0.97	0.12	.062
	Group II		21.15 ± 0.48	20.14 ± 0.62	−1.01	0.25	.085

[a] Group I, intrusion with single miniscrew; group II, intrusion with two miniscrews; T0, preintrusion; T1, postintrusion; U1, upper central incisor; U2, upper lateral incisor. Units are given in millimeters.

* Significant at $P < .05$, paired *t*-test.

Following 3 months of intrusion, maxillary CI RR was noted as 0.76 mm for the single-MS group and 0.57 mm for the dual-MS group. Group I experienced greater intrusive force on CI compared with group II. In group I, 100 gf was applied near CI, while in group II, 50 gf was applied between the canine and LI, farther from CI. The higher RR of CI in group I may be attributed to the increased intrusive force. Previous research on intrusion using conventional approaches found an RR of 0.6–2.5 mm in 6 months.[6,19,20]

Intrusive forces have been linked to RR as an adverse effect. Saga et al.[21] used FEM to simulate orthodontic intrusion on the maxillary incisors, and placing MS between LI and canine resulted in more balanced compressive stress distribution in the PDL than in other sites. MS placement at the midline concentrated the highest compression at the apex of CI, while positioning MS between LI and canine focused the highest compression at the apex of LI. This observation raised concerns about potential compromise to the periodontium, particularly due to the smaller root surface area of LI compared with CI. The current study found a statistically significant increase in RR for CI in group I and LI in group II when making intergroup comparisons.

MS-assisted intrusion often results in incisor proclination as the forces are applied anterior to CR. In vivo research conducted by Vela-Hernandez et al.[11] and FEM investigations by Saga et al.[21] and Sakdakornkul et al.[22] reported a greater degree of incisor proclination in single-MS subjects compared with a dual-

Table 3. Intergroup Comparison of Changes in Dentoalveolar Parameters[a]

Variable	Tooth Number	Group I T1–T0, Mean ± SD	Group II T1–T0, Mean ± SD	Group I–Group II		P
				Mean Difference	SD	
Change in mean vertical incisor position (intrusion), mm	U1	−1.55 ± 0.37	−2.09 ± 0.50	0.54	0.14	<.001*
	U2	−1.34 ± 0.38	−2.06 ± 0.41	0.72	0.13	<.001*
Change in mean incisor inclination, °	U1	4.26 ± 1.70	3.64 ± 1.16	0.62	0.46	.208
	U2	4.72 ± 1.44	4.84 ± 1.55	−0.12	0.47	.617
Change in mean incisor length (root resorption), mm	U1	−0.73 ± 0.27	−0.55 ± 0.20	−0.18	0.08	.024*
	U2	−0.69 ± 0.45	−0.89 ± 0.31	0.20	0.08	.016*
Change in mean buccal alveolar crest height, mm	U1	2.01 ± 0.73	1.87 ± 0.84	0.14	0.26	.487
	U2	2.42 ± 1.54	1.81 ± 0.72	0.61	0.38	.595
Change in mean horizontal distance from molar to canine, mm		−0.97 ± 0.12	−1.01 ± 0.25	0.04	0.11	.132

[a] Group I, intrusion with single miniscrew; group II, intrusion with two miniscrews; T1, postintrusion; T0, preintrusion; U1, right upper central incisor; U2, left upper lateral incisor. Units are given in millimeters.

* Significant at $P < .05$, unpaired *t*-test.

Table 4. Intragroup Comparison of Pre- and Postalveolar Bone Thickness[a]

Variable	Group	Tooth Number	Preintrusion T0, Mean ± SD	Postintrusion T1, Mean ± SD	T1–T0 Mean	T1–T0 SD	*P*
Labial bone thickness, mm	Group I	U1 (3 mm)	0.85 ± 0.18	0.47 ± 0.25	−0.38	0.19	<.001*
		U1 (6 mm)	0.66 ± 0.21	0.36 ± 0.18	−0.30	0.15	<.001*
		U1 (9 mm)	0.53 ± 0.17	0.93 ± 0.35	0.04	0.25	<.001*
		U2 (3 mm)	0.81 ± 0.21	0.46 ± 0.29	−0.35	0.25	<.001*
		U2 (6 mm)	0.63 ± 0.19	0.37 ± 0.27	−0.26	0.27	.005*
		U2 (9 mm)	0.50 ± 0.17	1.11 ± 0.33	0.61	0.30	<.001*
	Group II	U1 (3 mm)	1.05 ± 0.35	0.81 ± 0.33	−0.24	0.11	<.001*
		U1 (6 mm)	0.82 ± 0.32	0.56 ± 0.26	−0.26	0.17	<.001*
		U1 (9 mm)	0.68 ± 0.32	1.00 ± 0.34	0.32	0.11	<.001*
		U2 (3 mm)	1.01 ± 0.39	0.77 ± 0.36	−0.24	0.13	<.001*
		U2 (6 mm)	0.84 ± 0.45	0.60 ± 0.39	−0.24	0.13	<.001*
		U2 (9 mm)	0.73 ± 0.38	1.22 ± 0.39	0.49	0.22	<.001*
Palatal bone thickness, mm	Group I	U1 (3 mm)	1.41 ± 0.33	1.86 ± 0.61	0.45	0.51	<.001*
		U1 (6 mm)	2.55 ± 0.88	4.16 ± 0.86	1.61	0.80	<.001*
		U1 (9 mm)	4.39 ± 1.14	3.57 ± 0.95	−0.82	0.75	<.001*
		U2 (3 mm)	1.28 ± 0.31	1.84 ± 0.53	0.56	0.42	.002*
		U2 (6 mm)	2.44 ± 0.78	3.55 ± 1.03	1.11	0.67	<.001*
		U2 (9 mm)	4.15 ± 1.25	3.65 ± 1.20	−0.50	0.78	<.001*
	Group II	U1 (3 mm)	1.31 ± 0.38	1.65 ± 0.41	0.34	0.24	<.001*
		U1 (6 mm)	2.08 ± 0.62	2.60 ± 0.67	0.52	0.47	.027*
		U1(9 mm)	3.18 ± 0.89	2.51 ± 0.90	−0.67	0.50	<.001*
		U2 (3 mm)	1.42 ± 0.52	1.91 ± 0.62	0.49	0.26	<.001*
		U2 (6 mm)	2.00 ± 0.66	2.92 ± 0.69	0.92	0.54	<.001*
		U2 (9 mm)	3.15 ± 0.84	2.51 ± 0.70	−0.64	0.43	<.001*

[a] Group I, intrusion with single miniscrew; group II, intrusion with two miniscrews; T1, postintrusion; T0, preintrusion; U1, right upper central incisor; U2, left upper lateral incisor. Units are given in millimeters.

*Significant at $P < .05$, paired *t*-test.

MS group. Conversely, in this study, although incisor proclination was observed, no statistically significant difference was found. This might have been due to cinching the archwire distal to the second molar in both groups.

In addition, in both groups, there was a decrease in LBT and an increase in PBT at 3 mm and 6 mm. However, at 9 mm, both groups exhibited an increase in LBT and a decrease in PBT. These findings agreed with a study by Atik et al.[1] with dual implants (between central and LI) for intrusion. This observation was attributed to intrusion and a concurrent increase in inclination, expected to induce changes in the alveolar bone at the crestal level rather than the apical level.

Typically, upwardly directed intrusive forces in the maxillary arch concentrate stress on the LAC, causing significant resorption. In the present study, after 3 months of intrusion, a statistically significant increase

Table 5. Intergroup Comparison of Change in Mean Alveolar Bone Thickness[a]

Variable	Tooth Number	Group I T1–T0, Mean ± SD	Group II T1–T0, Mean ± SD	Group I–Group II Mean Difference	Group I–Group II SD	*P*
Change in mean labial bone thickness, mm	U1 (3 mm)	−0.38 ± 0.19	−0.24 ± 0.11	−0.14	0.05	.342
	U1 (6 mm)	−0.30 ± 0.15	−0.26 ± 0.17	−0.04	0.10	.781
	U1 (9 mm)	0.04 ± 0.25	0.32 ± 0.11	−0.28	0.06	.579
	U2 (3 mm)	−0.35 ± 0.25	−0.24 ± 0.13	−0.11	0.07	.034*
	U2 (6 mm)	−0.26 ± 0.17	−0.24 ± 0.13	−0.02	0.07	.486
	U2 (9 mm)	0.32 ± 0.11	0.49 ± 0.22	−0.17	−0.10	.379
Change in mean palatal bone thickness, mm	U1 (3 mm)	0.45 ± 0.51	0.34 ± 0.24	−0.09	0.14	.015*
	U1 (6 mm)	1.61 ± 0.80	0.52 ± 0.47	1.09	0.21	<.001*
	U1 (9 mm)	−0.82 ± 0.75	−0.67 ± 0.50	−0.15	0.20	<.001*
	U2 (3 mm)	0.56 ± 0.42	0.49 ± 0.26	0.07	0.11	<.001*
	U2 (6 mm)	1.11 ± 0.67	0.92 ± 0.54	0.19	0.20	<.001*
	U2 (9 mm)	−0.67 ± 0.50	−0.64 ± 0.43	−0.03	0.20	<.001*

[a] Group I, intrusion with single miniscrew; group II, intrusion with two miniscrews; T1, postintrusion; T0, preintrusion; U1, right upper central incisor; U2, left upper lateral incisor. Units are given in millimeters.

* Significant at $P < .05$, unpaired *t*-test.

in BACH was observed in both groups, implying crestal resorption. On intergroup comparison, no statistically significant differences were found between the changes in BACH.

Although incisor intrusion can trigger a concurrent response in molars, the present study did not show any significant sagittal displacement of molars. This was attributed to the application of figure-eight ligation to adjacent teeth and the use of a transpalatal arch.

This study was limited by its single-center and short-duration design, with more than two-thirds of participants being women, leading to gender bias. It also lacked an examination of changes in the maxillary canines, premolars, and molars and did not consider the long-term effects of intrusion.

CONCLUSIONS

- Gummy smile and deep-bite correction can be achieved successfully by miniscrew-assisted maxillary anterior intrusion.
- Maxillary central and lateral incisor intrusion was greater in subjects with two miniscrews.
- The apical root resorption of the maxillary central incisors was greater in subjects with one miniscrew, while the maxillary lateral incisor resorption was greater in subjects treated with two miniscrews.
- No significant differences were found between the one- and two-miniscrew groups regarding changes in incisor inclination, labial bone thickness, and buccal alveolar crest height.

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