Original Article

Lower incisor position in skeletal Class III malocclusion patients: a comparative study of orthodontic camouflage and orthognathic surgery

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ABSTRACT

Objectives: To determine the difference between orthodontic camouflage and orthodontic-orthognathic surgery using the traditional cephalometric measurement IMPA and the newly proposed IA/PA_{MD}, the angle between the long axis of the lower incisor (IA) and the principal axis of the mandibular alveolus (PA_{MD}).

Materials and Methods: This study included 40 cases each in the orthodontic camouflage group (OG) and orthodontic-orthognathic surgery group (SG). The differences between the IMPA and IA/PA_{MD} before and after treatment were compared between the two groups. T0 lateral cephalometric images of the 10 cases with the highest and lowest increase in the IA/PA_{MD} were analyzed to identify characteristics associated with a higher risk of overdecompensation of the lower incisors during presurgical orthodontic treatment.

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Results: Both the OG and SG showed a significant improvement in hard- and soft-tissue measurements. However, in the OG, there was significant lingual inclination of the lower incisor but only a small change in the IA/PA_{MD}. In the surgical group, the IMPA was close to 90° after treatment, but the IA/PA_{MD} significantly increased.

Conclusions: In orthodontic camouflage, the lower anterior teeth were significantly moved lingually with a better root-bone relationship. However, this relationship deteriorated in some surgical patients. Therefore, it is important to conduct cephalometric or cone-beam computed tomography examinations during preoperative orthodontics to identify and prevent possible periodontal risks. (*Angle Orthod*. 2024;94:504–511.)

KEY WORDS: Angle Class III; Lower incisor; Orthodontic camouflage; Orthognathic surgery

INTRODUCTION

Skeletal Class III patients often seek orthodontic therapy or orthognathic surgery to correct the anterior crossbite and improve profile esthetics.[1] However, evidence indicates that the alveolar bone around the lower incisors is thin in these patients, particularly in those with high mandibular plane angles.[2,3] The lower incisors in these patients are also vulnerable to alveolar bone loss during orthodontic treatment.[4] Therefore, the relationship between the lower incisor root and surrounding alveolar bone in skeletal Class III malocclusion has gained significant attention.[5]

For orthodontic-orthognathic surgery treatment, having the lower incisors perpendicular to the mandibular plane is a common objective of presurgical orthodontic decompensation.[6] Inadequate dental decompensation compromises the correction of skeletal discrepancies and the subsequent facial harmonization through orthognathic surgery.[7] However, labial movement of the lower incisors may increase the risk of gingival recession, dehiscence, and fenestration.[3,8] Consequently, augmented corticotomy-assisted presurgical orthodontic treatment has recently been popularized to prevent these periodontal complications.[5]

In orthodontic camouflage therapy, a Class III malocclusion is often corrected by increasing the existing dentoalveolar compensation.[9] This approach contradicts the traditionally proposed treatment objective of achieving a 90° angle between the lower central incisors and the mandibular plane (IMPA). Orthodontic treatment aims to upright the teeth within the alveolar bone, facilitating better transmission of occlusal forces.[10] However, the IMPA measurement does not directly reflect the relationship between the lower incisor and the surrounding alveolar bone. Therefore, a more direct measurement is needed to evaluate the position of the mandibular incisors within the alveolar bone.

The use of the angle between the long axis of the lower central incisor and the principal axis of the mandibular alveolus (IA/PA_{MD}) was previously proposed for evaluating the position of the mandibular incisors relative to the alveolar bone (Figure 1).[11] Usually (pretreatment), severe skeletal Class III patients exhibit lingual tipping of the lower incisors (IMPA of 73.85–80.78°, dental compensation) but also consistency between the long axis of the lower central incisor and the principal axis of the mandibular alveolus (IA/PA_{MD} of 2.33–3.70°).[11] This indicates that, in skeletal Class III patients, the lower incisors with dental compensation are still consistent with the surrounding alveolar bone. However, the influence of treatment, from both orthodontic camouflage treatment and orthodontic orthognathic surgical decompensation, on the changes in the IA/PA_{MD} remains unexplored.

This study compared the changes in cephalometric measurements of skeletal Class III patients between orthodontic camouflage and orthognathic surgery using the IA/PA_{MD} and IMPA to evaluate the lower incisor position. The aim was to better determine the position of the lower anterior teeth in clinical treatment, so that preemptive measures such as bone grafting could be planned to reduce the risk of periodontal health issues.

MATERIALS AND METHODS

Subjects

This retrospective study included 80 skeletal Class III adult patients who underwent either orthodontic camouflage treatment (13 males and 27 females, mean age: 18.42 $\pm$ 4.52 years) or orthodontic-orthognathic surgery (9 males and 31 females, mean age: 21.22 $\pm$ 4.51 years) between 2013 and 2023.

This study was approved by the Peking University School of Stomatology Biomedical Ethics Committee (PKUSSIRB-202054049). The inclusion criteria were (1) skeletal Class III malocclusion with $-6° \leq ANB \leq 0°$ before treatment, (2) anterior crossbite or incisor edge-to-edge relationship, and (3) concave facial profile. The exclusion criteria were (1) craniofacial syndromes, (2) tooth size anomalies, (3) poor oral hygiene or uncontrolled periodontal disease, (4) augmented

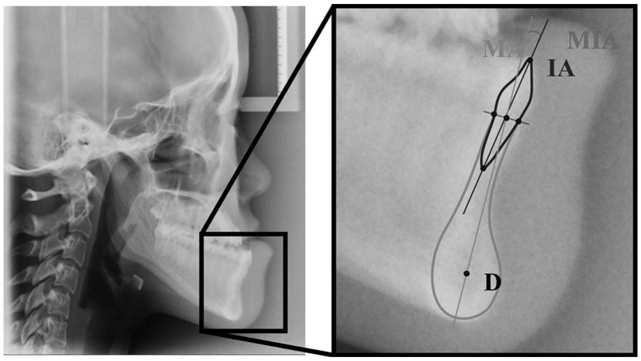

Figure 1. Illustration of the IA/PA$_{MD}$. (A) Illustration of IA/PA$_{MD}$ measurements. D indicates the center of the mandibular symphysis, in which the black line passes through the labial and lingual lower alveolar edge of the lower central incisor; IA, long axis of the lower central incisor; IA/PA$_{MD}$, angle between the IA and MA; MA, a line extending from the midpoint of the line between the labial and lingual lower alveolar edge to point D.

corticotomy, and (5) severe facial asymmetry (chin point deviation from the midline $\geq$4 mm).

Sample Size

The difference in the changes in the IMPA and IA/PA$_{MD}$ between T1 and T0 was used to calculate sample size. For the pretest analysis, 10 patients were randomly selected from each group and measured. The mean difference was 2° in the orthodontic-orthognathic surgery group (SG) and 6° in the orthodontic camouflage group (OG), with a standard deviation of 6°. With a type I error of .05 and a power of 80%, a minimum sample size of 28 patients in each group was required (http://powerandsamplesize.com/Calculators/Compare-2-Means/2-Sample-Equality?).

Treatment

All patients in the OG were treated using transmission straight-wire appliances (Shinye, China), developed by Lin from Peking University School and Hospital of Stomatology.[12] Patients in the SG were treated with straight-wire orthodontic appliances (MBT system, Shinye, China). Maxillary advancement, mandibular setback, and genioplasty were performed for each patient in the SG.

In the OG, 15 patients underwent extractions (teeth 15, 25, 34, and 44), while 25 patients did not have extractions. In the SG, 4 patients had four premolars extracted (14, 24, 35, and 45), 33 patients had extractions of only the maxillary premolars (14 and 24), and 3 patients did not have extractions.

Cephalometric Analysis

All lateral cephalograms were all taken by the same imaging machine. The patients were instructed to remain in the natural head position with the teeth in centric occlusion and relaxed lips. All cephalometric landmarks were located three times each by two senior residents who had undergone calibration training and were blinded to the study objectives. The points with higher dispersion were automatically detected by customized software and were checked by the same resident. The average of the six locations of each landmark was used in subsequent calculations by the customized cephalometric software CIS (developed by the Department of Computer Science and Technology, Peking University). The cephalometric analysis included six skeletal, seven dental, and seven soft-tissue measurements (Table 1).

Statistical Analysis

The measurements for both groups at different time points were described as means and standard deviations. The intraclass coefficient (ICC) test was used to assess interexaminer reliability. Changes in measurements across time points were analyzed using the paired *t*-test. The SG and OG were compared using the independent-sample *t*-test. Statistical significance was based on a type I error threshold of $\alpha = .05$.

To identify the characteristics associated with a higher risk for overdecompensation of the lower incisors during presurgical orthodontic treatment, T0 cephalograms of 10 cases with the highest and 10 cases with the lowest increase in the IA/PA$_{MD}$ were analyzed using independent-sample *t*-test.

RESULTS

The ICC values of all measurements were greater than .75, including .994 for the IA/PA$_{MD}$, showing high consistency (Table 1). The descriptive statistics at T0 and T1 are summarized in Table 2. There were no significant differences in skeletal measurements between the two groups at T0. Only values of L1/MP, UL-E, LL-E, and LL-B-Pos showed statistically significant differences between the groups at T0.

The cephalometric measurements and changes from T0 to T1 were analyzed to compare the outcomes of presurgical orthodontic treatment and orthodontic camouflage treatment (Table 2). Both the L1/MP and IA/PA$_{MD}$ increased significantly in the SG from T0 to T1 but decreased in the OG. In the SG, L1/MP increased by 7.63°, while it decreased in the OG by a similar value ($-$9.78°). The change in the IA/PA$_{MD}$ and IMPA for each patient in both the SG and

Table 1. Definitions of Cephalometric Variables and Intraclass Correlation Coefficients (ICCs)

Variable	Definition	ICC
SNA, °	Sagittal relationship of the maxilla to the cranial base	.998
SNB, °	Sagittal relationship of the mandible to the cranial base	.945
ANB, °	Sagittal relationship between the maxilla and mandible, relative to the cranial base	.753
Wits, mm	This entails drawing perpendiculars from subspinale and supramental onto the occlusal plane; *Wits* refers to the distances between the points of contact of the perpendiculars onto the occlusal plane	.963
MP/FH, °	Angle between the mandibular plane and Frankfort horizontal plane	.941
MP/SN, °	Angle between the mandibular plane and cranial plane	.960
U1/SN, °	Angle between the long axis of the upper central incisor and the cranial base	.971
L1/MP, °	Angle between the long axis of the lower central incisor and the mandibular plane	.935
U1/L1, °	Angle between the long axes of upper and lower central incisors	.949
U1-NA, mm	Distance from the tip of the upper incisor to a line extending from nasion to subspinale	.881
L1-NB, mm	Distance from the tip of the lower incisor to a line extending from nasion to supramental	.941
Overjet, mm	Horizontal distance from the edge of the upper incisor to the labial surface of lower incisor	.996
IA/PA_{MD}, °	Angle between IA and PA_{MD}. IA, the long axis of lower central incisor; PA_{MD}, the principal axis of the mandibular alveolar; IA/PA_{MD} is considered positive when IA is labial to the MA	.994
UL-SnPg, mm	Distance from the superior labial point to a line extending from subnasale to soft-tissue pogonion	.991
LL-SnPg, mm	Distance from the inferior labial point to a line extending from subnasale to soft-tissue pogonion	.992
Lip-Diff, mm	Difference between UL-SnPg and LL-SnPg	.981
UL-E, mm	Distance from the superior labial point to a line extending from the nasal tip to soft-tissue pogonion	.906
LL-E, mm	Distance from the inferior labial point to a line extending from the nasal tip to soft-tissue pogonion	.955
Cm-Sn-UL, °	Nasolabial angle: the angle between a line from columella to subnasale and a line from subnasale to superior labial point	.969
LL-B-Pos, °	Angle between a line from the inferior labial point to supramental and a line from supramental to soft-tissue pogonion	.998

OG is demonstrated in Figure 2. Histograms show the distribution of measures at different time points for the IA/PA_{MD} and IMPA (Figure 2). After presurgical orthodontic treatment, the number of patients with an IA/PA_{MD} $>15°$ increased from 3 to 18. The average increase in the IA/PA_{MD} was 8.41°, with five patients having an increase greater than 15°. However, after orthodontic camouflage treatment, the IA/PA_{MD} decreased by an average of 4.08°, from 4.44° to 0.36°. Notably, the L1/MP increase in the SG was

Table 2. Intergroup Analysis at T0 and T1

	Orthodontic-Orthognathic Surgery (SG)				Orthodontic Camouflage (OG)			SG T0 vs OG T0	Δ(T1–T0) vs Δ(T1–T0)	
Variable	T0	T1	T1–T0	*P*1 Value	T0	T1	T1–T0	*P*2 Value	*P*3 Value	*P*4 Value
SNA, °	80.94 ± 2.92	80.26 ± 2.94	−0.68 ± 1.44	.005*	81.09 ± 3.43	81.82 ± 3.8	0.73 ± 1.8	.014*	.837	.000*
SNB, °	84.22 ± 3.45	84.12 ± 3.75	−0.1 ± 1.35	.625	83.78 ± 3.23	83.58 ± 3.89	−0.2 ± 2.15	.560	.552	.814
ANB, °	−3.26 ± 1.74	−3.9 ± 2.47	−0.64 ± 1.81	.033*	−2.69 ± 1.47	−1.76 ± 2.01	0.93 ± 1.37	.000*	.116	.000*
Wits, mm	−10.80 ± 3.98	−12.51 ± 3.21	−1.71 ± 3.04	.001*	−10.5 ± 3.52	−7.83 ± 3.06	2.67 ± 2.48	.000*	.725	.000*
MP/FH, °	27.43 ± 6.39	27.09 ± 6.58	−0.34 ± 2.93	.464	27.07 ± 3.85	27.69 ± 4.49	0.61 ± 2.07	.068	.762	.096
MP/SN, °	36.7 ± 6.86	36.48 ± 7.23	−0.23 ± 2.89	.621	35.73 ± 4.33	36.07 ± 4.65	0.34 ± 2.49	.393	.450	.350
U1/SN, °	112.1 ± 7.25	104.84 ± 8.49	−7.26 ± 8.1	.000*	111.31 ± 6.39	116.07 ± 8.81	4.76 ± 8.66	.001*	.608	.000*
L1/MP, °	79.97 ± 7.17	87.6 ± 7.12	7.63 ± 6.7	.000*	83.12 ± 6.36	73.34 ± 8.05	−9.78 ± 6.36	.000*	.041*	.000*
U1/L1, °	131.22 ± 10.46	131.09 ± 8.92	−0.14 ± 11.95	.942	129.84 ± 8.62	134.53 ± 10.55	4.69 ± 12.5	.023*	.520	.082
U1-NA, mm	7.25 ± 2.2	5.03 ± 2.57	−2.22 ± 2.87	.000*	7.19 ± 2.24	8.34 ± 2.72	1.14 ± 2.23	.002*	.918	.000*
L1-NB, mm	4.58 ± 2.27	5.8 ± 1.86	1.22 ± 1.79	.000*	5.26 ± 2.36	2.51 ± 2.2	−2.74 ± 2.04	.000*	.198	.000*
Overjet, mm	−2.03 ± 2.6	−6.43 ± 2.3	−4.39 ± 2.58	.000*	−1.76 ± 1.34	3.48 ± 1.03	5.23 ± 1.55	.000*	.551	.000*
IA/PA_{MD}, °	6.82 ± 4.89	14.79 ± 6.86	8.41 ± 6.98	.000*	4.44 ± 3.88	0.36 ± 3.99	−4.08 ± 4.45	.000*	.067	.000*
UL-SnPg, mm	4.84 ± 1.58	4.24 ± 1.5	−0.6 ± 1.2	.003*	5.33 ± 1.6	5.63 ± 1.84	0.3 ± 1.35	.171	.171	.002*
LL-SnPg, mm	6 ± 2.22	7.27 ± 2.09	1.27 ± 1.37	.000*	6.99 ± 2.35	5.18 ± 2.08	−1.8 ± 1.33	.000*	.058	.000*
Lip-Diff, mm	−1.16 ± 1.86	−3.03 ± 1.78	−1.87 ± 1.26	.000*	−1.66 ± 1.69	0.45 ± 1.48	2.1 ± 1.39	.000*	.219	.000*
UL-E, mm	−4.15 ± 1.92	−5.33 ± 1.78	−1.18 ± 1.51	.000*	−2.96 ± 1.89	−2.55 ± 2.07	0.41 ± 1.63	.120	.007*	.000*
LL-E, mm	−0.17 ± 2.63	0.83 ± 2.25	0.99 ± 1.59	.000*	1.64 ± 2.66	0 ± 2.38	−1.64 ± 1.86	.000*	.003*	.000*
Cm-Sn-UL, °	90.82 ± 10.14	89.12 ± 11.23	−1.7 ± 6.94	.130	93.61 ± 8.89	95.37 ± 11.32	1.77 ± 8.57	.200	.194	.051
LL-B-pos, °	152.59 ± 13.22	149.23 ± 13.28	−3.36 ± 10.76	.055	142.65 ± 22.5	144.25 ± 10.58	1.61 ± 23.49	.668	.018*	.227

* $P < .05$.

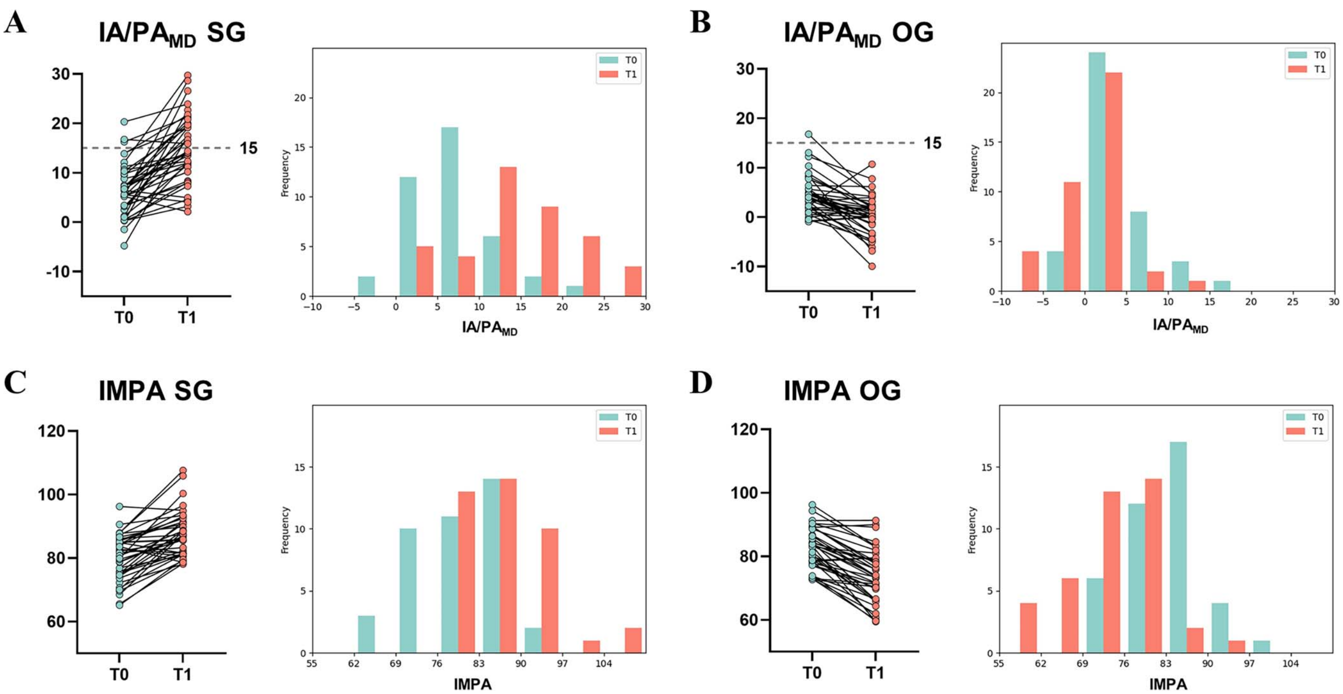

Figure 2. Changes in the IA/PA$_{MD}$ and IMPA in the SG and OG from T0 to T1. (A, B) Plots showing individual IA/PA$_{MD}$ changes from T0 to T1 and histograms showing the frequency distribution of the IA/PA$_{MD}$ at T0 and T1 in both groups. (C, D) Plots showing the individual IMPA changes from T0 to T1 and histograms showing the frequency distribution of IMPA at T0 and T1 in both groups.

similar to the increase in the IA/PA$_{MD}$ (7.63° vs 8.41°), whereas, in the OG, the change in L1/MP was significantly greater compared with the change in the IA/PA$_{MD}$ (−9.78° vs −4.08°).

In the SG, the L1/MP increased 9.21° ± 6.79° from T0 to T2, while the IA/PA$_{MD}$ increased 13.05° ± 8.56° from T0 to T2 (Table 3). A comparison of the posttreatment results between the SG (T2) and OG (T1) revealed that there were no significant differences in MP/FH, MP/SN, overjet, UL-SnPg, LL-E, or Cm-Sn-UL. Similarly, the comparative analysis of the overall treatment-related changes between the

Table 3. Intergroup Posttreatment Analysis

	Orthodontic-Orthognathic Surgery (SG)			SG T2 vs OG T1	ΔSG (T2–T0) vs ΔOG (T1–T0)
Variable	T2	T2–T0	*P*1 Value	*P*2 Value	*P*3 Value
SNA, °	83.85 ± 3.02	2.91 ± 2.55	.000*	.010*	.000*
SNB, °	81.39 ± 3.59	−2.84 ± 2.5	.000*	.011*	.000*
ANB, °	2.46 ± 1.99	5.72 ± 2	.000*	.000*	.000*
Wits, mm	−3.96 ± 2.32	6.84 ± 3.77	.000*	.000*	.000*
MP/FH, °	26.36 ± 4.77	−1.07 ± 3.5	.061	.205	.011*
MP/SN, °	35.49 ± 5.5	−1.21 ± 4.01	.064	.615	.041*
U1/SN, °	107.81 ± 7.83	−4.29 ± 6.64	.000*	.000*	.000*
L1/MP, °	89.18 ± 7.76	9.21 ± 6.79	.000*	.000*	.000*
U1/L1, °	127.51 ± 7.66	−3.71 ± 10.57	.032*	.001*	.002*
U1-NA, mm	4.57 ± 2.26	−2.67 ± 2.46	.000*	.000*	.000*
L1-NB, mm	5.01 ± 1.57	0.42 ± 2.1	.212	.000*	.000*
Overjet, mm	3.28 ± 0.95	5.32 ± 2.62	.000*	.388	.861
IA/PA$_{MD}$, °	19.43 ± 7.42	13.05 ± 8.56	.000*	.000*	.000*
UL-SnPg, mm	5.81 ± 1.51	0.97 ± 1.49	.000*	.630	.037*
LL-SnPg, mm	3.76 ± 1.94	−2.24 ± 1.67	.000*	.002*	.197
Lip-Diff, mm	2.05 ± 1.21	3.22 ± 1.74	.000*	.000*	.002*
UL-E, mm	-1.5 ± 1.74	2.64 ± 1.73	.000*	.016*	.000*
LL-E, mm	−0.94 ± 2.18	−0.78 ± 2.03	.020*	.068	.051
Cm-Sn-UL, °	97.17 ± 10.66	6.36 ± 7.12	.000*	.466	.011*
LL-B-Pos, °	132.88 ± 11.62	−19.72 ± 14	.000*	.000*	.000*

* $P < .05$.

two groups revealed no statistically significant differences regarding the changes in overjet, LL-SnPg, and LL-E.

To identify the characteristics of patients who were more prone to overdecompensation of the lower incisors during presurgical orthodontic treatment, the individuals exhibiting the highest 10 and lowest 10 increments in the IA/PA_{MD} during presurgical orthodontic treatment were selected for comparison of their cephalometric measurements at T0 (Table 4). Significant differences were observed in dental measurements, including U1/SN, L1/MP, U1/L1, L1-NB, and overjet, and in soft tissue measurements, including LL-SnPg, Lip-Diff, and LL-E. However, skeletal measurements exhibited no significant differences between the two subgroups.

Table 4. Comparison of Cephalometric Analyses at T0 Between Individuals With the 10 Highest and Lowest Increases in IA/PA_{MD} During Presurgical Orthodontic Treatment in the SG

	Highest 10		Lowest 10		
Variable	Mean	SD	Mean	SD	*P* Value
SNA, °	80.09	2.48	80.76	3.89	.650
SNB, °	83.91	2.58	85.29	4.07	.380
ANB, °	−3.82	1.20	−4.52	1.50	.263
Wits, mm	−12.03	4.97	−11.91	3.80	.952
MP/FH, °	26.67	7.91	26.71	6.26	.989
MP/SN, °	35.66	6.87	35.53	6.54	.967
U1/SN, °	108.49	6.49	114.88	7.05	.049*
L1/MP, °	75.52	7.83	82.85	6.19	.032*
U1/L1, °	140.34	9.75	126.74	8.52	.004*
U1-NA, mm	6.34	2.03	7.32	1.88	.276
L1-NB, mm	2.57	1.96	5.27	1.54	.003*
Overjet, mm	−1.79	1.96	−4.26	1.95	.011*
IA/PA_{MD}, °	4.79	3.46	9.26	5.83	.052
UL-SnPg, mm	4.31	1.55	4.98	1.33	.314
LL-SnPg, mm	4.06	1.98	7.15	1.32	.001*
Lip-Diff, mm	0.25	1.13	−2.18	1.50	.001*
UL-E, mm	−4.88	1.58	−3.92	1.71	.206
LL-E, mm	−2.39	2.16	1.17	1.78	.001*
Cm-Sn-UL, °	89.41	10.04	87.78	8.21	.697
LL-B-Pos, °	151.47	14.31	148.61	14.98	.668

* $P < .05$.

DISCUSSION

For orthodontists, treating skeletal Class III patients to achieve a healthy, esthetic, and stable result poses a significant challenge.[13] Previous studies indicated that the alveolar bone around the lower incisors was thin and vulnerable to alveolar bone loss during orthodontic treatment in skeletal Class III patients.[2] Therefore, positioning the lower incisors safely in the treatment of skeletal Class III malocclusion has gained increasing attention. IMPA is the most commonly used indicator of the position of the lower incisors, reflecting its relative position to the mandibular plane. However, there is a lack of research on the measurement of the relative positional relationship between the lower incisors and the surrounding alveolar bone. Recently, the angle between the long axis of the lower central incisor and the principal axis of the mandibular alveolus (IA/PA_{MD}) was proposed as a means to evaluate the positional relationship between the lower incisors and the surrounding alveolar bone.[11] In this study, a comprehensive evaluation was conducted to compare the difference between using the IMPA and IA/PA_{MD} to assess the treatment outcome from orthodontic camouflage vs surgical intervention in patients with skeletal Class III malocclusion.

Traditionally, an IMPA of 90° is thought to be an important reference for positioning of the lower incisors during orthodontic treatment. An optimal IMPA was considered to be essential to achieving ideal facial esthetics and stable occlusion.[14] Although the IMPA serves as an important guide for presurgical orthodontic treatment in skeletal Class III patients, it has certain limitations when used for assessing outcomes in orthodontic camouflage treatment. In previous studies, the final IMPA after orthodontic camouflage treatment of skeletal Class III deviated significantly from 90°, ranging from 73.29° to 86.65°.[6,15–17] Anatomically, the mandibular plane is not directly connected to the lower incisors. In addition, the mandibular plane, mental symphysis, and alveolar bone morphology exhibit considerable variation among individuals with different skeletal patterns.[3,18–20] Therefore, the IMPA does not directly reflect the relationship of the lower incisor to the surrounding alveolar bone. Ideally, tooth roots should be centered labiolingually over the basal bone and be surrounded by healthy alveolar bone.[10] Therefore, for orthodontic camouflage treatment, as long as the tooth positions meet this condition, it could be viewed as an acceptable compensated position. In contrast, even if the IMPA met the 90° ideal, if the tooth was not within the alveolar bone or the tooth axis deviated obviously from the basal bone long axis, it should not be considered as an appropriate position. Therefore, another practical reference to evaluate the lower incisor position in Class III treatment is needed.

The IA/PA_{MD} represents the angle between the long axis of the lower central incisor (IA) and the principal axis of the mandibular alveolus (PA_{MD}).[21] Theoretically, the two axes should be consistent with each other to ensure better bite force transmission from the incisor to the basal bone. Three-dimensional finite element analysis showed that placing dental implants vertically within the alveolar bone minimized stress exerted on the supporting bone.[22,23] In this study, at T0, the IA/PA_{MD} measurements in both groups indicated consistency between the long axis of the lower incisor and the principal axis of the mandibular alveolus in skeletal Class III patients (6.82° ± 4.89° in the SG and 4.44° ± 3.88° in the OG). This was in agreement with a previous study.[11] After treatment, the IA/PA_{MD} showed different trends for change in the SG and OG. In the SG, although IMPA (L1/MP) at T2 was 89.18° ± 7.76°, close to the ideal of 90°, the increased IA/PA_{MD} (from 6.46° ± 6.05° to 19.69° ± 6.79°) revealed inconsistency between the tooth axis and the basal bone axis. Presurgical orthodontic treatment emphasizes decompensation. Sufficient negative overjet before orthognathic surgery is an important prerequisite for adequate relative movement between the maxilla and mandible in orthognathic surgery.[6] However, overdecompensation can lead to periodontal complications, such as fenestrations and dehiscence, which may compromise long-term stability and health in these patients. In addition, inconsistency between the long axis of the lower incisor and mandibular alveolus may impair the transmission of occlusal forces (Figure 3A). Therefore, in patients with extremely thin lower anterior alveolar bone, subapical osteotomy should be considered to allow maintenance of the final incisor root position within the center of the alveolar bone. In the OG, though the IMPA further decreased from 83.07° ± 6.68° to 73.7° ± 7.48°, the change in the IA/PA_{MD} was small (from 5.06° ± 4.38° to 0.9° ± 3.19°). The roots of the lower incisors remained centered within the alveolar bone (Figure 3B). This indicated that the IMPA does not accurately reflect the relationship between the incisor root and alveolar bone. Despite the large inclination change of the teeth relative to the mandibular plane, the position of the teeth relative to the alveolar bone changed less. This could be explained by the "alveolar bending hypothesis" proposed by Baumrind[24] and De Angelis,[25] which stated that light forces can induce alveolar bone remodeling, perhaps due to mechanical periosteal stimulation. Therefore, orthodontic camouflage treatment with light force could retract the lower anterior teeth to correct the anterior crossbite while maintaining the consistency of the tooth axis with the alveolar bone axis through the bone-bending effect.

The study found that patients with greater lingual inclination of the lower incisors and better soft-tissue lateral profiles before treatment showed a greater increase in the IA/PA_{MD} during presurgical treatment, and the severity of skeletal deformity is not a risk factor for increased IA/PA_{MD}. Therefore, for patients with significantly less incisor compensation and better lateral profile appearance, it is important to pay close attention to the root-bone relationship during presurgical treatment. To prevent overdecompensation during presurgical orthodontic treatment, it is recommended to obtain additional lateral cephalometric films or perform cone-beam computed tomography (CBCT) to check the positional relationship between the lower incisor root and the alveolar bone. If a patient already has significant angulation between the lower incisor root and the alveolar bone, it is advisable to stop mandibular incisor decompensation and use bone augmentation or perform a subapical osteotomy if necessary.

Compared with cephalometric lateral radiographs, CBCT is a more accurate method for examining the relationship between the roots and surrounding alveolar bone. This retrospective study excluded CBCT data due to the lack of, or inconsistency in, CBCT information before and after treatment. In future studies, CBCT data should be used to investigate changes in the positional relationship between the anterior tooth roots and surrounding alveolar bone under different treatment methods more accurately. This will further assess the accuracy of the IA/PA_{MD} in evaluating the positional relationship between the anterior tooth roots and surrounding alveolar bone.

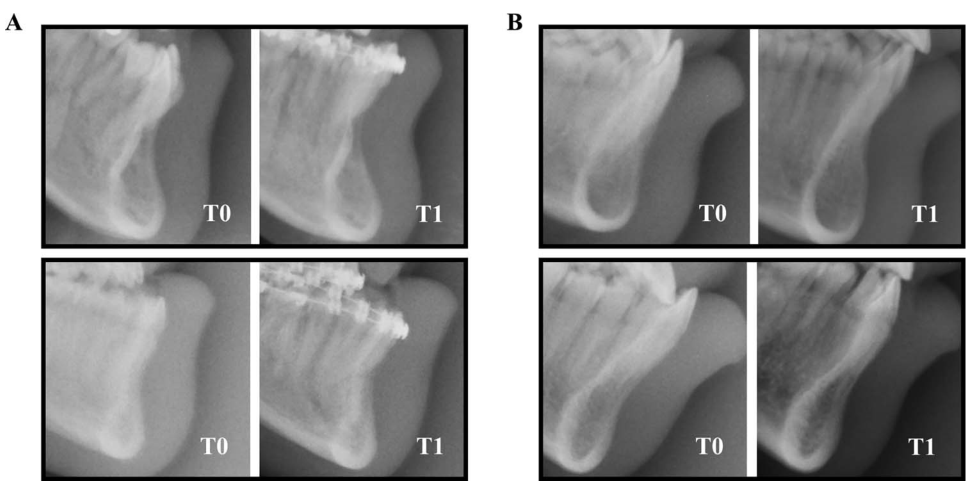

Figure 3. Cephalograms showing lower incisor changes in the SG and OG. (A) Examples of cephalograms exhibiting excessive angulation between the long axis of the lower incisor and the principal axis of the mandibular alveolus after presurgical orthodontic treatment. (B) Examples of cephalograms exhibiting lower incisors well-surrounded by the alveolar bone after orthodontic camouflage treatment.

CONCLUSIONS

- For patients with mild to moderate skeletal Class III malocclusion, orthodontic camouflage therapy is able to achieve similar overjet and soft-tissue changes as orthodontic-orthognathic surgery.
- In orthodontic camouflage, the lower anterior teeth were significantly tipped lingually with a better root-bone relationship. However, in some surgical patients, this relationship deteriorated.
- Additional cephalometric or CBCT imaging is recommended during presurgical orthodontic treatment to undertake necessary measures in a timely manner to prevent potential periodontal risks.

DISCLOSURES

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