Original Article

Total arch maxillary distalization using infrazygomatic crest miniscrews in the treatment of Class II malocclusion: a prospective study

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ABSTRACT

Objectives: To evaluate treatment effects in Class II patients using infrazygomatic crest (IZC) miniscrews (MS).

Materials and Methods: A prospective sample of 25 adolescents (14 females and 11 males; mean age: 13.6 ± 1.5 years) who underwent maxillary dentition distalization treatment with IZC MSs were recruited. Lateral cephalograms and digital models at the beginning of treatment (T1) and after Class II molar correction (T2) were obtained. To compare cephalometric and digital model changes, paired *t*-test and Wilcoxon test were used. A significance level of 5% was used.

Results: All patients achieved Class II molar correction over a mean period of 7.7 ± 2.5 months. The IZC MS therapy provided 4 mm of distalization; there was 1.2 mm of intrusion of the first molar with 11.2° distal tipping. The maxillary incisors were retracted 4.7 mm and tipped lingually 13.4°. Overjet and overbite showed a reduction of 3.6 mm and 2.4 mm, respectively. The occlusal plane rotated clockwise 2.8°. The upper lip was retracted by 1 mm and the nasolabial angle increased 5.1°. There was an increase in the interpremolar and intermolar distances.

Conclusions: Total arch distalization of the maxillary dentition using IZC MS was effective in the treatment of Class II malocclusions. (*Angle Orthod.* 2022;93:41–48.)

KEY WORDS: Total arch distalization; Class II treatment; Temporary anchorage devices (TADs)

INTRODUCTION

Class II malocclusion is one of the most prevalent types of malocclusion in contemporary orthodontic practice, being observed in 38% to 50% of patients.[1,2] It has been related to less favorable perceptions of facial and dental esthetics,[3,4] contributing negatively to the quality of life and self-esteem of patients.[5] Class II treatment in permanent dentition during the growth period can help establish an ideal and stable occlusion.[6]

Numerous therapeutic options are available for the treatment of Class II malocclusion, such as headgear, functional orthopedic appliances, mandibular protraction, conventional fixed appliances with intermaxillary elastics, and a combination of these mechanics with tooth extractions, which have proven to be effective; however, the options each require considerable cooperation of patients to fulfill their real goals.[7–9]

To overcome dependence on patient compliance, temporary anchorage devices (TADs) were introduced by Kanomi,[10] who placed miniscrews (MS) between the roots of posterior teeth to promote retraction of anterior teeth. These MS were classified as interradicular (IR). However, IR MS have some major problems such as a high rate of failure, interference with the path of tooth movement, and impingement on the roots of adjacent teeth.[11–13]

On the other hand, MS installed in the region of the infrazygomatic crest (IZC) of the maxilla have been highlighted in the literature,[14,15] allowing free dental movement along the path of posterior teeth since the

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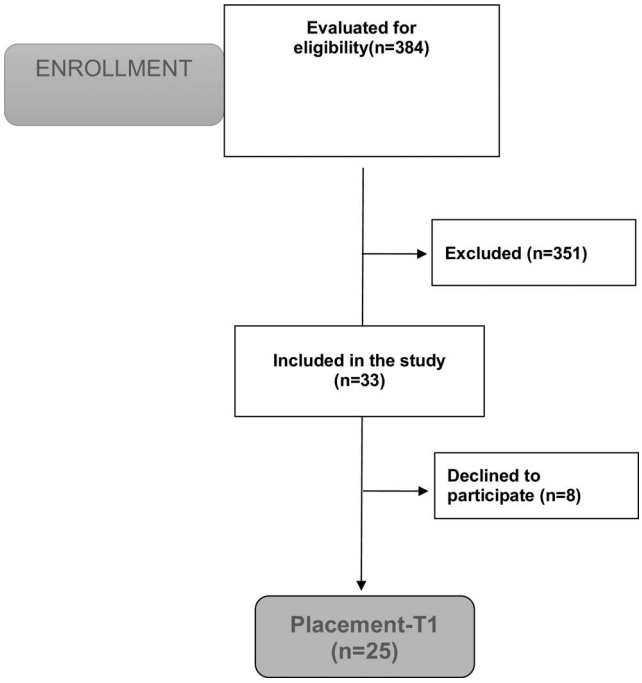

Figure 1. CONSORT Flow Diagram.

position of the MS is outside the roots. They may be used for various orthodontic mechanics, such as total arch maxillary distalization, severe crowding correction, and correction of asymmetry.[16–20]

There have been several methods advocated for total arch maxillary distalization through buccal placement of TADs.[21–27] Additionally, a modified C-palatal plate (MCPP) for maxillary distalization has also been suggested for Class II correction. The MCPP allows total arch distalization, being easily placed without raising a flap, in comparison to miniplates (MP).[28–30] Lee et al.[31] compared the treatment effects between palatally and buccally placed TADs and showed significantly greater amounts of distalization and intrusion with a smaller amount of distal tipping of the maxillary first molars using the MCPP.

There have been no prospective studies evaluating the effects of maxillary dentition distalization with MS implanted in the IZC. Therefore, the objective of this study was to analyze the treatment effects of IZC MS during distalization of the whole maxillary dentition. The hypothesis was that IZC TADs would be effective for total arch distalization.

MATERIALS AND METHODS

This prospective study was approved by the Review Board of the University of North Paraná, UNOPAR, Londrina-PR, Brazil and registered in the Brazilian registry of clinical trials (U1111-1258-6176). All patients were treated by one operator and appointments were made monthly. Sample size estimation was performed based on a significance level of 5% (alpha) and a beta value of 0.2, to achieve a minimum of 90% probability of detecting a mean difference of 2.8 mm in maxillary incisor retraction.[31] A minimum of 22 patients were required.

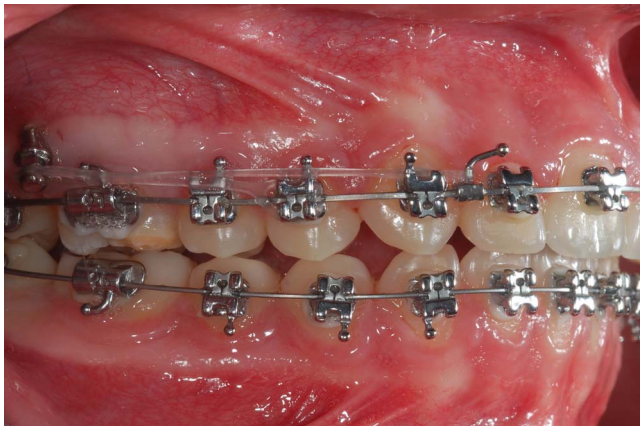

Figure 2. Total arch distalization.

A total of 384 patients were evaluated in municipal and private schools (Figure 1). Out of the 33 patients eligible, eight declined to participate and 25 patients were enrolled according to the following inclusion criteria: bilateral Class II molar relationship, age between 11 and 17 years, no history of previous orthodontic treatment, and presence of all permanent teeth fully erupted, except third molars. Those who presented with a posterior crossbite, syndromes, skeletal asymmetries, patients in need of extractions, agenesis (except for third molars), or dental anomalies were excluded. All patients had complete orthodontic records at the beginning (T1) of treatment and after Class II molar correction (T2). The sample of 25 patients (14 females and 11 males) with an initial mean age of 13.6 $\pm$ 1.5 years were analyzed.

Self-ligating brackets (Roth prescription, 0.022-inch slot, Orthometric, Marília, SP, Brazil) were bonded to all teeth. Leveling was carried out with a sequence of Copper-NiTi (Orthometric, Marília), beginning with 0.014-inch, 0.016-inch, and then 0.016 $\times$ 0.025-inch. Total arch distalization mechanics took place after the insertion of a 0.017 $\times$ 0.025-inch beta-titanium archwire with crimpable hooks placed on the distal aspect of the lateral incisors and the placement of IZC MS (diameter: 2 mm; length: 12 mm; Peclab, Belo Horizonte, MG, Brazil) between the maxillary first and second molars.[32] Distalization was initiated by engaging chain elastics (TP Orthodontics, La Porte, Indiana) between the MS and archwire hooks (Figure 2), applying 350 g of force.

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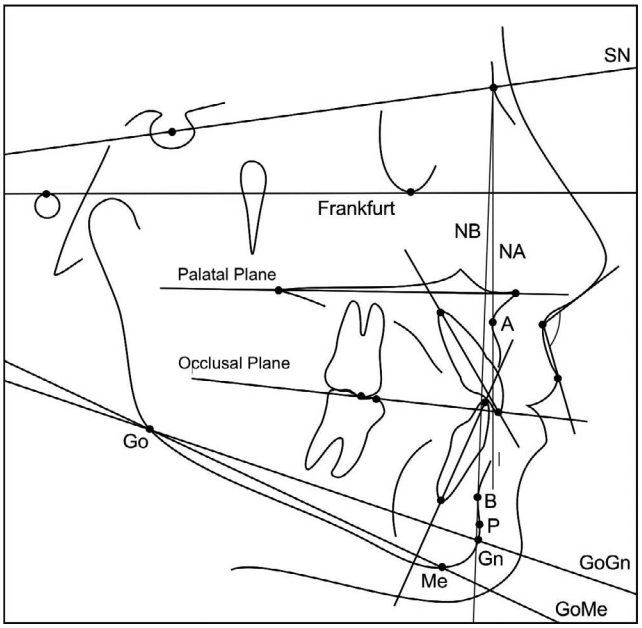

Figure 3. Cephalometric analysis: SNA (sella-nasion-A); SNB (sella-nasion-B); ANB (maxillary-mandibular relationship); Wits (A point to occlusal plane-B point to occlusal plane); FMA (mandibular plane to Frankfurt horizontal); SN.GoGn (Mandibular plane-SN line); SN-Occlusal Plane (sella-nasion-Occlusal plane); Overjet (sagittal distance between upper incisor tip to lower incisor tip); overbite (vertical distance between upper incisor tip to lower incisor tip); U1-PP (Upper incisor long axis-palatal plane angle); U1-NA (distance between the most anterior point of the upper central incisor and NA line); UL-SnPog' (distance between upper lip and SnPog' line); Nasolabial angle (subnasale to columella and subnasale to upper lip tip).

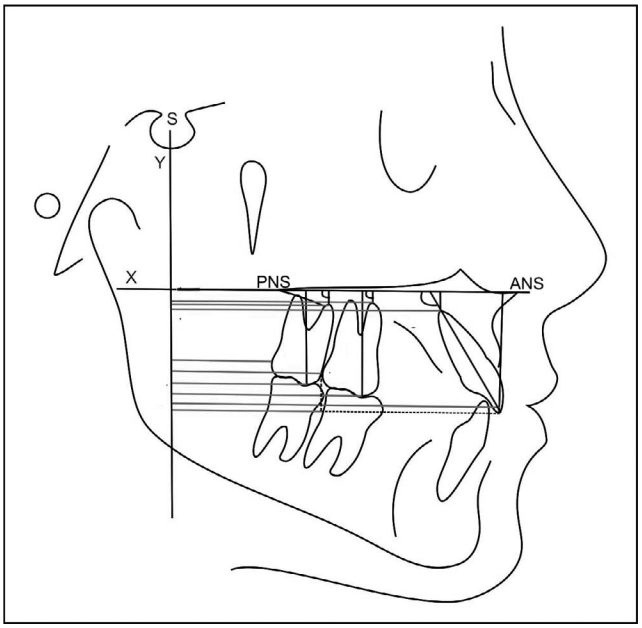

Figure 4. Cephalometric diagram used for cephalogram measurements: X: Horizontal reference line passing from anterior nasal spine (ANS) to the posterior nasal spine (PNS). Y: vertical reference line perpendicular to X axis passing through Sella Turcica. U1 tip to X (linear distance between maxillary incisor tip to X-axis perpendicularly); U1 apex to X (distance of maxillary incisor apex to X-axis); U1 tip to Y (distance of maxillary incisor edge to Y); U1 apex to Y (distance of maxillary incisor apex to Y-axis); U6 apex to X (distance of maxillary first molar mesio-buccal root apex to X-axis); U6 apex to Y (distance of maxillary first molar mesio-buccal root apex to Y-axis); U6 crown to X (distance of maxillary first molar mesio-buccal crown to X-axis); U6 crown to Y (distance of maxillary first molar mesio-buccal crown to Y-axis); U7 apex to X (distance of maxillary second molar mesio-buccal root apex to X-axis); U7 apex to Y (distance of maxillary second molar mesio-buccal root apex to Y-axis); U7 crown to X (distance of maxillary second molar mesio-buccal crown to X-axis); U7 crown to Y (distance of maxillary second molar mesio-buccal crown to Y-axis); U6D to Y (distance of maxillary first molar distal aspect of crown to Y-axis); U7D to Y (distance of maxillary second molar distal aspect of crown to Y-axis); U1tip to U6D (linear distance of maxillary incisor tip to maxillary first molar distal aspect perpendicular to X-axis); U1 to X (angulation of maxillary central incisor to X-axis); U6 to X (angle of a line perpendicular to maxillary first molar mesial surface to X-axis); U7 to X (angle of a line perpendicular to maxillary second molar mesial surface to X-axis).

Cephalometric and Digital Model Analysis

Lateral cephalograms were traced by one examiner using Dolphin Imaging software (version 11.7, Dolphin Imaging and Management Solutions, Chatsworth, Calif). A total of five linear and eight angular measurements were made as shown in Figure 3. Also, the measurements for evaluating the molar and incisor changes are summarized in Figure 4.

Digital models were captured by a 3Shape R700 3D scanner (3Shape A/S, Copenhagen, Denmark) to facilitate analysis with OrthoAnalyzer software (3Shape). Maxillary changes were evaluated regarding arch perimeter and length; and intercanine, interpremolar, and intermolar distances (Figure 5).

Statistical Analysis and Error of the Method

Data distribution was analyzed by the Shapiro-Wilk normality test. For comparison between the initial (T1) and after Class II molar correction (T2), paired *t*-tests were used when a normal distribution was seen. For non-normally distributed data, Wilcoxon test was used. Reliability was assessed by repeating cephalometric and digital model measurements for 30% of the sample after 30 days. The intraclass correlation coefficient (ICC) and Bland-Altman plot were used. All statistical procedures were performed with the aid of Statistica 5.0 software (StatSoft Inc., Tulsa, Okla). Significance level was set at 5%.

RESULTS

Table 1 shows gender distribution, severity of Class II molar relationship, treatment time, and mean age at the start of treatment. Intra and interexaminer reliability of the cephalometric analysis was excellent (ICC

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Table 1. Baseline Characteristics of the Sample[a]

		N	%
Gender	Male	11	44.0
	Female	14	56.0
Severity of Class II	Full	3	12.0
(Right side)	1/2	6	24.0
	1/4	5	20.0
	3/4	11	44.0
Severity of Class II	Full	3	12.0
(Left side)	1/2	6	24.0
	1/4	4	16.0
	3/4	12	48.0

	Mean	SD	min.	max.
Age (years)	13.63	1.59	11.17	16.50
Time to correct the Class II relationship (months)	7.76	2.50	5.00	14.00

[a] max. indicates maximum; SD, standard deviation; min., minimum.

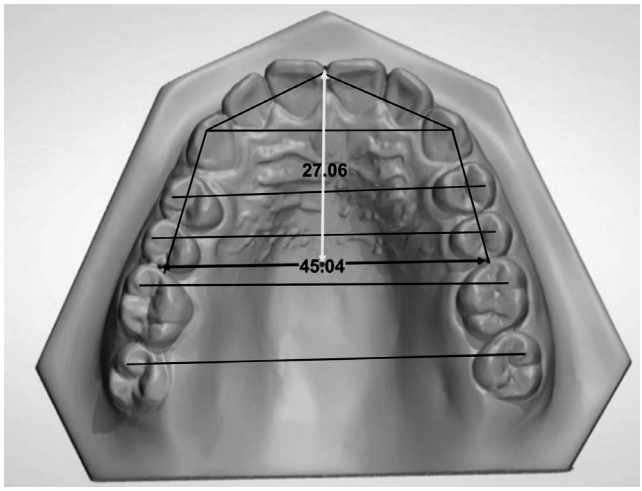

Figure 5. Digital models.

ranged from 0.96 to 1.00). High reliability was found for digital model measures (ICC ranged from 0.95 to 1). The Bland-Altman test showed a low degree of bias for most of the repeated measures (upper limit: 0.07 to 2.96; lower limit: –0.07 to 2.06).

There was a significant increase in the ANB angle (Table 2). Wits measurement showed a significant decrease (–1.6 ± 2.5 mm). No significant changes were found regarding vertical growth of the mandible. A clockwise rotation of the occlusal plane was seen (2.8 ± 3.9 mm). There were significant decreases in the overjet (–3.6 ± 2 mm) and overbite (–2.4 ± 1.7 mm). Significant retroclination (–13.4° ± 10.2°) and retrusion of the maxillary incisors (–4.3 ± 2.6 mm) were observed. Upper lips were significantly retracted (–1 ± 1.2 mm) and the nasolabial angle showed a significant increase (5.1 ± 8.3 mm).

IZC MS achieved 4 mm of maxillary first-molar distalization, 1.2 mm of intrusion, with 11.2° tipping. Also, there was 4.7 mm of retraction of the incisors, lingual tipping of 13.4°, labial movement of the apex of 0.9 mm, and 1 mm of apex extrusion (Table 3 and Figure 6). The apex of the mesiobuccal root of the first molar was significantly distalized by 1.3 mm.

The maxillary intercanine measures did not show significant changes (Table 4). However, interpremolar (first, 2.8 mm; second, 3.1 mm) and intermolar distances (first, 2.3 mm; second, 1.4 mm) showed a significant increase. No significant changes were observed in arch perimeter and arch length.

Table 2. Conventional Cephalometric Analysis of the Treatment Effects of IZC Miniscrew Mechanics From Beginning of Treatment (T1) to Postdistalization of Total Arch (T2)[a]

	T1		T2		T2–T1		
Variable	Mean	SD	Mean	SD	Mean	SD	*P* Value
Skeletal							
SNA (°)	83.53	3.26	83.98	3.06	0.45	1.65	.187
SNB (°)	77.25	3.24	76.96	3.09	−0.29	1.39	.310
ANB (°)	6.27	1.61	7.02	1.75	0.75	1.03	.001*
Wits Appraisal (mm)	4.73	2.86	3.08	2.66	−1.65	2.54	.004*
FMA (MP-FH) (°)	20.75	4.99	21.33	4.82	0.58	2.23	.206
SN. GoGn (°)	29.38	5.04	29.46	4.38	0.08	2.34	.865
SN. Occl. Plane Angle (°)	17.92	4.92	20.80	5.09	2.88	3.96	.001*
Dental							
Overjet (mm)	5.42	2.11	1.75	0.65	−3.67	2.05	<.001*
Overbite (mm)	3.82	2.03	1.40	1.17	−2.42	1.72	<.001*
U1. Palatal Plane (°)	112.29	7.88	98.85	6.45	−13.44	10.28	<.001*
U1-NA (mm)	3.20	2.31	−1.17	2.05	−4.37	2.69	<.001*
Soft Tissue							
Upper Lip -SnPog' (mm)	3.60	1.56	2.53	1.64	−1.08	1.21	<.001*
Nasolabial Angle (º)	113.54	8.95	118.73	11.46	5.19	8.32	.002**

[a] IZC indicates infrazygomatic crest; SD, standard deviation; U1, maxillary central incisor.
* $P < .05$ (Student's *t*-test).
** $P < .05$ (Wilcoxon test).

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Table 3. Maxillary Cephalometric Analysis of the Treatment Effects of IZC Miniscrew Mechanics From Beginning of Treatment (T1) to Postdistalization of Total Arch (T2)[a]

	T1		T2		T2-T1		
Variable	Mean	SD	Mean	SD	Mean	SD	*P* Value
U1 tip to X (mm)	26.66	3.00	27.40	2.86	0.74	1.86	.065
U1 Apex to X (mm)	3.03	2.20	4.02	1.83	1.00	1.69	.007*
U1 tip to Y (mm)	68.34	4.93	63.63	5.62	−4.70	2.63	<.001*
U1 Apex to Y (mm)	59.59	5.37	60.57	4.51	0.98	2.15	.031*
U6 Apex to X (mm)	2.31	1.83	1.71	2.59	−0.60	1.67	.082
U6 Apex to Y (mm)	40.64	4.63	39.28	4.43	−1.36	1.80	.001*
U6 Crown to X (mm)	20.36	2.60	19.14	3.04	−1.22	1.44	<.001*
U6 Crown to Y (mm)	38.35	5.25	33.03	5.76	−5.32	1.66	<.001*
U7 Apex to X (mm)	0.26	1.93	−0.94	2.39	−1.20	1.43	<.001*
U7 Apex to Y (mm)	32.13	3.79	30.59	4.67	−1.54	2.10	<.001#
U7 Crown to X (mm)	17.26	3.15	15.34	4.14	−1.92	1.72	<.001*
U7 Crown to Y (mm)	27.84	4.78	23.12	5.57	−4.72	1.94	<.001*
U6D to Y (mm)	30.38	5.06	26.38	5.25	−4.00	1.04	<.001*
U7D to Y (mm)	21.67	4.53	18.14	4.60	−3.53	1.21	<.001*
U1 tip to U6D (mm)	37.92	2.60	37.20	2.78	−0.71	2.47	.163
U1.X°	111.33	8.20	97.91	7.22	−13.42	10.13	<.001*
U6.X°	85.39	6.73	74.10	7.91	−11.29	5.31	<.001*
U7.X°	80.80	7.17	69.76	10.05	−11.04	7.10	<.001*

[a] IZC indicates infrazygomatic crest; SD, standard deviation; U1, maxillary central incisor; U6, maxillary first molar; U6D, distal aspect of maxillary first molar; U7, maxillary second molar; U7D, distal aspect of maxillary second molar.
* $P < .05$ (Student's *t*-test).

No failures of the MS were observed and no patients failed to complete treatment nor were they excluded after treatment began.

DISCUSSION

This prospective study evaluated the treatment effects of IZC MS. All patients showed correction of the Class II molar relationship in a mean period of 7 months. Molar distalization of 4 mm and intrusion of 1.2 mm were observed. The maxillary incisors were retracted 4.7 mm and extruded 1 mm, which helped reduce the overjet by 3.6 mm. Similarly, Wu et al.[33] found distalization (3.5 mm), intrusion of the molars (2.1 mm), and also retraction (4.3 mm) and extrusion (3.8 mm) of the maxillary incisors during a mean treatment time of 8 months using IZC MS. A similar magnitude of dental changes was showed by Bechtold et al.,[27] who achieved 4.2 mm of distalization and 3.4 mm of retraction of incisors using IR MS.

Although a similar amount of molar distalization was also achieved with IR MS, buccally placed TADs must be relocated to retract the whole dentition posteriorly

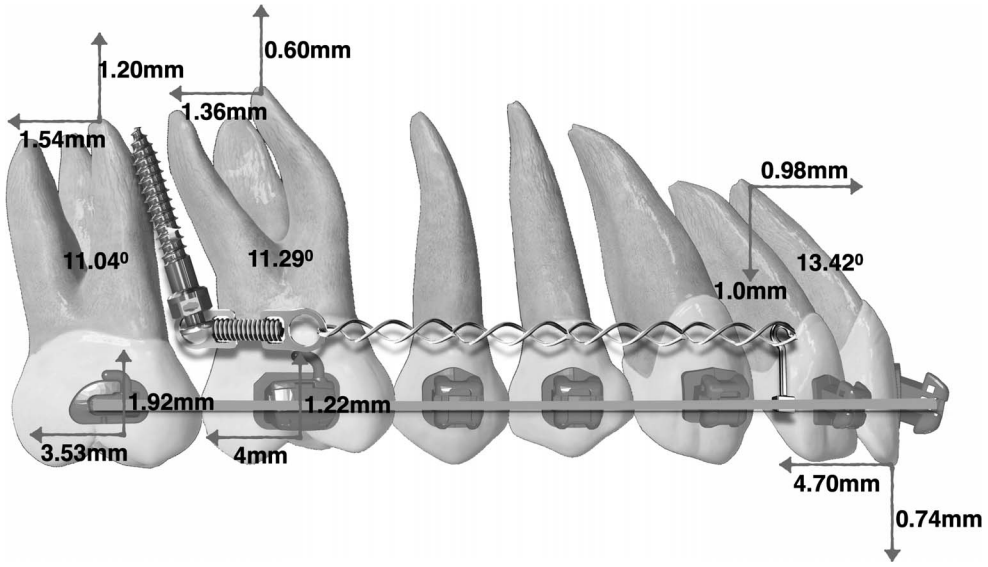

Figure 6. Schematic drawing of the mean treatment changes of the maxillary first molar and central incisor after the use of IZC MS mechanics.

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Table 4. Digital Model Analysis From T1 to T2[a]

	T1		T2		T2-T1		
Variable	Mean	SD	Mean	SD	Mean	SD	*P* Value
UCD 13, 23 (mm)	34.27	2.30	34.82	2.00	0.55	2.24	.234
UFPD 14, 24 (mm)	40.69	3.11	43.53	2.53	2.85	2.51	<.001*
USPD 15, 25 (mm)	45.34	3.46	48.49	2.85	3.15	2.73	<.001*
UFMD 16, 26 (mm)	49.84	3.68	52.20	3.11	2.36	1.76	<.001*
USMD 17, 27 (mm)	55.30	3.99	56.73	3.90	1.44	1.60	<.001*
U length (mm)	28.26	2.13	28.04	1.91	−0.22	2.10	.605
U perimeter (mm)	78.63	4.89	78.09	4.17	−0.54	4.00	.510

[a] SD indicates standard deviation; U, upper; UCD, upper intercanine cusp distance; UFPD, upper first interpremolar distance; USPD, upper second interpremolar distance; UFMD, upper first intermolar distance; USMD, upper second intermolar distance.
* $P < .05$ (Student's *t*-test).

due to the limited amount of space between the roots and the screws. A systematic review[34] described molar distalization ranging from 1.8 to 6.4 mm, with distal tipping ranging from 1.6° to 11.3°, and retraction of the incisors varying from 0.1 to 2.7 mm, during a mean treatment time ranging from 4.6 to 11.2 months. The current results were similar to those reported by Mohamed et al.[34] Comparing the modified C-palatal plate (MCPP) with interradicular miniscrews, Lee et al.[31] obtained greater amounts of distalization (4.2 mm) and intrusion (1.6 mm) with less distal tipping of the first molars (2°) and more extrusion of the incisors using MCPP; MS provided 2 mm of distalization of the molars and 0.1 mm of intrusion, as well as 2.5 mm of incisor retraction and 0.3 mm of extrusion.

The current study showed greater incisor retraction, apex extrusion, and lingual tipping compared to Lee et al.,[31] who obtained incisor retraction of 2.9 mm and lingual tipping of the incisor of 4.4°. Greater distal tipping of the molars was seen in the current study versus the study of Lee et al.,[31] who found 2° distal tipping. Since the apex moved labially 0.9 mm and the incisal edge of the incisors moved lingually 4.7 mm, the movement can be considered uncontrolled tipping. These differences may have occurred because, in the present study, 0.017 × 0.025-inch TMA wires were used in 0.022-inch slot brackets, while Lee et al.[31] used 0.017 × 0.025-inch stainless steel wires in 0.018-inch slot brackets, thus allowing less play between the bracket and wire.

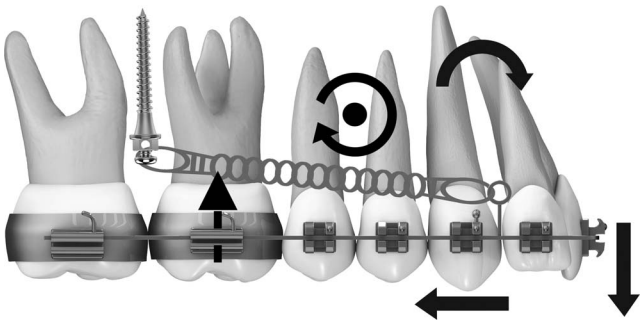

Figure 7. IZC miniscrew force system mechanics.

Another factor that influenced the results was the relationship between the line of action of the force from MS to the crimpable hook and the position of the center of resistance (CR). The IZC MS promoted a clockwise rotation of the maxillary occlusal plane because the line of force passed below the CR (Figure 7). Rotation of the maxillary occlusal plane was expected because it can improve the overjet and protrusion of anterior teeth in Class II patients. The differences in the amount of tooth displacement seemed to be due to the vertical position of the MS and the height of the hooks and variations in the direction of the force vector. The MS were implanted in the IZC approximately 11 mm above the occlusal plane[32] and the length of the hook was approximately 4 mm. The height of the hook could also influence torque of the incisors and the occlusal plane rotation and, thus, care should be taken when choosing the appropriate biomechanics for a given patient.[15]

The upper lip was retracted 1 mm and the nasolabial angle increased by 5.1°. Similar results were attained previously with 1.1 mm of upper lip retraction and 5.7° increase in the nasolabial angle using MCPP.[31] In the present study, there was an increase in the transverse widths between first (2.8 mm) and second (3.1 mm) premolars. A significant increase in the distances between first and second molars of 2.3 and 1.4 mm was also seen. In agreement with the present study, Wu et al.[33] found an increase in the molar region (6.2 mm). When evaluating the arch perimeter and arch length, no significant changes were noted.

The findings of this study supported the hypothesis that IZC MS are effective for total arch distalization in Class II correction. In addition, IZC MS are inexpensive and there is no need to relocate them during treatment as would be required for IR MS. They are also simpler for clinicians to use compared to miniplates or the MCPP. Considering that there was an increase in ANB and clockwise rotation of the occlusal plane when

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achieving maxillary total dentition distalization using IZC MS, appropriate selection among Class II patients for application of this method is required. The present study also had some limitations, such as the lack of a control group, a short-term evaluation period, and the possible influence of growth that may take place during treatment.

CONCLUSIONS

- IZC MS provided 4 mm of molar distalization and uncontrolled tipping to upright maxillary incisors.
- The occlusal plane rotated clockwise 2.8°.
- The upper lip was retracted by 1 mm and the nasolabial angle increased 5.1°.
- There was significant expansion of the maxillary dental arch.

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