Original Article

Do orthopedic corrections of growing retrognathic hyperdivergent patients produce stable results?

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ABSTRACT

Objectives: To determine if posterior dental intrusion produces stable orthodontic and orthopedic corrections in growing retrognathic hyperdivergent patients.

Materials and Methods: The sample included 14 subjects (five males and nine females), who were 13.4 ± 0.7 years pretreatment, treated for 3.5 years, and followed for 3.6 years posttreatment. During the initial orthopedic phase, 150 g NiTi coil springs were attached to two palatal miniscrew implants (MSIs) for maxillary intrusion; two buccal mandibular MSIs were used for posterior vertical control. Full orthodontic therapy was initiated to correct the malocclusions during the orthodontic phase. Patients were recalled a minimum of 1 year posttreatment (mean 3.6 ±1.6 years). Patients were compared to matched untreated controls.

Results: Relative to the untreated controls, during treatment and retention, maxillary and mandibular molars underwent 2.8 mm and 3.7 mm of relative posterior intrusion, respectively. Maxillary incisors were extruded 1.3 mm and the mandibular incisors underwent 2.9 mm of relative intrusion. Overall orthopedic changes included a reduction in the mandibular plane angle (MPA; 3.3°), an increase in SN-Pg (2.4°), an increase in S-N-B (2.1°), and a 4.3 mm relative reduction in anterior facial height. The maxillary incisors, which showed 0.6 mm of intrusion (relative to controls), was the only dental or skeletal measure to show a statistically significant between-group posttreatment difference.

Conclusions: Except for maxillary incisor position, the substantial dental intrusion and associated orthopedic corrections that were produced during treatment remained stable post-treatment. (*Angle Orthod.* 2019;89:552–558.)

KEY WORDS: Miniscrews; Growth; Orthopedics; Orthodontics; Stability; Posttreatment

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INTRODUCTION

Due to the complexity of their malocclusions and vertical skeletal growth patterns, retrognathic hyperdivergent patients are among the most difficult to treat. Although both surgical and nonsurgical orthodontic treatment approaches have been used, surgical correction has consistently demonstrated superior results because it provides skeletal improvements.[1] However, surgery must be delayed until early adulthood; many patients decline surgery due to the associated morbidity/risks and financial constraints.[2]

Traditional orthodontic treatments effectively correct dental malocclusions but they do not adequately address the skeletal and soft-tissue problems, and often fail to control the vertical dimension during treatment.[3,4] Vertical control of hyperdivergent retrognathic patients depends on true mandibular rotation, the primary determinant of anteroposterior chin position.[5,6] Based on the association between true mandibular rotation and changes in vertical dental

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positions, treatments aimed at reducing vertical skeletal dysplasia and improving profile convexity should focus on the vertical control of the dentition.[6,7]

Based on these ideas, a treatment approach was developed using miniscrew-assisted control of the maxillary and mandibular vertical dimensions.[8,9] Along with correction of the malocclusion, this approach produces beneficial orthopedic changes, including significant decreases in the mandibular plane angle, increases in the SNB angle, increases in chin projection, decreases in facial convexity, and control of vertical facial height. The long-term stability of this approach in growing patients remains to be established. The long-term stability for open-bite patients has been shown to be highly variable, ranging from 57% to 100% stability for surgical corrections and 30% to 100% stability for nonsurgical corrections.[1]

The purpose of the present study was to determine if the orthodontic and orthopedic corrections produced with nonsurgical posterior dental intrusion were stable when performed on growing retrognathic hyperdivergent patients. The primary aim was to compare the changes that occurred during treatment and a minimum of 1 year after treatment, to untreated matched controls.

MATERIALS AND METHODS

Study Design and Population

The study sample was drawn from 17 retrognathic hyperdivergent patients who were previously treated in the graduate orthodontic clinic at Texas A&M University College of Dentistry.[8,9] Both the original study evaluating treatment and the present follow-up study evaluating stability were prospective. All subjects had (1) end on or greater bilateral Class II molar and canine relationships, (2) an SNB angle one standard deviation or more below age- and sex-specific values,[10] (3) lower anterior facial height (ANS-Me) greater than age- and sex-specific values,[10] and (4) premolars that were fully erupted. The Institutional Review Board of Texas A&M University College of Dentistry reviewed and approved this study (2014-0750-BCD-FP).

All subjects were treated by the same orthodontist. Treatment has been previously described.[8,9] The rapid palatal expander (RPE) used was Dentaurum Variety SP (Dentaurum GmbH & Co. KG Ispringer, Germany), with bands on maxillary first molars and occlusal stops for the erupting maxillary second molars. After maxillary expansion, 2 miniscrew implants (MSIs) were placed in the posterior palate lateral to the maxillary first molars and immediately loaded with 150 g NiTi coil springs attached to the RPE. Orthodontic brackets and segmental wires were used on the maxillary premolars and molars during the intrusive phase. No appliances were used on the anterior six teeth to minimize incisor extrusion. Buccal MSIs were placed in the mandible between the second premolars and first molars, and ligated to the mandibular first molar orthodontic bracket with stainless steel ligatures. The lower molars of two patients who required more mandibular rotation were intruded using 150 g coil springs; lower lingual arches were placed to control tipping. After adequate posterior intrusion had been achieved, the remaining dentition was bonded and the malocclusions were corrected. Several of the patients required extractions. Posttreatment (T2) records were obtained upon completion of orthodontic treatment.

All but two of the treated subjects received maxillary full coverage thermoplastic retainers and mandibular-bonded 3-3 lingual retainers. The two patients who declined mandibular-bonded retainers used thermoplastic retainers. The lingual retainers were made from a 0.030-inch stainless steel wire fit to the teeth, microetched, and bonded to the canines. The maxillary retainers were thermoformed from Essix sheets to a thickness of 0.015 inches, extended to include the second molars, and placed on the day of appliance removal. Patients were instructed to wear the retainers full time (except during meals) for 6 months and then night-time only, indefinitely.

The current study included 14 of the original 17 subjects (five males and nine females). Three subjects were not recalled due to geographical relocation or incomplete records. The sample was 13.4 $\pm$ 0.7 years of at pretreatment (T1), 16.8 $\pm$ 1.3 years at post treatment (T2), and 20.4 $\pm$ 0.9 years at recall (T3). The orthopedic phase ended after approximately 25 months. Treatment (T1-T2) and posttreatment (T2-T3) lasted 3.5 $\pm$ 0.9 years and 3.6 $\pm$ 1.6 years, respectively. Posttreatment records were taken at least 12 months after active orthodontics because that is when most relapses occur.[11]

Measurements

Lateral cephalograms were rendered from the cone beam computed tomography data volumes (0.3 mm voxel size) using the right side of the skull and a portion of the left extending to the medial border of the left orbit. They were oriented on the midsaggital and Frankfort planes and digitized by one examiner using Dolphin Imaging (Patterson Technology, Chatsworth, CA).

The patients were compared to 22 untreated controls matched based on age, sex, molar classification, and pretreatment mandibular plane angle. The controls were drawn from records collected by the University of Montreal Growth Study. Lateral cephalograms were traced and the landmarks were identified.

Seventeen cephalometric landmarks were digitized by the same examiner using standard definitions (Figure 1),[10] from which eight measurements were computed:

- AP skeletal: mandibular protrusion (S-N-B) and chin projection (S-N-Pg)
- Vertical skeletal: mandibular plane angle (S-N/Go-Me) and total anterior face height (N-Me)
- Vertical dental: maxillary molar (U6⊥ANS-PNS), maxillary incisor (U1⊥ANS-PNS), mandibular molar (L6⊥Go-Me), mandibular incisor (L1⊥Go-Me), and overbite

All radiographs were digitized by the same examiner. All linear measurements were adjusted to eliminate magnification. Intra-examiner reliability was measured by replicate analyses of 15 subjects. There were no statistically significant systematic differences; landmark method errors were less than 0.5 mm.

Statistical Analysis

Treatment, posttreatment and overall long-term changes were analyzed using SPSS version 22 (SPSS Inc., Chicago, IL). The skewness and kurtosis statistics showed that the distributions were not normal. Central tendencies and dispersions were described with medians and interquartile ranges. Between- and within-group differences were evaluated using Mann-Whitney *U*-test and Wilcoxon test, respectively.

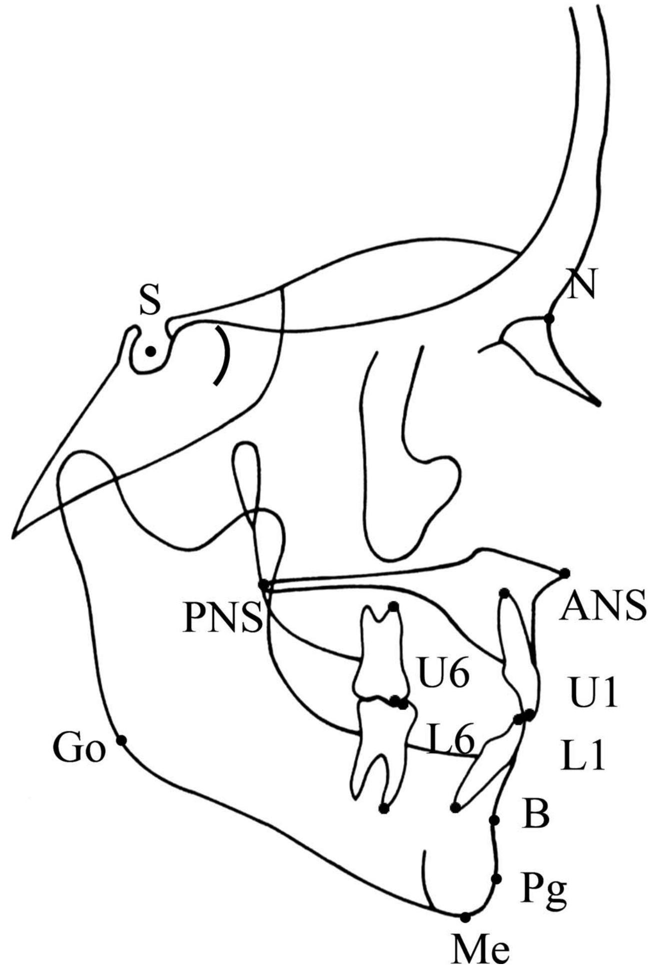

Figure 1. Cephalometric landmarks.

RESULTS

All patients finished treatment with Class I molar relationships, normal overjet (2–4 mm) and normal overbite (2–4 mm). There was some relapse during the posttreatment phase.

Dental Changes

The treated group showed a statistically insignificant 0.4 mm of maxillary molar intrusion during treatment, whereas the controls exhibited 2.9 mm of eruption (Table 1). During the posttreatment phase, the maxillary molars erupted slightly, but not significantly, more in the treated than control group. From the initiation of treatment through the long-term follow-up, there was a statistically significant 2.8 mm between-group difference in the vertical maxillary first molar movements.

The mandibular molars erupted significantly more (2.3 mm) in the control than treated group. There were minimal posttreatment changes, with both groups showing less than 0.5 mm of eruption. Overall, the treated mandibular molars exhibited 3.7 mm of relative intrusion (relative to the controls), which was a statistically significant vertical treatment effect.

During treatment, the maxillary incisors erupted and were extruded 2.85 mm, whereas the control incisors erupted significantly less (1.25 mm). Posttreatment, the maxillary incisors remained vertically unchanged in the treated group and erupted 0.6 mm in the control group. There was a 2.7 mm overall change of the maxillary incisor in the treated group compared to a 1.4 mm change in the control group.

The vertical position of the mandibular incisors did not change significantly during treatment (–0.1 mm), and they erupted slightly posttreatment (0.3 mm). The overall vertical change was only 0.4 mm. The control group showed 3.3 mm of vertical eruption, which was significantly more than the overall change of the treated group.

Skeletal Changes

The mandibular plane angle decreased 2.8° during treatment, while the control group remained relatively unchanged (Table 2). Posttreatment changes of the MPA were not statistically significant for either group. Overall, the mandibular plane angle was reduced 3.3°

Table 1. Treatment, Posttreatment, and Total Vertical Dental Changes of the Maxillary and Mandibular Molars and Incisors*

	Treatment Group			Control Group			Difference
	50th	25th	75th	50th	25th	75th	Probability
Treatment (T1–T2)							
U6 ⊥ PP	−0.44	−1.83	0.70	**2.85**	1.70	4.33	<.001
U1 ⊥ PP	**2.85**	1.43	4.23	**1.25**	−0.20	2.10	.006
L6 ⊥ MP	0.65	−0.95	2.20	**2.90**	2.05	3.68	.001
L1 ⊥ MP	−0.05	−1.43	1.48	**2.80**	1.00	3.80	.001
Post−treatment (T2–T3)							
U6 ⊥ PP	**0.95**	0.18	1.48	**0.35**	−0.15	0.98	.231
U1 ⊥ PP	0.00	−0.88	0.40	**0.60**	−0.20	0.90	.029
L6 ⊥ MP	0.50	−0.45	0.95	0.25	−0.10	1.25	.899
L1 ⊥ MP	0.30	−0.80	0.53	**0.50**	0.00	0.80	.083
Total change (T1–T3)							
U6 ⊥ PP	0.50	−1.95	1.78	**3.30**	1.35	4.50	<.001
U1 ⊥ PP	**2.65**	1.83	3.33	**1.40**	0.80	3.00	.042
L6 ⊥ MP	0.00	−0.30	1.93	**3.70**	2.13	4.95	<.001
L1 ⊥ MP	0.40	−1.90	1.85	**3.30**	1.20	4.20	<.001

* Bold indicates statistically significant ($P < .05$) within-group changes over time.

Table 2. Treatment, Posttreatment, and Total Skeletal Changes, Along With Between-Group Differences*

	Treatment Group			Control Group			Difference
	50th	25th	75th	50th	25th	75th	Probability
Treatment (T1–T2)							
MPA	−2.80	−3.73	−0.90	−0.17	−1.01	0.32	<.001
SN−Pg	1.85	0.28	2.45	0.29	−0.13	1.41	.020
S−N−B	1.10	0.48	2.05	0.15	−0.39	0.77	.001
N−Me	3.70	0.35	6.28	8.74	4.49	11.37	.010
Post−treatment (T2–T3)							
MPA	0.15	−3.00	1.30	−0.23	−0.76	0.35	.775
SN−Pg	0.60	−0.68	1.60	0.12	−0.59	0.56	.267
S−N−B	0.30	−0.85	1.43	−0.04	−0.54	0.37	.339
N−Me	0.25	−1.30	2.10	1.16	−0.12	1.93	.189
Total change (T1–T3)							
MPA	−3.25	−6.10	1.55	−0.48	−1.31	0.64	.038
SN−Pg	2.40	−0.43	4.40	0.52	−0.33	1.57	.066
S−N−B	2.10	−0.05	3.60	0.28	−0.94	0.82	.027
N−Me	4.70	−1.05	6.55	8.99	5.12	13.48	.001

* Bold indicates statistically significant ($P < .05$) within-group changes over time.

in the treated and 0.5° in the control group, which was a statistically significant difference.

Chin projection (SN-Pg) increased significantly (1.9°) in the treated group, but not in the control group. Posttreatment, the chin projection increased slightly, but not significantly, more in the treated (0.6°) than control group (0.1°). Overall, chin projection increased 2.4° in the treated group and 0.5° in the control group.

Initially, the S-N-B angle increased significantly more in the treated (1.1°) than control (0.2°) group. Posttreatment between-group differences in the S-N-B changes were not statistically significant. Overall, there was a statistically significant increase of the S-N-B angle in the treated group (2.1°) and only minimal change in the control group (0.3°).

The treated group showed significantly less (5 mm) lower anterior face height increase during treatment than the control group. Although the treatment group showed no statistically significant change in lower anterior face height during the postretention phase, the control group showed an increase, but the between-group difference was not significant. Overall, lower anterior face height increased approximately 4.3 mm less in the treated than control group.

DISCUSSION

This nonsurgical orthodontic treatment approach produced favorable reductions of the MPA. The 2.8° decrease observed in the present study compared closely to the 0.9°–3.3° reductions reported for adults treated with MSIs and plates.[12–15] Importantly, nongrowing adults required substantially more intrusion than the growing patients in the present study, which could affect long-term stability. Headgear or vertical-pull chin cups produced MPA changes ranging from a 0.3° increase to a 1.4° decrease.[6,16–19] The only exception was a study by Pearson,[20] who documented a 3.9° decrease of the MPA using a vertical-pull chin cup. The MPA decrease in the present study was also comparable to the 0.3°–3.4° surgical changes reported for hyperdivergent anterior open bites.[21–23]

Facial height underwent a substantial relative decrease with this approach, increasing 5 mm less in the treated than the control group. Kuroda et al.,[22] who compared nonsurgical intrusion in adults to two-jaw orthognathic surgery, showed a 3.8 mm decrease in facial height (N-Me) for the surgical group and a 4.0 mm decrease for the nonsurgical group. The surgical findings were slightly less than those observed in the current study, indicating that nonsurgical vertical control via mandibular autorotation in growing patients provides a potent approach for reducing facial height.

Treatment also produced significant anteroposterior (AP) skeletal improvements. Vertical posterior control during treatment allowed the mandible to rotate forward, which is the most important determinant of chin position.[6–8,20] Chin projection for the patients in the present study was improved by approximately 1.5°. Previous posterior intrusion studies have shown SNB increasing 1.3°–1.9° in adults.[12–15] The AP skeletal results compared favorably with those obtained with various orthognathic procedures that autorotate the mandible. The forward rotation that occurred also helped correct the molar relationships.

Vertical control of the posterior dentition is key for achieving orthopedic skeletal changes and profile improvements. Hyperdivergent patients typically present with excessive dentoalveolar heights, primarily due to overeruption of teeth.[24] To produce meaningful

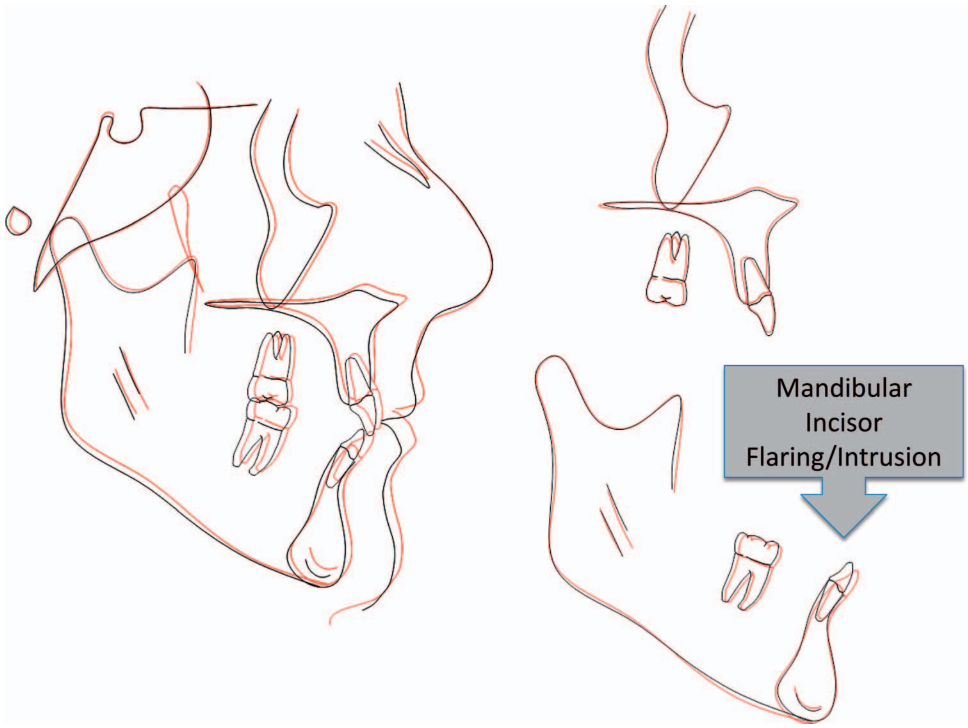

Figure 2. Patient recalled 3.7 years posttreatment who returned with a mild open bite.

mandibular rotation and increase chin projection in growing adolescents, the vertical positions of both the upper and lower posterior teeth must be controlled.[25] The maxillary molars were actively intruded only 0.5 mm during treatment, which represents a substantial treatment effect when compared to the 2.9 mm of eruption that occurred in the untreated control group. The mandibular molars demonstrated similar amounts of relative intrusion. The mandibular molar erupted 0.7 mm during treatment, which probably occurred before the MSIs were placed. The mandibular molars of the control group erupted approximately 2.9 mm, producing a total of nearly 6 mm relative intrusion of the maxillary and mandibular posterior dentition. Such changes are only possible in growing patients. This allowed the mandible to rotate forward into a more favorable anteroposterior and vertical position.

The maxillary incisors erupted and were extruded a total of 2.9 mm during treatment. This was significantly more than the 1.3 mm of eruption that occurred in the control group. Despite efforts to limit incisor extrusion through segmental posterior intrusion, maxillary incisor extrusion occurred during the orthodontic finishing phase. The maxillary molars of the female patients in the present study who had only limited growth potential were not sufficiently intruded during the orthopedic phase. The mandibular incisors were maintained in virtually the same position throughout treatment, resulting in nearly 3 mm of relative mandibular incisor intrusion, probably related to vertical skeletal control of the mandibular molars. Posterior vertical control resulted in mandibular autorotation and anterior bite deepening, thus limiting the need for mandibular incisor extrusion. Though sample sizes were small, power was not an issue in the present study due to the large statistically significant treatment effects that occurred.

Posttreatment Stability

The posttreatment results showed that most of the orthodontic and orthopedic changes were stable. The vertical positions of the molars and mandibular incisors did not relapse, with changes comparable to those of untreated controls. The maxillary incisor, which was significantly extruded during treatment, remained unchanged posttreatment, while it erupted an additional 0.60 mm in the control group. This produced a net vertical posttreatment relapse of the maxillary incisors. Forced incisor extrusion has been shown to be unstable,[26] which is why posterior segmental intrusion mechanics were used in the present study. Additional maxillary molar intrusion in the present study would have reduced maxillary incisor extrusion and, potentially, produced a more stable outcome. There also were possible tongue posturing/positional problems. The lower incisors of one patient flared and intruded (Figure 2), whereas the maxillary incisors of another patient intruded and proclined (Figure 3).

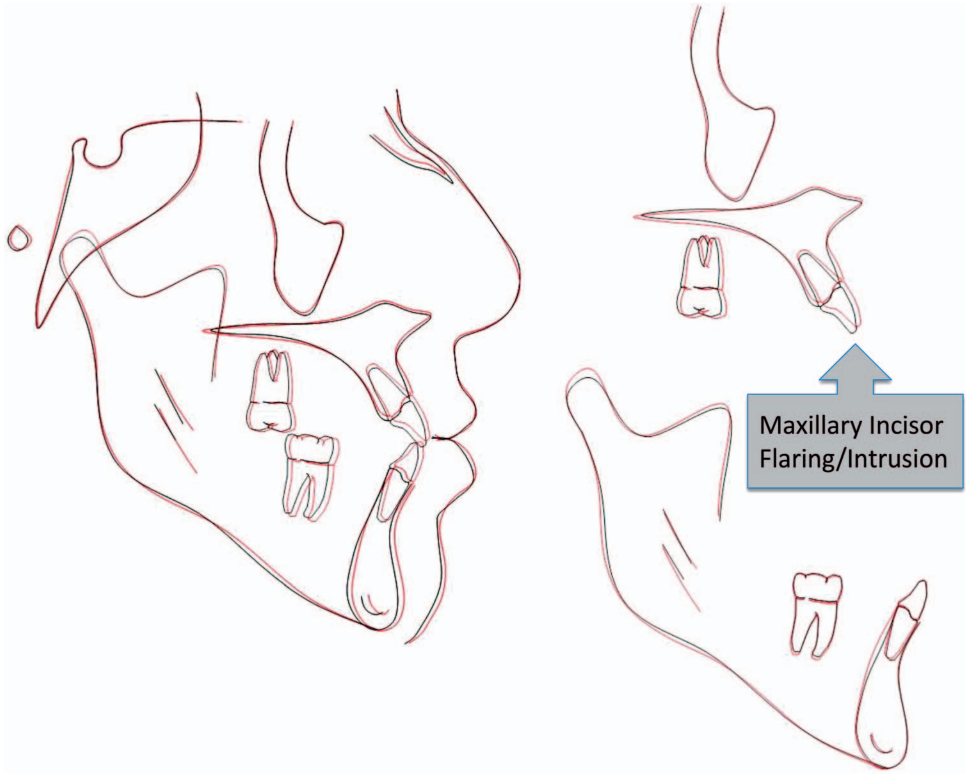

Figure 3. Patient recalled 1.6 years posttreatment who returned with a minor relapse.

The maxillary and mandibular molars continued to erupt posttreatment as expected in growing patients. However, they did not erupt any more in the treatment than control group, indicating relative molar stability. Although there are no comparable studies in growing children, the present results were more stable than those reported for adults, which have demonstrated relapse ranging from 10.4%–30%.[11,27]

This orthopedic treatment produced high levels of stability. There were no between-group differences in the vertical and anteroposterior skeletal measurements post-treatment. Chin projection, facial height, and the S-N-B angle continued to increase slightly posttreatment in both groups. Most importantly, the MPA increased only 0.15° posttreatment, suggesting that this new treatment approach was more stable than surgery. Long-term rotational relapse of bilateral sagittal split osteotomies used to correct anterior open-bite malocclusions ranged from 33.4% one year postsurgery[28] to 60% four-and-a-half years postsurgery.[23] Substantial relapse has also been reported for double jaw surgery, which allows for greater rotational control of the dento-skeletal complex.[29]

CONCLUSIONS

- This nonsurgical intrusion protocol can be used to produce substantial vertical and AP orthopedic corrections in growing children.
- Except for the maxillary incisor, there was no evidence of orthodontic or orthopedic relapse present when compared to untreated control patients.

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