Case Report

Combined use of miniscrews and continuous arch for intrusive root movement of incisors in Class II division 2 with gummy smile

Sung-Jin Kim[a]; Jin-Wook Kim[a]; Tae-Hyun Choi[a]; Kee-Joon Lee[b]

ABSTRACT

Adequate intrusion and torque control of the retroclined maxillary incisors are critical for the treatment of Class II division 2 (div2) malocclusion. In addition, anterior retraction via lingual root movement can be challenging. This case report demonstrates a combined use of miniscrews and continuous arch with additional torque for intrusion, retraction, and torque control of maxillary incisors in the Class II div2 with gummy smile. A 20-year-old woman presented with multiple issues, including impacted canine, lip protrusion, prolonged retained mandibular primary molar, and two missing maxillary premolars. In order to improve her facial profile and eliminate the need for prosthetic work, the mandibular primary molar and contralateral premolar were extracted. Two miniscrews were placed at the maxillary buccal alveolar bone to apply the posterosuperior force for retraction of anterior teeth, with additional labial crown torque on the arch wire. The results were the intrusion (4 mm) and lingual root movement (17°) of the maxillary incisors without anchorage loss of maxillary molars, flattening of the Curve of Spee, and Class I molar relation that were maintained after 50 months of retention period. The combined use of miniscrews and continuous arch could be a reliable and effective treatment modality for torque control and intrusion of retroclined maxillary incisors in the Class II div2 patient. (*Angle Orthod.* 2014;84:910–918.)

KEY WORDS: Class II division 2; Miniscrew; Continuous arch; Torque control; Intrusion; Gummy smile

INTRODUCTION

Treatment of Class II division 2 (div2) malocclusion, characterized by retroclination of the maxillary incisors and deep overbite, has been considered challenging as a result of the difficulty of incisor axis control.[1,2] Since the resting pressure from the lower lip has been reported to be associated with the retroclination of the maxillary incisors and the posttreatment relapse of its orthodontic correction,[1–4] intrusion of the maxillary incisors away from the lower lip pressure may be crucial for long-term stability.[3,4] In order to maintain the intruded incisors, the interincisal angle should be increased so that the mandibular incisor tips are in contact with the lingual slope of the maxillary incisors.[5] Thus, both the intrusion and torque control of the retroclined maxillary incisors are considered important treatment objectives. In particular, if a patient with Class II div2 relation displays protrusive lips, retraction of the anterior segment via lingual root movement should be recognized as a main treatment goal.

A traditional shape-driven approach using additional torque on the arch wire to produce moment for lingual root movement of maxillary incisors[6] may cause flaring of incisors and/or mesial migration of molars, termed the ''row-boat effect,'' and the pure root movement is questioned mainly as a result of the unknown amount of moment.[7] In contrast, force-driven torque springs extending distally from the incisor segment can create a statically determinate force system.[8] However, the static equilibrium for large lingual moment in the anterior segment dictates the extrusion and flaring of incisors in spite of relatively complicated appliance fabrication. As a result of the low fail safety, frequent appliance reactivation is essential,[9,10] and additional extraoral appliances to prevent unwanted mesial migration of anchor teeth may be required.[8] Therefore, neither conventional shape-driven nor force-driven appliance appears to be reliable for the correction of

[a] Resident, Department of Orthodontics, School of Dentistry, Yonsei University, Seoul, South Korea.

[b] Professor, Department of Orthodontics, School of Dentistry, Yonsei University, Seoul, South Korea.

Corresponding author: Dr Kee-Joon Lee, Department of Orthodontics, School of Dentistry, Yonsei University, 134 Shinchon-dong, Seodaemun-gu, Seoul 120–752, South Korea (e-mail: orthojn@yuhs.ac)

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Figure 1. Pretreatment photographs.

retroclined and extruded incisor, which is a common phenotype of Class II div2. Incorporation of miniscrew-type temporary anchorage devices placed in the interradicular area may help eliminate the side effects of conventional appliances, since they produce a constant intrusive force vector with varying vertical angulations.[11]

This case report demonstrates a combined use of miniscrews and continuous arch with additional torque for intrusion, retraction, and torque control of maxillary incisors in the Class II div2 malocclusion, which eventually led to elimination of additional prosthetic work.

CASE REPORT

Diagnosis

A 20-year-old woman visited the Orthodontic Department at the Yonsei University with the chief complaint of impacted tooth and lip protrusion. The facial photographs showed a convex facial profile with a retrognathic mandible, protrusive lips, and excessive gingival display related to supra-erupted maxillary anterior teeth. The mandibular dental midline was 2 mm to the right of the facial midline, with no evidence of facial asymmetry. The intraoral clinical examination revealed Class II canine and molar relationships on both sides, missing maxillary right first premolar and left second premolar, and prolonged retention of maxillary left primary canine and mandibular left second primary molar. Maxillary and mandibular tooth-size arch-length discrepancies were 6.5 mm and 2.0 mm, respectively, if the impacted canine was erupted and missing premolars were restored with dental implants. The patient's overbite was 6 mm, and her overjet was 4 mm (Figure 1).

The panoramic radiograph confirmed the impaction of the maxillary left canine and the absence of the

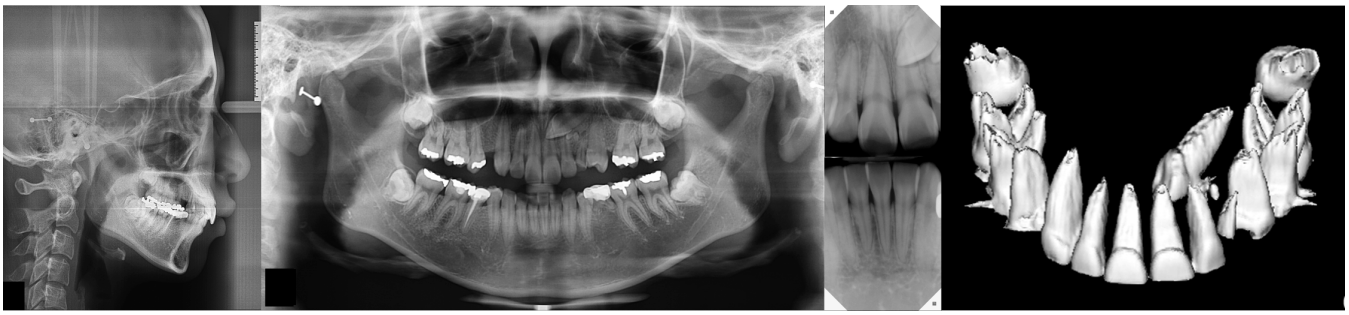

Figure 2. Pretreatment radiographs and three-dimensional computed tomography image.

maxillary right first premolar, left second premolar, and mandibular left second premolar. Three dimensionally reconstructed computed tomographic images demonstrated palatal impaction of the maxillary left canine, with a supernumerary tooth located labial to the crown of the canine (Figure 2). The cephalometric analysis indicated a skeletal Class II jaw relationship (ANB angle, 6.0°; Wits, 1.1 mm), with uprighted maxillary incisors (U1 to SN, 90.3°) and hyperdivergent facial profile (SN-GoMe, 37.2°). Moderate Curve of Spee was found in the mandibular arch. Her lips were protrusive relative to the E-line (Figure 2; Table 1).

Based on these findings, the patient was diagnosed as Class II div2 malocclusion with an impacted canine, congenitally missing premolars, and moderate lip protrusion.

Treatment Objectives and Options

The treatment objectives were to (1) provide orthodontic traction for the impacted canine; (2) establish ideal overbite, overjet, and Class I molar relationships on both sides; (3) improve facial esthetics by reducing the excessive gingival display and lip protrusion; (4) obtain proper inclination of the maxillary incisors; (5) correct the mandibular dental midline; and (6) relieve crowding of the mandibular teeth.

Table 1. Comparison of Pretreatment, Posttreatment, and 50-Month Retention Cephalometric Measurements

Measurement[a]	Pretreatment	Posttreatment	Retention
SNA, °	81.2	79.1	79.3
SNB, °	74.8	74.2	74.3
ANB, °	6.4	4.9	5.0
Wits appraisal, mm	0.6	0.3	0.4
Mandibular body length, mm	77.5	77.6	77.8
SN-GoMe, °	37.2	37.3	37.3
Björk sum, °	397.2	397.3	397.3
SN-occlusal plane, °	23.2	22.5	22.7
U1 to facial plane, mm	12.4	9.4	9.5
L1 to facial plane, mm	7.6	5.0	5.2
Point A to N perp, mm	2.1	−0.1	0
U1 to SN, °	85.7	102.5	101.8
IMPA, °	97.2	99.2	99.3
Upper lip to Ricketts E-line, mm	2.4	−0.7	−0.9
Lower lip to Ricketts E-line, mm	3.4	−0.6	−0.6

[a] A indicates point A; B, point B; Go, gonion; IMPA, incisor–mandibular plane angle; L1, mandibular incisor; Me, menton; N, nasion; Pog, pogonion; S, sella; and U1, maxillary incisor.

One possible option for the missing premolars was to regain space for dental prosthesis of maxillary premolars and to retain the mandibular primary molar. According to Bjerklin and Bennett,[12] the primary molars that have survived in the dental arch at 20 years of age have a good prognosis for long-term survival. According to recent reports, the long-term success rate of dental implants ranges from 76% to 89% after 10-year follow-up[13] or 82.94% after 16-year follow-up,[14] which hardly justifies the implant work, considering the patient's age. Moreover, the maxillary molars should be distalized to achieve Class I molar relationships, and the facial profile of the patient would not be improved.

The second option was to close the premolar spaces and to retain the primary molar. The molar relationships would end up being Class II; however, this option still would not improve the lip protrusion and mandibular denture midline.

The third option was to extract the primary molar and mandibular right second premolar and to close all of the residual spaces. Without the need for dental implants, the facial profile can be improved. However, in order to establish a concrete Class I molar relationship, differential anchorage control is crucial, especially for the retraction and torque control of maxillary incisors.

The last option was chosen as a final treatment plan, since the patient was concerned about her facial profile and reluctant to agree to additional prosthesis. The occlusogram visualized tentative treatment objectives, including 4-mm retraction of the incisors with no mesial molar movement in the maxillary arch and 3-mm retraction of incisors with 4-mm mesial molar movement in the mandibular arch. Vertically, 4-mm intrusion of the maxillary incisors and maintaining of the mandibular incisors were planned to correct the patient's deep overbite (Figure 3).

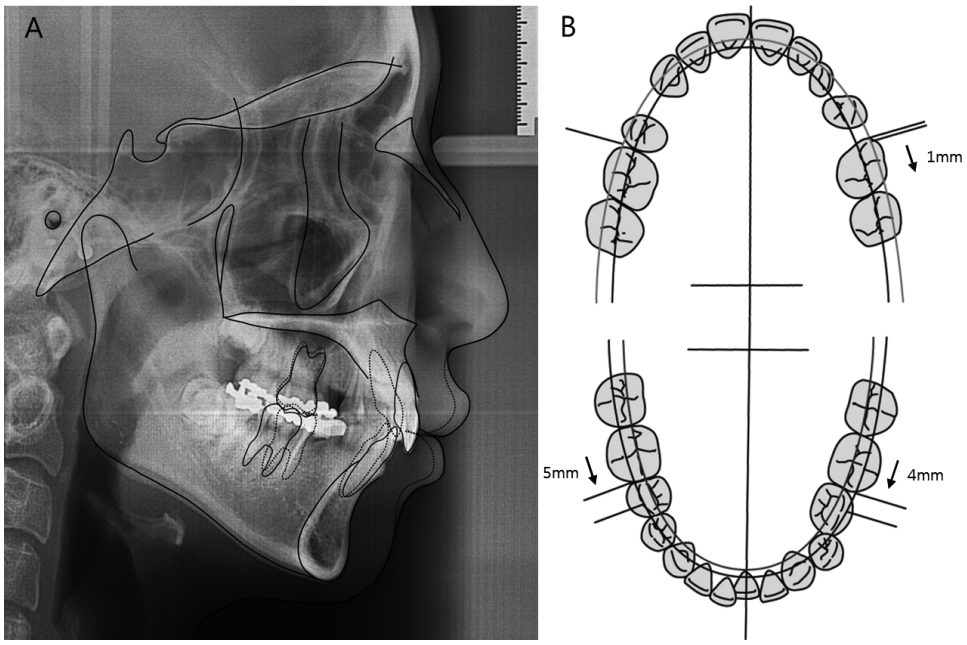

Figure 3. (A) Visualized treatment objectives (VTO), indicating absolute anchorage and intrusive root movement in the maxilla and moderate anchorage in the mandible (Solid line: Pretreatment; Dotted line: VTO). (B) Occlusogram visualizing the required tooth movement in each quadrant.

Treatment Progress

The patient was referred to the oral surgeon for removal of the supernumerary tooth and surgical exposure of the impacted canine. A wide mucoperiosteal flap, as is utilized in the closed-eruption technique,[15] was raised, and a metal button was bonded for traction. After 0.018 × 0.025-inch preadjusted edgewise brackets were bonded to the maxillary arch, a miniscrew (9.0-mm length × 1.8-mm diameter; Orlus®, Orthолution, Seoul, Korea) was placed on the maxillary palatal side to apply the traction force for the impacted canine distally (Figure 4A).

The mandibular right second premolar and left second primary molar were extracted, and brackets were also bonded to the mandibular arch. Two additional miniscrews (7.0-mm length × 1.8-mm diameter; Orlus®, Orthолution) were placed at the maxillary alveolar buccal bone between the second premolar and the first molar on both sides, and the retraction force was applied to the crimpable hooks located distal to the canine on a 0.016 × 0.022-inch stainless-steel wire with additional labial crown torque (10°) on the incisor segment. Retraction and intrusion of incisor segment was performed using constant intrusive vector from the miniscrews (Figure 4B).

Following the exposure of the impacted canine, the primary canine was extracted, and the buccal traction force was applied from the miniscrews placed at the buccal interdental bone. Later, a preadjusted edgewise bracket was bonded on the canine, and an auxiliary 0.014-inch nickel-titanium (NiTi) wire was overlaid on the main arch for aligning of the canine (Figure 4C).

The appliances and the miniscrews were removed after 28 months of active treatment. Fixed lingual retainers were bonded to both arches, and the patient was instructed to wear a removable circumferential retainer on the maxillary arch additionally for 24 hours each day for the first 3 months and thereafter at night only for 9 months.

Treatment Results

The impacted maxillary left canine was brought into proper occlusion with a good alignment of the gingival margin. Bilateral Class I molar relationships and normal overjet/overbite were achieved, and the mandibular dental midline was corrected. The protrusive lips and excessive gingival display were improved, resulting in a harmonious facial profile and a nice smile (Figure 5).

The final panoramic radiograph showed intact roots and proper root alignment, including that of maxillary left canine. The maxillary incisors had mild apical root resorption, possibly due to the significant lingual root movement (Figure 6).

The cephalometric analysis and superimposition registered on the sella-nasion line showed the intrusion (4 mm) and lingual root movement (17°) of the maxillary incisors without any anchorage loss of the maxillary molars, which was contrasted to the mesial movement of the mandibular molars, leading to Class I

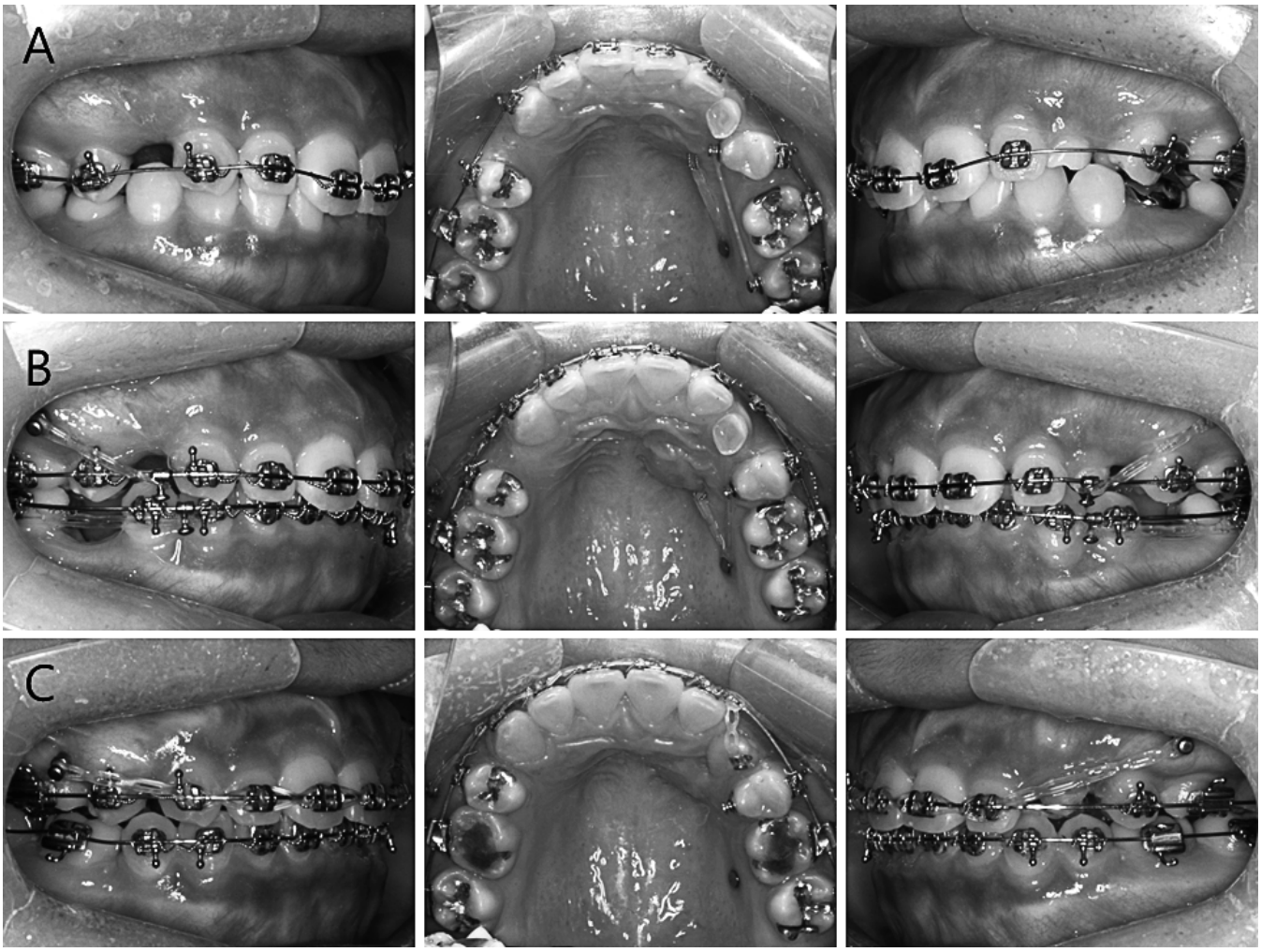

Figure 4. Treatment progress showing gradual change of incisor relationship. (A) Distal traction force for the impacted canine was applied from the miniscrew. (B) Posterosuperior retraction force was applied on a 0.016 × 0.022-inch stainless-steel wire with additional labial crown torque (10 degree). (C) Buccal traction force was applied to the exposed impacted canine.

molar relationships (Table 1; Figure 7). The intrusion of the maxillary first molar was related to the intrusive force vector from the miniscrews, and the extrusion of the mandibular first molar helped the leveling of the Curve of Spee. As the maxillary and mandibular incisors were retracted 4 mm and 3 mm, respectively, the upper and lower lips were placed on the esthetic line (−0.5 mm and 0.1 mm, respectively).

The treatment results were maintained after 50 months of retention period. The overbite and midline change was less than 1 mm during the retention phase, and the minor space between the central incisors was hardly noticeable, leading to clinically acceptable occlusion (Figures 8 and 9; Table 1).

DISCUSSION

Skeletal anchorage devices have been applied to various clinical situations demanding either incisor or molar movement, leading to reliable clinical outcomes regardless of the patients' compliance. Considering the force consistency from the elastic chain, the outcomes can be largely dependent upon the constructed force system. In the present patient, intrusion, root movement, and maximum retraction of incisors were all important treatment objectives to correct the gummy smile, incisor axis, and lip protrusion, respectively. In addition, transition from Class II to Class I molar relation and improvement of the lateral facial profile were also required. Since the patient had a retrusive chin and convex profile, extrusive appliances such as Class II elastics were contraindicated to prevent the mandible from rotating backward and downward. In addition, the patient had severe gingival exposure on smiling, such that the anterior deep overbite had to be corrected, mainly by intrusion of the upper incisors, not that of the lower incisors. Therefore, the maxillary molars as well as the maxillary

Figure 5. Posttreatment photographs.

Figure 6. Posttreatment radiographs.

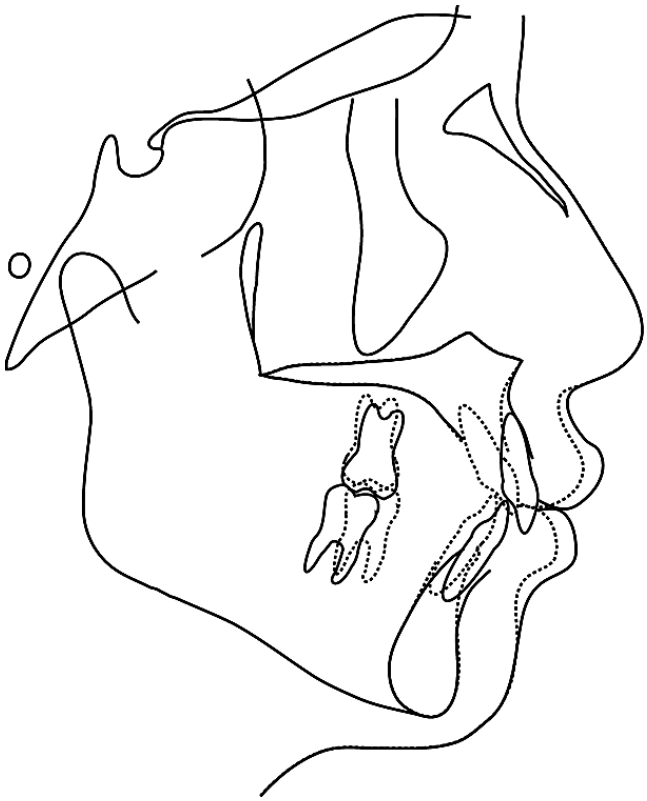

Figure 7. Cephalometric superimposition registered on the sella-nasion line. Solid: Pretreatment; Dotted: Posttreatment.

incisors had to be intruded for the improvement of profile and completion of Class I denture relation. Conventional intrusive appliances, such as a utility arch or three-piece intrusion arch, were not appropriate for this case because of the possible extrusion of molars, which would worsen the convex profile.

Vertical force from the miniscrew(s) placed underneath the anterior nasal spine or between the roots of the maxillary lateral incisor and canine have been proposed for intrusion of maxillary incisors.[16,17] However, the force vector tends to result in labial flaring rather than lingual root movement of incisors as a result of the distance between the line of action and the center of resistance of incisor segment.[18] Moreover, addition of a retraction force to prevent the flaring can cause a loss of posterior anchorage, and the combined intrusive and retraction force vector still passes below the imaginary center of resistance of the incisor segment, and hence does not assist with the root movement of incisors. In the present patient, intrusive maximum retraction of incisors with lingual root movement was attained mainly by using a continuous rectangular arch wire with partial torque along the incisor segment, combined with miniscrews placed between the second premolar and the first molar. Considering the bracket-wire play known to measure 9.5° between the 0.018 × 0.025-inch slot and 0.016 × 0.022-inch rectangular wire,[19] an additional 10° of labial torque was added to the arch wire only on four maxillary incisors. The posterosuperior elastic force was initially as low as 100 g, which is subject to

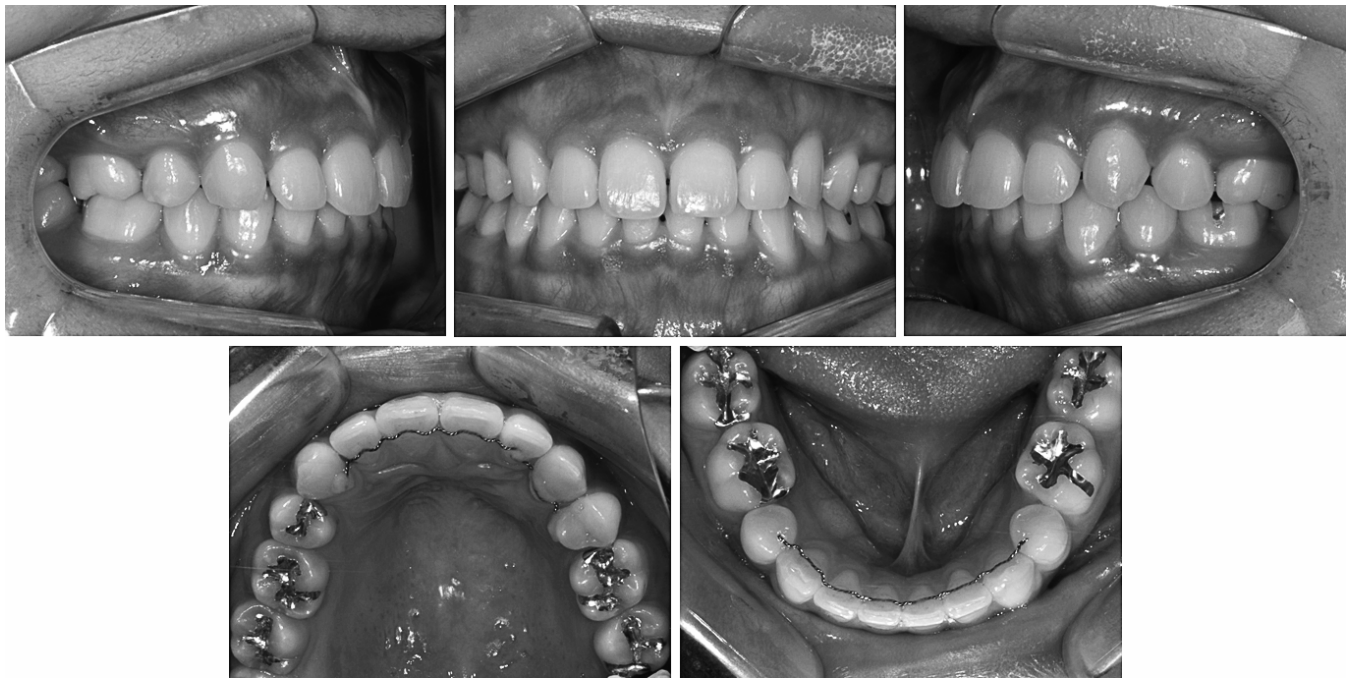

Figure 8. Intraoral photographs at 50-month retention.

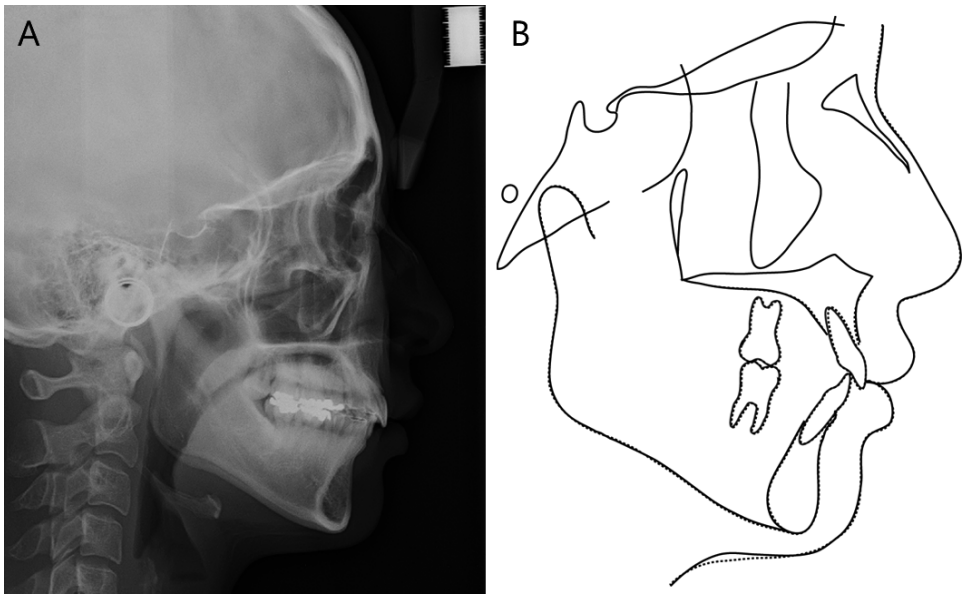

Figure 9. (A) Cephalogram taken at 50-month retention; (B) Cephalometric superimposition registered on the sella-nasion line (Solid line: Posttreatment; Dotted line: 50-month retention).

decrease over time. This weak force combined with an unknown magnitude of moment surely forms a statically indeterminate force system, in which the single force would effectively prevent the extrusion of molars and flaring and extrusion of incisors, minimizing the possible round-trip movement of the incisors.

Jeong et al.[20] reported that the center of resistance of the maxillary whole dentition was estimated at the midroot level of the second premolar. In the event of premolar extraction, the center of resistance of the maxillary arch in this patient may be slightly shifted to the posterior area. Since the anterior and posterior segment were connected by the continuous arch wire, the displacement of the whole arch can be explained by the relationship of the center of resistance of the whole arch and the line of action generated between the miniscrews and force application points. Therefore, the posterosuperior force, passing closely to the imaginary center of resistance of the maxillary dentition, led to the intrusion of the maxillary molars as well as the incisors. In spite of the intrusion of the maxillary molars, the mandibular plane angle was not reduced as a result of the extrusion and mesial shift of the mandibular molars, which was inevitable for the flattening of the Curve of Spee and correction of Class II molar relation.

Schematic comparison among Burstone's incisor root spring, continuous arch with lever arm, and the combined use of miniscrews and continuous arch is presented in Figure 10. By applying posterosuperior force from the miniscrews, labial flaring and extrusion of the incisors can be prevented in a simple and fail-safe way (Figure 10C). The lever arms without additional torque on the arch wire (Figure 10B) are not readily indicated in the labial side, since the hooks can hardly reach the level of the center of resistance, especially when the incisors are upright. Moreover, it is difficult to construct an intrusive force system with long lever arms attached on the wire.

In this patient, the impaction of the maxillary left canine was another issue. Between two options for palatally impacted canines—open exposure technique

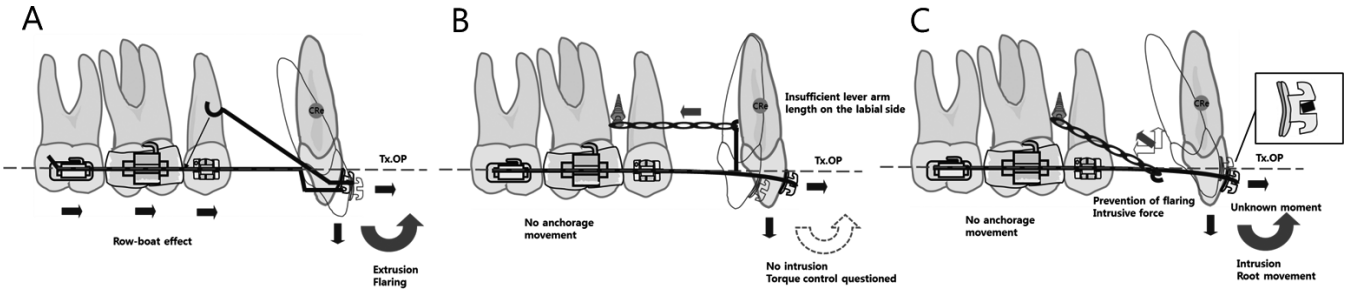

Figure 10. Schematic comparison among Burstone's incisor root spring (A), continuous arch with lever arm (B), and combined use of miniscrews and continuous arch with additional torque on the arch wire (C).

and closed eruption technique[21]—the closed eruption technique was chosen based on periodontal morbidity, faster healing, and less postoperative pain and postsurgical bleeding.[21] In order to effectively relocate the crown away from the adjacent roots and to assess the possibility of ankylosis, an additional miniscrew on the palatal side between the first and second molars was used.[15,21] The orthodontic traction was performed independently from the correction of incisors, supporting the reduction of overall treatment time.

At the end of the treatment, mild root resorption was observed on the maxillary incisors. Parker and Harris[22] reported that intrusive movement and lingual root torque, possibly due to the stress concentration around the apex in either movements,[23] were the strongest predictors of external apical root resorption. However, the amount of resorption did not appear to affect the longevity of incisors, and obviously the root movement has contributed to the elimination of possible prosthesis by closing the edentulous area. Nonetheless, careful monitoring of the root lengths throughout the treatment would be essential.

The overbite and inclination of the maxillary incisors were relatively well maintained after 50 months of retention period. Although the factors for prolonged stability are not clear yet, establishment of adequate interincisal relationship may be crucial. These stable results are encouraging in that even a large amount of intrusion and root movement could also be maintained in a stable fashion. However, these movements should be performed within the anatomical limits, since excessive incisor retraction may yield bony dehiscence and fenestration of the alveolar bone, as well as relapse of the root position, which were not evident in this case.[24]

CONCLUSIONS

- The combined use of miniscrews and continuous arch with anterior additional torque could offer a reliable and effective treatment modality for torque control and intrusion of retroclined maxillary incisors in the Class II div2 patient.

REFERENCES

1. Lapatki BG, Mager AS, Schulte-Moenting J, Jonas IE. The importance of the level of the lip line and resting lip pressure in Class II, division 2 malocclusion. *J Dent Res*. 2002;81: 323–328.
2. Lapatki BG, Klatt A, Schulte-Monting J, Jonas IE. Dentofacial parameters explaining variability in retroclination of the maxillary central incisors. *J Orofac Orthop*. 2007;68: 109–123.
3. Lapatki BG, Baustert D, Schulte-Monting J, Frucht S, Jonas IE. Lip-to-incisor relationship and postorthodontic long-term stability of cover-bite treatment. *Angle Orthod*. 2006;76: 942–949.
4. Devreese H, De Pauw G, Van Maele G, Kuijpers-Jagtman AM, Dermaut L. Stability of upper incisor inclination changes in Class II division 2 patients. *Eur J Orthod*. 2007;29: 314–320.
5. Mills JR. The problem of overbite in Class II, division 2 malocclusion. *Br J Orthod*. 1973;1:34–48.
6. Rauch E. Torque and its application to orthodontics. *Am J Orthod*. 1959;45:817–830.
7. Jayade V, Annigeri S, Jayade C, Thawani P. Biomechanics of torque from twisted rectangular archwires. A finite element investigation. *Angle Orthod*. 2007;77:214–220.
8. Burstone CJ. The mechanics of the segmented arch techniques. *Angle Orthod*. 1966;36:99–120.
9. Viecilli RF, Chen J, Katona TR, Roberts WE. Force system generated by an adjustable molar root movement mechanism. *Am J Orthod Dentofacial Orthop*. 2009;135:165–173.
10. Martins RP, Buschang PH, Gandini LG Jr. Group A T-loop for differential moment mechanics: an implant study. *Am J Orthod Dentofacial Orthop*. 2009;135:182–189.
11. Janssen KI, Raghoebar GM, Vissink A, Sandham A. Skeletal anchorage in orthodontics—a review of various systems in animal and human studies. *Int J Oral Maxillofac Implants*. 2008;23:75–88.
12. Bjerklin K, Bennett J. The long-term survival of lower second primary molars in subjects with agenesis of the premolars. *Eur J Orthod*. 2000;22:245–255.
13. Al-Nawas B, Kammerer PW, Morbach T, Ladwein C, Wegener J, Wagner W. Ten-year retrospective follow-up study of the TiOblast dental implant. *Clin Implant Dent Relat Res*. 2012;14:127–134.
14. Simonis P, Dufour T, Tenenbaum H. Long-term implant survival and success: a 10–16-year follow-up of non-submerged dental implants. *Clin Oral Implants Res*. 2010; 21:772–777.
15. Kokich VG. Surgical and orthodontic management of impacted maxillary canines. *Am J Orthod Dentofacial Orthop*. 2004;126:278–283.
16. Creekmore TD, Eklund MK. The possibility of skeletal anchorage. *J Clin Orthod*. 1983;17:266–269.
17. Upadhyay M, Nagaraj K, Yadav S, Saxena R. Mini-implants for en masse intrusion of maxillary anterior teeth in a severe Class II division 2 malocclusion. *J Orthod*. 2008;35:79–89.
18. Park H, Sung E, Cho Y, Mo S, Chun Y, Lee K. 3-D FEA on the intrusion of mandibular anterior segment using orthodontic miniscrews. *Korean J Orthod*. 2011;41:384–398.
19. Sebanc J, Brantley WA, Pincsak JJ, Conover JP. Variability of effective root torque as a function of edge bevel on orthodontic arch wires. *Am J Orthod*. 1984;86:43–51.
20. Jeong GM SS, Lee KJ, Chun YS, Mo SS. Finite-element investigation of the center of resistance of the maxillary dentition. *Korean J Orthod*. 2009;39:83–94.
21. Becker A, Chaushu S. Palatally impacted canines: the case for closed surgical exposure and immediate orthodontic traction. *Am J Orthod Dentofacial Orthop*. 2013;143: 451–459.
22. Parker RJ, Harris EF. Directions of orthodontic tooth movements associated with external apical root resorption of the maxillary central incisor. *Am J Orthod Dentofacial Orthop*. 1998;114:677–683.
23. Reitan K. Biomechanical principles and reactions. In: Graber T, Swain B, eds. *Orthodontics: Current Principles and Techniques*. St Louis, Mo: Mosby; 1985:92–101.
24. Liou E, Lin J. Appliances, mechanics, and treatment strategies toward orthognathic-like treatment results. In: Nanda R, Uribe F, eds. *Temporary Anchorage Devices in Orthodontics*. St Louis, Mo: Mosby; 2009:167–197.