Case Report

Class II treatment by palatal miniscrew-system appliance: *A case report*

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ABSTRACT

This case shows that using a rapid palatal expander (RPE) and then a pendulum appliance anchored to palatal miniscrews is an option for improving treatment management in a noncompliant patient requiring maxillary expansion and molar distalization in the late mixed dentition. First, an RPE was used to expand the maxillary arch. Then, a modified pendulum appliance was used to distalize the maxillary first permanent molars. Optimal positioning of two palatal miniscrews enabled both appliances to be supported by skeletal anchorage. Treatment was finished using multibracket fixed appliances, and after 2 years, skeletal Class I as well as dental Class I canine and molar relationships were achieved. (*Angle Orthod.* 0000;00:000–000.)

KEY WORDS: Surgical guide; Miniscrews; Pendulum; RPE; Rapid palatal expansion; Molar distalization

INTRODUCTION

Maxillary molar distalization is a procedure frequently required in orthodontic patients with Class II malocclusion. This treatment option is indicated in the mixed-dentition stage of development[1] in normo- or brachyfacial patterns with deep bite and/or flat profile, in third molar agenesis cases, and when patients and/or their parents refuse extraction treatment and the clinician considers distalization as an ethically acceptable therapy.[2]

Patient cooperation is one of the most influential factors of treatment,[3] but unavoidably, it tends to decrease over time,[4–8] resulting in unpredictable outcomes in patients with extraoral and intraoral appliances.[9] To facilitate distalization, a wide range of distalizing devices has been developed over the years.

Extraoral devices, such as headgear,[10,11] help overcome most side effects, even if they are invasive, unesthetic, and highly dependent on the patient's active cooperation.[12] Hence, alternatives that are not dependent on patient compliance, such as Carano's distal jet,[13] repelling magnets,[14] the MGBM system,[15] and Herbst appliance,[16] among others, are preferred by many clinicians. Of these devices, one of the most frequently used is Hilgers pendulum,[17] presumably because of its ease of use and fabrication. However, despite its effectiveness in terms of distalization,[18,19] the pendulum appliance produces some undesirable effects, such as premolar mesialization and anterior anchorage loss[20] (24%–29% of the space opened between molars and premolars[21]).

The growing demand for orthodontic treatment methods requiring minimal cooperation but maximum anchorage control has led clinicians to search for means of achieving bone-supported anchorage.[22] After years of research, miniscrews (as a temporary anchorage device) have been recognized as a valuable tool[23,24] because of their small size, ease of insertion and removal, low cost, immediate loading,[25] and ability to be safely inserted into different locations of the alveolar bone.[26]

Here, a case report is presented in which maxillary expansion and molar distalization were achieved using a rapid palatal expander (RPE) and a pendulum appliance, both anchored in sequence to two palatal

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Figure 1. Extraoral photographs at the beginning of treatment.

miniscrews, in a noncompliant patient in the late mixed dentition. The validity of this treatment option, which may improve treatment management by increasing anterior resistance while avoiding undesirable movements and maximizing skeletal effects, is demonstrated.

Diagnosis and Etiology

A 13-year-old female patient with a chief complaint of unsatisfactory esthetic appearance of her misaligned teeth presented for treatment. Extraoral examination revealed an oval face with slight left mandibular asymmetry. The lower third of the face seemed to be slightly reduced. Lip competence was present at rest, but upon smiling, there was increased exposure of the incisors. The profile seemed acceptable, but the nasolabial angle and mentolabial angle appeared to be slightly increased (Figure 1).

Mandibular deviation toward the left was evident on opening and closing, and the patient also displayed atypical deglutition and a lip-sucking habit. Intraoral examination revealed a late mixed dentition, narrow maxilla, slight anterior crowding in the upper arch, multiple lower rotations, and a mandibular dental midline deviation toward the left (Figures 2 and 3).

Cephalometric data (Table 1) and radiographs (Figure 4) confirmed a skeletal Class II, Division 2 malocclusion. The vertical dimension showed a hypo-

Figures 2–3. Intraoral photographs at the beginning of treatment.

Table 1. Cephalometric Assessment Pre- and Posttreatment

Horizontal Skeletal	Initial	Final	Norm
SNA, °	82.3	81.7	82.0 ± 3.5
SNB, °	76.5	77.3	80.0 ± 3.0
ANB, °	5.8	4.4	2.0 ± 2.4
Maxillary skeletal (A-Na Perp), mm	5.4	4.2	0.0 ± 3.1
Mandibular skeletal (Pg-Na-Perp), mm	3.5	2.8	−4.0 ± 5.3
Wits appraisal, mm	3.5	−1.2	0.0 ± 1
FMA (MP-FH), °	15.6	18.2	26.0 ± 5
MP-SN, °	29.1	30.7	33.0 ± 6
Palatal-mandibular angle, °	19.7	23.5	28.0 ± 6
Palatal-occipital plane, °	11.6	14.1	10.0 ± 4.0
Mandibular plane to occipital plane, °	8.1	9.3	15.6 ± 5.0
U-incisor protrusion (U1-APo), mm	4.2	2.7	6.0 ± 2.2
L1 protrusion (L1-APo), mm	−1.2	−0.4	2.0 ± 2.3
U1-palatal plane, °	106.3	105.4	110.0 ± 5.0
U1-occipital plane, °	62.1	60.5	54.0 ± 7.0
L1-occipital plane, °	70.7	75.8	72.0 ± 5.0
IMPA, °	101.2	94.8	95.0 ± 7.0

divergent growth pattern (FMA = 15.6°). Mandibular incisor inclination was increased (IMPA = 101.2°), while the inclination of the maxillary incisors was in the normal range (U1-PP = 106.3°). The patient also showed severe deep bite.

Treatment Objectives

The primary aim of the treatment was to expand the maxillary arch to promote mandibular advancement in order to correct the skeletal Class II and improve the profile. It was also necessary to correct the dental Class II malocclusion, reduce the increased overjet, improve the incisor inclination, and reduce the deep bite through extrusion of the posterior teeth.

To coordinate the arches correctly, overcome the maxillary transverse deficit, and level the increased curve of Wilson, maxillary arch expansion was required. A bone-borne appliance was used so that the orthopedic force exerted by the appliance would result in a purely skeletal movement, minimizing unwanted dental tipping and providing sufficiently negative torque.

Treatment Alternatives

Four treatment options were considered. The first involved extraction of the maxillary and mandibular first premolars to solve the occlusal problem, but this risked worsening the patient's profile and would be highly dependent on her cooperation. The second option was to extract only two upper premolars. Although this would have led to acceptable occlusal results, there would be no change to the patient's profile. Functional therapy was also considered to bring about mandibular advancement and improve the profile. However, the skeletal effects would have been limited[27–29] and compliance would have been required. Fixed appliance therapy with intermaxillary elastics could have solved the occlusal discrepancies with a certain amount of esthetic improvement, but, in addition to necessitating the patient's full cooperation, there would be a high risk of lower incisor proclination. The fourth option was therefore the one agreed upon in consultation with the patient: this involved expansion of the maxillary arch followed by distalization of the permanent maxillary first molars, both using skeletal anchorage, and then finishing by means of multibracket fixed appliances.

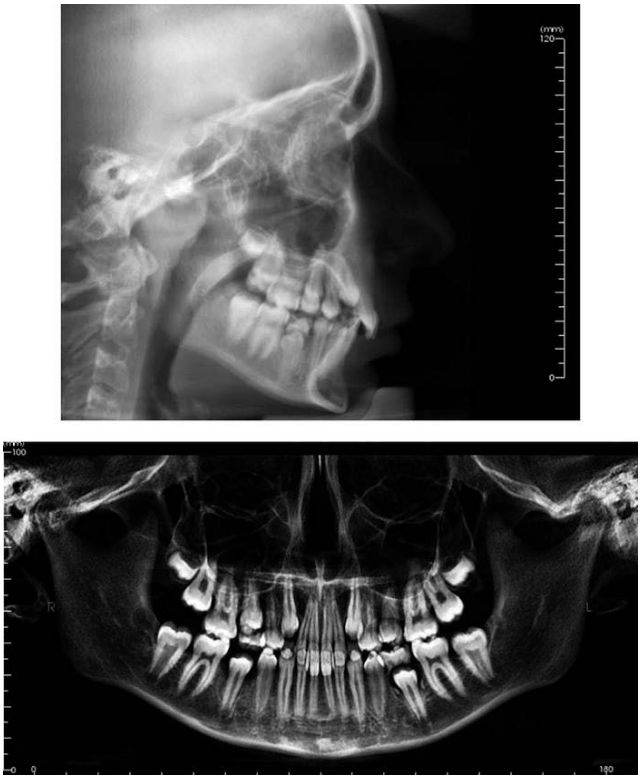


Figure 4. Initial radiographs.

Treatment Progress

The most favorable site and direction of miniscrew insertion were identified on a cone-beam computed tomography (CBCT) scan (Figure 5). A digital scan of the upper arch was superimposed on the patient's CBCT scan (Figure 6), and a surgical insertion guide[30,31] was custom manufactured. This consisted of two rigid cylindrical sheaths that ensured that the head of the miniscrews would be inserted at the correct angle and to the required depth (Figure 7).

Next, two self-tapping miniscrews (Spider Screw K2 Regular Plus; HdC, Vicenza, Italy)[32] were implanted through the guide, one 11 mm in length and 2 mm in diameter on the right and one 9 mm in length and 2 mm in diameter on the left. Then, a hybrid Hyrax RPE[33] was cemented on the teeth and fixed to the miniscrews

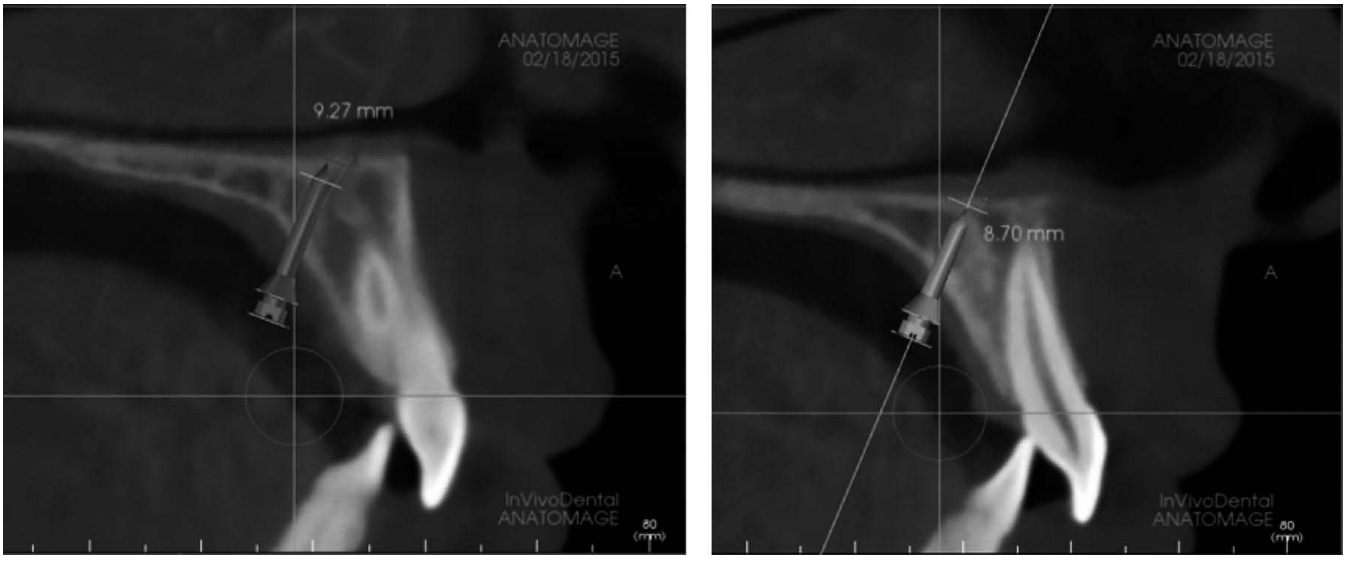


Figure 5. Cross section of the maxilla and virtual position of the miniscrews.

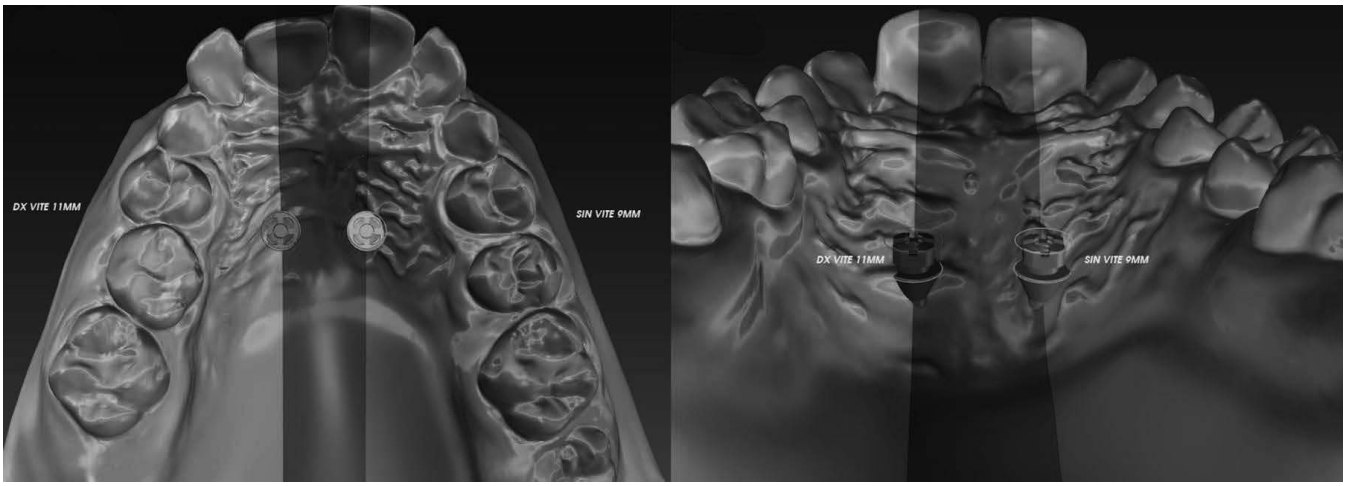


Figure 6. Tridimensional digital model of the upper arch with the miniscrews inserted.

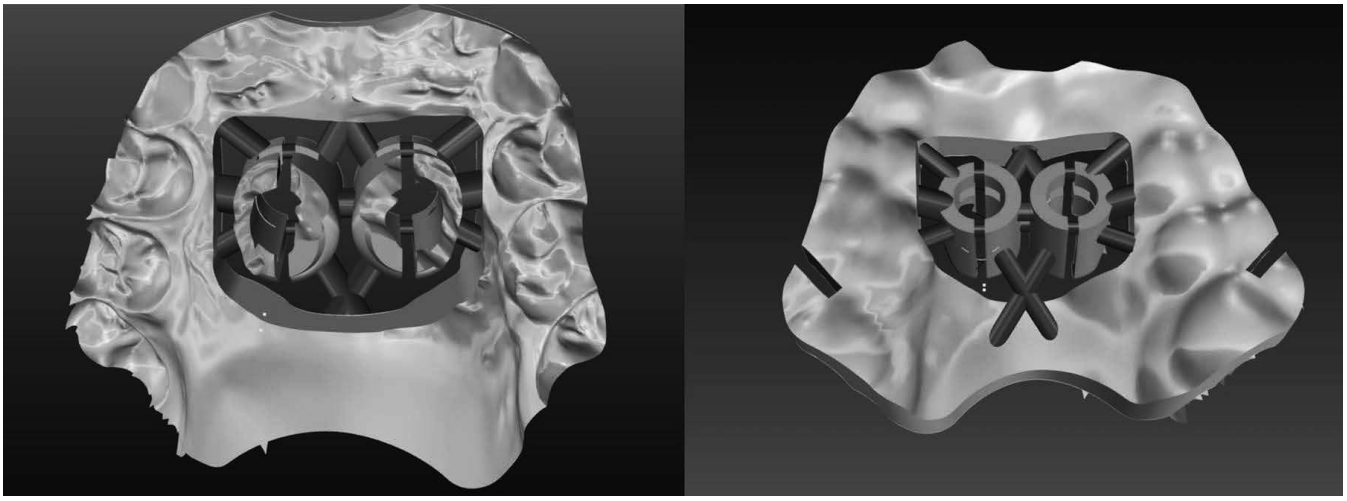


Figure 7. Connection bridges between cylindrical guides and template body.

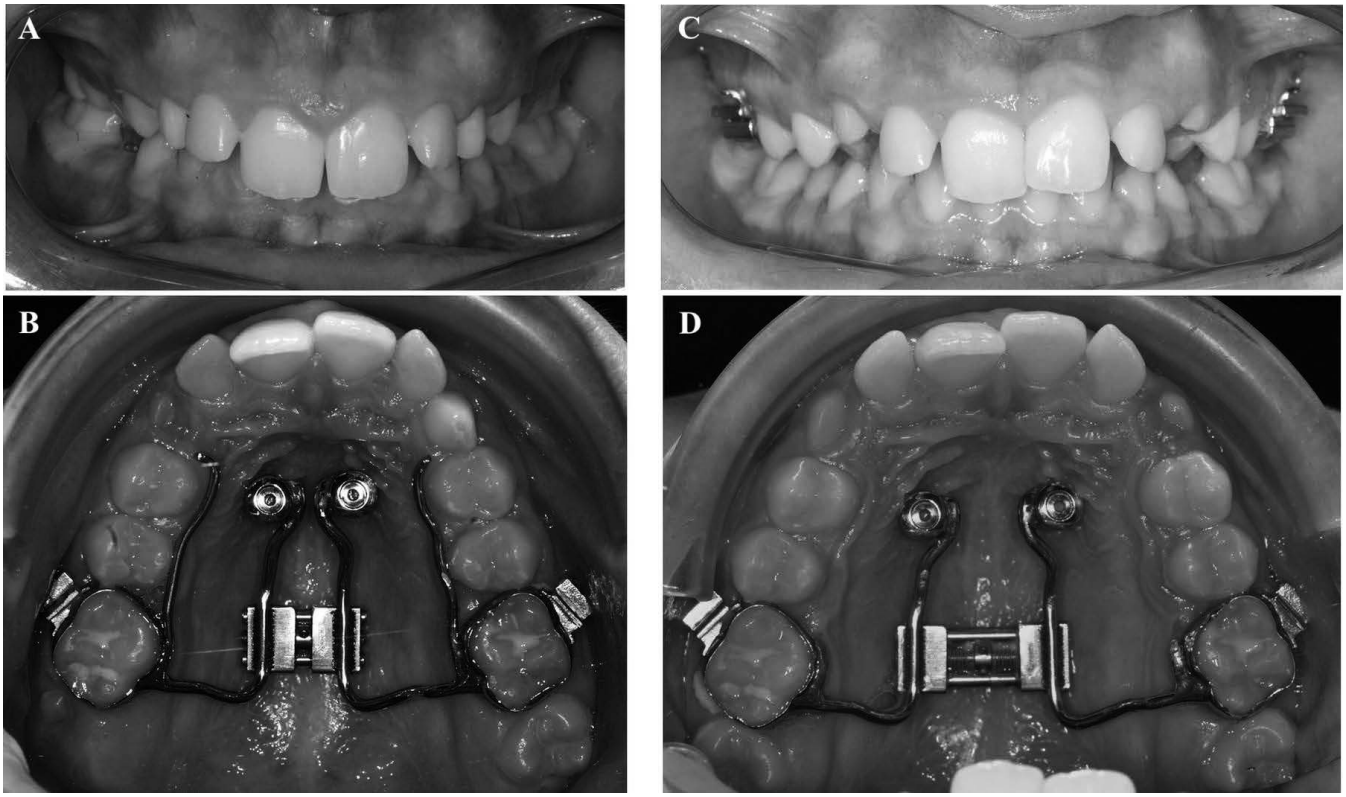


Figure 8. Rapid palatal expander: (A,B) Pretreatment. (C,D) After midpalatal suture opening.

(Figure 8). The anterior arms of the Hyrax were soldered to two metal abutments designed to fit the heads of the miniscrews. The activation protocol was a one-fourth turn (0.2 mm) once a day, with an overall activation period of 37 days followed by a 2-month retention period. The progress was monitored at monthly intervals.

After 10 months of treatment, the palatal expander was removed and a new polyvinyl siloxane impression of the upper arch was taken to fabricate a modified pendulum appliance.[34] The distalizing device (Figure 9) was composed of a modified palatal acrylic Nance button (an acrylic plate 1.5- to 2-mm thick) borne by the miniscrews. The button also supported two 0.032-inch titanium molybdenum alloy active wire springs, which were engaged in lingual tubes on the first molar bands. The springs were activated to approximately 45°. At the end of the seventh month, sufficient space had been created, owing also to the spontaneous distal drift of the second premolars due to the action of the transseptal fibers (Figure 10).

Once a super Class I molar relationship had been achieved, alignment and leveling of the mandibular arch was begun with multibracket fixed appliances and a 0.016-inch nickel-titanium archwire. At the end of this phase, the two miniscrews were removed from the palate. Within 2 weeks, the soft tissues had completely healed.

Then, fixed appliances were bonded to the upper arch, achieving alignment and leveling by means of a 0.016-inch nickel-titanium archwire, followed by a 0.019 × 0.025-inch nickel-titanium archwire, and a

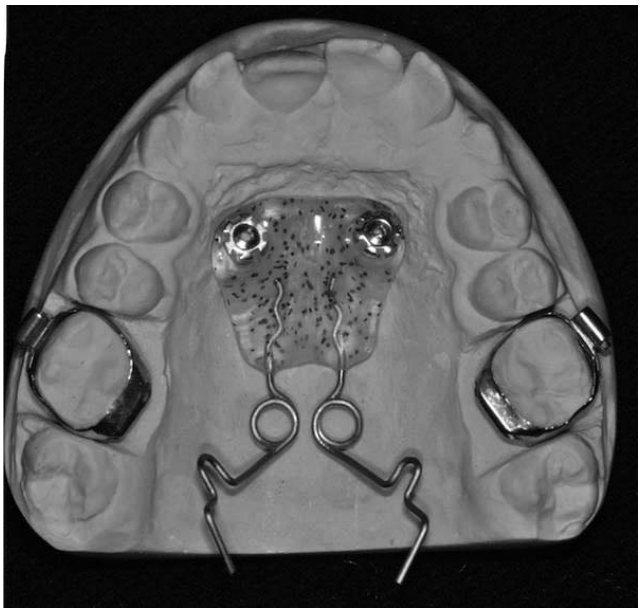


Figure 9. Modified pendulum appliance.

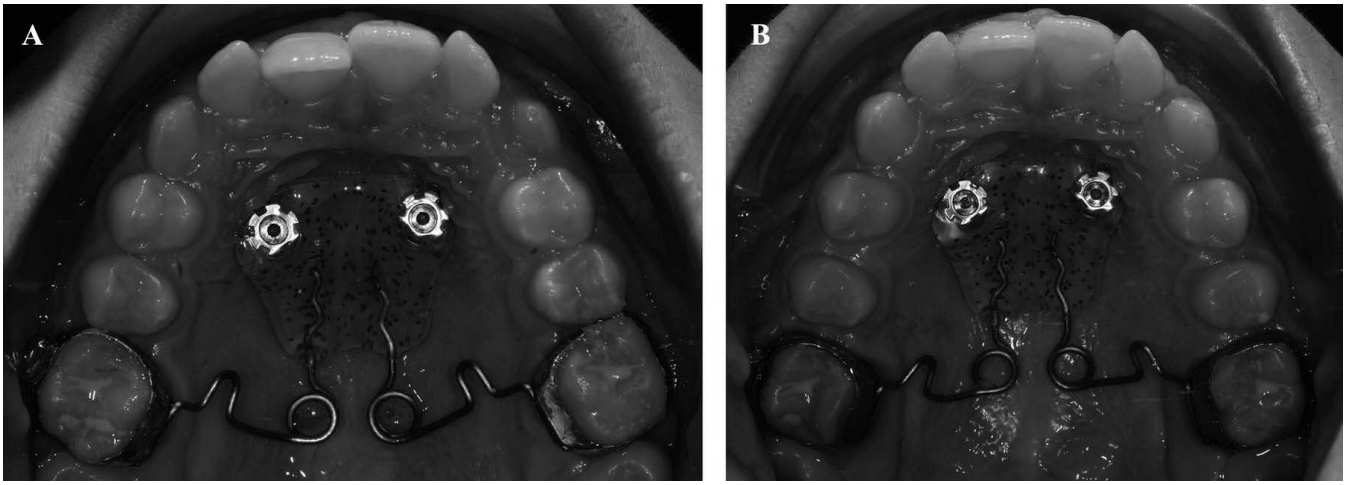


Figure 10. Pendulum. (A) Pretreatment occlusal view. (B) After distalization.

0.019 × 0.025-inch stainless-steel archwire for finishing.

Treatment Results

After 2 years of treatment, skeletal Class I was achieved, as confirmed by cephalometric analysis (Table 1). Dental Class I canine and molar relationships were also achieved by rotation of the maxillary first molars around the palatal root, mesial shift of the lower first molar into the leeway space, and normal forward growth of the mandible. Overbite and overjet relationships were ideal. The cephalometric changes included increases in both vertical face height (FMA = 18.2°) and mandibular incisor inclination (IMPA = 94.8°; Figures 11–17). Measurements of the arch width supported the decision to expand the maxillary arch with an RPE. Improvements in premolar width (38.64 mm before and 43.06 mm after treatment) and molar width (47.46 mm before and 53.29 mm after treatment) were measured.

Additional laterolateral teleradiography was not performed following distalization because it would have resulted in unnecessary and excessive biological cost for the patient.

DISCUSSION

Miniscrews can be used to manage different types of orthodontic mechanics, but a successful technique depends on the availability of supporting bone. Several authors have demonstrated that the palatal vault is a safe[26] and suitable site for anchorage[35–37] because of the absence of dental roots, and miniscrews placed in the paramedian anterior palate have optimal survival rates.[38,39] Although the thickness of the palatal vault can vary between patients,[35,36] it has been shown to be a safe insertion site[26] by many authors.

Kircelli et al.[40] used a bone-anchored pendulum appliance to obtain molar distalization without anchorage loss, while Kinzinger et al.[41] conducted an in vivo study employing a bone-anchored distal jet appliance. They found this to be more hygienic for the palatal

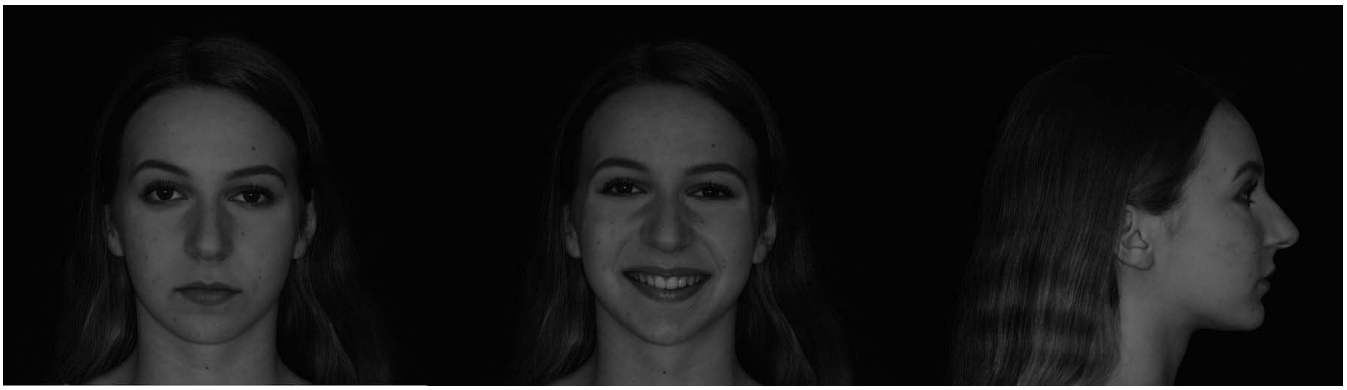


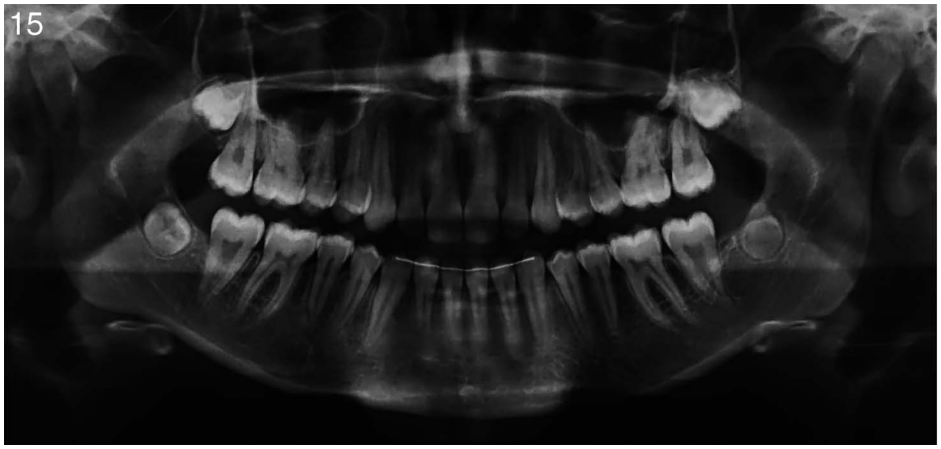
Figure 11. Extraoral photographs at the end of treatment.

Figures 12–14. Intraoral photographs at the end of treatment.

mucosa by eliminating the acrylic button, but they also obtained an unwanted mesial inward and distal outward rotations of the molars.

Winsauer et al.[42] used a bone-borne Hyrax expander supported by one or two pairs of miniscrews, successfully opening the midpalatal suture. As in the current case, they found that a bone-borne appliance was a good option for rapid palatal expansion.

Cozzani et al.[43] demonstrated that an implant-supported maxillary molar distalization appliance compared favorably with a traditional tooth-supported distal jet. In the current case, molar distalization was obtained in a shorter period than that reported by Cozzani et al.,[43] more in line with that reported by Kircelli et al.[40] In this case, a miniscrew insertion guide was used, which not only ensured a safe and effortless positioning of the miniscrews into both cortical layers but also enabled the parallel positioning of multiple implants.[30,31] The surgical insertion guide proved to be a significant aid in terms of treatment management, allowing successful achievement of both transverse expansion and molar distalization, exploiting the anchorage provided by only two miniscrews.



Figures 15–16. Final radiographs.

CONCLUSIONS

- Correction of Class II, Division 2 malocclusion with transverse discrepancy was successfully, safely, and reliably achieved without anterior anchorage loss or the need for patient cooperation. In particular, the surgical insertion guide enabled determination of the optimal anteroposterior palatal miniscrew placement sites, considering the palatal vault thickness and width, and therefore the optimal deployment of only two palatal miniscrews to provide skeletal anchorage for two separate appliances.

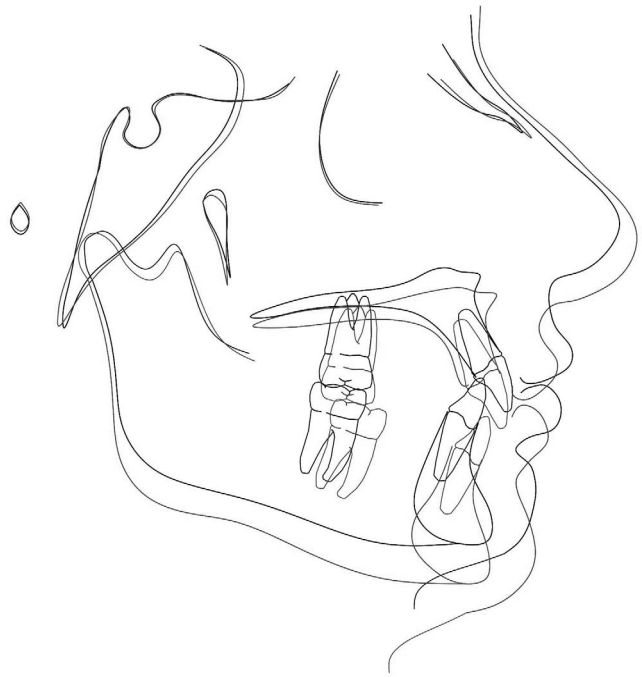


Figure 17. Superimposition of pre- and posttreatment cephalometric tracings.

REFERENCES

1. Gianelly AA. Distal movement of the maxillary molars. *Am J Orthod Dentofacial Orthop*. 1998;114:66–72.
2. Cozzani M, Gracco A, Lombardo L, Siciliani G. Why, when and how distalizing maxillary molars. *Ortognatod Ital*. 2007; 14:21–27.
3. Behrents RG. Iatrogenic problems associated with the clinical practice in orthodontics. In: McNamara JA Jr, Trotman C, eds. *Orthodontic Treatment: The Management of Unfavourable Sequelae*. Craniofacial Growth Series 31. Ann Arbor, Mich: Center for Human Growth and Development, the University of Michigan; 1996:1–28.
4. Nanda RS, Kierl MJ. Prediction of cooperation in orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 1992;102:15–21.
5. Tulloch JF, Proffit WR, Phillips C. Influences on the outcome of early treatment for Class II malocclusion. *Am J Orthod Dentofacial Orthop*. 1997;111(5):533–542.
6. Brandão M, Pinho HS, Urias D. Clinical and quantitative assessment of headgear compliance: a pilot study. *Am J Orthod*. 2006;129:239–244.
7. Roykó A, Dénes Z, Razouk G. The relationship between the length of orthodontic treatment and patient compliance. *Fogorv Sz*. 1999;92(3):79–86.
8. Arreghini A, Trigila S, Lombardo L, Siciliani G. Objective assessment of compliance with intra- and extraoral removable appliances. *Angle Orthod*. 2017;87:88–95. doi:10.2319/020616-104.1
9. Nanda RS, Kieri MJ. Prediction of cooperation in orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 1992;102:15–21.
10. Kloehn SJ. Evaluation of cervical traction of the maxilla and upper first permanent molar. *Angle Orthod*. 1961;31:91–104.
11. Haas AJ. Headgear therapy: the most efficient way to distalize molars. *Semin Orthod*. 2000;6:79–90.
12. Egolf RJ, BeGole EA, Upshaw HS. Factors associated with orthodontic patient compliance with intraoral elastic and headgear wear. *Am J Orthod Dentofacial Orthop*. 1990;97: 336–348.
13. Carano A, Testa M. The distal jet for upper molar distalization. *J Clin Orthod*. 1996;30:374–380.

14. Gianelly AA, Viatas AS, Thomas WM. The use of magnets to move molars distally. *Am J Orthod*. 1989;96:161–167.
15. Maino BG, Gianelly AA, Bednar J, Mura P, Maino G. MGBM system: new protocol for Class II non extraction treatment without cooperation. *Prog Orthod*. 2007;8:130–143.
16. Pancherz H. The mechanism of Class II correction in Herbst appliance treatment: a cephalometric investigation. *Am J Orthod*. 1982;82:104–113.
17. Hilgers JJ. The pendulum appliance for Class II non-compliance therapy. *J Clin Orthod*. 1992;26:706–714.
18. Byloff FK, Darendeliler MA. Distal molar movement using the pendulum appliance. Part 1: clinical and radiological evaluation. *Angle Orthod*. 1997;67:249–260.
19. Byloff FK, Darendeliler MA, Clar E, Darendeliler A. Distal molar movement using the pendulum appliance. Part 2: the effects of maxillary molar root uprighting bends. *Angle Orthod*. 1997;67:261–270.
20. Antonarakis GS, Kiliaridis S. Maxillary molar distalization with noncompliance intramaxillary appliances in Class II malocclusion. *Angle Orthod*. 2008;78:1133–40.
21. Sfondrini MF, Cacciafesta V, Sfondrini G. Upper molar distalization: a critical analysis. *Orthod Craniofac Res*. 2002; 5:114–126.
22. Geinforth BL, Higley LB. A study of orthodontic anchorage possibilities in basal bone. *Am J Orthod Oral Surg*. 1945;31: 406–417.
23. Costa A, Raffaini M, Melsen B. Miniscrews as orthodontic anchorage: a preliminary report. *Int J Adult Orthodon Orthognath Surg*. 1998;13:201–209.
24. Papadopoulos MA, Tarawneh F. The use of miniscrew implants for temporary skeletal anchorage in orthodontics: a comprehensive review. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2007;103:e6–e15.
25. Melsen B, Costa A. Immediate loading of implants used for orthodontic anchorage. *Clin Orthod Res*. 2000;3:23–28.
26. Poggio M, Incorvati C, Velo S, Carano A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. *Angle Orthod*. 2006;76:191–197.
27. Cozza P, Baccetti T, Franchi L, De Toffol L, McNamara JA Jr. Mandibular changes produced by functional appliances in Class II malocclusion: a systematic review. *Am J Orthod Dentofacial Orthop*. 2006;129:599.e1–12.
28. Zymperdikas VF, Koretsi V, Papageorgiou SN, Papadopoulos MA. Treatment effects of removable functional appliances in patients with Class II malocclusion: a systematic review and meta-analysis. *Eur J Orthod*. 2015;37:418–434.
29. Batista KBSL, Thiruvenkatachari B, Harrison JE, O'Brien KD. Orthodontic treatment for prominent upper front teeth (Class II malocclusion) in children and adolescents. *Cochrane Database Syst Rev*. 2018(3):CD003452.
30. Maino G, Paoletto E, Lombardo L, Siciliani G. A three-dimensional digital insertion guide for palatal miniscrew placement. *J Clin Orthod*. 2016;50:12–22.
31. Maino G, Paoletto E, Lombardo L, Siciliani G. MAPA: a new high-precision 3D method of palatal miniscrew placement. *EJCO*. 2015;3. doi:10.12889/2015_C00239
32. Maino BG, Bednar J, Pagin P, Mura P. The spider screw for skeletal anchorage. *J Clin Orthod*. 2003;37:90–97.
33. Wilmes B, Nienkemper M, Drescher D. Application and effectiveness of a mini-implant- and tooth-borne rapid palatal expansion device: the hybrid Hyrax. *World J Orthod*. 2010; 11:323–330.
34. Scuzzo G, Pisani F, Takemoto K. Maxillary molar distalization with a modified pendulum appliance. *J Clin Orthod*. 1999;33:645–650.
35. Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative cone-beam computed tomography evaluation of palatal bone thickness for orthodontic miniscrew placement. *Am J Orthod Dentofacial Orthop*. 2008;134:361–369.
36. Winsauer H, Vlachojannis C, Bumann A, Vlachojannis J, Chrubasik S. Paramedian vertical palatal bone height for mini-implant insertion: a systematic review. *Eur J Orthod*. 2014;36:541–549.
37. Choi JH, Yu HS, Lee KJ, Park YC. Three-dimensional evaluation of maxillary anterior alveolar bone for optimal placement of miniscrew implants. *Korean J Orthod*. 2014;44: 54–61.
38. Ludwig B, Glasl B, Bowman SJ, Wilmes B, Kinzinger GS, Lisson JA. Anatomical guidelines for miniscrew insertion: palatal sites. *J Clin Orthod*. 2011;45:433–441.
39. Lombardo L, Gracco A, Zampini F, Stefanoni F, Mollica F. Optimal palatal configuration for miniscrew applications. *Angle Orthod*. 2010;80:145–152. doi:10.2319/122908-662.1
40. Kircelli BH, Pektaş ZO, Kircelli C. Maxillary molar distalization with a bone-anchored pendulum appliance. *Angle Orthod*. 2006;76:650–659.
41. Kinzinger GS, Gülden N, Yildizhan F, Diedrich PR. Efficiency of a skeletonized distal jet appliance supported by miniscrew anchorage for noncompliance maxillary molar distalization. *Am J Orthod Dentofacial Orthop*. 2009;136:578–586. doi:10.1016/j.ajodo.2007.10.049
42. Winsauer H, Vlachojannis J, Winsauer C, Ludwig B, Walter A. A bone-borne appliance for rapid maxillary expansion. *J Clin Orthod*. 2013;47:375–381.
43. Cozzani M, Pasini M, Zallio F, et al. Comparison of maxillary molar distalization with an implant-supported distal jet and a traditional tooth-supported distal jet appliance. *Int J Dent*. 2014;2014:937059. doi:10.1155/2014/937059