Adult patient treated with a miniscrew-assisted rapid palatal expansion combined with surgical exposure of three impacted teeth and several ageneses

Carmen Lorente,[a,b] Maria Perez-Vela,[b] Gabriela Wills Castro,[b] Pedro Lorente,[b] and Teresa Lorente[a,b]
Zaragoza, Spain

This case report outlines the orthodontic management strategies employed for a young adult male patient presenting with a maxillary transverse deficiency and ectopically impacted bilateral maxillary canines and right second premolar requiring surgical exposure. In addition, the patient exhibited agenesis of all four mandibular permanent incisors. The treatment protocol encompassed three sequential stages: (1) correction of transverse deficiency through maxillary expansion using a miniscrew-assisted rapid palatal expansion appliance, (2) surgical exposure of the three ectopically impacted teeth through a closed eruption technique, and (3) orthodontic traction to stimulate their eruption and subsequent alignment. The treatment outcomes were successful, achieving satisfactory maxillary expansion, which enabled the establishment of a balanced occlusion. The ectopically impacted maxillary teeth erupted in their correct positions, with normal clinical crown height and a gingival line harmonious with the adjacent teeth. The strategic incorporation of cantilever arms enhanced the control of forces and traction vectors, mitigating potential stress and minimizing the risk of damage to the adjacent teeth. (Am J Orthod Dentofacial Orthop Clin Companion 2025;5:180-95)

Carmen Lorente

Maria Perez-Vela

An ectopically impacted tooth has not erupted in its intended position. The third molars are the most commonly ectopically impacted teeth, followed by maxillary canines, maxillary incisors, and both maxillary and mandibular premolars.[1] The estimated prevalence of ectopically impacted maxillary canines varies across populations, typically ranging 1.7%-4.7%.[2] It is considered that 8% of patients with impacted maxillary canines are bilateral.[3] The prevalence of ectopically impacted premolars in the general population is approximately 2.1%.[4]

The etiology of ectopically impacted teeth is multifactorial, involving both local and genetic factors. Genetic influences are notably linked to several dental abnormalities,

[a]Department of Human Anatomy and Histology, University of Zaragoza, Zaragoza, Spain.

[b]Private practice, Zaragoza, Spain.

Address correspondence to: Carmen Lorente, Lorente Clinic, Av Paseo de la Constitución, 29 (local), 50001 Zaragoza, Spain; e-mail, clorente@unizar.es

Fig 1. Pretreatment facial and intraoral photographs.

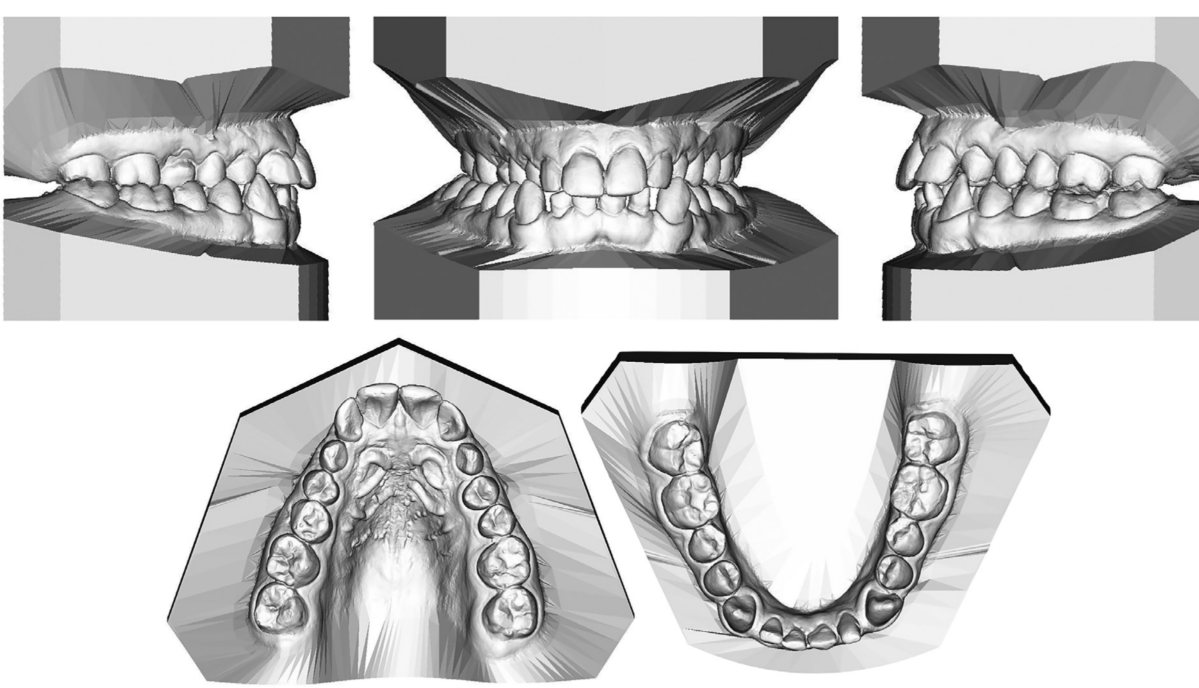

Fig 2. Pretreatment digital models.

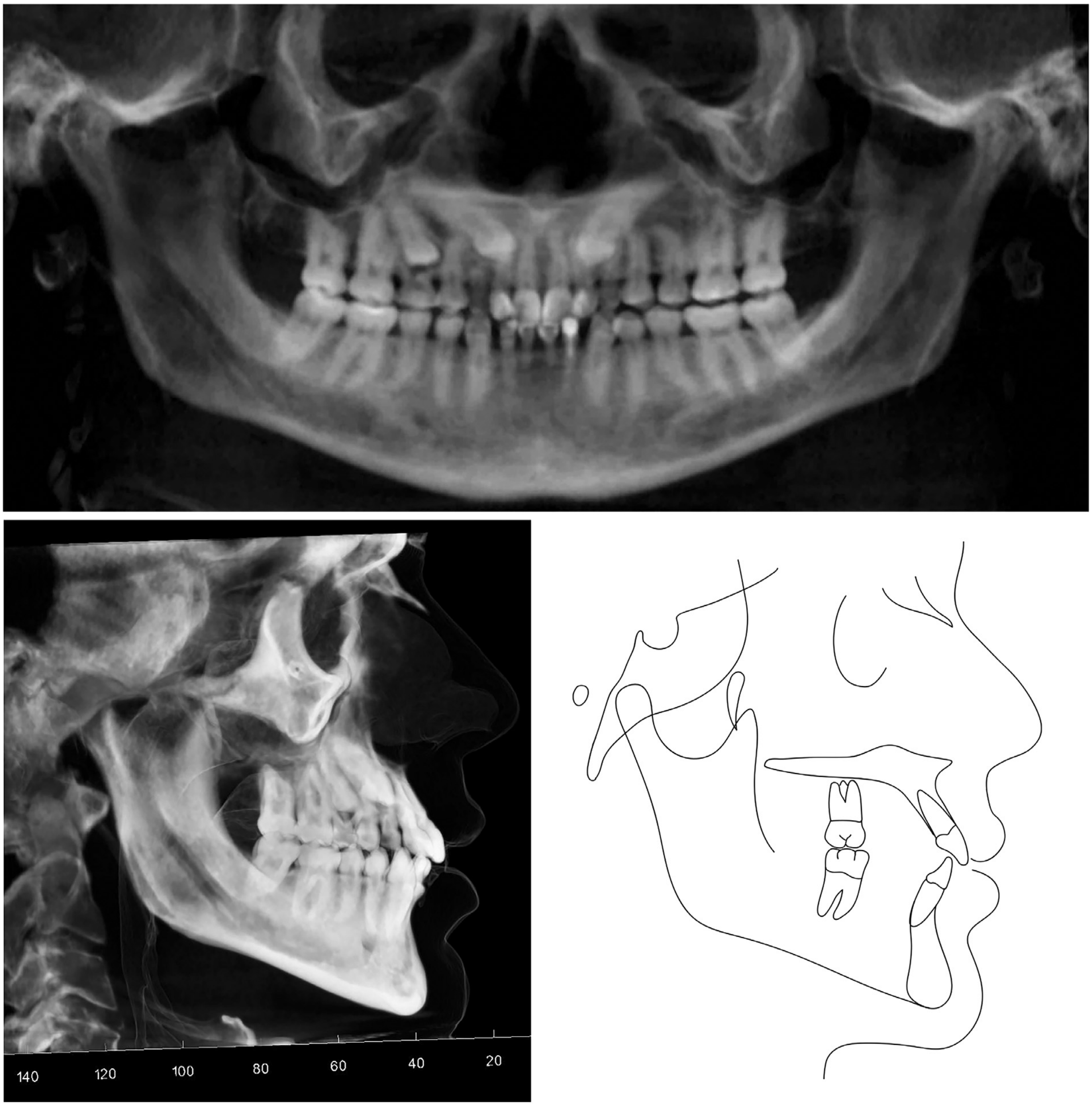

Fig 3. Pretreatment radiographs and tracing.

such as a reduction in tooth number and size,[5] and transverse maxillary deficiency.[6]

In the context of dental abnormalities, the development of lateral incisors shows significant variability and is frequently characterized by congenital absence.[7] In addition, maxillary lateral incisors often display deficient morphology, typically presenting as small or peg-shaped crowns.[8,9] The absence or peg-shaped formation of lateral incisors, coupled with arrested root development, can interfere with the normal eruption of the canine.[7]

Transverse maxillary deficiency, affecting 21% of children and 10% of adults, significantly contributes to ectopically impacted canines.[10] Rapid maxillary expansion effectively increases arch perimeters in children.[11] Orthodontists often consider nonsurgical maxillary alveolar expansion for adult patients with narrow arches.[12] Surgical options, such as surgically-assisted rapid palatal expansion, are recommended for adults with skeletal transverse deficiency.[13,14] Miniscrew-assisted rapid palatal expansion (MARPE) has yielded successful outcomes,[15-19] with Oliveira et al[20] demonstrating an 81.8% success rate in

Table I. Cephalometric measurements

Measurement	Norm[†]	Pretreatment	Posttreatment
Skeletal pattern			
SNA (°)	82.0 ± 2.0	83.4	83.6
SNB (°)	80.0 ± 2.0	81.8	81.6
ANB (°)	2.0 ± 2.0	1.6	2.0
SN-GoGn (°)	32.0 ± 5.0	31.1	33.0
Dental pattern			
Interincisal angle (°)	130.0 ± 6.0	117.8	127.4
IMPA (°)	90.0 ± 3.0	98.0	92.8
Mx1 to A-Po (mm)	3.5 ± 2.3	6.8	4.2
Md1 to A-Po (mm)	1.0 ± 2.3	2.5	1.4
Profile			
Lower lip to E-Plane (mm)	−2.0 ± 2.0	−1.6	−2.7
Facial axis (°)	90.0 ± 3.5	92.2	91.0

[†]Values are presented as mean ± standard deviation.

suture opening among patients aged 20-29 years. The success rate of suture opening decreases with age.[21]

The ectopically impacted maxillary canine is more common in patients with constricted maxilla.[6] Early extraction of the primary canine, combined with prompt palatal expansion, can prevent ectopically impacted maxillary canines.[3,22] When advanced prevention is not possible, surgical exposure and orthodontic treatment are commonly used in permanent dentition.[23] In adults, ankylosis of the impacted teeth often leads to noneruption, worsening the prognosis with age.[24]

This case report details the correction of a transverse maxillary deficiency in an adult patient using MARPE. In addition, it explains the procedural steps for repositioning ectopically impacted maxillary teeth, which involved surgical exposure and the use of biomechanical orthodontic traction cantilever arms.

DIAGNOSIS AND ETIOLOGY

A 27-year-old man presented with a chief complaint of dissatisfaction with his smile. After obtaining informed consent, comprehensive orthodontic assessments revealed a well-proportioned, symmetrical face with a mesofacial type, straight profile, and passive lip closure at rest. Smile analysis showed a slightly inferior resting lip on the left side and noticeable buccal corridors (Fig 1).[25]

Pretreatment intraoral photographs revealed retained deciduous teeth, including the maxillary deciduous canines, maxillary right second deciduous molar, and all four mandibular deciduous incisors. Furthermore, a right unilateral posterior crossbite was identified, coupled with a transverse maxillary deficiency. In addition, a dental crossbite involving the mandibular left canine was observed. The maxillary dental midline was aligned with the facial midline, whereas the mandibular midline was deviated 1.5 mm to the right. Esthetic reconstructions had previously been performed to augment the size and contour of all four maxillary permanent incisors and mandibular deciduous incisors. The maxillary lateral incisors exhibited a peg-shaped form with a wider mesiodistal crown dimension at the cervical margins. Furthermore, the maxillary incisors were proclined, with an overjet and overbite of 3.7 and 0.8 mm, respectively (Fig 1).

The pretreatment digital casts revealed a bilateral Class I molar relationship; regarding the canine relationship, the patient presented with bilateral Class I, although it had to be assessed with the maxillary deciduous canines (Fig 2). Impaction of both the maxillary canines and the maxillary right second premolar was evident on the panoramic radiograph. In addition, all four permanent incisors and third molars in the mandibular arch were congenitally absent. During the intraoral examination, palpation revealed the bulging of both canines at the level of the palatal rugae. Cephalometric analysis revealed a skeletal Class I relationship (ANB, 1.6°), characterized by a slight protrusion of both the maxilla (SNA, 83.4°) and mandible (SNB, 81.8°) and a mesofacial profile (Facial axis, 92.2°). Both maxillary and mandibular incisors were proclined, maintaining a favorable vertical relationship (SN-GoGn, 31.1°) (Fig 3; Table I).

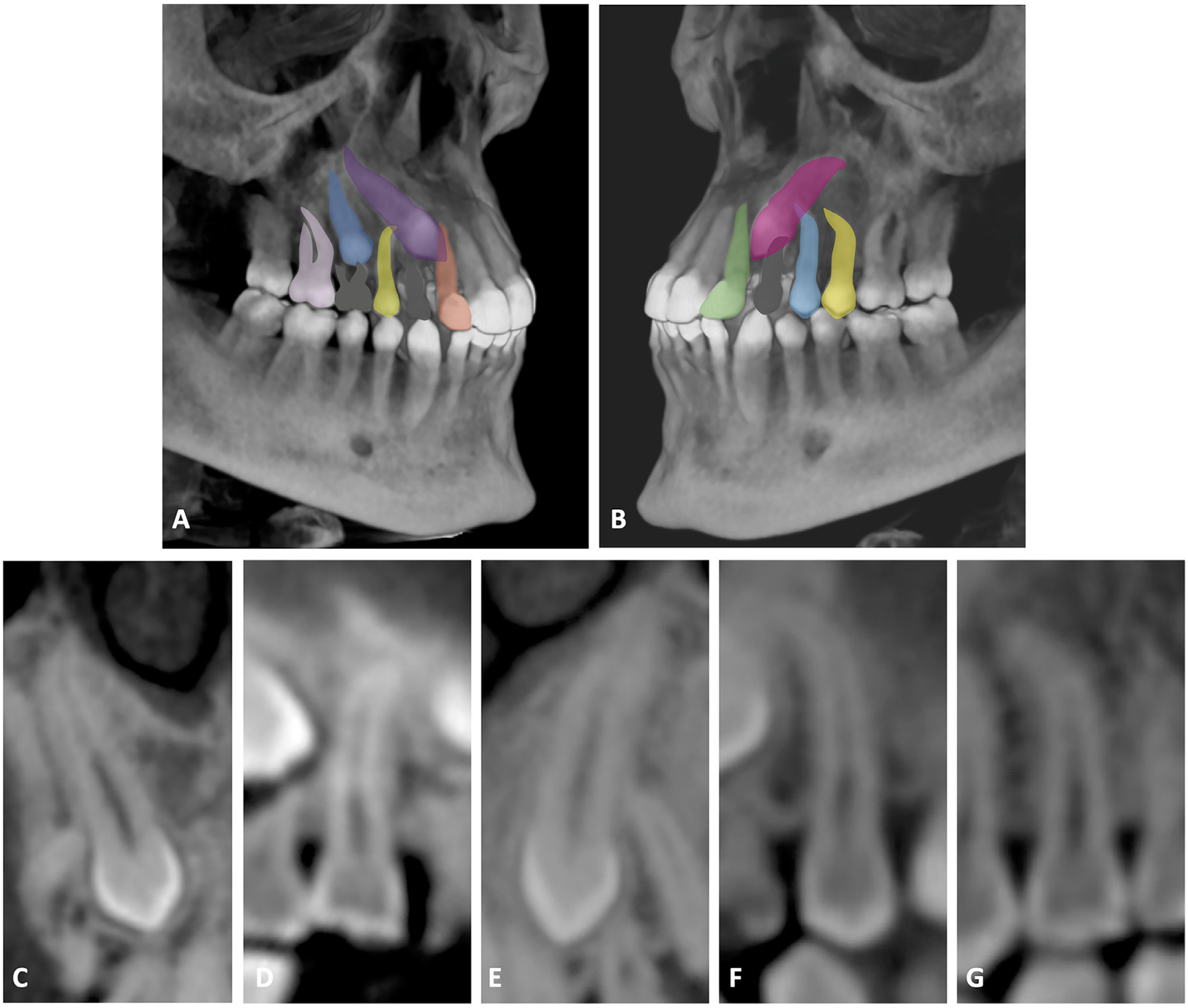

Fig 4. **A** and **B**, Pretreatment views of the CBCT with diagrams of the dilacerated roots; **C**, Maxillary right canine; **D**, Maxillary right first premolar; **E**, Maxillary left canine; **F**, Maxillary left first premolar; **G**, Maxillary left second premolar.

Cone-beam computed tomography (CBCT) was used to evaluate the transverse skeletal deficiency and the ectopically impacted maxillary teeth, using parameters of 36 mA, 120 kVp, 36-second exposure time, and a voxel size of 0.25 mm (I-CAT scanner; Imaging Sciences International, Hatfield, Pa). The transverse maxillary deficiency, in accordance with the University of Pennsylvania analysis,[26] was 7.35 mm, with maxillary and mandibular skeletal widths of 50.37 and 57.72 mm, respectively.

In the sagittal view, the cusp distance and the angulation of the tooth axis were measured in relation to the occlusal plane.[27] The distance of the left canine was 10.89 mm, and the angulation was 44.72°. On the right side, the canine was 11.35 mm, and the premolar was 8.55 mm. The angulations were 38.10° and 57.20°, respectively.

In the frontal view, only the 2 canines could be measured in relation to the midline. The left canine was found at a distance of 10.09 mm and with an angulation of 13.03°. The right canine was located at a distance of 6.03 mm and with an angulation of 23.18° with respect to the midline. In the coronal view, the maxillary right canine was angled at 34.03° to the lateral incisor, and the maxillary left canine exhibited an angle of 20.57°.[28]

CBCT analyses indicated that the lateral incisor roots were within 1 mm of the ectopically impacted teeth, with undisturbed cross-sectional contours. Furthermore, the roots of the maxillary canines and the maxillary first and second premolars were dilacerated (Fig 4 A-G).

TREATMENT OBJECTIVES

The objectives were as follows: (1) correction of transverse maxillary deficiency and a unilateral posterior crossbite by opening the midpalatal suture and dental expansion, (2) bringing the ectopically impacted maxillary

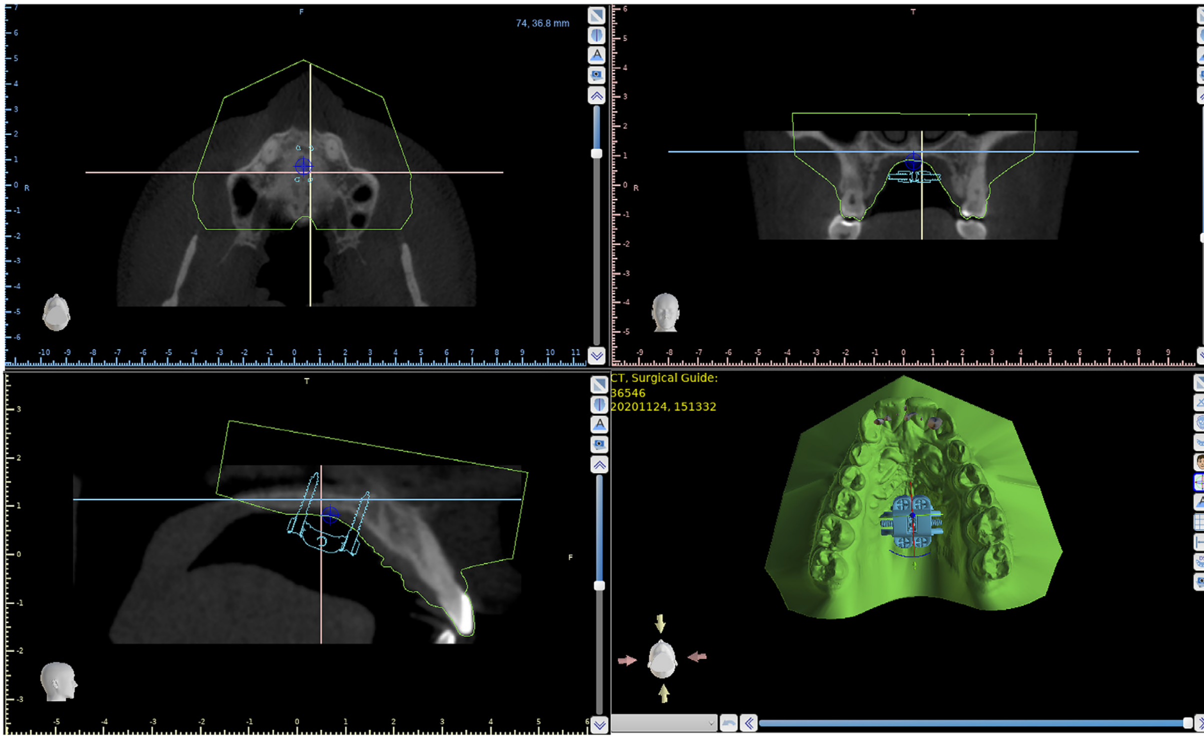

Fig 5. Digital planning of the MARPE with the Blue Sky Plan software (version 4.7; Blue Sky Bio, LLC, Grayslake, Ill). Digital imaging and communications in medicine files were superimposed with the stereolithography files of the initial dental maxillary model and the MARPE.

canines and maxillary second premolar into occlusion with minimal trauma to adjacent teeth, (3) level and align the arches, (4) achieve a Class I molar-canine relationship, (5) coordinate the dental midlines, and (6) achieve a correct overjet and overbite correcting the proclination of the maxillary and mandibular incisors.

TREATMENT ALTERNATIVES

Various treatment options for transverse skeletal maxillary deficiency were explored, including referral to a maxillofacial surgeon for conventional surgically-assisted rapid palatal expansion, but the patient refused this treatment option. Considering the patient's age and, therefore, the

Fig 6. Intraoral photographs of the maxillary expansion achieved with the MARPE appliance.

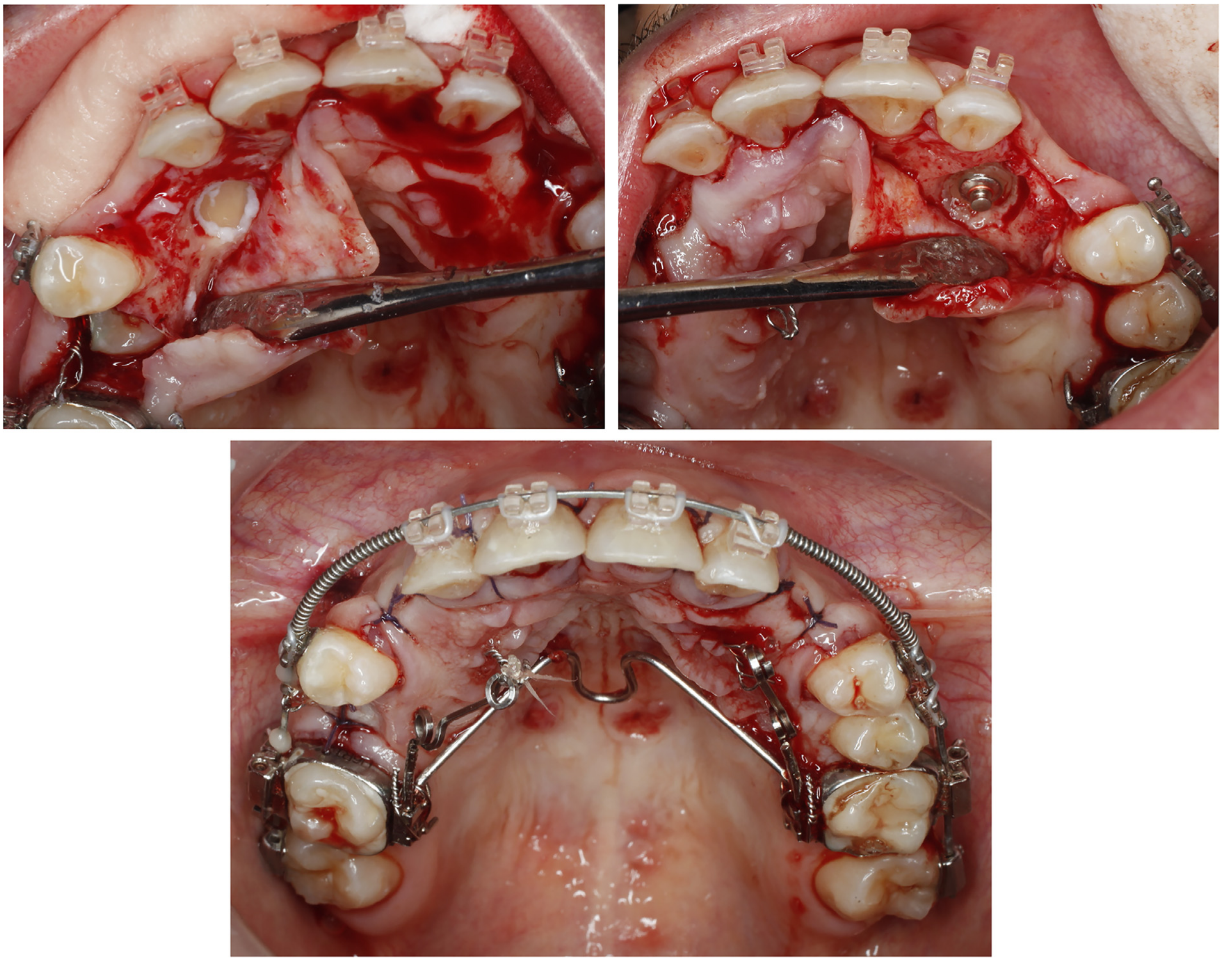

Fig 7. Closed surgical exposure and appliance for orthodontic extrusion of palatally impacted maxillary canine with a stainless steel cantilever on a transpalatal bar.

potential for basal expansion of the maxilla using a MARPE device, this option was proposed.[15-19] For the ectopically impacted teeth, extraction followed by restoration with either a fixed prosthesis or implants was considered. This approach entails the loss of three teeth, with an elevated risk of alveolar bone loss and compromised esthetics. An alternative solution was the autotransplantation or surgical reimplantation of the impacted teeth, but this procedure carries risks such as root resorption, periodontal compromise, negative pulpal response, and possible ankylosis.[29] The last proposed approach involves the surgical exposure of ectopically impacted teeth, followed by orthodontic traction.

Dental implants were recommended for missing permanent mandibular incisors. Even though the patient opted to retain the deciduous teeth and declined any prosthodontic treatment. This decision was made with full awareness of the potential risk of subsequent occlusal or esthetic complications because of the uncertain longevity of the deciduous teeth, underscoring the necessity for prosthetic replacement in the near term.

Opting for the most conservative approach, the patient underwent MARPE and surgical tooth movement.

TREATMENT PROGRESS

To address the transverse maxillary deficiency, a MARPE (Power MARPE type 1 screw; Osteonic Co Ltd, Seoul, South Korea) was inserted. CBCT was used to determine the position and length of the miniscrew and appliance using Blue-Sky Plan software (version 4.7; Blue Sky Bio, LLC, Grayslake, Ill) (Fig 5). Furthermore, digital imaging and communications in medicine files were superimposed with stereolithography files of the initial maxillary dental cast and MARPE. The correct length for bicortical skeletal anchorage Palalign Round Head Type microimplants, measuring 14 mm in length and 1.8 mm in diameter, was determined through this process. Miniscrews were positioned 2-3 mm paramedian from the midpalatal suture (Fig 6).[30] MARPE was inserted using a contra-angle driver by the clinician (C.L.) and activated with two-quarters of a turn immediately after placement, followed by a daily quarter turn.

Fig 8. Intraoral photographs during treatment with the modification of the cantilevers to the buccal side.

Concurrent with MARPE placement, fixed orthodontic appliances with a Roth 0.022 × 0.028-in slot size were bonded to both the maxillary and mandibular dentition. Initially, the tooth roots adjacent to ectopically impacted canines and premolars are deliberately tipped to generate space and minimize the risk of damage during repositioning. The roots of both maxillary lateral incisors were tipped mesially, and the maxillary left first premolar root was tipped distally with respect to the position of the canine.

Weekly follow-ups were scheduled to monitor suture opening by observing the maxillary midline diastema until

Fig 9. Intraoral photographs of the different treatment stages.

Fig 10. Posttreatment facial and intraoral photographs.

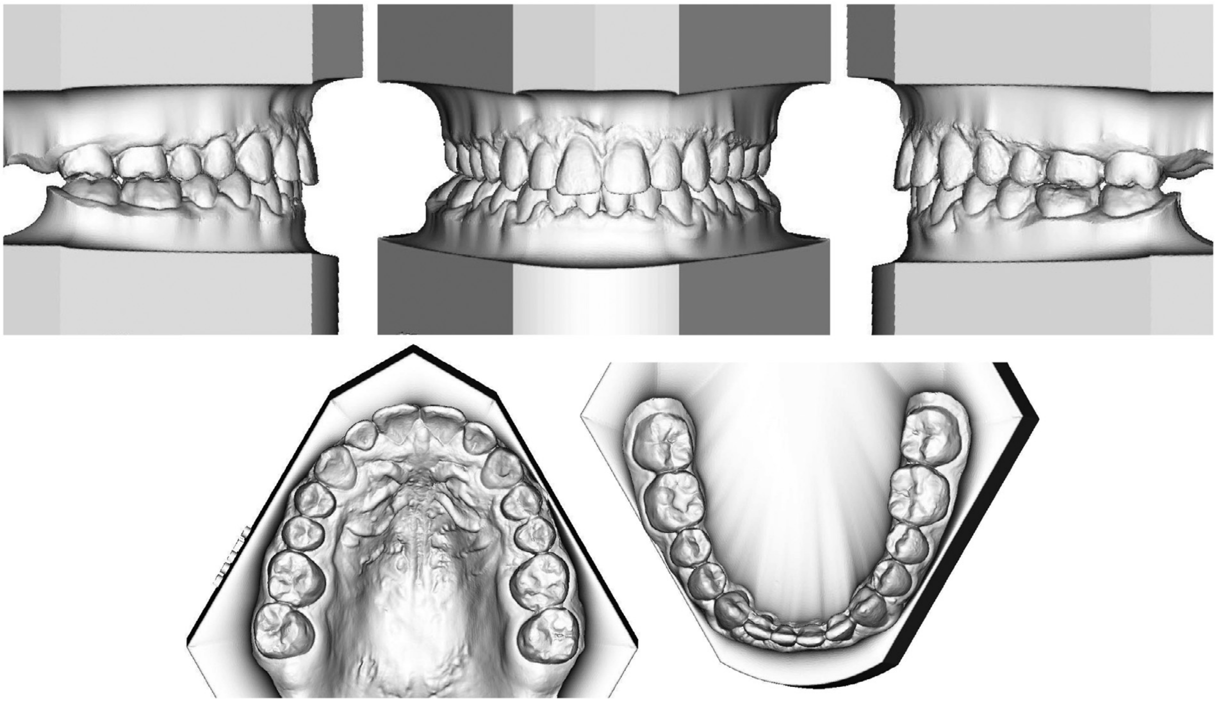

Fig 11. Posttreatment digital models.

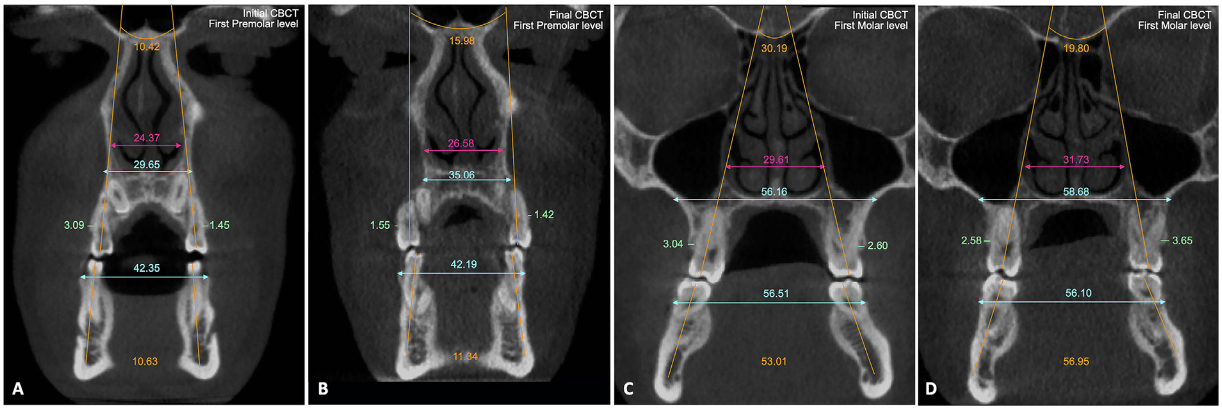

Fig 12. CBCT coronal images were acquired before and after expansion at the first premolar (**A** and **B**) and first molar (**C** and **D**) levels. Measurements of interdental angle (*orange*), nasal cavity width (*pink*), basal bone width (*blue*), and buccal bone thickness on the right and left sides (*green*).

the desired expansion was achieved (Fig 6). After the completion of the active expansion, a rest period of 3 months is advised before the removal of the expansion appliance, as skeletal retention is a determinant after opening the suture to prevent skeletal relapse.[15,31] MARPE was removed and replaced with a transpalatal bar (0.019 × 0.025-in stainless steel) to prioritize the fenestration of the ectopically impacted teeth and preserve the expansion achieved. Although this method was not ideal for maintaining the desired expansion, the transpalatal arch provided reliable support for the attachment of the cantilever arms, allowing direct traction on the impacted teeth (Fig 7). A postexpansion CBCT scan was performed to strategize the surgical exposure of the ectopically impacted teeth. The selected approach involved the bilateral closed exposure of the ectopically impacted maxillary canines and right second premolar.[32,33] Canine traction was initiated on the day of surgery and was activated every 2 weeks using elastic thread attached to 2 cantilever arms welded to the transpalatal bar with distopalatal direction (Fig 7). After adequate separation of the crowns of the canines from the roots of the maxillary lateral incisors, the traction cantilever arms were shifted to the accessory buccal tube on the molar band. The canines were guided laterally toward the arch, with a vestibular direction (Fig 8). This was done to avoid traction directly on the arch, which could have increased radicular resorption on the adjacent teeth because of overload forces. After the repositioning of the

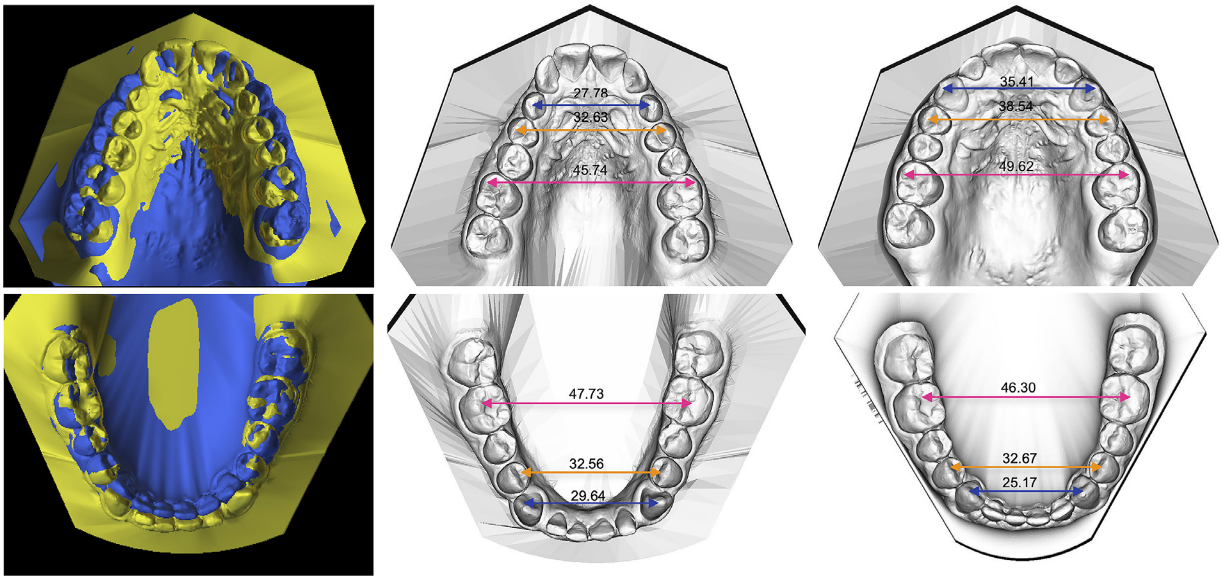

Fig 13. Pretreatment and posttreatment digital dental casts show expansion obtained in the maxillary arch. The superposition of pretreatment (*yellow*) and posttreatment (*blue*) digital models shows the transverse changes produced during treatment. Measurements of intercanine (*blue*), interpremolar (*orange*), and intermolar widths (*pink*).

Table II. Comparison of transverse dimensions T0 and T1 expansion

Measurements	*Tooth*	*T0*	*T1*	*Difference (T1−T0)*
Maxillary				
Dental				
Intercanine distance (mm)	C	27.78	35.41	7.63
Interpremolar distance (mm)	PM1	32.63	38.54	5.91
Intermolar distance (mm)	M1	45.74	49.62	3.88
Interdental angle (°)	PM1	10.42	15.98	5.56
	M1	30.19	19.8	−10.39
Dentoalveolar				
Buccal bone thickness (right, mm)	PM1	3.09	1.55	−1.54
	M1	3.04	2.58	−0.46
Buccal bone thickness (left, mm)	PM1	1.45	1.42	−0.03
	M1	2.60	3.65	1.05
Skeletal				
Nasal cavity width (mm)	PM1	24.37	26.58	2.21
	M1	29.61	31.73	2.12
Basal bone width (mm)	PM1	29.65	35.06	5.41
	M1	56.16	58.68	2.52
Mandibular				
Dental				
Intercanine distance (mm)	C	29.64	25.17	−4.47
Interpremolar distance (mm)	PM1	32.56	32.67	0.11
Intermolar distance (mm)	M1	47.73	46.30	−1.43
Interdental angle (°)	PM1	10.63	11.34	0.71
	M1	53.01	56.95	3.94
Skeletal				
Basal bone width (mm)	PM1	42.35	42.19	−0.16
	M1	56.51	56.10	−0.41

T0, initial; *T1*, final; *C*, canine; *PM1*, first premolar; *M1*, first molar.

teeth, a permanent bracket was bonded, and routine leveling and alignment procedures were performed. The final coordination of arch space closure and alignment was achieved using bilateral intermaxillary elastics (6.5 oz, 1/8-in) for interdigitation (Fig 9).

After the appliance was removed, a fixed lingual retainer was placed from canine to canine in the mandibular arch and lateral to lateral in the maxillary arch. In addition, the patient was provided with thermoplastic retainers for nocturnal use.

TREATMENT RESULTS

The orthodontic treatment spanned 28 months and was conducted in stages, each addressing specific priorities (Figs 10 and 11). A comprehensive analysis of dentoalveolar and skeletal expansions was performed using the method developed by Park et al.[15] Assessment of the maxillary first premolar and first molar expansions at the buccal cusp level increased by 5.91 and 3.88 mm, respectively. Maxillary basal bone width increased by 5.41 and 2.86 mm at the first premolar and first molar levels, respectively, and

Table III. CBCT measurements of root lengths in the T0 and T1 CBCT

Tooth	*T0 (mm)*	*T1 (mm)*	*Difference (T1−T0)*
Maxillary right central incisor	16.86	16.07	0.79
Maxillary right lateral incisor	16.12	15.13	0.99
Maxillary right canine	18.02	17.54	0.48
Maxillary right first premolar	12.00	10.72	1.28
Maxillary right second premolar	13.10	12.84	0.26
Maxillary left central incisor	16.51	15.85	0.66
Maxillary left lateral incisor	16.34	15.30	1.04
Maxillary left canine	18.19	17.27	0.92
Maxillary left first premolar	15.64	14.59	1.05

Note. Values were obtained between a traced line connecting the cementoenamel junction and the apex of the teeth.
T0, initial; *T1*, final.

changes produced in the mandibular arch were also analyzed (Figs 12 and 13; Table II).

Orthodontic traction persisted for 4 months for the maxillary right second premolar, 6 months for the maxillary left canine, and 12 months for the maxillary right canine. Extrusive orthodontic forces can induce substantial changes in root resorption in both the maxillary canine and adjacent teeth owing to the subsequent action and reaction effect (Table III).[34,35] Cantilever arms were used to guide the ectopically impacted teeth to mitigate excessive secondary effects on the roots of adjacent teeth (Fig 8). The differences in root length before and after treatment are shown in Table III. Despite maintaining their vitality, root resorption ranging from 0.26-1.30 mm was observed in maxillary teeth under stress, likely because of expansion forces and the presence of dilacerated root anatomy (Fig 14; Table III). It is also pertinent to mention that root resorption was more pronounced in the lateral incisors than in the central incisors, which is likely attributable to the proximity of the impacted teeth to the roots of the lateral incisors.[36]

The gingival heights of the maxillary right lateral incisor and canine were within normal limits, and the dental midline coincided with the medial sagittal plane. Despite achieving balanced occlusion after treatment completion, an increased overbite persisted, which was attributed to the presence of all 4 retained deciduous mandibular incisors and subsequent tooth mass discrepancy. Given their healthy condition and the fact that the patient denied extraction, retaining them for as long as feasible was decided on, acknowledging their potential impact on occlusion and esthetics. After the bonding of fixed retainers, the patient is currently undergoing posttreatment monitoring. The patient expressed high satisfaction with both the functional and esthetic outcomes of the treatment. The widths of the maxillary and mandibular arches harmonized with facial characteristics, resulting in an excellent esthetic smile with filled buccal corridors (Figs 10 and 11). Furthermore, the bilateral Class I relationship of the canines and molars contributed to an improved interincisal angle (Fig 15).

DISCUSSION

MARPE is a treatment modality with a high success rate, with a mean success rate of 92.5% in skeletal and dental maxillary expansion.[17] The potential for the skeletal effects of expansion to be reduced by advancing age is acknowledged; however, the success of treatment is deemed satisfactory when a minimum of 1 mm of suture opening is achieved.[12,19-21] In the patient under consideration, the maxillary evaluation resulted in an increase in bone width of 2.52 mm at the first molar level (from 56.16 to 58.68 mm), which is in accordance with the 2.33 mm of mean skeletal expansion identified by Kapetanović et al[17] in their systematic review, although there was a greater degree of expansion at the premolar region compared with the molar region (from 29.65 to 35.06 mm) (Table II).

The assessment of the maxillary first premolar and maxillary first molar expansions at the buccal cusp level revealed increases of 5.91 and 3.88 mm, respectively. Previous studies have reported buccal tipping was higher with tooth-borne expansion devices than with bone-borne devices.[37] These findings are consistent with those of this study, which demonstrated a 9.6° reduction in the interdental angle at the level of the first molar (Table I). In addition, the pretreatment and posttreatment values for the mandibular arch were analyzed, both at the dental and skeletal levels (Table II). On analysis of these values, it can be deduced that at the skeletal level, no changes were observed in the mandibular arch, as expected. However, dentoalveolar compensations were evident, which helped to correct the initial crossbite. The mandibular dental measurements indicate a reduction in intercanine and intermolar width (by −4.47 and −1.43 mm, respectively) and changes in inclination at the molar level (3.94°). Therefore, it can be concluded that the correction of the initial crossbite in this patient was produced by a combination of the basal expansion achieved in the maxilla by the MARPE device and also by

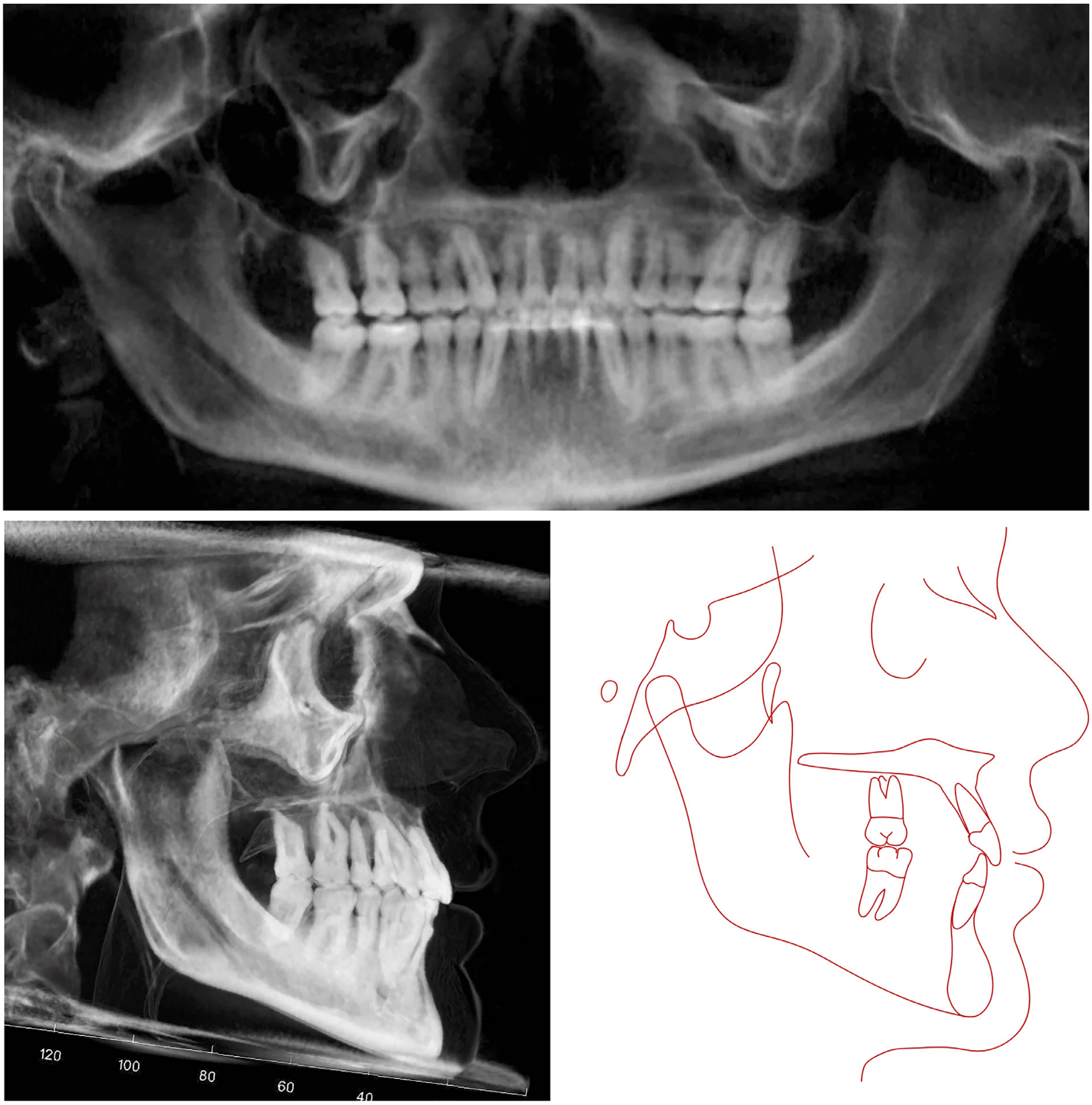

Fig 14. Posttreatment radiographs and tracing.

dentoalveolar compensations, especially at the mandibular level.[15,17]

Conversely, skeletal expansion is associated with several adverse effects, including root resorption, reduced root volume, and buccal alveolar bone loss.[37] Notably, substantial damages during treatment were observed in the maxillary right first premolar, with a reduction of 1.28 mm in root length. This could be attributed to its position between the two ectopically impacted teeth, expansion stress, and dilacerated root anatomy (Fig 4, *D;* Table III). In addition, compared with the pretreatment CBCT, a reduction in the buccal bone thickness of 1.54 mm at the same level was observed (Fig 12, *A* and *B*; Table II). Despite carefully designing traction forces using vector control attachments, studies have indicated that teeth in proximity to ectopically erupted teeth are more susceptible to root resorption.[38,39] Root resorption in ectopically impacted canines is 0.3-2.1 mm,[40] which is consistent with our findings of 0.5-1.0 mm (Table III). Addressing ectopically impacted teeth requires consideration of the position, severity of impaction, patient's age, the relationship of the ectopically impacted tooth with adjacent teeth, anchorage requirements, and underlying pathologic conditions,[41] which is why a 3-dimensional classification system is imperative for assessing CBCT images diagnosis and treatment planning.[28,42,43] The implementation of a predictive model, following the methodology

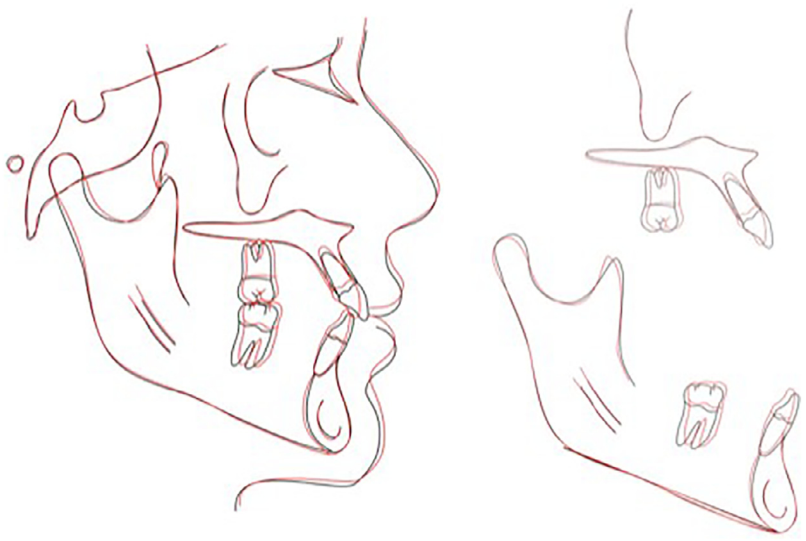

Fig 15. Superimposition of pretreatment (*black*) and posttreatment (*red*) cephalometric tracings.

specified by Alqerban et al,[28] aids in determining the likelihood of tooth impaction and the optimal timing for intervention. Their proposed formula indicated 98.82% and 94.39% probabilities of maxillary right and left canine eruptions, respectively. Despite a success rate of 69.5% for surgeries in adults, all three impacted teeth in our patient were accurately positioned.[24]

A recent review by Sampaziotis et al[44] compared periodontal, esthetic, and postoperative pain outcomes of open and closed techniques, finding no statistically significant differences. The open technique offers a shorter surgery time, whereas the closed technique provides a shorter recovery period, reducing discomfort, pain, and complications.[45,46] Given the necessity for surgical exposure of 3 teeth, the closed technique was deemed the optimal choice for the patient's well-being despite a potential increase in repositioning time in the arch.[46] However, in this patient, orthodontic traction was only required for 4 months for the maxillary right second premolar, 6 months for the maxillary left canine, and 12 months for the maxillary right canine.

Becker et al[47] concluded that an incorrect orthodontic traction direction could result in damage to the adjacent teeth. Various options have been proposed to protect the soft tissues and adjacent teeth, such as a cantilever system, temporary skeletal anchorage devices, traction of MARPE or transpalatal arch, double-archwire mechanics, easy-way-coil system, auxiliary springs, K-9 springs, bent loops, and modified hooks.[48] The ectopically impacted teeth in our patient were repositioned in the dental arch using extrusive traction forces using stainless steel cantilever arms fixed on a transpalatal bar.[34] Initially, the teeth were retracted distopalatally, followed by a strategic adjustment of the cantilever arms to further guide their movement buccally. This method avoids excessive force on adjacent teeth, particularly the lateral incisor, and allows for the adjustment of the arm position to modify traction vectors, enhancing control over the relationship with adjacent tooth roots and thereby reducing the risk of root resorption.[49]

The treatment duration was 28 months. The severity of the ectopically impacted tooth position in the buccolingual, vertical, and anteroposterior dimensions, and teeth with dilacerated roots may contribute to prolonged treatment times.[24,40,50]

CONCLUSIONS

Owing to specific clinical conditions that presented considerable orthodontic risks, meticulous treatment planning was required for this patient. The CBCT data guided the selection of biomechanics at each stage, ensuring optimal occlusal results with the least invasive approach.

The MARPE procedure was found to be the optimal solution for treating maxillary transverse deficiency in this adult patient.

Cantilever arm traction should be employed for successful treatment with minimal impact on adjacent teeth. This approach facilitates root control through diverse traction vectors and ensures an optimal force during eruption.

CONFLICTS OF INTEREST

All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.

AUTHOR CREDIT STATEMENT

Carmen Lorente Clinical investigation, Conceptualization, Methodology, Writing—original draft; Maria Perez-Vela Formal analysis, Data curation, Software, Writing

—review & editing; Gabriela Wills Castro Data curation, Research, Writing—review & editing; Pedro Lorente Project administration, Resources, Supervision; Teresa Lorente Supervision, Validation, Visualization, Formal analysis

STATEMENT OF INFORMED CONSENT

Written informed consent and approval were obtained from the patient for the publication of this case report.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.xaor.2024.12.001.

REFERENCES

1. Fernandez CCA, Pereira CVCA, Luiz RR, Vieira AR, De Castro Costa M. Dental anomalies in different growth and skeletal malocclusion patterns. Angle Orthod 2018;88:195-201.
2. Lövgren ML, Dahl O, Uribe P, Ransjö M, Westerlund A. Prevalence of impacted maxillary canines-an epidemiological study in a region with systematically implemented interceptive treatment. Eur J Orthod 2019;41:454-9.
3. Bishara SE. Clinical management of impacted maxillary canines. Semin Orthod 1998;4:87-98.
4. Arabion H, Gholami M, Dehghan H, Khalife H. Prevalence of impacted teeth among young adults: a retrospective radiographic study. J Dent Mater Tech 2017;6:131-7.
5. Peck S, Peck L, Kataja M. Concomitant occurrence of canine malposition and tooth agenesis: evidence of orofacial genetic fields. Am J Orthod Dentofacial Orthop 2002;122:657-60.
6. Schindel RH, Duffy SL. Maxillary transverse discrepancies and potentially impacted maxillary canines in mixed-dentition patients. Angle Orthod 2007;77:430-5.
7. Becker A, Chaushu S. Etiology of maxillary canine impaction: a review. Am J Orthod Dentofacial Orthop 2015;148:557-67.
8. Brook AH. Dental anomalies of number, form and size: their prevalence in British schoolchildren. J Int Assoc Dent Child 1974;5:37-53.
9. Brin I, Becker A, Shalhav M. Position of the maxillary permanent canine in relation to anomalous or missing lateral incisors: a population study. Eur J Orthod 1986;8:12-6.
10. Cacciatore G, Poletti L, Sforza C. Early diagnosed impacted maxillary canines and the morphology of the maxilla: a three-dimensional study. Prog Orthod 2018;19:20.
11. Lagravere MO, Major PW, Flores-Mir C. Long-term skeletal changes with rapid maxillary expansion: a systematic review. Angle Orthod 2005;75:1046-52.
12. Handelman CS. Nonsurgical rapid maxillary alveolar expansion in adults: a clinical evaluation. Angle Orthod 1997;67:291-305.
13. Hernandez-Alfaro F, Mareque Bueno JM, Diaz A, Pagés CM. Minimally invasive surgically assisted rapid palatal expansion with limited approach under sedation: a report of 283 consecutive cases. J Oral Maxillofac Surg 2010;68:2154-8.
14. Haas Junior OL, Matje PRB, Rosa BM, Rojo-Sanchis C, Guijarro-Martínez R, Valls-Ontañón A, et al. Minimally invasive surgical and miniscrew-assisted rapid palatal expansion (MISMARPE) in adult patients. J Craniomaxillofac Surg 2022;50:211-7.
15. Park JJ, Park YC, Lee KJ, Cha JY, Tahk JH, Choi YJ. Skeletal and dentoalveolar changes after miniscrew-assisted rapid palatal expansion in young adults: a cone-beam computed tomography study. Korean J Orthod 2017;47:77-86.
16. Lee KJ, Choi SH, Choi TH, Shi KK, Keum BT. Maxillary transverse expansion in adults: rationale, appliance design, and treatment outcomes. Semin Orthod 2018;24:52-65.
17. Kapetanović A, Theodorou CI, Bergé SJ, Schols JGJH, Xi T. Efficacy of miniscrew-assisted rapid palatal expansion (MARPE) in late adolescents and adults: a systematic review and meta-analysis. Eur J Orthod 2021;43:313-23.
18. Wang C, Liu C, Mao Q, Zhou L, Xiang X. Skeletal and dentoalveolar modifications in adults with different sagittal facial patterns after personalized miniscrew-assisted rapid palatal expansion: a prospective cone-beam computed tomography study. Am J Orthod Dentofacial Orthop 2023;164:843-54.
19. Zhong X, Wang H. Dentoperiodontal and skeletal changes induced by miniscrew-assisted rapid maxillary expansion (C-expander) treatment in adults: a retrospective clinical trial. Am J Orthod Dentofacial Orthop 2024;165:303-13.
20. Oliveira CB, Ayub P, Angelieri F, Murata WH, Suzuki SS, Ravelli DB, et al. Evaluation of factors related to the success of miniscrew-assisted rapid palatal expansion. Angle Orthod 2021;91:187-94.
21. Meirelles CM, Ferreira RM, Suzuki H, Oliveira CB, Souza de Jesus A, Garcez AS, et al. Analysis of factors associated with the success of microimplant-assisted rapid palatal expansion. Am J Orthod Dentofacial Orthop 2023;164:67-77.
22. Baccetti T, Mucedero M, Leonardi M, Cozza P. Interceptive treatment of palatal impaction of maxillary canines with rapid maxillary expansion: a randomized clinical trial. Am J Orthod Dentofacial Orthop 2009;136:657-61.
23. Crescini A, Nieri M, Rotundo R, Baccetti T, Cortellini P, Prato GPP. Combined surgical and orthodontic approach to reproduce the physiologic eruption pattern in impacted canines: report of 25 patients. Int J Periodontics Restorative Dent 2007;27:529-37.
24. Becker A, Chaushu S. Success rate and duration of orthodontic treatment for adult patients with palatally impacted maxillary canines. Am J Orthod Dentofacial Orthop 2003;124:509-14.
25. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 2. Smile analysis and treatment strategies. Am J Orthod Dentofacial Orthop 2003;124:116-27.
26. Tamburrino RK, Vanarsdall RL, Secchi AG. The transverse dimension: diagnosis and relevance to functional occlusion. RWISO J 2010;2:13-22.
27. Keener DJ, de Oliveira Ruellas AC, Aliaga-Del Castillo A, Arriola-Guillén LE, Bianchi J, Oh H, et al. Three-dimensional decision support system for treatment of canine impaction. Am J Orthod Dentofacial Orthop 2023;164:491-504.
28. Alqerban A, Jacobs R, Fieuws S, Willems G. Radiographic predictors for maxillary canine impaction. Am J Orthod Dentofacial Orthop 2015;147:345-54.

29. Patel S, Fanshawe T, Bister D, Cobourne MT. Survival and success of maxillary canine autotransplantation: a retrospective investigation. Eur J Orthod 2011;33:298-304.

30. Cantarella D, Dominguez-Mompell R, Mallya SM, Moschik C, Pan HC, Miller J, et al. Changes in the midpalatal and pterygopalatine sutures induced by micro-implant-supported skeletal expander, analyzed with a novel 3D method based on CBCT imaging. Prog Orthod 2017;18:34.

31. Jeon JY, Choi SH, Chung CJ, Lee KJ. The success and effectiveness of miniscrew-assisted rapid palatal expansion are age- and sex-dependent. Clin Oral Investig 2022;26:2993-3003.

32. Lorente T, Lorente C, Murray PG, Lorente P. Surgical and orthodontic management of maxillary canine-lateral incisor transpositions. Am J Orthod Dentofacial Orthop 2016;150:876-85.

33. Lorente C, Lorente P, Pérez-Vela M, Esquinas C, Lorente T. Orthodontic management of a complete and an incomplete maxillary canine-first premolar transposition. Angle Orthod 2020;90:457-66.

34. Iancu Potrubacz M, Chimenti C, Marchione L, Tepedino M. Retrospective evaluation of treatment time and efficiency of a predictable cantilever system for orthodontic extrusion of impacted maxillary canines. Am J Orthod Dentofacial Orthop 2018;154:55-64.

35. Woloshyn H, Årtun J, Kennedy DB, Joondeph DR. Pulpal and periodontal reactions to orthodontic alignment of palatally impacted canines. Angle Orthod 1994;64:257-64.

36. Botticelli S, Byriel T, Stoustrup P, Cattaneo PM, Küseler A. Apical incisor root resorption due to ectopic maxillary canine eruption: association with time of diagnosis and type of intervention in a retrospective population-based cohort study. Orthod Craniofac Res 2024;27:165-73.

37. Ning R, Chen J, Liu S, Lu Y. Treatment effects after maxillary expansion using tooth-borne vs tissue-borne miniscrew-assisted rapid palatal expansion appliance. Am J Orthod Dentofacial Orthop 2023;164:545-53.

38. Chaushu S, Kaczor-Urbanowicz K, Zadurska M, Becker A. Predisposing factors for severe incisor root resorption associated with impacted maxillary canines. Am J Orthod Dentofacial Orthop 2015;147:52-60.

39. Yan B, Sun Z, Fields H, Wang L. Maxillary canine impaction increases root resorption risk of adjacent teeth: a problem of physical proximity. Am J Orthod Dentofacial Orthop 2012;142:750-7.

40. Amuk M, Gul Amuk N, Ozturk T. Effects of root−cortex relationship, root shape, and impaction side on treatment duration and root resorption of impacted canines. Eur J Orthod 2021;43:508-15.

41. Chaushu S, Chaushu G, Becker A. The role of digital volume tomography in the imaging of impacted teeth. World J Orthod 2004;5:120-32.

42. Kau CH, Lee JJ, Souccar NM. The validation of a novel index assessing canine impactions. Eur J Dent 2013;7:399-404.

43. Zeno KG, Ghafari JG. Palatally impacted canines: a new 3-dimensional assessment of severity based on treatment objective. Am J Orthod Dentofacial Orthop 2018;153:387-95.

44. Sampaziotis D, Tsolakis IA, Bitsanis E, Tsolakis AI. Open versus closed surgical exposure of palatally impacted maxillary canines: comparison of the different treatment outcomes-a systematic review. Eur J Orthod 2018;40:11-22.

45. Cassina C, Papageorgiou SN, Eliades T. Open versus closed surgical exposure for permanent impacted canines: a systematic review and meta-analyses. Eur J Orthod 2018;40:1-10.

46. Björksved M, Ryen L, Lindsten R, Bazargani F. Open and closed surgical exposure of palatally displaced canines: a cost-minimization analysis of a multicentre, randomized controlled trial. Eur J Orthod 2021;43:498-505.

47. Becker A, Chaushu S. Palatally impacted canines: the case for closed surgical exposure and immediate orthodontic traction. Am J Orthod Dentofacial Orthop 2013;143:451-9.

48. Bedoya MM, Park JH. A review of the diagnosis and management of impacted maxillary canines. J Am Dent Assoc 2009;140:1485-93.

49. Ruíz-Mora GA, Arriola-Guillén LE, Rodríguez-Cárdenas YA, Aliaga-Del Castillo A, Boessio-Vizzotto M, Dias-Da Silveira HL. Changes in alveolar bone morphology after traction of buccally vs palatally unilateral maxillary impacted canines: a cone-beam computed tomography study. Am J Orthod Dentofacial Orthop 2021;159:258-70.

50. Stewart JA, Heo G, Glover KE, Williamson PC, Lam EWM, Major PW. Factors that relate to treatment duration for patients with palatally impacted maxillary canines. Am J Orthod Dentofacial Orthop 2001;119:216-25.