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Adjunctive low frequency ultrasound during orthodontic management of bilaterally impacted maxillary canines. Case report

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Keypoints

Cephalometric analysis demonstrated improvement in the skeletal Class II relationship, severe deep overbite, and incisor inclination.

Abstract

Introduction

Impacted maxillary canines are among the most frequent eruption disorders in adolescents. Standard management – surgical exposure followed by orthodontic traction – is commonly performed under general anesthesia or deep sedation, so non-invasive adjuncts capable of promoting eruption without an operative procedure are of interest beyond orthodontics. A trans-mucosal low-frequency ultrasound protocol intended to stimulate delayed eruption of permanent teeth was previously developed and experimentally investigated by our research group; clinical evidence supporting its effectiveness remains limited.

Methods

We report on the management of a 14-year-11-month-old girl with bilaterally impacted maxillary canines, Class II Division 2 malocclusion and deep overbite. Diagnosis was based on clinical examination, panoramic radiography, lateral cephalometry and cone-beam computed tomography. Treatment comprised rapid maxillary expansion and fixed appliance therapy. Trans-mucosal low-frequency ultrasound (26.5 kHz, 1 W/cm², amplitude 40–60 μm) was applied to the mucosa overlying the left impacted canine (tooth 23) according to the previously developed protocol, in ten sessions of 5 s.

Results

The right maxillary canine (tooth 13) erupted spontaneously without adjunctive intervention. After the ultrasound course, the crown of tooth 23 emerged clinically; an orthodontic attachment was then bonded and traction initiated. Both canines were aligned into a functional Class I occlusion with satisfactory esthetic and occlusal outcomes.

Conclusions

Clinical emergence of the ultrasound-treated canine followed the adjunctive intervention; causality cannot be established from a single case because of concurrent orthodontic treatment and the absence of interval radiographic assessment. Standardized low-frequency ultrasound protocols warrant evaluation in controlled clinical studies as a potential non-surgical, anesthesia-sparing option in adolescents.

Keywords

impacted maxillary canine; low-frequency ultrasound; orthodontic treatment; tooth eruption; malocclusion.

Introduction

Impacted maxillary canines represent a clinically significant eruption disturbance because of the important role of these teeth in dental arch continuity, functional occlusion, periodontal support, and smile esthetics. The reported prevalence of maxillary canine impaction ranges from 1% to 3%, making the maxillary canine one of the most frequently impacted permanent teeth after the third molar [1,2]. If left untreated, an impacted canine may be associated with prolonged retention of the primary canine, displacement of adjacent teeth, external root resorption, follicular or cystic changes, and increasing treatment complexity [1,3].

Clinical examination and conventional radiographic assessment provide essential information regarding the presence, angulation, vertical position, and mesiodistal location of an impacted canine. However, two-dimensional radiographs may be insufficient for determining their exact buccopalatal position, relationship to adjacent roots, and the presence or extent of root resorption. Cone-beam computed tomography can provide more accurate three-dimensional localization when conventional imaging does not supply sufficient information for diagnosis or treatment planning [4,5]. The decision to align an impacted canine is influenced by the patient's age, available arch space, stage of root development, angulation and depth of impaction, relationship to adjacent teeth, associated pathology, and anticipated periodontal prognosis [1,6].

When spontaneous eruption is considered unlikely and preservation of the canine is biologically feasible, treatment commonly involves creation of adequate space, surgical exposure, and controlled orthodontic traction. Although this combined surgical–orthodontic approach generally permits successful alignment, treatment may be prolonged, and the duration and complexity of traction are strongly influenced by the initial anatomical position of the canine and the individual biological response [6,7]. These limitations have encouraged investigation of adjunctive methods intended to modulate periodontal and alveolar bone remodeling during orthodontic treatment.

Physical stimulation modalities, including photobiomodulation, mechanical vibration, and low-intensity pulsed ultrasound (LIPUS), have been investigated as non-surgical adjuncts for accelerating orthodontic tooth movement [8,9]. Experimental studies suggest that ultrasound may influence cellular signaling, periodontal ligament activity, local inflammatory responses, and bone remodeling. However, clinical studies have used highly variable devices, frequencies, intensities, application schedules, and outcome measures. A recent systematic review and meta-analysis of human studies found inconsistent effects on orthodontic tooth movement and concluded that the current evidence remains insufficient to support the routine clinical use of LIPUS [10]. Importantly, these investigations primarily evaluated teeth subjected to active orthodontic forces rather than impacted teeth. Therefore, evidence regarding the potential role of ultrasound in facilitating the eruption of impacted maxillary canines remains limited.

The aim of this case report was to describe the application of a previously developed continuous low-frequency ultrasound protocol as an adjunct to comprehensive orthodontic treatment in a patient with bilaterally impacted maxillary canines. During treatment, one canine erupted spontaneously, whereas adjunctive ultrasound was applied to the contralateral canine to facilitate eruption. This report describes the clinical course of both teeth and is intended to generate a clinical hypothesis rather than demonstrate treatment efficacy.

Case report

A 14-year-11-month-old female patient presented to the Department of Dentistry of Azerbaijan Medical University, with the chief complaints of the absence of the permanent maxillary canines and malocclusion. The clinical treatment described in this report was carried out as part of a research project on the diagnosis and treatment of impacted teeth, including the use of adjunctive low-frequency ultrasound stimulation. Written informed consent for publication of the clinical data and accompanying images was subsequently obtained from the patient and her legal guardian. All procedures were performed in accordance with the ethical standards of the institution and with the Declaration of Helsinki and its later amendments.

The patient's medical history was significant for chronic upper airway obstruction and impaired nasal breathing during childhood. She had no systemic diseases, was not taking any regular medications, and had no history of previous orthodontic treatment. Clinical examination demonstrated normal temporomandibular joint function, with no pain, joint sounds, or limitation of mandibular movements.

Extraoral examination revealed a slightly concave facial profile with mild maxillary retrusion and mild facial asymmetry. Intraoral examination demonstrated a bilateral full-cusp Class II molar relationship, deep overbite, retained primary maxillary canines, and the absence of clinical eruption of both permanent maxillary canines, consistent with Class II Division 2 malocclusion. Pretreatment extraoral and intraoral photographs are presented in Figure 1.

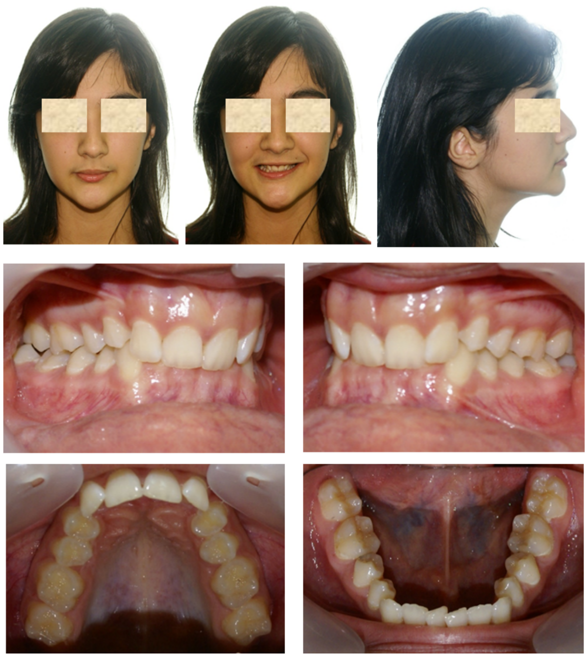

Figure 1. Pretreatment extraoral and intraoral photographs.

Pretreatment radiographic evaluation included panoramic radiography, lateral cephalometry, and cone-beam computed tomography (CBCT). These examinations confirmed bilateral impaction of the maxillary canines and provided detailed three-dimensional information on their position and relationship to adjacent anatomical structures, facilitating comprehensive treatment planning (Figure 2).

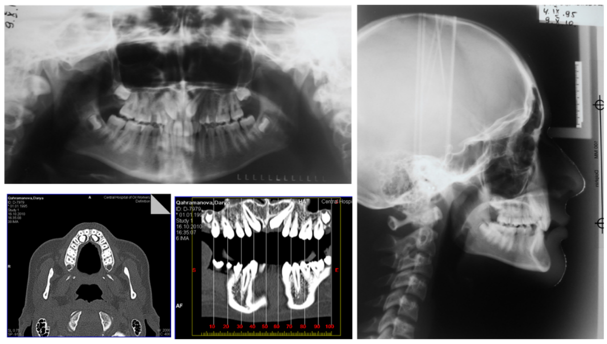

Figure 2. Pretreatment radiographic examination: panoramic radiograph, lateral cephalogram, and representative CBCT views demonstrating the positions of the impacted maxillary canines.

Clinical and Radiographic Findings

Clinical examination revealed retained primary maxillary canines and the absence of eruption of the permanent maxillary canines (teeth 13 and 23). The patient presented with bilateral Angle Class II Division 2 malocclusion, characterized by severe deep overbite and retroclined maxillary incisors. The mandibular incisors contacted the palatal mucosa because of the excessive overbite. The maxillary dental midline was deviated approximately 2 mm to the left. All permanent teeth, except the maxillary canines and third molars, were present. No swelling, pain, or signs of infection were observed in the canine regions. A habitual lower lip-biting habit was noted during clinical examination. Mild facial asymmetry was observed on frontal examination.

Panoramic radiography and cone-beam computed tomography (CBCT) confirmed bilateral palatal impaction of the maxillary canines with nearly complete root formation. The initial position of the impacted canines was assessed according to the radiographic criteria described by Ericson and Kurol [11]. Tooth 13 demonstrated a more favorable eruption prognosis than tooth 23. The angulation of tooth 13 relative to the midline measured 30.1°, whereas tooth 23 demonstrated a greater angulation (39.2°). According to the sector classification, the cusp tip of tooth 13 was located in Sector 3, whereas tooth 23 was positioned in Sector 4. In addition, tooth 13 was located closer to the occlusal plane, whereas tooth 23 occupied a deeper position within the alveolar bone, indicating a less favorable baseline eruption prognosis (Figure 3).

These baseline anatomical differences should be considered when interpreting the subsequent clinical course, as tooth 13 exhibited a more favorable eruption prognosis before adjunctive ultrasound was applied to tooth 23.

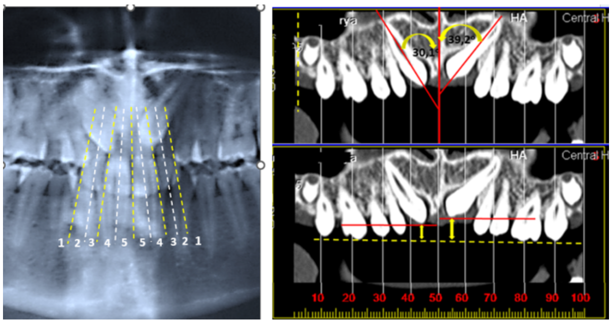

Figure 3. Pretreatment panoramic radiograph and CBCT assessment of the bilaterally impacted maxillary canines (α-angles and Ericson–Kurol sectors).

Cephalometric Findings

Pretreatment cephalometric analysis demonstrated a skeletal Class II pattern with a pronounced deep-bite tendency. The ANB angle increased to 4.1°, accompanied by a reduced SNB angle of 77.0°, indicating that the sagittal discrepancy was predominantly associated with a relatively retrusive mandibular position. This interpretation was further supported by a reduced anteroposterior dysplasia indicator (APDI) of 77.9°.

A pronounced vertical deep-bite pattern was demonstrated by an increased overbite depth indicator (ODI) of 80.8° and an overbite of 7.1 mm. The reduced FMA (15.0°), MP–SN (27.2°), and ML/NL (17.3°) angles were consistent with a hypodivergent vertical skeletal pattern. In addition, marked retroclination of both the maxillary and mandibular incisors (U1–palatal plane, 85.1°; IMPA, 76.0°) was consistent with the clinical diagnosis of an Angle Class II Division 2 malocclusion with a deep overbite.

Treatment Planning and Selected Approach

The treatment objectives were to create and maintain adequate space for alignment of both impacted maxillary canines, correct the severe deep overbite and anterior crowding, improve the sagittal dental relationships, and obtain a functional final occlusion while preserving the patient's soft-tissue profile.

Based on clinical and radiographic findings and digital treatment simulation, a non-extraction approach was selected. The treatment plan included rapid maxillary expansion (RME) to increase the available maxillary arch space, followed by comprehensive fixed-appliance treatment and distalization of the posterior teeth to provide adequate space for the impacted canines. Low-frequency ultrasound stimulation was planned as an adjunctive intervention if spontaneous eruption of the more deeply positioned maxillary left canine (tooth 23) did not occur after adequate space had been created.

Low-frequency ultrasound was applied using a SIAZ-EGS Med-Stomo physiotherapy device (model SIAZ 10-01-M-H-220; EGS, manufactured in Azerbaijan), fitted with a 10-mm-diameter distal working tip (Figure 4). The treatment parameters were based on those previously reported for the SIAZ-EGS Med-Stomo method, namely a frequency of 26.5 kHz, an intensity of 1 W/cm², an amplitude of 40–60 µm, and a reported wavelength of 0.012 m [12,13].

Figure 4. SIAZ-EGS Med-Stomo low-frequency ultrasound physiotherapy device

Treatment Progress

The pretreatment clinical condition is shown in Figure 5a. Rapid maxillary expansion was initiated with the placement of a Hyrax-type rapid palatal expander (Figure 5b). The expansion protocol comprised a total of 28 activations over approximately 3 weeks. During the first week, three activations per day were performed for the initial 3 days, followed by two activations per day for 2 days and subsequently one activation per day. By the end of the second week, after 21 activations, a clinically evident midline diastema had developed (Figure 5c). Expansion was continued at one activation per day, and the planned 28 activations were completed during the third week (Figure 5d). The expander was subsequently maintained in place for retention.

Comprehensive fixed-appliance treatment was performed using ceramic brackets. Additional space for the impacted maxillary canines was created bilaterally with open-coil springs between the lateral incisors and first premolars on a 0.016 × 0.022-inch titanium–molybdenum alloy archwire (Figure 5e–f). Space was maintained on a rigid rectangular archwire to provide anchorage control and minimize unwanted tooth displacement. Following space creation, the maxillary right canine (tooth 13), which had a more favorable initial position, began to erupt spontaneously without ultrasound stimulation. Progressive clinical emergence of the canine was observed (Figures 5g–h and 6a). In contrast, the more deeply positioned maxillary left canine (tooth 23) showed no comparable clinical emergence despite adequate space. Low-frequency ultrasound was therefore applied trans-mucosally over the palatal mucosa overlying tooth 23 according to the protocol previously developed by our research group [12,13]. A total of 10 applications were performed, divided into two 5-session periods separated by a 2-day interval (Figure 6b). Each application lasted 5 seconds. The applicator was held stationary, in light contact with and perpendicular to the palatal mucosa, with medical-grade petroleum jelly used as the coupling medium. All applications were performed by the same operator. Ultrasound was delivered in continuous (non-pulsed) mode at a frequency of 26.5 kHz, an intensity of 1 W/cm², an amplitude of 40–60 µm, and a wavelength of 0.012 m. No clinically detectable adverse events associated with the ultrasound application were observed during the treatment course or at subsequent follow-up visits. Following completion of the ultrasound course, the clinical condition of tooth 23 was documented (Figure 6c). At this stage, tooth 13, which had erupted spontaneously without ultrasound stimulation, had sufficient clinical exposure for bonding of an orthodontic button and initiation of traction (Figure 6d). Kilroy Springs were subsequently used to provide controlled extrusive forces for traction of the maxillary canines (Figure 6e). After removal of the rapid palatal expander, traction and alignment were continued using metal ligatures connected to the stabilized maxillary archwire (Figure 6f), and both canines were progressively incorporated into the dental arch. Further treatment included maxillary molar distalization, deep-overbite correction, and finishing with intermaxillary elastics. Active treatment was completed after approximately 28 months, with both maxillary canines successfully aligned, correction of the deep overbite, and achievement of functional occlusion (Figure 6g). At the 4-year 9-month follow-up, the achieved clinical and radiographic results remained stable (Figure 6h).

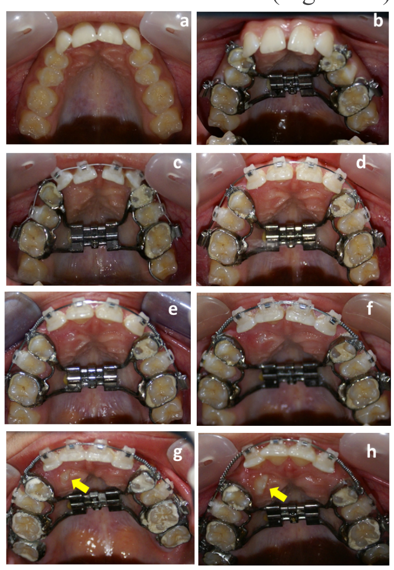

Figure 5. Initial stages of orthodontic treatment and spontaneous eruption of tooth 13 (a–h). Details are provided in the text.

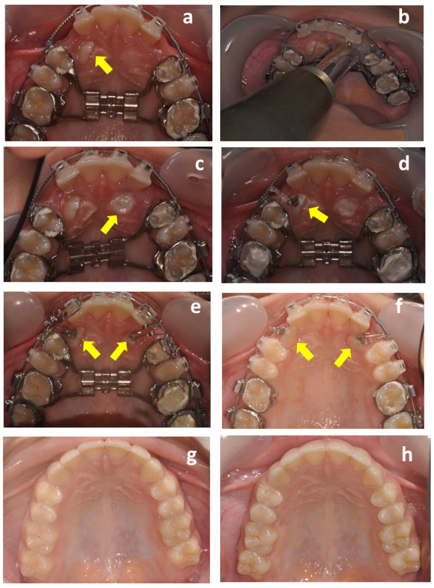

Figure 6. Ultrasound application, orthodontic traction and alignment of the maxillary canines, treatment outcome, and long-term follow-up (a–h). Details are provided in the text.

Treatment results

At completion of the 28-month active treatment period, both maxillary canines (teeth 13 and 23) were successfully aligned within the dental arch. The maxillary and mandibular arches were well coordinated, with satisfactory intercuspation and bilateral Class I molar and canine relationships. The severe deep overbite was corrected, and clinically acceptable overjet and overbite were achieved. Posttreatment extraoral and intraoral photographs demonstrated improvement in dental alignment, occlusal relationships, and smile esthetics (Figure 7).

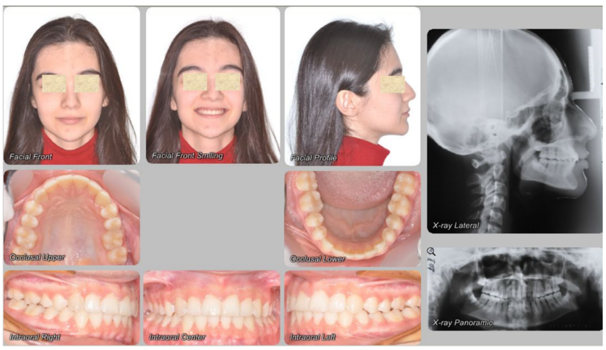

Figure 7. Posttreatment extraoral and intraoral photographs, panoramic radiograph, and lateral cephalogram

At the 4-year 9-month follow-up, the achieved treatment results remained stable, with maintenance of canine alignment, arch coordination, and satisfactory occlusal relationships. No clinically evident relapse was observed during the follow-up period (Figure 8). The cephalometric parameters obtained before treatment, after treatment, and at long-term follow-up are summarized in Table 1.

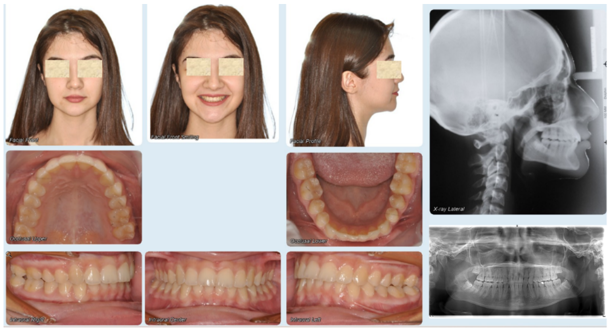

Figure 8. Extraoral and intraoral photographs, panoramic radiograph, and lateral cephalogram at the 4-year 9-month follow-up, demonstrating long-term stability of the treatment results.

Measurement	Unit	Norm	Pretreatment	Posttreatment	4-year 9-month follow-up	Clinical interpretation
Sagittal skeletal relationship						
SNA	°	82.0	81.0	81.1	81.0	Maxillary position relative to cranial base
SNB	°	80.9	77.0	78.1	78.0	Mandibular position relative to cranial base
ANB	°	1.6	4.1	3.0	3.0	Class II tendency present; improved after treatment
Wits appraisal	mm	−1.0	2.4	−0.4	0.2	Sagittal discrepancy normalized after treatment
APDI	°	81.4	77.9	82.2	79.9	Improvement of sagittal skeletal relationship
Vertical relationship						
ODI	°	74.5	80.8	70.6	72.5	Marked deep-bite tendency corrected and maintained
ODI + APDI	°	155.0	158.6	152.8	152.5	Combined vertical and sagittal assessment
Overbite	mm	2.5	7.1	1.5	2.2	Severe deep overbite corrected to acceptable range
Overjet	mm	2.5	1.8	2.8	2.4	Normalized to a clinically acceptable range
FMA (MP–FH)	°	23.9	15.0	16.9	13.8	Vertical skeletal pattern
MP–SN	°	33.0	27.2	31.7	28.2	Mandibular plane inclination
ML/NL	°	26.0	17.3	23.0	20.3	Intermaxillary vertical relationship
Incisor inclination						
U1–Palatal plane	°	110.0	85.1	116.0	114.9	Maxillary incisor retroclination corrected and maintained
IMPA (L1–MP)	°	95.0	76.0	102.2	109.9	Mandibular incisor retroclination corrected
Interincisal angle	°	130.0	179.3	118.9	114.5	Marked pretreatment increase reduced after treatment

Table 1. Cephalometric changes from pretreatment to posttreatment and long-term follow-up

Discussion

The principal scientific interest of the present case is the clinical course of two bilaterally impacted maxillary canines with different baseline radiographic characteristics, one of which was managed with adjunctive low-frequency ultrasound stimulation. Management of impacted maxillary canines requires careful three-dimensional assessment of canine position, creation and maintenance of adequate space, and controlled orthodontic guidance into the dental arch [1,6]. Although several adjunctive methods intended to facilitate or accelerate eruption and orthodontic movement have been investigated, the available evidence remains limited and heterogeneous, and apparent treatment effects should therefore be interpreted cautiously [14]. An important consideration is that the impacted canines were not anatomically equivalent at baseline. Tooth 13 had a more favorable position than tooth 23, with a smaller α-angle (30.1° vs 39.2°), a less mesial sector location (Sector 3 vs Sector 4), and a position closer to the occlusal plane. These features are associated with a more favorable eruption prognosis [7,15,16]. Tooth 13 subsequently erupted spontaneously without ultrasound stimulation, whereas the more deeply positioned tooth 23 showed no comparable clinical emergence. Low-frequency ultrasound was therefore applied only to tooth 23 as an adjunct to conventional treatment. Following the 10-session course, clinical emergence in the region of tooth 23 was observed, allowing subsequent orthodontic guidance into the dental arch.

Although the temporal association between ultrasound application and clinical emergence of tooth 23 is noteworthy, causation cannot be established. The protocol used in this case also differs substantially from conventional low-intensity pulsed ultrasound (LIPUS), which typically uses higher frequencies (~1.5 MHz), much lower intensities (~30 mW/cm²), pulsed delivery, and longer daily exposure [9,10]. Recent orthodontic studies of LIPUS have involved different devices, biological targets, and treatment settings and therefore cannot be directly extrapolated to the present protocol [17]. Moreover, current evidence on physical methods for accelerating maxillary canine retraction remains heterogeneous and of limited certainty [18].

Previous clinical-morphological observations by our group demonstrated epithelial and connective-tissue changes following low-frequency ultrasound exposure, suggesting that local tissue responses might facilitate clinical crown exposure [13]. In the present case, the clinical emergence of tooth 23 could have resulted from tooth movement, changes in the overlying soft tissues, conventional treatment, or a combination of these factors. However, the optimal exposure parameters and potential tissue effects of this device-specific protocol require further investigation.

At the 4-year 9-month follow-up, the principal sagittal, vertical, and dentoalveolar corrections were largely maintained. Only minor posttreatment changes were observed, including some additional proclination of the mandibular incisors. Clinical follow-up confirmed stable canine alignment and satisfactory occlusal relationships without clinically evident relapse.

Conclusions

Conventional management of palatally impacted maxillary canines generally involves surgical exposure followed by orthodontic traction. In this case, the two impacted canines followed different clinical courses. Tooth 13, which had a more favorable initial position, erupted spontaneously after space creation without ultrasound stimulation. Tooth 23 was positioned more deeply and showed no comparable clinical emergence; therefore, adjunctive low-frequency ultrasound was applied only to tooth 23. Clinical emergence was observed following the 10-session ultrasound course, after which both canines were guided into the dental arch using conventional orthodontic traction.

However, because ultrasound was used alongside comprehensive orthodontic treatment and no matched control or quantitative assessment of canine displacement was available, its causal or treatment-accelerating effect cannot be established.

Cephalometric analysis demonstrated improvement in the skeletal Class II relationship, severe deep overbite, and incisor inclination. At the 4-year 9-month follow-up, the principal sagittal, vertical, and occlusal corrections were largely maintained without clinically evident relapse.

Within the limitations of this case report, the observed clinical course suggests that adjunctive low-frequency ultrasound warrants further investigation as a potential supportive intervention in the management of impacted teeth. No causal relationship can be established from this observation alone, and further controlled studies are required to evaluate its effectiveness.

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Consent for Publication. Written informed consent for publication of the clinical data and the accompanying images was obtained from the patient and, at the time of treatment, from her legal guardian.

Conflict of Interest. The authors declare that there are no conflicts of interest regarding the publication of this paper.

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