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Original Article

Treatment Outcomes of Inversely Impacted Maxillary Central Incisors Using Surgical-Orthodontic Traction

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ABSTRACT

Aberrant positioning and displacement of the central incisor can disrupt the normal eruptive process. In general, inversely impacted maxillary central incisors do not undergo spontaneous eruption. Implementing traction and controlled extrusion for an inversely impacted maxillary central incisor displaying a high crown angulation angle poses substantial technical difficulty. The present study set out to explore whether orthodontic correction is feasible for severely inverted maxillary central incisors, drawing on case examples. Radiographic imaging quantified crown-axis angulation, root curvature severity, and the length of the already developed root. Surgical fenestration of the involved teeth was then performed, followed by traction delivered through a lingual arch appliance in combination with elastic forces. The average crown axis angulation reached 113°, the degree of root curvature was 97.3°, and root development stood at 36.1%. Even though crown axis inclination and root curvature were both markedly severe, every incisor was successfully moved into its proper location while retaining vitality, through coordinated surgical exposure and orthodontic forces. Orthodontic traction ought to commence during the incipient phase of incisor development, at a point when root formation has not yet advanced significantly, without regard to the presenting tooth angulation.

Keywords: Dilaceration, Maxillary central incisor, Inversely impacted, Orthodontic, Fenestration, Orthodontic traction

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Introduction

In pediatric dentistry practice, patients often present with primary concerns regarding eruption anomalies of the permanent dentition. Among such anomalies, the disordered emergence of the permanent central incisors is the most commonly encountered. These teeth may at times exhibit dilaceration and occupy an inverted, impacted position, a circumstance that precludes natural eruption [1]. Surgical approaches or transalveolar autotransplantation of impacted teeth have been documented within the literature [2-4]. One longitudinal appraisal of surgical repositioning reported a substantial incidence of major complications, a finding that has narrowed the scope of this modality for addressing impacted teeth [5]. Given this background, the two principal therapeutic pathways for this clinical entity are extraction with subsequent prosthetic rehabilitation, whether a bridge or an implant, versus fenestration coupled with orthodontic traction. Factors that guide treatment selection in these scenarios encompass the spatial positioning and orientation of the impacted tooth, the extent of root development and its curvature, and the sufficiency of arch space to accommodate the impacted tooth [6, 7]. Traction-based management is generally considered challenging for maxillary central incisors that are inversely impacted and present with pronounced crown-axis inclination or severe root curvature. In cases of such severity, extraction is often considered the preferred course. Certain orthodontic clinicians show reluctance to manage teeth with marked dilaceration, citing the potential for treatment failure owing to unfavorable sequelae, namely ankylosis, loss of periodontal attachment, external root resorption, and root surface exposure in the wake of orthodontic traction [7-9]. Should root exposure ensue, interventions such as endodontic treatment or apicoectomy may be indicated [7, 10]. That said, several case reports advocating a conservative treatment philosophy have been published [4, 11]. In more recent times, an expanding pool of clinicians has communicated successful results in cases featuring severely dilacerated teeth [1, 12]; yet, the bulk of such communications rest on solitary case reports, and consensus regarding a clear threshold for electing traction as the therapeutic option remains poorly delineated. With these considerations in mind, scrutinizing the interplay between the probability of treatment success and the variables that bear upon orthodontic outcomes through a case-series format proves valuable. In the current work, we describe three cases of orthodontic intervention addressing dilaceration and inversely impacted maxillary central incisors. We examine the related aspects of intervention timing, crown-axis inclination, and root curvature of the central incisor. A coordinated, multidisciplinary approach to managing impacted maxillary central incisors has achieved satisfactory aesthetic and functional outcomes.

Materials and Methods

The study enrolled patients aged 7–10 years who had been diagnosed with an inverted maxillary central incisor and referred to the Department of Pediatric Dentistry at Tohoku University Hospital. Patients afflicted with systemic disease or intellectual disability were excluded. The final number of subjects examined in this analysis totaled three ($n = 3$). Informed consent was obtained from the legal guardian of each enrolled patient. Measurements of crown axis inclination, root curvature, and root formation were derived from pre-treatment radiographic records, comprising lateral cephalograms or computed tomography (CT) acquisitions **(Figure 1)** [13]. After fenestration of the impacted central incisor, traction was provided with a lingual arch appliance and elastics, and the tooth was ultimately aligned with a multi-bracket orthodontic appliance. The duration of the overall orthodontic treatment, crown-axis inclination, root curvature, and root-formation parameters were examined for each case.

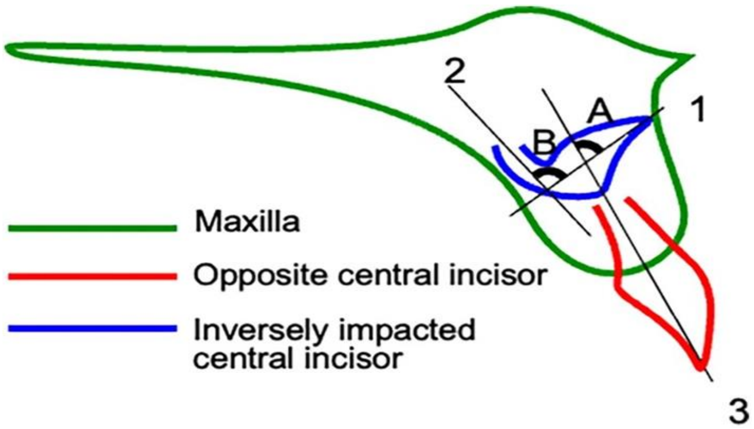


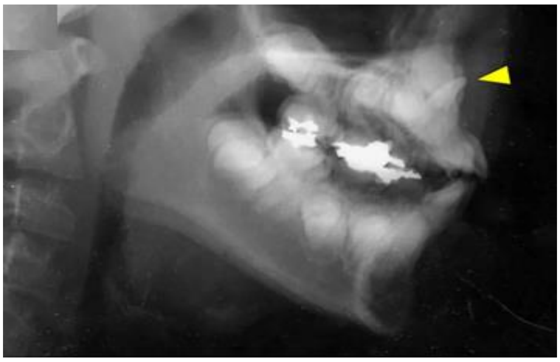
Figure 1. The angulation of the tooth crown axis, the amount of root bending, and the extent of root formation were all assessed from X-ray images. Lateral cephalometric radiographs obtained before treatment were used in the study. Three reference lines were plotted on these images: one for the crown axis (1) and another for the root axis (2) of the impacted central incisor, plus a third for the tooth axis (3) of the contralateral central incisor on the opposite side. The angle of crown axis inclination (A) was derived from the intersection where the crown axis of the impacted central incisor (line 1) meets the tooth axis of the opposing central incisor (line 3). The angle of root curvature (B) was measured using the divergence that separates the crown axis (line 1) from the root axis (line 2) of the same impacted central incisor.

Results and Discussion

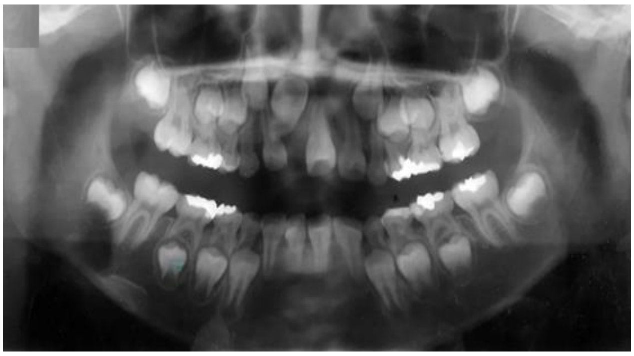
Case 1: a girl aged 9 years and 1 month

The patient attended our hospital for a thorough assessment and treatment of an impacted right maxillary central incisor. She had been under periodic observation by general dental practitioners (GDP), who flagged a delay in the emergence of the right maxillary central incisor. While the right maxillary lateral incisor had already broken through, the right maxillary primary central incisor remained unexfoliated, and the space available for its eruption was insufficient **(Figure 2a)**. The right maxillary primary central incisor bore composite resin fillings on its mesial and distal surfaces, suggestive of prior carious involvement. Whether any dental trauma or intrusive injury had occurred was uncertain. The right maxillary primary central incisor showed moderate mobility, and an abscess was present on its labial gingiva. On radiographic assessment, root resorption of the right maxillary primary central incisor extended to half the root length, with periapical periodontitis discernible around the root. The images revealed that the right maxillary central incisor was flipped upward and that its root curved in the direction of the right lateral incisor **(Figures 2b and 2c)**. The angulation of the crown axis reached 120°, root curvature measured 110°, and root formation was at the 1/2 stage. The left maxillary central incisor had nearly completed root formation. A minor delay in mandibular development was apparent on cephalometric evaluation (ANB = 6°). Moreover, both upper and lower incisor angulations were tipped labially (U1 to SN = 114°, L1 to Mand.Pl. = 102°). Study model analysis indicated a normal anterior occlusal relationship, a Class I first molar relationship bilaterally, and lingual positioning of the left maxillary lateral incisor. The maxillary arch length discrepancy (ALD) registered at −1 mm.

a)



b)



c)

Figure 2. The pre-treatment radiographic records for case 1: (a) Periapical film obtained at the first visit, (b) Radiograph taken along the sagittal plane. The red arrowhead pinpoints the inversely impacted maxillary central incisor, and (c) Panoramic image acquired after the removal of the upper right deciduous central incisor.

During the initial consultation, the right maxillary primary lateral incisor was removed. One month afterward, the right upper central incisor had yet to emerge **(Figures 3a and 3b)**. The following treatment step consisted of installing a lingual arch combined with a multi-bracket system across the upper arch. Surgical uncovering and application of traction to the dilacerated tooth were carried out two months after the extraction of the primary tooth. With the introduction of orthodontic forces, the space required for eruption was successfully restored **(Figure 3c)**. A window was surgically created, and a lingual button was bonded to the palatal aspect of the central incisor to exert traction at the two-month point of care **(Figure 3d)**. After six months of traction, the button was shifted to the labial surface, and traction was maintained **(Figure 3e)**. By the one-year mark, the right maxillary central incisor occupied a well-aligned position within the dental arch **(Figure 3f)**. A swelling on the labial gingiva, stemming from the curved root apex, was noticed beside the right maxillary incisor **(Figure 3g)**. Radiographic images captured at this time disclosed that the root length of the right maxillary central incisor measured roughly half of that seen on the left maxillary incisor **(Figure 3h)**. An intact lamina dura surrounded the right maxillary central incisor, and no periapical radiolucency was evident. Upon completion of orthodontic treatment, the dilacerated right maxillary central incisor remained vital. Over the subsequent four-year observation period, the root apex remained gingivally embedded, while the pulp remained vital. Both the clinical crown length and the gingival margin contour appeared within normal limits on the treated tooth.


a)


b)


c)


d)


e)


f)


g)


h)

Figure 3. The fenestration and traction intervention applied to the impacted tooth in case 1: (a) Frontal intraoral view obtained after the upper right primary central incisor had been extracted, (b) Occlusal perspective of the maxillary arch following removal of the upper right primary central incisor, (c) The lingual arch appliance is secured to the maxilla, (d) Beginning of the fenestration and traction protocol, (e) Condition six months after traction was initiated, (f) Condition one year after traction was initiated, (g) Condition noted during the retention period, and (h) Periapical radiograph of case 1 taken after treatment completion.

Case 2: a boy aged 7 years and 5 months

The patient presented to our hospital with the chief complaint that the left maxillary central incisor had not erupted within the expected timeframe. While the right maxillary central incisor had come in at 6 years of age, the left one had still not appeared. A panoramic image acquired at the general dental practitioner's office showed the left maxillary central incisor stuck in an inverted position. On examination, the right maxillary central incisor was nearly fully in place, yet both left maxillary primary incisors were still retained **(Figures 4a and 4b)**. These two deciduous incisors had received vital pulpectomy treatment and been rebuilt with composite resin on their palatal sides. The child and his parents possessed no clear recollection of any earlier dental trauma. Mobility of the primary teeth was graded as moderate, and an abscess was present at the apical gingiva of the left maxillary primary lateral incisor. A palatal elevation was evident, thought to correspond to the root of the left maxillary central incisor **(Figure 4b)**. The left maxillary primary canine was missing, either congenitally or for an unknown reason. Radiographs verified that the left maxillary central incisor was situated beneath the primary incisors, with its crown oriented superiorly **(Figures 4c and 4d)**. External resorption had affected the mesial and distal aspects of the roots of the left maxillary primary incisors, and a radiolucent area existed within the alveolar bone around those roots **(Figure 4d)**. The crown axis inclination was found to be 110°, root curvature was 112°, and the degree of root formation was approximated at one-third **(Figure 4e)**. Cephalometric tracing in the lateral view demonstrated a Class I skeletal pattern and an ANB angle of 6.2°. However, both jaws were slightly overgrown in the anteroposterior direction (A'-Ptm' = 46.1 > 1 S.D., Gn-Cd = 100.0 > 1 S.D.). The maxillary and mandibular central incisors both exhibited labial proclination (U1 to SN = 105°, L1 to Mand.Pl. = 93°). Cast analysis pointed to a normal degree of overbite, Class II molar occlusions bilaterally, and a positive ALD in both arches.

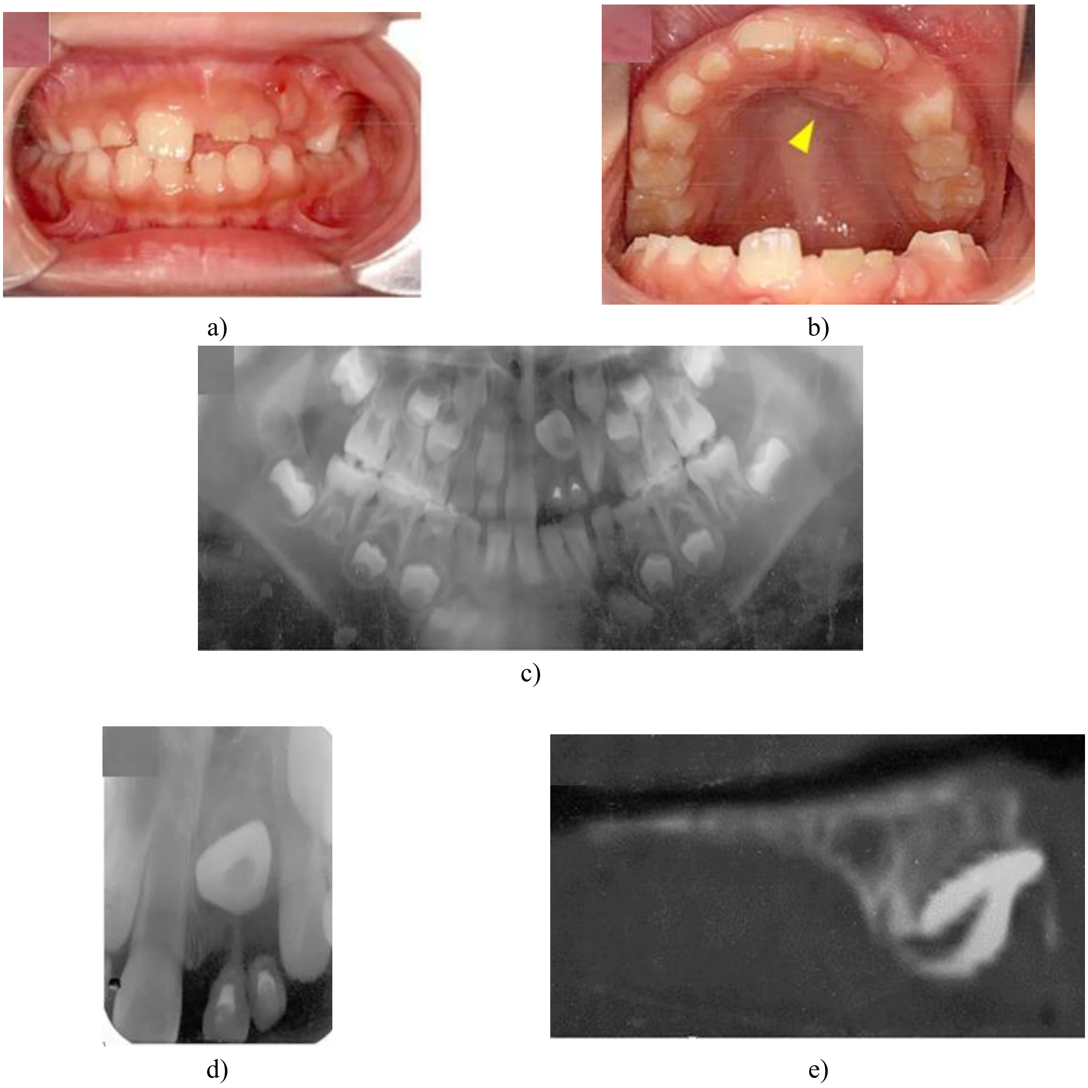


Figure 4. Intraoral photographs and radiographic images collected during the baseline evaluation of case 2: (a) Frontal intraoral perspective, (b) Maxillary occlusal intraoral perspective, (c) Panoramic x-ray, (d) Periapical x-ray centered on the left maxillary central incisor, and (e) Sagittal computed tomography (CT) cross-section of the left maxillary central incisor.

The initial treatment step involved removing both left maxillary primary incisors at the first visit. Four months after that, a lingual arch was fitted, and fenestration together with traction of the left maxillary central incisor was commenced **(Figures 5a and 5b)**. At the six-month point, the incisal tip of the impacted tooth became clinically detectable. The lingual button was then shifted onto the labial face, and traction was sustained **(Figure 5c)**. Following a total traction span of one year and five months, the left maxillary central incisor had been pulled into its proper position within the dental arch **(Figure 5d)**. A root bend was noticeable roughly at the halfway mark along its length, with elongation advancing toward the apex **(Figure 5e)**. Retention of the arch was subsequently initiated. The labial gingival margin had undergone recession, and the root curvature could be palpated beneath the labial alveolar mucosa **(Figure 5f)**. At this point, root formation on the left side was approaching completion, yet the curvature remained at the mid-root level **(Figure 5g)**. The root length of the left maxillary central incisor measured approximately four-fifths of that on the right. No indication of external root resorption was found, and the pulp remained vital. A slight midline diastema was observed, but the tooth remained vital 1.5 years post-treatment **(Figure 5h)**. Crown height showed a mild discrepancy between the two maxillary central incisors, while the alveolar bone height was essentially even.

a)

b)

c)

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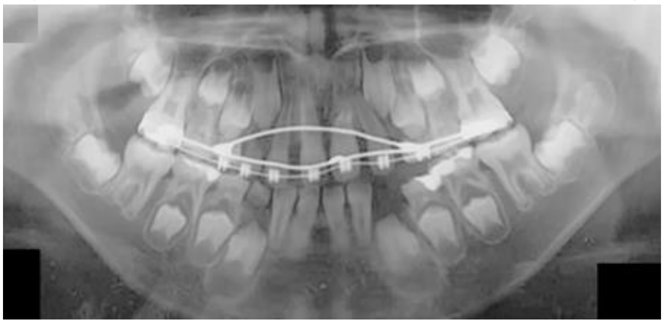

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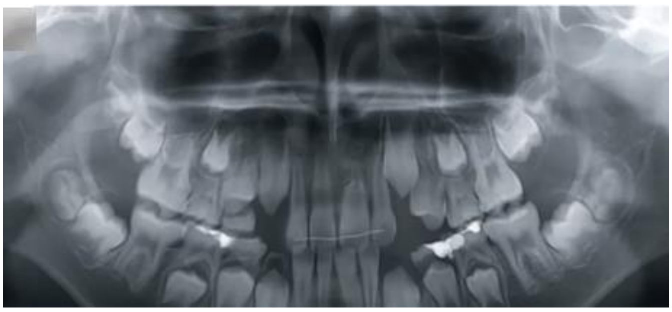


h)

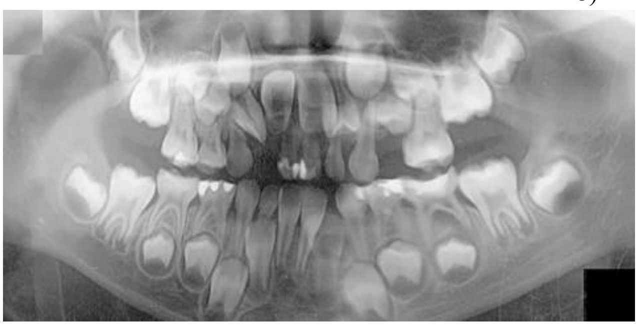
Figure 5. The stepwise progress of fenestration and orthodontic traction performed on the impacted tooth of case 2: (a) Frontal intraoral view obtained as fenestration and traction were launched, (b) Maxillary occlusal intraoral view obtained as fenestration and traction were launched, (c) Presentation six months after traction commenced, (d) Presentation one year and five months after traction commenced, (e) Panoramic radiograph taken upon completion of one year and five months of traction, (f) Presentation during the retention phase, (g) Panoramic radiograph recorded at the end of treatment, and (h) Presentation at one year and six months following the termination of treatment.

Case 3: a girl aged 7 years and 8 months

The child visited our hospital for assessment and care of an inversely impacted tooth in the right maxillary region. Radiographs originally taken at the GDP clinic for caries screening had unexpectedly disclosed an anomalous eruption trajectory of the right maxillary central incisor. No clear traumatic event could be recalled during history-taking. The left maxillary primary central incisor had composite resin fillings on both its mesial and distal surfaces and showed moderate looseness, consistent with an approaching exfoliation **(Figures 6a and 6b)**. A raised area was visible at the mucobuccal fold adjacent to the right maxillary primary central incisor, likely representing the incisal edge of the buried right maxillary central incisor **(Figure 6a)**. The panoramic view confirmed that the crown of the right maxillary central incisor faced upward and that the corresponding lateral incisor was rotated **(Figure 6c)**. Periapical films illustrated roughly 50% root resorption of the left maxillary primary central incisor, whereas the root of the right primary central incisor showed no such loss **(Figure 6d)**. A distinct radiolucent lesion was not appreciated around the left maxillary primary central incisor. Crown axis inclination equaled 109°, root curvature measured 70°, and root formation had not yet reached one-quarter of completion **(Figure 6e)**. All cephalometric and model analyses were unremarkable and within standard values.

a)

b)



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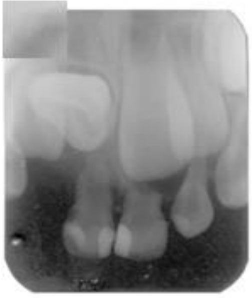


d)

e)

Figure 6. Pre-treatment intraoral and radiographic materials collected during the initial evaluation of case 3: (A) Frontal intraoral perspective, (B) Maxillary occlusal intraoral perspective, (C) Panoramic x-ray, (D) Periapical x-ray focused on the right maxillary central incisor, and (E) Sagittal computed tomography (CT) cross-section of the right maxillary central incisor.

The right maxillary primary lateral incisor was taken out, and a lingual arch appliance was fitted to the maxilla two months later, coinciding with the start of fenestration and traction for the right maxillary central incisor **(Figures 7a and 7b)**. By the three-month mark of traction, the right maxillary central incisor lay in a horizontal plane. The lingual button was then transferred to the labial aspect, and traction was maintained **(Figure 7c)**. Substantial improvement in tooth axis was evident after eight months of traction **(Figure 7d)**, and once the maxillary incisors had emerged, full alignment was undertaken with a multi-bracket setup **(Figure 7e)**. Two years after traction was initiated, the right maxillary central incisor had been drawn into the arch, though a degree of labial gingival recession remained apparent **(Figure 7f)**. Radiographs revealed that the root of this tooth had adopted a sigmoid curvature **(Figures 7g and 7h)**. No periapical radiolucency could be discerned around the root. Alveolar bone height was unremarkable, yet the gingival margin contour lacked symmetry between the right and left incisors.

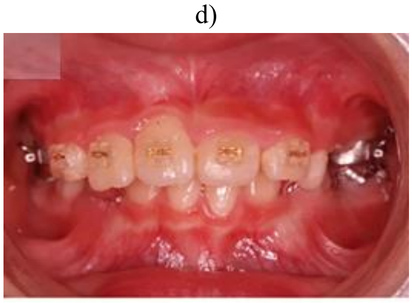
a)

b)

c)

d)

e)



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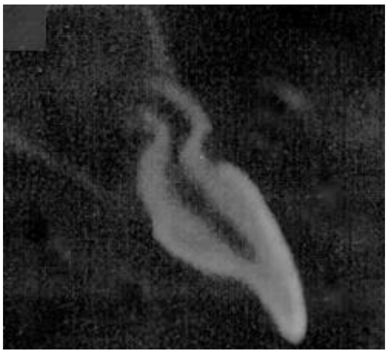

h)

Figure 7. Chronological documentation of the fenestration and orthodontic traction executed for the impacted tooth in case 3: (a) Frontal intraoral photograph taken at the initiation of fenestration and traction, (b) Maxillary occlusal intraoral photograph taken at the initiation of fenestration and traction, (c) Condition at three months into traction, (d) Condition at eight months into traction, (e) Condition at one year and six months into traction, (f) Condition at two years into traction, (g) Periapical radiograph recorded at the two-year time point of traction, and (h) Sagittal computed tomography (CT) section of the right maxillary central incisor at the two-year time point of traction.

The characteristics of inversely impacted teeth in all cases

The three patients had a mean age of 8 years and 1 month **(Table 1)**. The average crown-axis inclination was 113°, indicating a position tilted beyond the horizontal. Root curvature averaged 97.3°, representing a bend sharper than a right angle. Root formation averaged 36.1%, meaning less than half of the roots had developed. The mean treatment duration was 1 year and 6 months.

Table 1. Condition of the maxillary central incisor in each case and duration of treatment.

Case	Age (years)	Extent of root formation	Degree of root curvature	Crown axis inclination	Duration of treatment
Case 1	9 years 1 month	50%	110°	120°	1 year 1 month
Case 2	7 years 5 months	33.3%	112°	110°	1 year 5 months
Case 3	7 years 8 months	25%	70°	109°	2 years 0 months
Mean value	8 years 1 month	36.1%	97.3°	113°	1 year 6 months

Dilaceration may arise in both the permanent and primary dentitions, yet its occurrence in primary teeth is infrequent [14]. Reported prevalence rates for maxillary central and lateral incisors are 0.4% and 1.2%, respectively [15]. Crown dilaceration in a permanent tooth constitutes 3% of all traumatic insults to developing teeth and generally results from intrusion or avulsion of the overlying primary predecessor [16]. The developmental window during which injury occurs governs how dilaceration presents in the succeeding permanent tooth [17]. The traumatized Hertwig's epithelial root sheath continues to deposit dentin at the same velocity as before the insult. Hence, the definitive root contour of a permanent maxillary central incisor traces an uninterrupted labial arc until apex closure is achieved [18]. In addition, Hertwig's epithelial root sheath stays lodged within the alveolar bone, withstanding the eruptive thrust of the developing tooth and steering the direction of root growth. Consequently, the crown of the permanent central incisor shifts labially and superiorly for as long as uneven root calcification persists [18]. In cases 1 and 2, a radiolucent region surrounded the root of the preceding primary tooth, implying an inflammatory periapical condition of the primary central incisor that triggered dilaceration of its permanent replacement. In case 2, the left primary central and lateral incisors were both pulpless, and the left primary canine was already gone by the first visit. These dental signs hint at a prior traumatic episode that could have instigated the dilaceration. In case 3, no periapical pathology was detected in relation to the right primary central incisor, and the history of past injury was vague at the time of the history-taking. The GDP had extracted a right maxillary primary lateral incisor due to excessive mobility; the cause of that mobility, however, was not determined. Periapical disease was therefore considered a likely culprit.

Some management pathways exist for dilacerated teeth: (i) surgical removal of the dilacerated tooth with preservation of the gap for a bridge or implant; (ii) surgical removal of the dilacerated tooth combined with orthodontic gap closure and prosthetic reshaping of the lateral incisor; (iii) in situ surgical rotation to reposition the dilacerated tooth; (iv) orthodontic traction of the dilacerated tooth into correct alignment, with or without orthodontic space opening [19]. Orthodontic traction offers several advantages: it preserves the natural tooth, obviates the need for future restorations or implants, safeguards alveolar bone dimensions in the anterior region, and optimizes the aesthetic outcome [12]. In the present work, these therapeutic options were presented to patients and their guardians, and orthodontic traction was chosen as the preferred initial approach. Although every one of our cases succeeded in shepherding the dilacerated tooth into the arch with pulp vitality intact, attempting traction on a severely dilacerated tooth remains technically challenging. Patients must be informed beforehand that the pulp may become non-vital during traction, possibly necessitating an apicoectomy, and that, should traction fail, extraction of the dilacerated tooth may become the fallback plan [7]. In our series, the teeth remained vital during treatment; however, a labial bony prominence was noted in some cases. Protracted follow-up of pulpal status after traction of a dilacerated tooth is essential. Our cases employed an open-eruption surgical technique, prized for the convenience it affords during traction. On the other hand, a certain unevenness of the gingival margin was observed following orthodontic alignment of the dilacerated teeth. While such gingival discrepancies may correct with symmetry as the alveolar bone matures, the closed-eruption surgical technique may yield a superior aesthetic outcome [18].

With respect to orthodontic traction of dilacerated teeth, the literature highlights several variables as influential in securing a favorable prognosis: (i) where the impacted tooth is situated, (ii) how far root formation has progressed, and (iii) the angles formed by the root and crown axes [4, 6, 7, 20, 21]. Traction is typically considered a feasible option only when the root inclination remains below 90° [15]. In a handful of circumstances, a rotational surgical procedure is performed to improve this angle [19, 22, 23]. By contrast, deliberate extraction and replantation of a dilacerated tooth is not advised, given that removal can be technically demanding and may split the already curved root [24]. Because root dilaceration channels occlusal forces into the periodontium in a concentrated fashion, a dilacerated tooth pressed into service as a prosthetic abutment runs a greater chance of fracture. As an alternative, splinting such an abutment may be worth weighing in selected situations [25]. These various strategies offer ways to enhance orthodontic management [26-29]. Crown height, the crown-root angle, and the child's age are thought to affect treatment duration [20, 30, 31]. Reports of failed traction in dilacerated teeth tend to cluster around a shared set of circumstances: older age, male gender, impaction high in the maxilla, atypical root resorption, and an inability to improve position due to ankylosis [32, 33]. In our series, case 1 presented with a crown-axis inclination of 120° and root curvature of 110°; case 2, with 110° and 112°; and case 3, with 109° and 70° **(Table 1)**. Traction was predicted to be difficult in each, yet fenestration and traction were chosen over extraction. Ultimately, every impacted, dilacerated tooth was successfully brought into the arch. In cases 1 and 2, the angulated root could be felt under the labial soft tissue **(Figures 3f and 5f)**, whereas in case 3, the root could not be palpated through the mucosa but displayed a sigmoid-shaped bend. All three dilacerated teeth tested vital at the conclusion of care. At the point traction was initiated, root formation had reached one-half in case 1, one-third in case 2, and less than one-quarter in case 3, meaning every child had an immature root **(Table 1)**. Shi *et al*. [21] have suggested that starting traction before age 10 is associated with better outcomes. In the present cases, all patients were indeed under 10 when traction commenced. Moreover, immature roots are generally considered to have a better prognosis during traction because of their generous blood flow and vigorous alveolar bone remodeling [4, 34]. Despite the flexure, root elongation continued in cases 2 and 3, demonstrating that the traction process did not halt root development. Apart from pulp canal obliteration, yellowish or grayish discoloration of the crown and pulp death may also be encountered after traction of dilacerated teeth [35]. The root curvature seen in case 3 was likely shaped by the steep crown axis inclination (109°), even though very little root had formed. This suggests that at the beginning of traction, the extent of root curvature can be influenced by both the crown axis inclination and the amount of root that has already formed. These two baseline parameters appear central to whether traction succeeds or fails [4, 6, 7, 21].

In every case, a button was bonded to the lingual face of the uncovered tooth, and traction was exerted via a lingual arch and elastics. The lingual button remained in place for 6 months in case 1, 8 months in case 2, and 3 months in case 3 before being switched to the labial side. After correction of the crown axis, an additional year (case 1) and 1 year and 5 months (case 2) were required to bring the tooth into the arch. Case 3 spanned two full years because a waiting period for incisor eruption was included. One prior study reported a mean treatment time of 21.6 ± 8.7 months, associated with the vertical position of the tooth [32], while another documented 9 months of traction and 21 months of total treatment [32]. The traction speed attained in our three cases was therefore consistent with these benchmarks.

These outcomes suggest that the decisive consideration in selecting a treatment path for an inversely impacted maxillary central incisor is not the anticipated complexity of traction, but whether the tooth can function satisfactorily afterward. The likely determinants are the severity and depth of the root curvature. For this reason, once dilaceration is diagnosed, steps should be taken before the root becomes excessively curved and drifts higher in the alveolus. Early identification is key, particularly when the overlying primary tooth has suffered trauma or undergone endodontic therapy. Given the potential for an abnormal eruption pattern, the permanent incisor region should be closely monitored from roughly age 6. Any left-right disparity in the timing of permanent tooth eruption should raise suspicion of an aberrant eruption path and prompt a radiographic workup.

This study's limitations are as follows: (i) the sample was small and narrow in its age spread; (ii) because all treated teeth had incomplete roots, comparison against success rates in cases with fully formed roots is still needed. Collecting a larger number of cases for future analysis is essential.

Conclusion

In the three cases presented, the maxillary tooth that was inversely impacted was successfully aligned orthodontically. All dilacerated teeth remained vital and carried on with root development, although in select instances a labial gingival bulge was noted at the apical region of the incisor after treatment. Additionally, early treatment allowed redirection of the root's developmental axis. These observations support the view that early traction applied during dilaceration is associated with a favorable prognosis. When an inversely impacted incisor comes to light, traction should be instituted at the earliest opportunity, before root formation has progressed considerably, irrespective of the crown axis inclination or root curvature measurements.

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Ethics Statement: The studies involving humans were approved by the Tohoku University Graduate School of Dentistry Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

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