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CASE REPORT

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Digital-assisted diagnosis and orthodontic management of an impacted mandibular lateral incisor: a case report

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Abstract

Background The impaction of mandibular lateral incisors presents significant aesthetic and functional challenges in orthodontics, including Bolton ratio discrepancies and anterior occlusal anomalies. The increasing preference for nonextraction treatment further complicates space management within the dental arch. However, the advent of digital-assisted orthodontic technologies, particularly advanced digital simulations, has revolutionized the precision and effectiveness of diagnosis and treatment planning. These technologies enable clinicians to strategically leverage natural jaw development and create the necessary space for the alignment of impacted teeth without resorting to extraction.

Case presentation This case report details the treatment of a 12-year-old male with an impacted mandibular lateral incisor, which resulted in both aesthetic concerns and functional impairments, alongside Class II malocclusion. By employing a digital-assisted diagnostic approach, including comprehensive digital simulations, we meticulously evaluated the feasibility of a nonextraction treatment plan. The strategy centred on harnessing the patient's mandibular growth potential to expand the available space naturally. The treatment involved surgical exposure of the impacted tooth, followed by precise orthodontic traction guided by continuous digital monitoring. The integration of digital tools throughout the treatment process was crucial in achieving successful eruption and alignment of the impacted tooth, thus restoring optimal aesthetics and function without the need for extraction.

Conclusion This case highlights the transformative impact of digital-assisted technologies in the management of complex orthodontic cases, such as impacted mandibular lateral incisors. The successful integration of these advanced tools with a nonextraction treatment approach underscores their potential to significantly enhance clinical outcomes. Digital technologies not only improve the accuracy and effectiveness of treatment but also facilitate a multidisciplinary approach that elevates the standard of patient care in addressing complex orthodontic challenges.

Keywords Impacted incisor, Orthodontic traction, Root curvature, Digital-assisted diagnosis

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Background

The failure of an impacted tooth to erupt in its normal position during tooth eruption for various reasons (e.g., impaction by alveolar bone, fibrous tissue, or other teeth) is known as impaction, which can occur in any tooth with a high prevalence of 2.0–14.4% (excluding the third molar) [1–4]. Incisors play a crucial role in the stomatognathic system and are a significant factor in facial aesthetics and harmony. However, local or systemic factors may also cause impaction of incisors, resulting in craniomandibular aesthetics and dysfunction. According to previous studies, the rate of mesial incisor occlusion in the upper jaw is between 0.06% and 0.2% [5, 6], whereas mandibular incisor occlusion is even less common. Altered incisor eruption can cause significant concern for patients. A correct diagnosis of incisor impaction and a clear understanding of its prognostic implications are necessary to design an appropriate treatment plan.

The aetiology of incisor impaction includes increased resistance to eruption due to factors such as trauma to the deciduous teeth, abnormal local mucosal density, and neighbouring ectopic teeth. Furthermore, tooth impaction may also be caused by pathological systemic diseases, supernumerary teeth, cysts and tumours [7–10]. Among these morphological abnormalities, root dilaceration is the most common. This condition not only increases the complexity of treatment but also poses risks of complications such as root resorption and root exposure following orthodontic traction. Particularly during treatment, when the root apex comes into contact with the labial cortical bone, controlling torque becomes more challenging, further complicating the treatment process [11, 12].

The most common treatments for incisor impaction are guided forced eruption, extraction of the impaction, and orthodontic space closure. Given that impaction typically occurs in younger patients, any postextraction restorative measures are generally provisional and must be followed by permanent restoration once the patient reaches maturity. During this interim period, significant alveolar bone loss at the extraction site may occur, which not only complicates subsequent restorative procedures but also potentially hinders the effectiveness of orthodontic space closure [11, 12]. Therefore, clinicians generally prefer the former approach, which considers the preservation of tooth structure, alveolar bone width achieved through force-induced bone regeneration, overall periodontal health, and aesthetic benefits. Patients often desire to retain impacted teeth and restore them to their original position [12–14].

This clinical case illustrates the complex decision-making process and therapeutic strategies involved in managing a rare case of mandibular lateral incisor impaction with associated class II malocclusion and facial proclination. Preoperative digital simulation plays a crucial role in determining the feasibility of guided eruption, ultimately leading to successful treatment outcomes. This case highlights the effectiveness of a combined approach involving guided eruption surgery and orthodontic treatment, resulting not only in successful repositioning of the impacted tooth but also in significant improvements in the patient's facial aesthetics and overall oral health.

Case presentation

Diagnosis and aetiology

A 12-year-old male patient sought orthodontic treatment due to concerns about insufficient lip closure and a protrusive mouth. The patient had a history of childhood chin and dental trauma, although the details were unclear and reported a habit of mouth breathing.

The intraoral examination revealed disturbed tooth eruption with tooth 32 absent, a 5 mm deep overbite, an 8 mm overjet, a 2 mm space in the mandibular dentition, a bilateral Class II canine relationship, a left Class III molar relationship, and a right Class I molar distal relationship (Fig. 1). Facial analysis revealed that the patient had a symmetrical facial profile with a convex facial contour, prominent upper lip, a receding chin, and incomplete lip closure. Panoramic radiographs and CBCT confirmed the vertical impaction of tooth 32; digital reconstruction with Mimics and Geomagic revealed that the crown of tooth 32 was positioned distally, with the apical third of the root also curving distally at nearly a 90° angle from the long axis and a hypodense area around the crown indicating a follicular cyst. No significant root resorption was noted on tooth 31, and the root of tooth 33 was incompletely formed. In the upper jaw, tooth 25 was located palatally and twisted 55.3° away from its normal position in the upper jaw (Figs. 2 and 3). Cephalometric analysis revealed a depression of the lower margins of the second and third cervical vertebrae and a transformation of the third and fourth cervical vertebrae from a horizontal trapezoid to a horizontal rectangle, indicating the CS3 to CS4 stage of cervical maturation and suggesting that the patient was at the peak of their growth spurt with significant growth potential. The upper anterior teeth were inclined anteriorly, with a combined saddle angle, joint angle, and mandibular angle of 395.21° and a normal S-Go/N-Me ratio, indicating an average growth pattern, whereas the OP-FH angle was reduced, and the occlusal plane angle was low (Fig. 2 and Table 1).

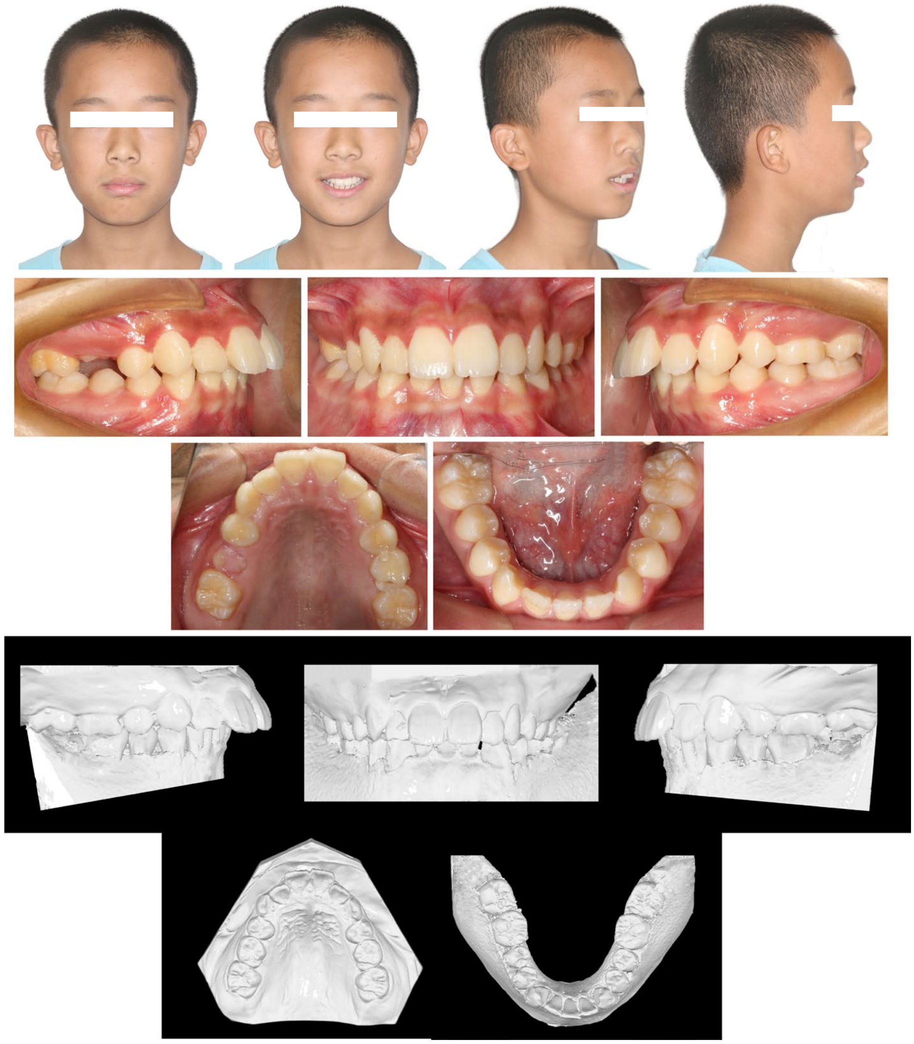

Fig. 1 Pretreatment facial, intraocclusion and dental model photographs

Treatment objectives

1. Levelling and aligning the dental arches while correcting individual tooth rotations.
2. Managing the impacted mandibular incisor to establish an optimal occlusal relationship.
3. Leveraging the patient's growth potential to promote mandibular advancement and improve the soft-tissue profile.
4. Maintaining the upper midline and adjusting the lower midline as needed.
5. Achieving a stable and functional occlusion.

Treatment alternatives

1. For the mandible:

The key to the mandibular treatment plan lies in whether to retain or extract tooth 32. Therefore, the patient and his parents were given the following options on the basis of the treatment objectives. The first option was as follows:

1) Space expansion and an attempt to induce eruption of the impacted tooth:

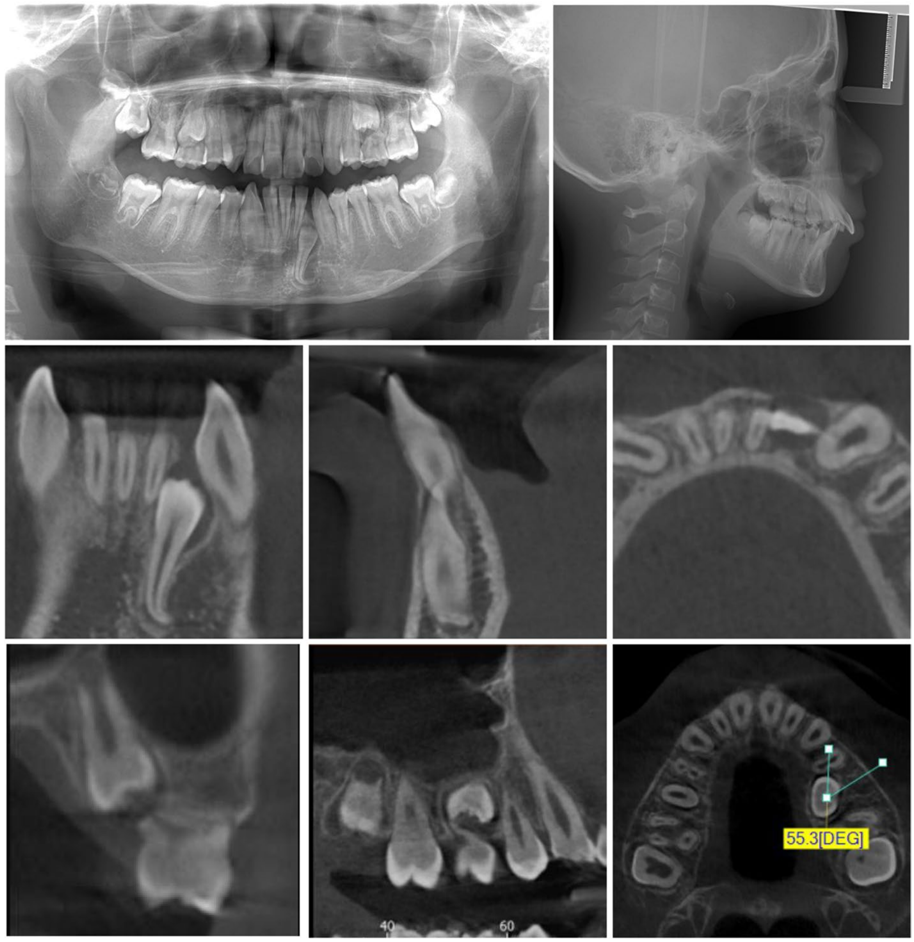

Fig. 2 Pretreatment records: (**A**) Dental panoramic X-ray view, (**B**) Lateral cephalography, (**C**) Three-dimensional imaging of impacted lateral incisors, (**D**) Three-dimensional imaging of impacted premolars

Preserving the width of the alveolar bone surrounding the impacted tooth is crucial [7, 15]. Facilitating the natural eruption of the impacted tooth aligns best with the physiological principles of tooth movement. However, this approach poses certain challenges, including a prolonged treatment duration, the necessity for interdisciplinary collaboration, and potential issues related to crown and gingival aesthetics. Selection of the surgical exposure technique and the direction of orthodontic traction must be approached with great care [16]. To evaluate the feasibility of guided eruption for tooth 32, a digital simulation of tooth arrangement and a comprehensive space analysis were conducted: DICOM data obtained from the patient's preoperative CBCT scan were directly imported into Mimics software for modelling. Surface models of the left mandibular lateral incisor and the mandibular segment were extracted and subsequently imported into Geomagic Studio, a specialized reverse engineering software, for smoothing and refinement, resulting in a detailed three-dimensional representation of the morphology and spatial orientation of tooth 32. The root of tooth 32 exhibited a 90° curvature, indicating vertical impaction, with no significant contact between the root and adjacent teeth. The literature [17] suggests that the greater the crown–root curvature angle, the greater is the treatment difficulty. Curvatures near the cervical region present substantial challenges, whereas those near the root are considered less problematic. Overall, the difficulty of inducing eruption for this impacted tooth is moderate, but there is a potential risk of root resorption during the eruption process. By measuring the width of tooth 32 in the 3D model and calculating the space required for its alignment within the dental arch, we utilized the Invisalign alignment tool to simulate the space needed for alignment and levelling, which fell within our estimated growth potential (Figs. 3 and 4 and Table 2).

2) Surgical extraction of the impacted lateral incisor with subsequent orthodontic space closure or restorative treatment:

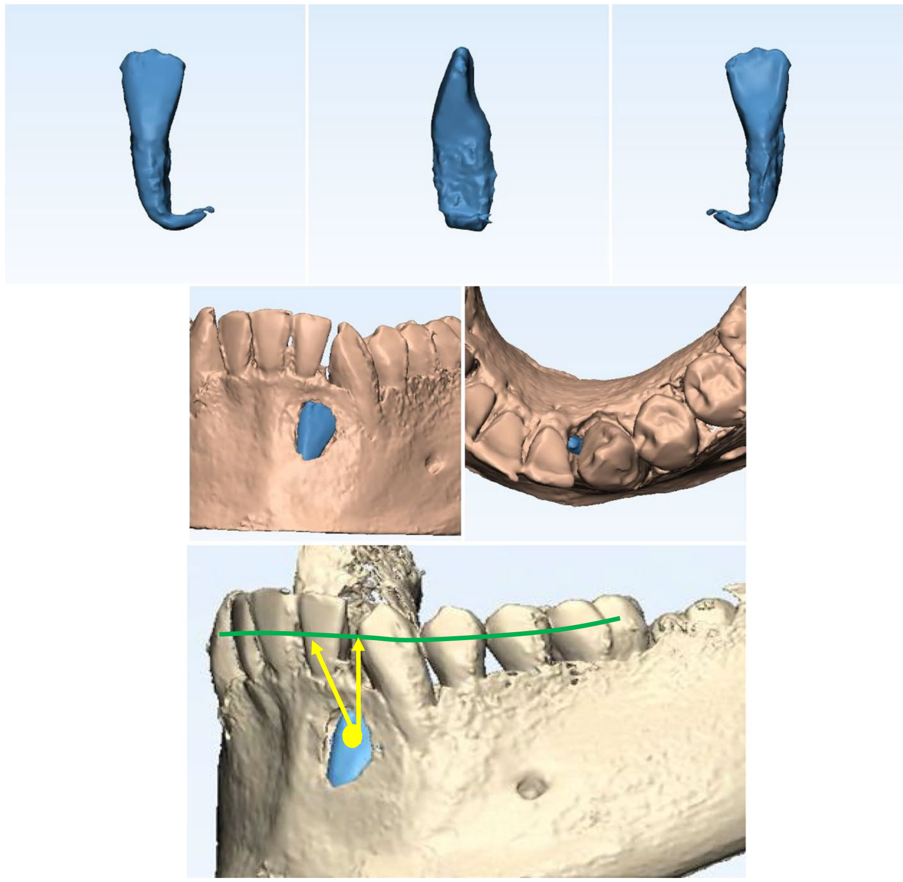

Fig. 3 Pretreatment digital simulation of the mandibular left lateral incisor

This treatment approach offers a shorter duration; however, direct space closure fails to address the Bolton discrepancy of the anterior teeth. Posttreatment, there may be a misalignment of the upper and lower dental midlines, and the vertical proclination of the lower anterior teeth may exacerbate the deep overbite, all of which are disadvantageous for the patient. Restorative treatment would need to be delayed until the patient reaches maturity, and the prolonged absence of the tooth could lead to alveolar bone resorption, potentially resulting in further aesthetic challenges in the future.

2. For the Maxilla:

Maxillary expansion: The patient had a deep overbite, deep overjet, and incomplete lip closure, which required retraction of the upper anterior teeth. To prevent further deepening of the overjet, the upper anterior teeth should be tilted and intruded appropriately. The GALL line was used as a reference, and the upper anterior teeth were retracted by 1 mm while being intruded by 3°, requiring approximately 4 mm of space. With mild crowding in the upper dental arch and a rounded canine arch shape, expanding the width between the upper canines could provide approximately 3 mm of space for the anterior teeth. The patient had 0.9 mm of space due to the unshed left second deciduous molar, resulting in a total of approximately 4 mm of space. In such cases, enamel stripping may be necessary.

In summary, after considering the above options, the patient and his parents elected to pursue guided eruption of tooth 32 combined with maxillary expansion.

Treatment progress

The patient was treated with 0.020×0.025-inch brackets, and the arch was sequentially replaced with nickel–titanium (NiTi) wires ($0.012-0.018$-inch NiTi, $0.016\times0.022-0.019\times0.025$-inch NiTi) for alignment and levelling. The arch was stabilized with 0.019×0.025 stainless steel wires. A spring was added to widen the space between teeth 24 and 26. After eruption of tooth 25, brackets were attached to the buccal side, and an elastic rubber chain was used to suspend the wire. Lingual side brackets were bonded to teeth 24

Table 1 Cephalometric data

Measurement	Chinese Norm	Pretreatment	Posttreatment
SNA(°)	82.8±4.0	79.5	81.4
SNB(°)	80.1±3.9	75.7↓	78.8
ANB(°)	2.7±2.0	3.8	2.6
Wits (mm)	-1.0±1.0	1.5	-0.9
MP-SN(°)	32.5±5.2	35.5	34.0
MP-FH(°)	29.1±4.8	25.9	25.8
OP-FH(°)	14.2±3.7	8.2↓	8.3↓
NA-PA(°)	7.5±4.6	7.4	2.9↓
NP-FH(°)	84.4±2.7	85.7	88.3↑
Y-Axis(°)	65.8±3.1	61.0↓	61.5↓
N-S-Ar(°)	125.7±4.7	121.7	119.0↓
S-Ar-Go(°)	148.3±5.7	154.2↑	154.5↑
Ar-Go-Me(°)	123.8±4.9	119.2	120.6
ANS-Me/N-Me(%)	55.0±3.0	53.8	55.3
S-Go(mm)	78.0±5.0	72.3	84.5↑
S-Go/N-Me(%)	65.0±4.0	63.9	66.7
U1-SN(°)	105.7±6.3	108.0	105.1
U1-NA(°)	22.8±5.7	28.5	23.6
U1-NA(mm)	5.1±2.4	7.6	5.3
L1-NB(°)	30.3±5.8	28.3	27.1
L1-NB(mm)	6.7±2.1	5.4	5.0
L1-MP(°)	96.9±6.0	97.0	95.8
U1-L1(°)	124.2±7.3	119.3	125.1
UL-EP(mm)	1.0±2.0	0.5	-0.7
LL-EP(mm)	2.0±2.0	2.8	0.7
Nasolabial angle	53.6±4.7	40.5↓	49.6

Table 2 Digital simulation of mandibular tooth movement

Tooth	Elongation (E)/Intrusion (I), mm	Relative Elongation/Intrusion, mm	Overall Movement Buccal/Lingual	Mesial/Distal Overall Movement	Rotation (M/D)	Axial Inclination (M/D)	Tilt (B/L)
4.7	0.8 E	1.6 E	0.2 L	3.1 D	14.1 D	16.2 D	2.1 B
4.6	0.1 I	0.5 E	0	2.3 D	5.3 M	7.8 D	0.4 L
4.5	0.8 E	1.6 E	0.3 B	2.2 D	1.3 M	10.4 D	2.0 L
4.4	0.5 E	0.7 E	0	2.2 D	0.6 D	1.0 M	2.5 B
4.3	0.7 I	0.3 I	0.4 B	2.5 D	11.4 M	0.9 M	3.7 B
4.2	0.3 I	0	0.2 L	3.1 D	0.2 M	5.9 D	1.0 B
4.1	0.8 I	0.1 I	0.4 L	3.0 D	6.3 D	8.0 D	0.9 L
3.1	0	0.4 E	0.4 L	2.6 M	5.2 M	10.7 M	0.1 L
3.2	/	/	/	/	/	/	/
3.3	0.8 E	1.3 E	0.9 B	2.9 D	20.0 M	1.4 D	7.5 B
3.4	1.0 E	1.6 E	0.5 B	2.8 D	14.2 D	8.0 D	1.4 B
3.5	0	1.1 E	0.6 B	2.6 D	12.5 D	12.3 D	2.1 L
3.6	0.2 I	0.6 E	0	2.6 D	6.1 M	4.3 D	0.4 B
3.7	1.3 E	2.5 E	0.2 L	3.6 D	8.4 D	6.0 D	4.2 B

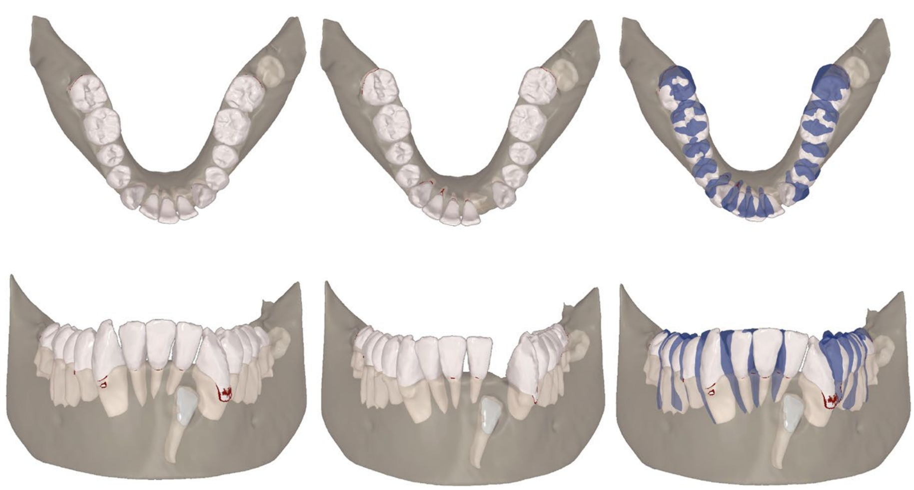

Fig. 4 Digital simulation of mandibular space expansion and tooth movement overlap diagram

and 25, and an elastic rubber chain was used to connect the lingual side clasps. An '8' ligature was used for the teeth 23 and 24 brackets to provide traction to correct the twist in tooth 25. After replacement with a 0.019 × 0.025 stainless steel wire, Class III plastic traction (5/16, 4.5 oz) was added between teeth 16 and 43 and between teeth 26 and 33, pulling teeth 33 and 43 towards the distal centre. To achieve the desired space, a push spring was inserted and maintained between teeth 31 – 33. Apical radiographs of tooth 32 were taken every 3–6 months to monitor for signs of eruption. After approximately 1 year of space expansion, tooth 32 reached the subgingival position with an encapsulated low-density shadow around the crown (Fig. 5). This phenomenon indicated an incomplete resorption of the capsule, resulting in a lack of eruptive force. To facilitate eruption, the cystic sac was cleaned, and the crown of tooth 32 was exposed on the labial side, with a lingual clasp bonded to the tooth. Approximately 60–90 g of elastic traction was added to the affected tooth while maintaining the position of the push spring. Continuous light traction was applied to the crown of the impacted lateral incisor, resulting in eruption at approximately crown 4/5. The buccal tubes were bonded to teeth 17, 27, 37, and 47, and a nickel–titanium round wire was used for alignment. When gingival recession was observed on tooth 32, the bracket on tooth 32 was counterbonded, and the axial inclination of the root was adjusted (Fig. 5). In the mandible, a 0.016 × 0.022-inch stainless steel square wire was used in combination with a portal auxiliary arch to correct the torque of the affected teeth (Fig. 5). Fine adjustments were made by closing small openings in the premolar region via triangular traction at teeth 34, 35, 44, and 45. The patient achieved a Class I relationship between the canines and molars on both sides, with the upper and lower midlines essentially in the centre. The maxillary and mandibular clear retainers were left in place after the fixed orthodontic appliances were removed. A postoperative impression was obtained, and medical advice was provided.

Treatment results

Following treatment, the deep overbite and overjet were resolved, resulting in bilateral canine and molar neutral relationships with the upper and lower midlines centred. Tooth 32 was correctly positioned, showing gingival recession up to the cervical third, a probing depth (PD) of 3 mm, and partial exposure of alveolar bone. The teeth remained intact without significant tenderness, percussion pain, or mobility. These features prompted a referral to periodontics for consultation. The soft tissue profile was deemed favourable. Additionally, the treatment improved the width of the anterior and middle segments of the upper dental arch without significantly altering the posterior segment, which transitioned the arch form from pointed to ovoid, providing the necessary space. The distal movement of the lower canines resulted in an increased width of anterior segment 4 of the lower dental arch. As a result of growth potential, the middle and posterior segments widened posttreatment, ensuring that the upper and lower arch widths were harmonized. Panoramic radiography and postoperative CBCT revealed that the roots were parallel. Tooth 32 had a blunted root, a large apical foramen, and root resorption up to the apical third, but there were no signs of inflammation or discontinuities in the periodontal ligament. Postoperative CBCT revealed symmetrical

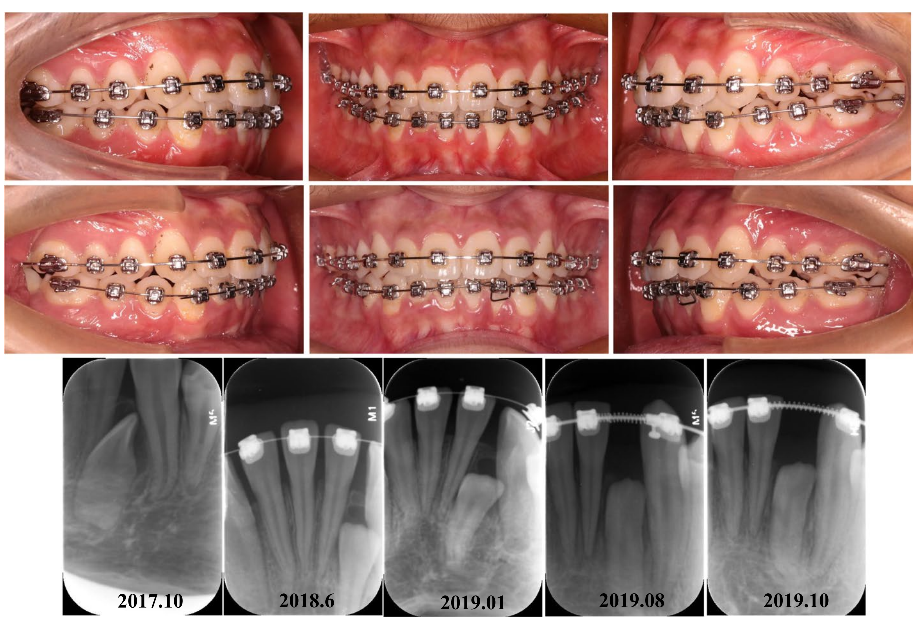

Fig. 5 **A** Intratreatment intraoral conditions. **B** Impacted lateral incisor periapical radiograph images

temporomandibular joint spaces, with no significant narrowing or widening observed. The condylar morphology appeared normal, with no evidence of bony destruction or abnormal proliferation (Fig.S.1). The superimposed cephalometric images demonstrated forward and downward mandibular growth, which improved the mandibular retrusion and soft tissue profile, indicating successful treatment outcomes (Figs. 6, 7 and 8).

Discussion

1. Possible aetiology of lateral incisor impaction

Since the patient was in the mixed dentition period at the time of consultation, information about the deciduous dentition could only be obtained by direct inquiry from the patient. Therefore, we could only analyse the possible aetiology of the patient's lateral incisor impaction. The patient denied any history of systemic underlying disease or medication. Imaging findings did not reveal any abnormally dense bone or low-density mass interfering with eruption. The clinical examination also did not reveal a nonpathologic source of soft tissue thickening interference.

Typically, after birth, the permanent tooth germ is positioned within a bony depression beneath the root of the deciduous tooth, encased by the dental sac tissue. The tooth germ remains in this location until approximately three-fourths of the root development is completed, at which point it breaks through the dental sac and begins

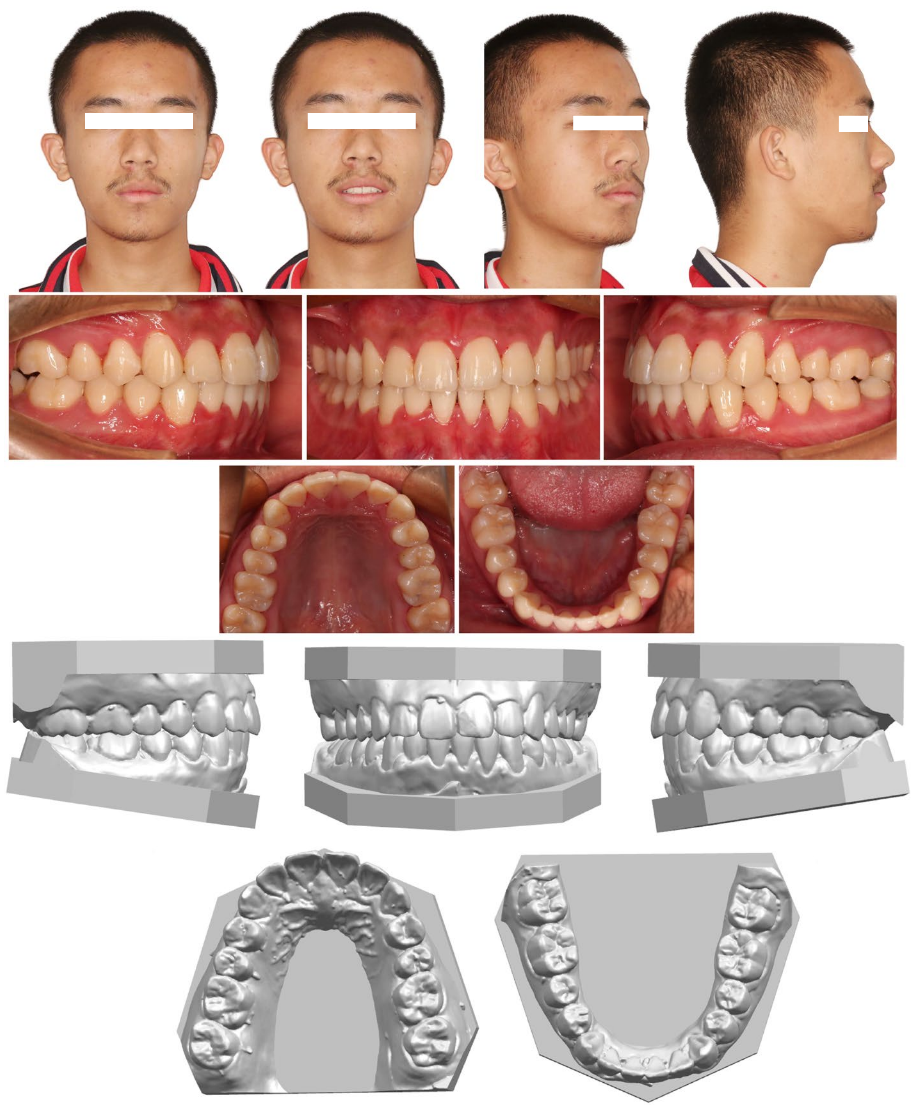

Fig. 6 Posttreatment facial, intraocclusion and dental model photographs

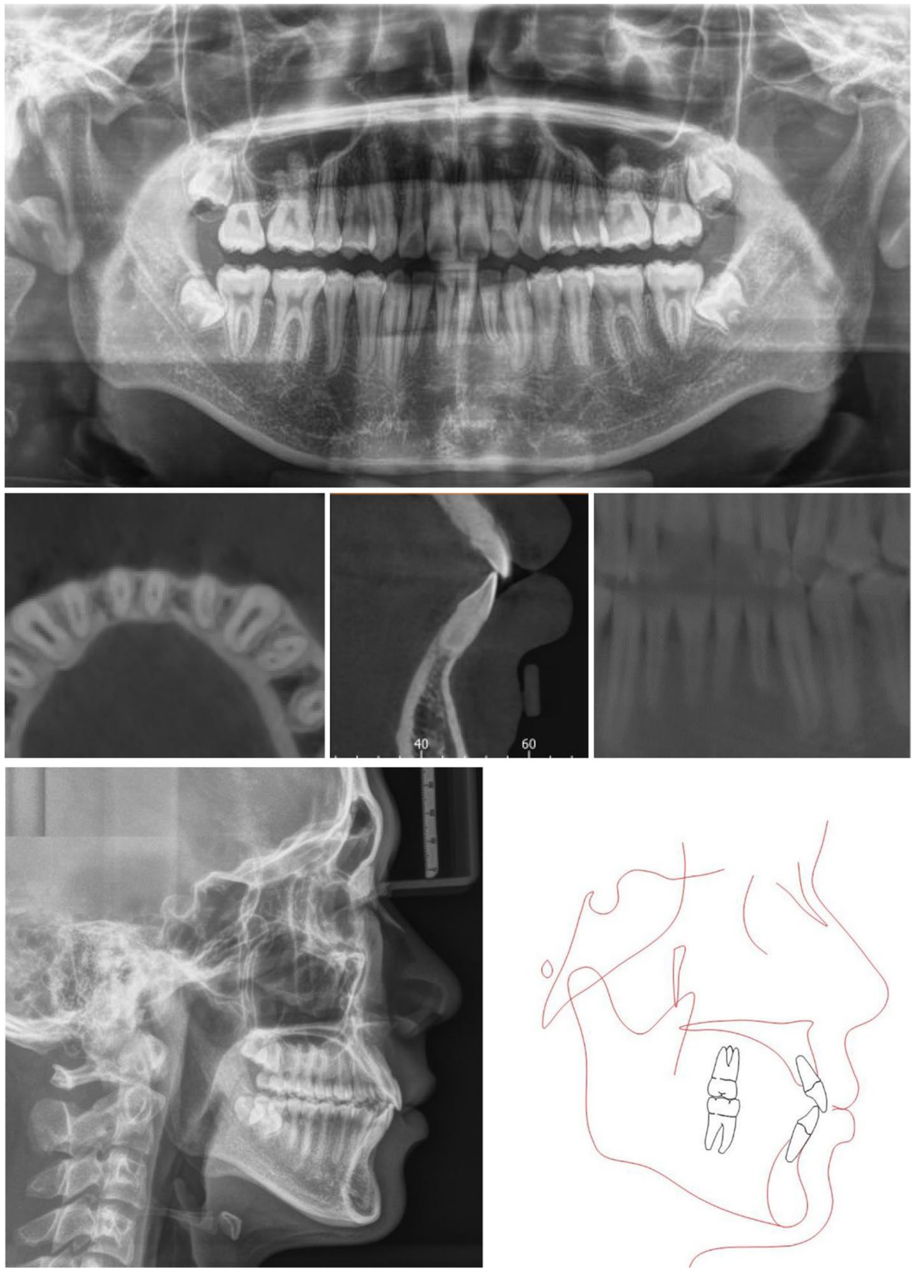

Fig. 7 Posttreatment records: (**A**) Dental panoramic X-ray view. **B** Three-dimensional imaging of the impacted lateral incisor. **C** Lateral cephalography and lateral cephalometric tracing

to erupt, usually around the time the child reaches school age [18–20]. During this process, any inflammation of the root caused by caries or the impaction of deciduous teeth can exert abnormal pressure on the permanent tooth germ, leading to alterations in the anatomical morphology of the developing permanent dentition [21–23]. Notably, the patient reported a history of chin and dental trauma in childhood, although the details were unclear, and minor changes in the dental arch may not have been noticed by the patient or their parents. However, abnormal impact forces could have displaced the tooth germ to an abnormal position or angle, obstructing its normal eruption path and potentially leading to impaction. The panoramic radiograph revealed a curved root of the impacted lateral incisor in this patient. When the developing tooth germ is subjected to sustained mechanical forces beyond its tolerance, it can result in an abnormal tooth morphology. The rigid crown structure may deviate

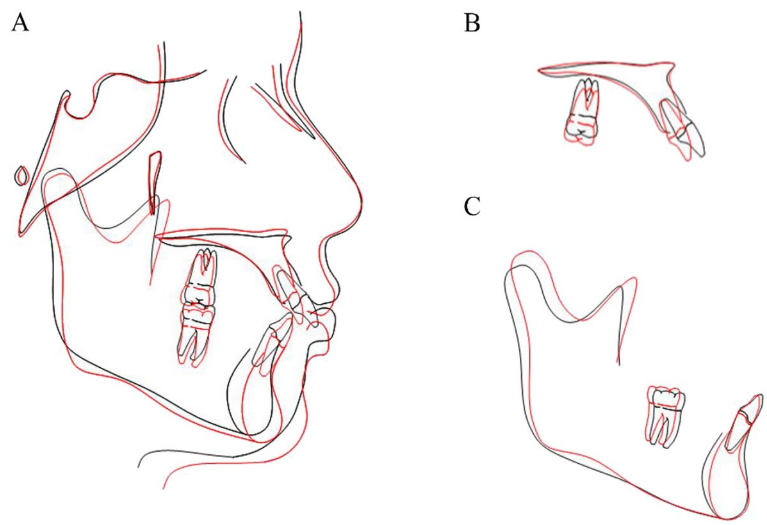

Fig. 8 Pretreatment (black) and posttreatment (red) cephalometric superimposition images

from the normal eruption axis, causing deformation of the elastic dental apical complex tissues, which histologically include Hertwig's epithelial root sheath, the apical papilla, and the surrounding dental follicle, ultimately leading to partial root curvature [24].

2. Treatment strategy: space expansion and growth patterns

The primary consideration for this patient was the source of the space. Since the patient's scattered mandibular pretreatment spaces did not match the width of the blocked teeth, proper spaces had to be obtained through molar distalization or mandibular arch expansion. According to growth and development studies [25, 26], development of the cuspal interdental width of the mandibular dental arch stops at approximately 11 years of age, but the available space in the posterior segment of the dental arch increases by 1.45 mm per year in boys younger than 17 years of age. The development of the cuspal interdental width of the mandibular teeth in this patient was almost complete, and the posterior segment of the mandibular dental arch still had more available space.

When performing space analysis, it is important to consider vertical dimensions in addition to sagittal and horizontal space expansion. Considering that this was a normodivergent case, the total Jarabak angle [27] was within the normal range, and the direction of mandibular growth was normal. Control of the vertical orientation can be slightly relaxed. According to Sato et al. [28], in the growing facial skeleton, the vertical height of the maxillary teeth determines the position of the occlusion plane, whereas the growth of the maxillary alveolar bone determines the inclination of the occlusion plane, and a gently sloping posterior occlusal plane of the maxilla facilitates the development of the mandible in a counterclockwise direction. In this case, we used elastic Class III traction to distally move the cuspids to gain clearance while elongating the upper molars to guide the maxillary posterior occlusal plane to flatten, which helped the mandible grow in the correct direction and lift the deep overlay of the occlusion; the side effect force of proximocentral movement of the 26 teeth generated by elastic traction was offset by the push springs between teeth 24 and 26. During the alignment phase, we corrected the axial inclination of the upper anterior teeth, and with further development of the mandible, the patient's mouth and lips were able to close, and the side effect of lip inclination of the anterior teeth produced by elastic traction was counteracted by the strong functional orthodontic forces generated by the lip and buccal muscles. Scattered spaces were present in the lower anterior teeth, and the push springs did not cause lip tilt in the lower anterior teeth; during the space creation phase, we added a small amount of the rocking chair type to the upper and lower archwires to depress the anterior teeth and maintain the anterior torque (Fig. 8).

By leveraging digital technology, we can accurately assess the available space in the patient's mandibular arch and precisely measure the width of the impacted tooth and the required space through three-dimensional simulation. This process allows us to predict whether future growth will provide adequate space. Additionally, the 3D simulation provides a clear visualization of the morphology of tooth 32 and its relationship with adjacent teeth, helping to identify the path of least resistance and to optimize the direction of traction. When formulating the treatment plan, the 3D model and digital simulation also enable patients and their families to better understand the proposed treatment, aiding those without a medical background in comprehending the treatment process and the rationale behind decision-making.

3. Treatment strategy: timing of treatment

The success of treatment for an impacted tooth depends on the position of the tooth, the degree of root curvature, the timing of treatment, the available space in the dental arch, and the activity of the Hertwig epithelial root sheath [22, 29]. According to the literature [30, 31], even when the root of an impacted tooth is fully developed and the resistance from the crown is reduced, there is still a tendency for the impacted tooth to erupt upwards, and the earlier the intervention on the impacted tooth, the more likely it is to erupt naturally. According to Baccetti T-modified cervical spine analysis [32], this patient was at the peak of growth and development in the CS3-CS4 stage, with high growth potential, and because the impacted tooth was curved in the proximal apical 1/3 and vertically impacted, it was a moderately difficult curved tooth [33–35]. Therefore, there is a certain possibility of inducing natural eruption of the impacted tooth, but resorption is likely to occur when the curved root is extruded by the alveolar bone. During the induction process, forceful intervention on the impacted tooth should be as little as possible to increase the likelihood of natural eruption and to promote the formation of normal keratinized gingiva [7]. If there is no significant change in the position of the blocked tooth within six months of the induction intervention, excessive resistance to eruption should be considered, and traction treatment should be used instead. Although the preinduction intervention in this case brought the blocked tooth to the subgingival level, there was still no significant change at six months, and it was hypothesized that the capsule was encircling the crown of the blocked tooth, resulting in the inability to continue erupting; therefore, we surgically exposed the blocked tooth, bonded a small traction device, and increased traction to assist in eruption.

4. Treatment strategies: biomechanics and complications

During traction, the blocked teeth were subjected to upward and forward forces due to the buccal position of the orthodontic archwires. Although we used light force traction, unavoidable root resorption and gingival recession occurred postoperatively (Fig. 5).

The process of orthodontic tooth movement is accompanied by continuous remodelling of the root-surface cementum, and when the orthodontic force or resistance is too high, the cementum resorption is greater than the restoration, and irreversible defects appear on the root surface of the tooth [36, 37]. Sameshima concluded that a malformed root morphology increases the risk of root resorption during the treatment process [38]. The recommended force to move an impacted tooth is between 60–100 g [39]. We used a force of 60–90 g for pulling, but the force exerted on the affected tooth was a continuous traction force, and the anatomical morphology of the affected tooth itself may have been the trigger for root resorption. Nevertheless, the treated impeded tooth had an acceptable crown-to-root ratio, although the root apex was rounded, and it still exhibited good retention with no associated endodontic symptoms.

The uneven thickness of the bone wall around the root may cause the gingiva of the affected tooth to be inconsistent with the height of the healthy tooth, as it is impossible to ensure that the direction of traction of the impacted tooth exactly matches the position of the impaction during traction of the tooth out of the alveolar bone [40]. In the present case, the upward-forward traction resulted in loss of the buccal bone wall of the affected tooth and gingival recession of the affected tooth. To solve this problem, we counterbonded the brackets on the affected teeth and used aussie wire to fabricate a torque ring to assist in applying lingual torque force and alleviate the problem of gingival recession on the impacted teeth. Although there was still some degree of gingival recession after surgery, postoperative CT revealed that the buccolingual bone plate of the blocked tooth was within the acceptable range. We recommended that the patient undergo gingival soft tissue surgery, which the patient declined. Long-term follow-up observation of this affected tooth is necessary.

5. Treatment strategy: treatment risks to consider for impacted teeth

If guided eruption of the impacted tooth fails, surgical transplantation is an option. While transplantation can occur before or after full root development, studies indicate that fully developed roots may require endodontic treatment but do not worsen the prognosis [41]· However, male patients might have lower success rates because of greater occlusal forces [42]. Transplanting a tooth with a curved root complicates root canal treatment and often requires multidisciplinary care, leading to uncertain outcomes.

Alternatively, extraction followed by space expansion and later implant or restorative treatment is feasible, although implants generally have lower survival rates and higher risks of peri-implant mucositis in comparison to natural teeth [43, 44]. Long-term implant use may cause loosening of adjacent teeth, periodontal disease, and aesthetic issues while also being less effective in maintaining the alveolar bone volume. In this case, removing the impacted tooth and closing the space via posterior tooth movement would likely result in significant Bolton ratio discrepancies. Additionally, some of the upper anterior dental tissues might need to be sacrificed to improve the occlusal relationship and the soft-tissue profile, thereby introducing further disadvantages for the patient.

Conclusion

A successful treatment plan was developed using digital simulation of the mandibular lateral incisor. Posttreatment imaging confirmed that the impacted tooth was in a satisfactory final position, the arch space was effectively utilized, and biomechanical forces were managed strategically to facilitate eruption of the tooth and maintain the stability of adjacent teeth.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-024-04902-6.

Supplementary Material 1.

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Authors' contributions
JC and SC contributed equally to conceiving the case report focus, acquiring the case data, conducting the case report, summarizing the manuscript, writing the first draft, and finalizing the manuscript; LC, XY, XD, and ZD contributed to the acquisition and analysis of case data; LX designed and directed the case report and played a pivotal role as a guiding factor in executing the treatment for this case.
All the authors have read and agreed to the final version of the manuscript.

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Availability of data and materials
All the data generated or analysed during this study have been incorporated into this published article.

Declarations

Ethics approval and consent to participate
The authors declare that written informed consent was obtained from the patient for the publication of this case report, and this case report was approved by the Biomedical Research Ethics Committee of the Affiliated Stomatology Hospital of Fujian Medical University (2020-IRB-040).

Consent for publication
Written informed consent was obtained from the patient for the publication of this case report and any accompanying images, and the patient expressed the hope that her information would benefit others.

Competing interests
The authors declare no competing interests.

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