In situ rotation surgery for correction of growing, inversely impacted maxillary central incisors

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Treatment of an impacted incisor with a dilacerated root is challenging for clinicians because of the position of the impacted incisor, the abnormality of the root, unfavorable prognosis, and, especially, the long treatment duration. We report on 2 young patients who had inversely impacted maxillary central incisors with developing labially dilacerated roots. Both patients were treated by a novel surgical approach, in situ rotation, by which the crowns of the inversely impacted incisors were carefully rotated to a relatively normal position, whereas the apical location remained relatively unchanged. About 2 weeks after surgery, spontaneous eruption of the treated incisors was observed. Three months later, the postoperative central incisors were further aligned into the maxillary arch with a fixed orthodontic appliance. Follow-up visits 2 or 3 years after surgery indicated that the positions of the dilacerated incisors maintained stability with good gingival esthetics, and the pulpal vitality was favorable. The roots grew further in a relatively normal direction of the incisor's longitudinal axis, which was different from the initial curvature angle. Moreover, with the in situ rotation surgery, treatment time was greatly reduced and resulted in a favorable prognosis compared with conventional treatment. (Am J Orthod Dentofacial Orthop 2021;159:536-44)

The prevalence of impacted maxillary central incisors is reported to be between 0.06%[1] and 1.4%.[2] Although the exact causes of tooth impaction are not fully clear, studies have indicated that some systemic and/or local factors might be related to it. Systemic (general) factors refer to Cleidocranial Dysplasia, Gorlin syndrome, endocrine disorders, and so on. Local factors include supernumerary teeth, odontoma, cysts, ankylosis, and trauma to the deciduous predecessors.[3,4] The central incisor impaction not only influences the patient's appearance, speech, and chewing function but also tends to affect the eruption and position of the adjacent teeth,[5,6] resulting in unfavorable occlusion and interproximal caries.

Interestingly, most impacted central incisors have crown or root dilacerations,[1] and dilaceration is considered as the most common cause leading to impacted central incisors.[2] The most common direction of a dilacerated maxillary central incisor is that the crown directs upward and labially with the root curving in a labiolingual direction.[7] Although the cause of root dilaceration is still unclear, studies have suggested some potential causes. For example, in the development of the permanent incisor, the direction of the crown changes because of trauma to the primary predecessor. However, the Hertwig's epithelial root sheath (HERS) of the permanent incisor remains in the original position and guides the root dentin as it would have before the trauma. As a result, further root development continues in the previous direction, which is different from the affected and

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shifted crown. This creates an unusual angle between the 2 parts of the tooth, preformed calcified tissue and uncalcified tissue, which results in local curvature of the longitudinal axis of the permanent incisor, leading to dilaceration.[8,9]

Treatment of the impacted dilacerated incisors is a clinical challenge because of the impaction position, which is not easy to handle, the abnormal morphology of the root, and the long treatment duration.[6] The conventional treatment is a 2-stage therapy. First, the crown is surgically exposed, then followed by orthodontic traction.[10] This kind of treatment is generally successful, but it has some shortcomings. The whole treatment process is time-consuming, and the method is technically complicated.[11] Moreover, some complications, such as ankylosis, can occur during orthodontic traction.[8,12] As a result, these kinds of impacted incisors sometimes need to be extracted or autotransplanted. Tooth extraction for young patients or adolescents always leads to local alveolar bone resorption, which may severely influence future prosthodontic rehabilitation or implantation.[13] Autotransplantation surgery may cause deformation of the impacted incisor root, such as pulp calcification and a narrower root canal.[14]

In this report, the authors describe a novel treatment option for the inversely impacted maxillary central incisor with dilacerated root in 2 mixed-dentition patients. After surgical exposure of the impacted central incisor crowns, the incisal edge was rotated gently and carefully to the relatively normal position, whereas the apex of the root remained almost unchanged. With this immediate reposition surgery, not only did the impacted incisor erupt spontaneously, but also the dilacerated roots continued to develop, and the growth pattern changed to a relatively normal path.

CASE REPORTS

Patient 1 was an 8-year-old girl with a complaint of an unerupted maxillary right central incisor. The intraoral examination showed that the maxillary right central incisor had not erupted (Fig 1, *A* and *B*). The panoramic radiograph and spiral computed tomographic (CT) images showed that the maxillary right permanent central incisor was impacted with an incisal edge in an upward direction (Fig 1, *D-F*). The longitudinal axis of the impacted crown was tilted labially over 90°. The root was developing toward the cervical third. An angle between the crown and root had formed, and the root dilacerated labially (Fig 1, *F*). Based on her mother's statement, the patient was healthy without any systemic disease. The patient was diagnosed with maxillary right permanent central incisor inverse impaction with a dilacerated developing root.

The patient and her parents were informed of several treatment options. The first was to extract the impacted maxillary right central incisor and install an implant or

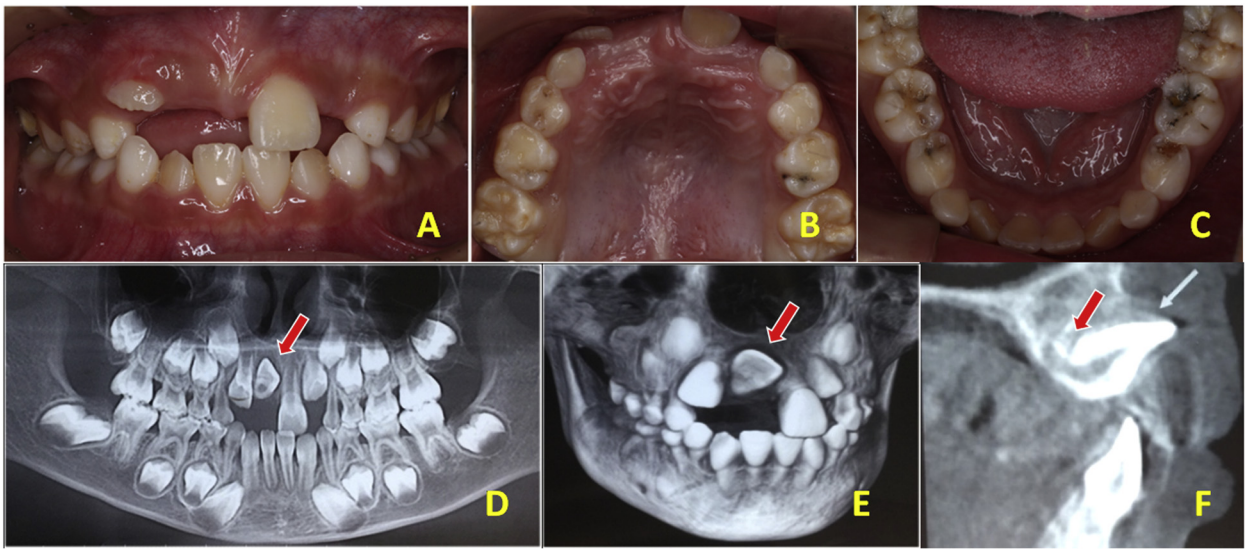

Fig 1. The intraoral and radiographic examinations for patient 1. The maxillary right central incisor was unerupted **(A, B)**. The condition of mandibular teeth and dentition was showed (**C**). The panoramic radiograph **(D)** and spiral CT images **(E)** showed that the maxillary right central incisor was impacted, and the crown rotated upward (**D, E**; *red arrow*). The long axis of the crown was tilted labially over 90°, and the root started to dilacerate labially (**F,** *red arrow*).

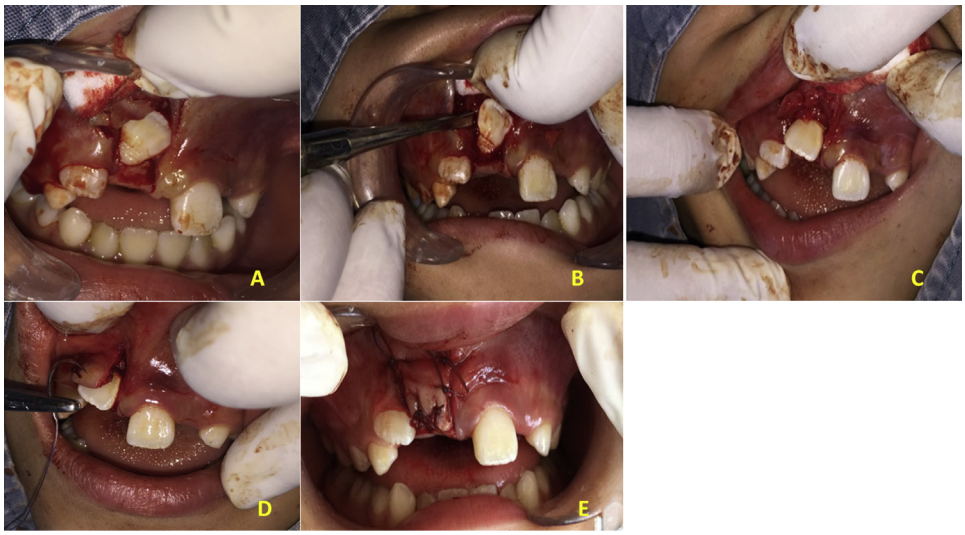

Fig 2. The procedure of the in situ rotation surgery for the impacted dilacerated incisor. The palatal side of the impacted incisor crown was totally exposed **(A)**. The incisal edge was gently turned downward **(B)**. The crown was rotated down more than 90° to the relatively normal position **(C)**. The flap was repositioned and sutured **(D, E)**.

fixed prosthetic when the patient was mature. The second was to extract the impacted incisor, align the maxillary dentition, and redistribute the space using fixed orthodontic appliances. Then, the maxillary right lateral incisor and canine would be managed with prosthetic restoration to replace the central incisor and lateral incisor. The third was surgical exposure and orthodontic traction, which would be time-consuming. The fourth was in situ rotation surgery followed by orthodontic alignment. The parents wished to bring out the impacted incisor and save time, so they chose the fourth treatment option.

SURGICAL PROCEDURE

The surgery was performed under local anesthesia. A midcrestal incision was made within the keratinized gingiva at the edentulous alveolar ridge corresponding to the impacted incisor. The incision was extended to the vestibular groove between the maxillary right lateral incisor and left central incisor. A full-thickness flap was then raised labially to gain access to the impacted incisor. The very thin labial cortical bone tissue was carefully removed to avoid any damage to the impacted incisor. After the palatal surface of the impacted incisor was exposed clearly (Fig 2, *A*), the incisal edge was gently, slowly, and carefully rotated downward to the relatively normal position with an osteotome or an elevator (Fig 2, *B*). It was critical to maintain the apical area of the root as a pivot point, as much unchanged as possible, during the entire rotation surgery. Then, the rotated incisor was in a relatively normal position (Fig 2, *C*) with labial-palatal and mesial-distal mobility. The flap was repositioned and sutured with resorbable sutures (Fig 2, *D* and *E*).

ORTHODONTIC TREATMENT

After 2 weeks, the operated incisor erupted spontaneously, and the incisal edge was exposed inside the oral cavity (Fig 3, *A*). Three months later, the rotated incisor erupted further, and there was no special mobility (Fig 3, *B*). Then, the orthodontic treatment was accomplished with a fixed appliance (Fig 3, *C*). The maxillary right central incisor was moved into a normal position after 4 months (Fig 3, *D*). The total treatment time was about 7 and a half months. On the completion of treatment, the radiographic examination indicated that a continuous elongation of the dilacerated root was present, and the root was dilacerated again (Fig 3, *F* and *G*). Based on the spiral CT image, it was observed that the root was growing, but not along the previous curved direction (Fig 3, *H*). The developing root was in a relatively normal direction in accordance with the longitudinal axis of the erupted crown (Fig 3, *H*). No alveolar bone resorption was observed around the 2 dilacerations. The presence of lamina dura surrounding the entire tooth socket of the incisor was identified on the spiral CT image. After orthodontic treatment, the patient wore a clear retainer for 1 year.

TREATMENT RESULTS

The treated incisor was routinely examined clinically for eruption status, mobility, and electric pulp testing,

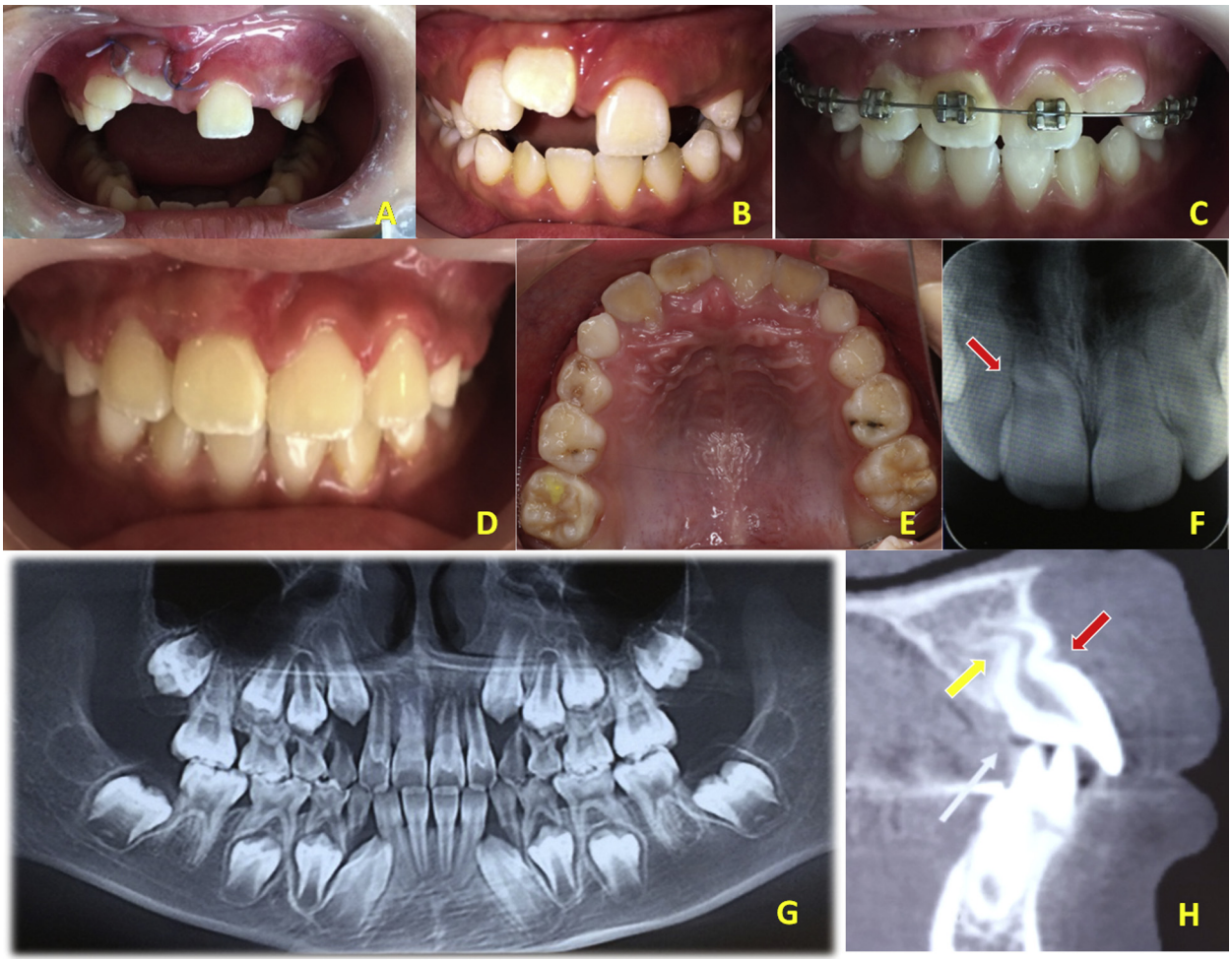

Fig 3. Spontaneous eruption and orthodontic treatment of the postoperative dilacerated incisor. Two weeks after the operation, the rotated maxillary right central incisor erupted spontaneously, and the incisal edge was exposed inside the oral cavity **(A)**. Three months later, the postoperative incisor had erupted further **(B)**. The rotated incisor was aligned with a fixed appliance **(C)**. Four months after fixed orthodontic treatment, the rotated incisor was moved into a normal position **(D, E)**. X-ray image examination **(F)** and the spiral CT image **(G, H)** were then taken to observe further the directional changes of the dilacerated root (**F, H**; *red arrow*). The dilacerated root recurved (**H**, *yellow arrow*) differently from the initial angle (**H**, *red arrow*).

and radiographically during the whole treatment period. Orthodontic treatment was completed 7 and a half months after the surgery. A normal overjet and overbite were obtained, and the treated dilacerated incisor was well aligned in the maxillary arch. The maxillary right central incisor presented in a stable condition without any mobility and responded to electric tooth pulp testing (Electric Pulp Tester; Denjoy Dental Co, Ltd, Hunan, China) well. A clinical examination revealed a normal periodontal state for the dilacerated incisor and the adjacent teeth (probing depths <3 mm) and an adequate width of the attached gingiva. No loss of clinical attachment was detected, and the gingival contour was normal.

Radiographic examinations were performed at follow-up visits to monitor the managed incisor. During the follow-up observation, the apical closure was gradually completed (Fig 4, *E* and *F*). Three years after treatment (Fig 4, *A*-*C*), cone-beam computed tomography was performed to evaluate the volume of the alveolar bone in the anterior region of the maxilla. Results confirmed normal continuity of the alveolar process. The dilacerated root was located within the alveolus and was completely covered by the labial cortical plate.

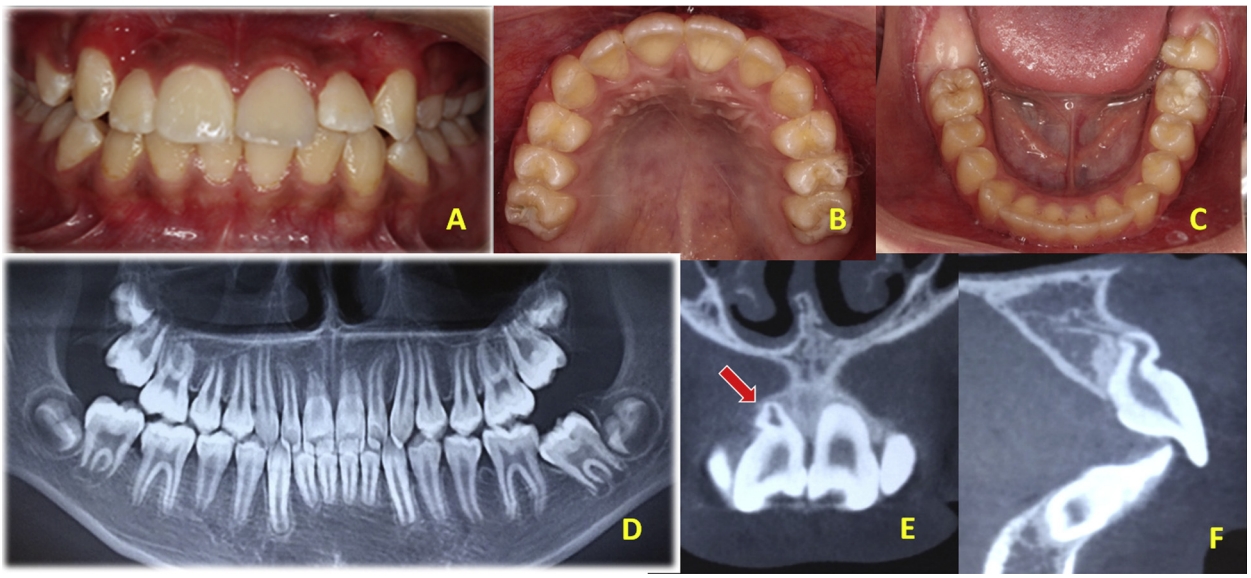

Fig 4. Follow-up examination for the treated dilacerated incisor. At the 3-year follow-up, the treated maxillary right central incisor was stable in the maxillary dental arch **(A, B)**. The condition of mandibular teeth and dentition was showed (**C**). The dilacerated root of the treated incisor grew, and the apical closure was complete (**D, E**; *red arrow*). The dilacerated root was located within the alveolus and was covered by the labial and palatal cortical plate **(F)**.

The morphology of the dilacerated root was as stable as it was immediately after orthodontic treatment.

Patient 2 was an 8-year-old girl with a chief complaint of an unerupted maxillary left central incisor. There was nothing special in her medical or dental history. The examination showed that the maxillary left central incisor was unerupted (Fig 5, *A*). The maxillary right central incisor and left lateral incisor tilted toward the space occupied by the unerupted tooth, and the dental midline of her maxillary arch deviated 2 mm to the left (Fig 5, *A* and *B*). The space of the unerupted central incisor was insufficient. Some primary teeth had caries, including the maxillary left first and second primary molars, the mandibular right primary canine, the second primary molar, and the left first and second primary molars. There was an early loss of the maxillary and mandibular right first and second primary molars (Fig 5, *B* and *C*). The cone-beam computed tomography images showed that the maxillary left permanent central incisor was inversely impacted (Fig 5, *D* and *E*). The root had developed only to one-third of its normal length and dilacerated labially (Fig 5, *F*). The parents were informed of the several treatment options mentioned above. They chose in situ rotation surgery and orthodontic alignment.

Three months were spent to align the maxillary dentition and gain space for the impacted maxillary left central incisor using a fixed appliance. Then the in situ rotation surgery was performed (Fig 6, *A*-*F*). An immediate postsurgical radiographic image showed repositioning of the inverted impacted incisor and root apex position (Fig 6, *G*). Two weeks after surgery, the maxillary left central incisor erupted (Fig 7, *A*). After 3 months, the rotated maxillary left central incisor erupted further and was stable without mobility (Fig 7, *B*). By radiographic examination, the periodontal and periapical condition of the rotated incisor had improved (Fig 7, *C*). The incisor was aligned with a fixed appliance (Fig 7, *D*). The root grew longer, and the apex changed direction toward the palatal alveolar bone (Fig 7, *E* and *F*). The maxillary left central incisor was moved into a normal position after 3 months of fixed orthodontic treatment (Fig 8, *A* and *B*), then the patient wore a clear retainer for 1 year.

The treated maxillary left central incisor was routinely examined clinically and radiographically during the whole treatment period and 2-year follow-up visit. The treated incisor was well situated in the maxillary dental arch with a normal overjet and overbite and stable with normal pulp vitality and gingival esthetics. A normal periodontal state for the treated incisor and adjacent teeth was observed by clinical and radiographic examination. The root developed further, and apical

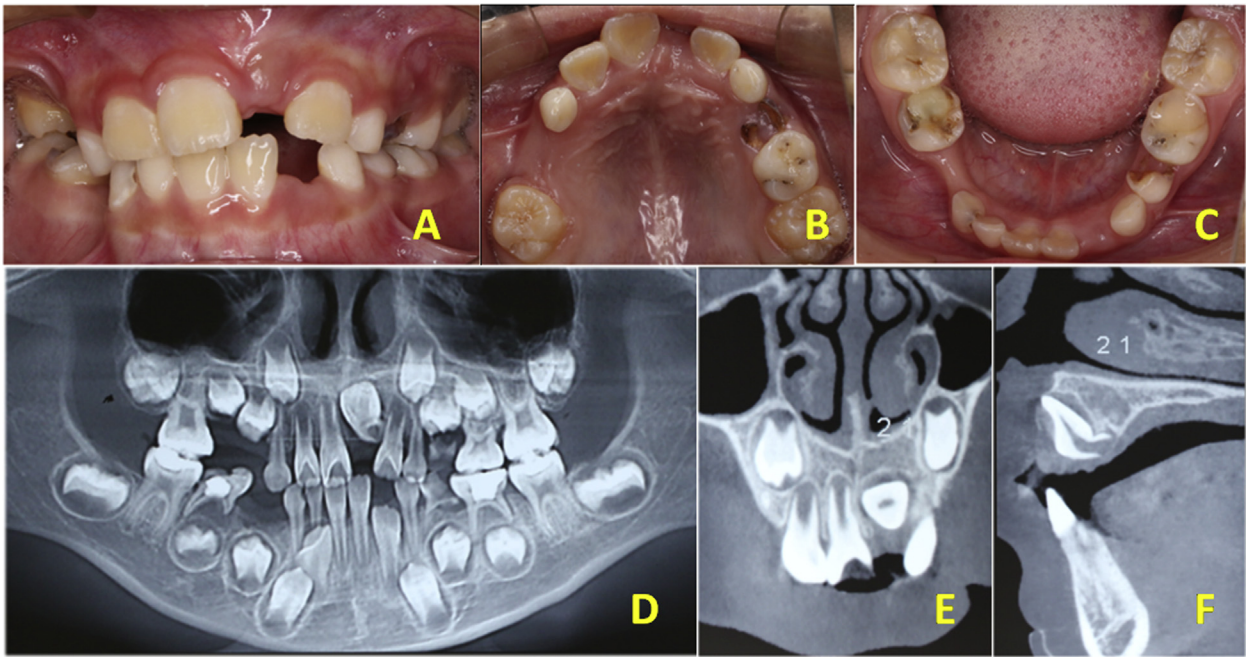

Fig 5. The intraoral and radiographic examinations of patient 2. The maxillary left central incisor was unerupted, and the space was insufficient **(A, B)**. The condition of mandibular teeth and dentition was showed (**C**). The panoramic radiograph **(D)** and cone-beam computed tomography images showed that the maxillary left central incisor was impacted inversely, and the crown rotated upward **(D, E)**. An angle was formed at the cervical third of the root, and the root dilacerated labially **(F)**.

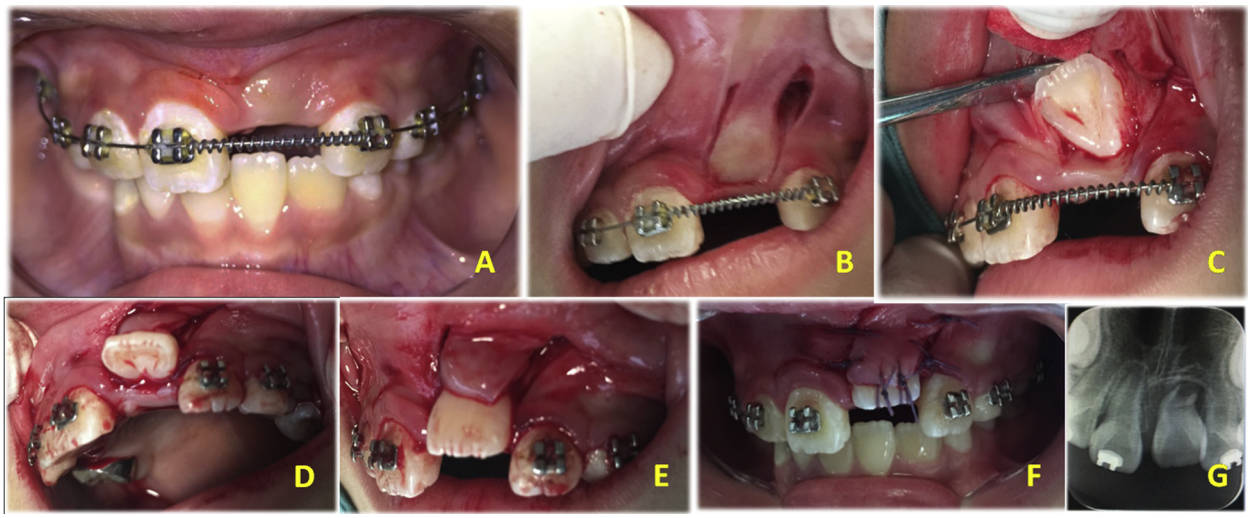

Fig 6. The procedure of the in situ rotation surgery for the impacted dilacerated incisor. The maxillary dentition was aligned, and the space for the impacted left central incisor was gained through fixed orthodontic treatment **(A)**. The incision was made **(B),** and the palatal side of the impacted incisor crown was totally exposed **(C)**. The incisal edge was gently turned downward **(D)**. The crown was rotated downward more than 90° to a relatively normal position **(E)**. The flap was repositioned and sutured to fix the rotated incisor **(F)**. The x-ray showed the repositioned incisor immediately after the surgery **(G)**.

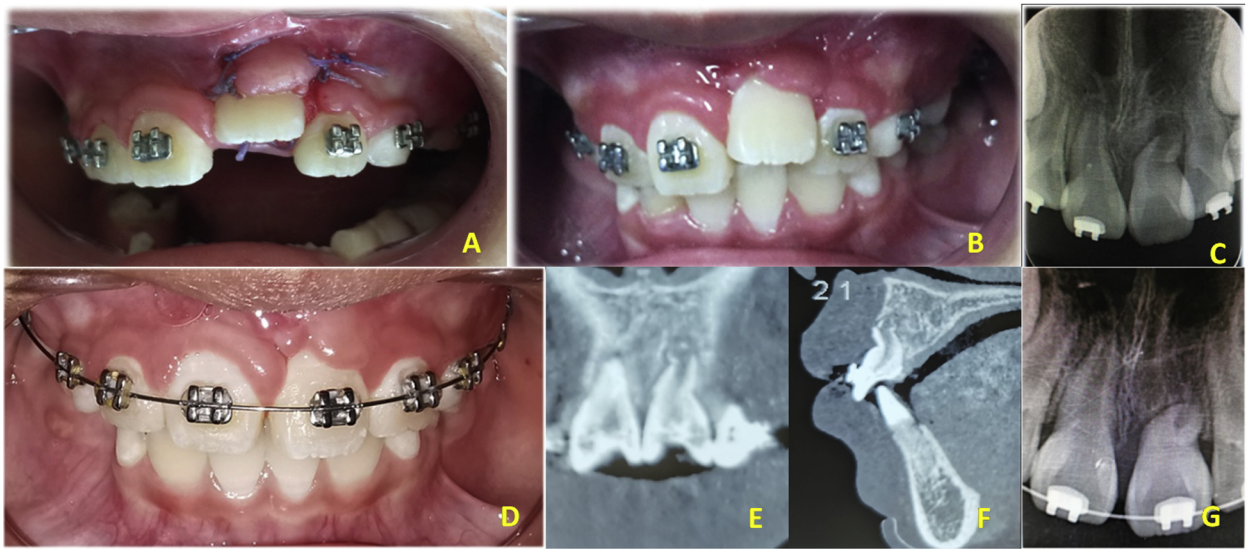

Fig 7. Spontaneous eruption and orthodontic treatment for the dilacerated incisor after surgery. Two weeks after the operation, the rotated maxillary left central incisor erupted spontaneously **(A)**. Three months later, the postoperative incisor erupted further **(B)**; the x-ray at that time shows this **(C)**. The rotated incisor was aligned with a fixed appliance **(D)**. The cone-beam computed tomography images 5 months after surgery showed the dilacerated root had grown continuously **(E),** and the root apex had recurved toward the palatal alveolar bone **(F)**. The x-ray image examination showed a better periodontal and periapical condition of the operated incisor **(G)**.

closure was completed (Fig 8, *E* and *F*). In addition, the root apex changed into a relatively normal direction in accordance with the crown longitudinal axis.

DISCUSSION

In this report, a novel surgical therapeutic method for the inversely impacted incisor, in situ rotation, was described. The impacted maxillary central incisor with a dilacerated root was found to erupt spontaneously 2 weeks after the in situ rotation surgery and erupt further with time. The developing root continued to grow in the relatively correct orientation in accordance with the longitudinal axis of the crown. Periodontal status, such as the alveolar bone height, clinical attachment loss, and bleeding on probing was healthy. In addition, after the surgery and orthodontic treatment, the impacted incisor gained gingival esthetics and was stable in the arch.

Surgical exposure followed by orthodontic traction is the conventional treatment most widely used clinically to treat impacted incisors. Extraction, surgical repositioning,[5] and surgical reimplantation[15] are also therapeutic strategies for this condition. Nevertheless, each treatment has some drawbacks. For the conventional treatment, it is difficult to isolate the impacted incisor from contamination by saliva and hemorrhage during surgery, and the procedure is time-consuming. In a previous study, authors reported that with conventional surgical-orthodontic treatment, an average time of 9 months was spent only for orthodontic traction to the impacted incisor, with an average time of 21 months to complete the whole treatment, including orthodontic traction and alignment.[13] In addition, because of the complicated location, orthodontic traction is always more difficult than normal alignment. There is a risk of failure because of an intractable position, ankylosis, external root resorption, and root exposure after orthodontic traction.

In contrast, dilacerations were reported to be related to a longer stage of traction.[13] Therefore, it is important to reduce traction time to change root dilaceration deformity. In the current patients, we established an in situ rotation surgical method. By this method, the treatment step of long-term orthodontic traction was largely avoided. Not only does this shorten treatment time, but it also reduces the risk of serious dilaceration of the root. In the current patients, the dilacerated root was induced to grow in a relatively favorable direction that was different from the original dilaceration.

Although surgical reposition or reimplantation of an impacted incisor offers simplified treatment and shows immediate esthetic improvement, the treatment

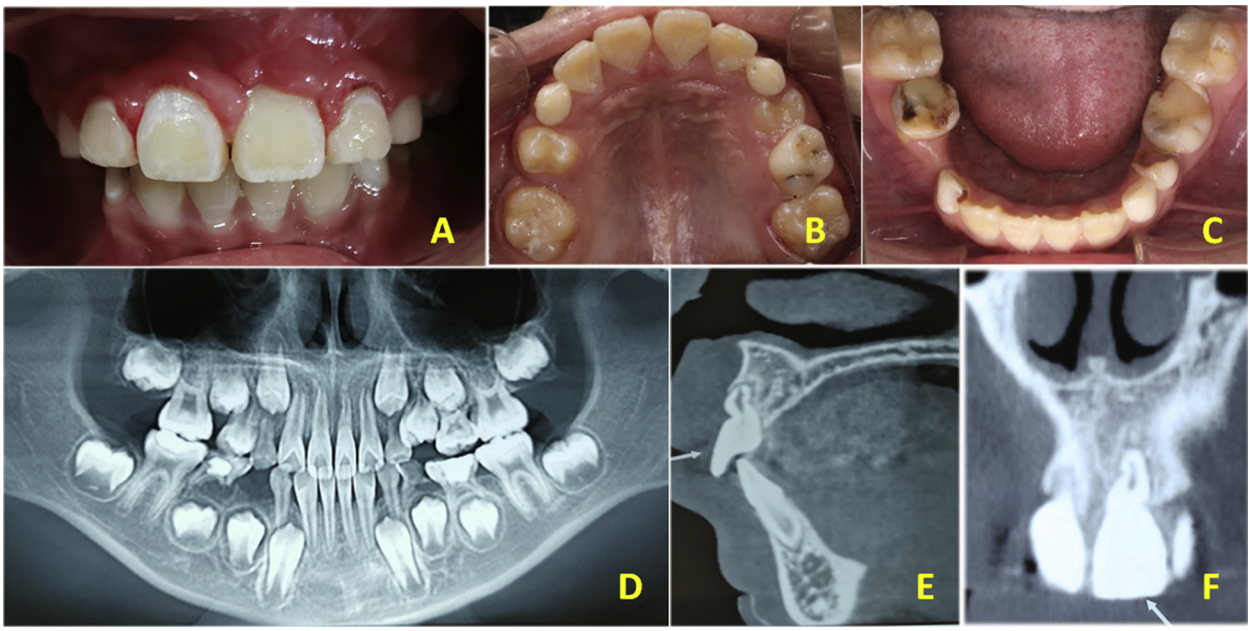

Fig 8. Treatment completion and follow-up examination for the treated dilacerated incisor. Three months after fixed orthodontic treatment, the rotated incisor was moved into a normal position **(A-D)**. At the 2-year follow-up, the dilacerated root recurved differently from the initial angle **(E)**. In addition, the root of the treated incisor grew, and the apical closure was completed **(E, F)**. The dilacerated root was located within the alveolus and was covered by the cortical plate **(F)**.

procedure is similar to trauma. As a result, the damage to the pulp, HERS, and the periodontal ligament could lead to complications such as pulp necrosis, inflammation, or replacement root resorption.[16,17] To promote root development for young patients, it is critical to minimize damage to the apical tissue and preserve an intact and healthy pulp, HERS, periodontal ligament, and the stem cells from the apical papilla during the whole reposition surgery. In the present report, during the in situ rotation surgery, the apical area of the root was not moved much and was kept as a pivot point within the minimum momentum. Simultaneously, the incisal edge was gently rotated to a relatively normal position. The minimal force was exerted to the root apex of the inversely impacted incisor. Therefore, the periapical tissues, including pulp, HERS, and stem cells from the apical papilla, were well protected. In the follow-up visit, the treated incisor was normal clinically and radiographically, and the root continued to grow, indicating that the present treatment strategy kept the pulpal vitality without damage to the apex.

During the in situ rotation surgery, the apical positions of impacted teeth should not be moved or moved as minimal as possible to reduce tissue injury. That is of critical importance to maintain teeth vitality and to promote further root development. Up till now, over 30 patients of in situ rotation surgeries have been carried out. At present, all teeth received this technique maintained vitality and continued to develop without root resorption or replacement resorption. However, a phenomenon could occasionally be observed. After or during erupted teeth (central incisors) were aligned followed by in situ rotation surgery, the ipsilateral canines erupted in the labial side of the lateral incisors, which may be a complication that needs to be dealt with at some point.

In conclusion, the in situ rotation surgery, as a novel therapeutic method for impacted dilacerated incisors, quickly repositions the impacted tooth, changes the root's originally unfavorable dilacerated direction, and makes the root grow at a rate and in a direction that is healthy. In future work, a clinical study with a larger sample size is needed to clarify the success rate and related complications of this novel technique.

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