Evaluation of the Effect of the Closed-eruption Technique on Impacted Immature Maxillary Incisors

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Objective: *To investigate the effects of the closed-eruption technique on impacted immature maxillary incisors.*

Methods: *The contour and position of the gingival margin, root development, and pulp status were evaluated in 50 impacted immature maxillary incisors immediately after treatment and 2 years later.*

Results: *Chronic periapical periodontitis and trauma of the primary teeth were the main causes of impacted immature maxillary incisors. The average treatment time was 11 months. After treatment, the contour of the impacted incisor gingival margin, which had already erupted, conformed with the contralateral incisors; the gingival margin positions of 34 (68%) impacted incisors were the same as those of the contralateral incisors but the other 16 (32%) were more apical. All roots developed normally; pulp vitality was normal and conformed with the contralateral incisor change into a period. Three (6%) impacted incisors were slightly labially inclined because the dilacerated part of their roots was too long.*

Conclusion: *The closed-eruption technique is an effective method of treating impacted immature maxillary incisors.*

Key words: *closed-eruption technique, immature incisor, impacted maxillary incisor*

Caries of the maxillary primary incisors tends to occur at a younger age and trauma to the maxillary primary incisors results in high morbidity. During the period of permanent tooth formation, the permanent germ is closed at the apex of the primary tooth. If there is chronic periapical periodontitis around the root of the primary tooth, development of the succeeding permanent germ may be affected, the root may become dilacerated as a result of severe infection, and the tooth cannot erupt normally and becomes impacted[1]. Usually patients do not visit the dentist until a central incisor remains unerupted and the contralateral incisor has already erupted. Some elderly patients visited an orthodontic dentist at the age of 12 years, but their maxillary incisor roots had already developed and were dilacerated. No prompt treatment for this condition is available except extraction, as the treatment opportunity is lost. The maxillary frontier area is important as it can affect facial appearance. Once maxillary incisors have been extracted; aesthetics, speech pronunciation, mastication, and psychology of children are affected. No postnatal prosthetics can replace natural human teeth. Therefore, whether these patients should receive early closed-eruption technique treatment and begin sequential treatment to correct their impacted teeth, whose roots are beginning to dilacerate, must be determined.

Some dentists choose the open-eruption technique as the first option[2]. This technique may result in an infected wound, which has a long-duration, as well as poor contour and poor positioning of the gingival mar-

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gin after treatment. The closed-eruption technique is a regulated treatment that avoids wound infections and shortens treatment time. Some case reports[3,4] and studies[5] have shown that the gingival margin and impacted maxillary incisors and canines can be successfully treated using this technique. But, there is a lack of systematic studies on this problem.

This study was conducted to evaluate the sequential early closed-eruption technique. The aims of this study were: 1) to define the indications for the early closed-eruption technique and favourable treatment time, to evaluate outcomes, and to standardise the clinical operation; 2) to utilise the potential of growing roots to help impacted teeth erupt quickly and roots develop normally, which could save impacted teeth and increase success rates.

Materials and methods

Study population

Fifty patients (18 males and 32 females; age range was 6.4 to 10.4 years old; mean age was 8.4 years) with impacted immature maxillary central incisors were included, as they met the following criteria: 1) unilateral osseous-impacted maxillary central incisor whose root was dilacerated and had formed no more than two-thirds of the entire root length, and the contralateral maxillary central incisor had already erupted (control group); 2) the thickness of the labial and lingual alveolar bone of the contralateral incisor (the dilacerated part of the root) was sufficient for the entire root and covered with alveolar bone after treatment; 3) 6 to 10 years of age; 4) able to maintain excellent oral hygiene with their parent's help; 5) no systemic disease; 6) patient and parents were able to cooperate with the treatment plan and informed consent could be obtained.

Research approach

Figure 1 (a to f) shows photographs of a male patient as an example, in order to provide a better understanding of our research approach.

A medical history was taken and clinical and radiological examinations were conducted by the same pediatric dentist. Dental casts and intraoral pictures were obtained at the first visit (Figs 1a, 1g and 1h).

Impacted immature maxillary central incisors were treated with a combined surgical-orthodontic technique by the same pediatric dentist. The incisors were exposed with a flap, and a bonded attachment device was applied during surgery. Sutures were removed on the seventh postoperative day. Periapical films and intraoral pictures were taken to evaluate tooth development at typical stages (Figs 1b and 1c).

Orthodontic traction force was applied 2 to 3 weeks after surgery to guide the impacted central incisor toward the centre of the alveolar ridge. In some cases, there was a need to expand the area in order to create sufficient space at the same time. Periapical films and intraoral pictures were taken to evaluate tooth development at typical stages (Figs 1d and 1e).

The maintenance phase lasted 3 to 6 months after the erupting incisor was properly aligned within the dental arch. The patients were recalled every 3 months to evaluate roots and alveolar bone development by radiological examination (Fig 1e).

At the end of the orthodontic treatment, dental casts and intraoral photographs were taken, and a radiological examination was conducted to evaluate root development, the position of the gingival margin, and pulp vitality of the impacted and contralateral teeth (Figs 1e, 1h, and 1i).

The follow-up results 2 years after treatment were systematically summarised and evaluated, including intraoral pictures and clinical and radiological examinations (Fig 1f).

Results

Pathogenic analysis

The study population consisted of 50 patients all of whom had mixed dentition. There were 30 (60%) impacted incisors whose primary teeth were affected by chronic periapical periodontitis, 14 (28%) impacted incisors whose primary teeth had been traumatised, two (4%) cases with mesiodens, and four (8%) cases with unknown reasons for impaction (Fig 2). The main causes of impacted teeth were chronic periapical periodontitis due to primary tooth caries and primary tooth trauma.

Typical clinical manifestations

The adjacent teeth, including the contralateral central incisor and homolateral lateral incisor, were often inclined to the edentulous space, as the immature maxillary central incisor was impacted, which caused loss of the space and a midline deviation to the impacted tooth. In this study, 32 cases (64%) lacked space and the remaining 18 (36%) cases did not.

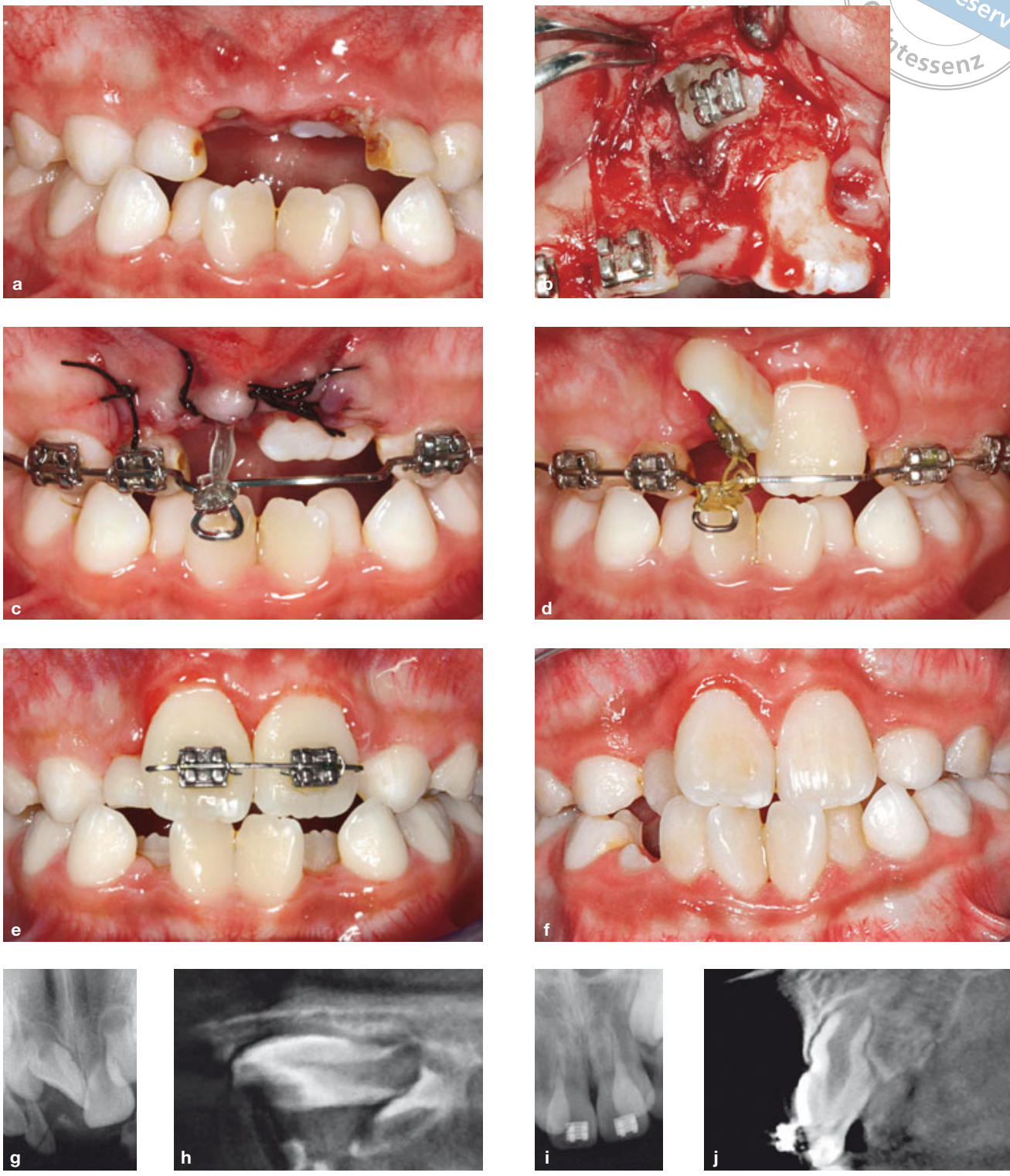

Fig 1 The patient was male, 7 years and 8 months old, with a unilateral impacted immature maxillary incisor: **a)** pre-surgical view; **b)** surgical crown exposure showing the palatal surface; **c)** immediate post-surgical view; **d)** crown exposure due to orthodontic traction force; **e)** the erupting incisor was properly aligned within the dental arch and the maintenance phase lasted 11 months; **f)** final clinical aspect 1 year and 5 months after the end of treatment; **g)** pre-surgical periapical radiograph; **h)** pre-surgical cone beam computed tomography (CBCT); **i)** periapical radiograph at the end of the maintenance phase; **j)** CBCT when the maintenance phase was completed.

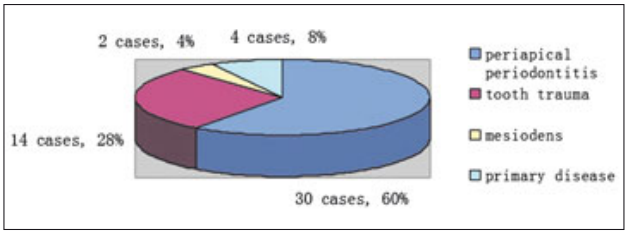

Fig 2 The causes of impacted maxillary central incisors.

Results of clinical treatment

- Treatment time: Average treatment time (from the time that the bonded attachment device was applied during surgery to when the impacted tooth was aligned within the dental arch) was 11 months. A lack of space made the treatment more difficult and lengthened treatment time, which was 1 to 3 months longer than those with sufficient space. Retention time after alignment was 3 to 6 months. Thus, the entire treatment time was 14 to 17 months.
- The contour and position of the gingival margin: After treatment, the gingival margin contour of the impacted incisor, which had already erupted, was conformed with that of the contralateral incisor. The condition observed for two gingival margin positions were: 34 (68%) cases conformed with the control group criteria and 16 (32%) cases were more apical than that of the control group (five (10%) cases were 0.5 mm more apical than that of the control group; four (8%) cases were 1.0 mm more apical; four (8%) cases were 1.5 mm more apical; and three (6%) cases were 2.0 mm more apical than that of the control group) (Table 1). It was clear that the closed-eruption technique facilitated recovery of the gingival margin contour. In some cases, the gingival margin position returned to normal with age. One case was 1.5 mm more apical than the control group immediately after treatment but completely conformed with the control group after 18 months.
- Root development: All roots of the impacted teeth and contralateral incisors continued to develop normally in the normal position after treatment, without internal or external resorption, canal calcification, atresia or stenosis, and the lamina dura was clear and continuous. Pulp vitality of the 10 cases whose roots had developed completely after treatment was similar to that of the control group.
- Recurrences after 2 years: Three (6%) impacted incisors were slightly labially inclined after treatment because the dilacerated part of their roots was too long. A lingual retainer was placed and the results were good. No wound infections were observed.

Discussion

The main reasons for impacted immature maxillary central incisors in our study were periapical periodontitis (30 cases; 60%) caused by primary tooth caries and primary tooth trauma (14 cases; 28%). These observations were consistent with other studies. Wang et al reported that the reasons for impacted immature maxillary central incisors were primary tooth periapical periodontitis (57%), primary tooth trauma, supernumerary teeth and odontomas[1]. Therefore, dentists should prevent and cure primary tooth caries, due to the chronic recurrent periapical periodontitis caused by these caries. Primary teeth, where the lamina dura of succeeding germs are broken, should be extracted as early as possible. Primary tooth trauma usually occurs at < 3 years old. The effects of traumatised primary teeth on the succeeding permanent germs should not be ignored, and patients should be recalled regularly. Once replacement of the teeth is determined to be abnormal, the closed-eruption technique should begin to reduce the effects of primary tooth trauma on succeeding permanent germs.

Many factors can affect treatment of impacted teeth, such as their initial position, development phase, the development and angle of the impacted teeth roots, patient age, and whether the patient received surgery or orthodontic treatment[6]. Most treatment failures in past case reports were because the treatment was too late. When impacted teeth are aligned within the dental arch, the dilacerated part of the root is too long or the dilacerated root had finished development, and the dilacerated root apex was uncovered by the labial osseous lamella and gingiva, which led to treatment failure. Therefore, sufficient indications and proper treatment time are the keys to success. We found that the indications should satisfy the following conditions: 1) the impacted root formed no more than two-thirds of the entire root length, the patients was 7 to 8 years old, sexual distinction was not restricted, and the patient was otherwise healthy; 2) the contralateral maxillary central incisor had already erupted as the control group and the thickness of the labial and lingual alveolar bone of the contralateral incisor (the dilacerated part of the root) was sufficient for the entire root to be covered with alveolar bone after treatment. The roots of the impacted immature teeth in our study had not finished developing, and the growth potential of the roots helped to obtain better results. Our results showed that the remaining part of the dilacerated root developed normally in the normal place. In addition, as the growth potential of the roots could be fully utilised during treatment, the traction force exerted mainly on the impacted incisors was

Table 1 The gingival margin contour of impacted maxillary incisors after closed-eruption treatment.

	Confirmed with control group	More apical than control group			
		0.5 mm more apical	1.0 mm more apical	1.5 mm more apical	2.0 mm more apical
Numbers	34	5	4	4	3
%	68%	10%	8%	8%	6%

small, which avoided the effect on adjacent anchorage and impacted teeth. The roots of both impacted and contralateral teeth developed and formed normally. In 10 cases (20%) where roots had developed completely, an electronic pulp vitality test was carried out; the results indicated that the impacted teeth were normal and in accordance with those of the contralateral teeth.

In this study, 32 cases (64%) were limited by lack of space, which increased the difficulty of performing the closed-eruption technique and would have a negative effect on the development of the dental arch if the treatment was delayed. Therefore, the early closed-eruption technique was necessary. We found that the periodontal bone had finished reconstruction, and that the lamina dura was clear and continuous on a radiological examination after 3 months of the clinical maintenance phase. However, we suggest that the maintenance phase should be prolonged to 6 to 9 months in patients whose dilacerated root is long. A lingual retainer should be considered in patients whose impacted teeth are labially inclined, which would satisfy the functional and aesthetic needs after treatment.

One of the key problems with the early use of the closed-eruption technique is the position of the gingival margin[7]. In this study, 32% cases were more apical than that of the control group, and most were 1.0 mm more apical than that of the control group. The roots of the impacted teeth had not finished development, and most of the cases recovered normally as the roots developed and soft and hard tissues were reconstructed. This is an advantage of early artificial eruption and the closed-eruption technique. Furthermore, the closed-eruption technique avoided wound infection.

The early closed-eruption technique is the best option to save and cure impacted immature maxillary central incisors. Kolokitha et al suggested that close monitoring and multidisciplinary cooperation during the various treatment phases leads to successful aesthetic results, with good periodontal health and functional occlusion[6]. Other researchers have cured impacted maxillary mature central incisors and canines using this method[4]. The following are the advantages of this method as suggested by our data: 1) use of the closed-eruption technique avoided discomfort, wound infection, complex cleaning, frequent visits, and prolonged treatment time; 2) the growth potential of the roots was fully utilised during treatment, and the traction force mainly exerted on the impacted incisors was small, which avoided an effect on adjacent anchorage teeth. The duration of artificial eruption includes the processes of root development, periradicular osseous tissue reconstruction, and the formation of the contour and position of the gingival margin, which is similar to natural eruption with less recurrence. Treatment and retention time were shortened and multiple effects were achieved; 3) the impacted teeth erupted in a normal place and the remaining part of the root developed normally, which contributed to the development of the contour and the position of the gingival margin.

Clininal significance to paediatric dentists

This study systematically evaluated the outcomes of the early closed-eruption technique, including the contour and position of the gingival margin and root development. The results show that the early closed-eruption technique is a good option, in order to save and cure impacted immature maxillary central incisors.

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