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Effect of mandibular distraction osteogenesis on developing molars

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Structured Abstract

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Objective – To observe the effect of mandibular distraction osteogenesis (DO) on developing molars.

Design – Descriptive clinical study.

Setting – University hospital setting. Seventeen children (mean age 7.6 years) with various syndromes (hemifacial⁄craniofacial microsomia, Goldenhar syndrome, Treacher Collins syndrome, Nager syndrome and Pyle–Bakwin–Krida syndrome) participated.

Experimental variable – Severely retrognathic lower jaws were distracted (mean 30 days) with an extraoral bicortically fixed DO device.

Outcome measure – Consecutive panoramic tomograms were analysed after a mean follow-up period of 3.6 years, range 1–6.9 years.

Results – The mandibular molars were affected by DO in 13 of the 17 patients which included 18 of 63 mandibular molars studied. Structural changes included root malformations, hindered tooth development and the destruction of tooth follicles. Positional changes such as shifted and tilted teeth were also found. Three injured teeth failed to erupt. These changes were because of splitting of the tooth follicle during the osteotomy (22%), piercing of the tooth follicle by the pin (39%) or migration of tooth germ towards the newly created bone (39%). Fifteen per cent of first molars, 43% of second molars and 31% of third molars were affected during the distraction process. Of all dental injuries, 44% were noticed while the appliance was in place. A further 17% of injuries were noted between 3 months and 1 year postoperatively and 33% during the second postoperative year.

Conclusions – Although dental injuries are a minor disadvantage compared with the vast benefits offered by DO, focusing on these drawbacks might lead to re-consideration of the type of the device as well as the timing of DO.

Key words: adverse effects; complication; distraction osteogenesis; mandible; tooth development

Introduction

During the last decade, distraction osteogenesis (DO) has proven to be an effective treatment in reconstructing craniofacial structures, with a broad range of applications (1–4). It has especially transformed the surgical treatment of children with a hypoplastic or retrognathic lower jaw as mandibular lengthening using conventional sagittal split osteotomy is technically impossible in a small jaw filled with developing tooth germs.

Mandibular DO is considered to be a safe and predictable procedure, with a low incidence of major complications (5). Reported negative findings include surgical complications such as hypoesthesia of the mandibular nerve, infection or premature ossification (6–9). Reported device-related problems include loosening of the pins and breakage of the device (6, 8–10). The major benefit of DO is considered to be decannulation of the tracheotomy tube (11). However, failure to decannulate is also reported (12, 13). Recently, disappointing treatment outcomes in mandibular stability have been described in syndromic children (14–16).

To date, only a few studies have addressed the dental complications of DO. In a comprehensive review of the most common problems in DO, tooth damage was noticed in only one of 589 mandibular distraction patients (9). In addition, in a large evaluation of a DO-based questionnaire, mandibular tooth damage was reported in only 2% of the patients (8). One case report described an osteotomy across the tooth follicle followed by development of a dentigenous cyst, relapse or fibrous union and failure of osteogenesis (5).

This long-term descriptive study focused on dental development in the DO region to determine whether or not DO has a negative effect on the development of the dentition in the hypoplastic mandible of young children. Follow-up panoramic tomograms were analysed to detect any structural or positional changes in the molars of the operated area, to categorize the cause of the injury and to define the teeth most likely to be affected.

Patients and methods

Patients

In this study, the inclusion criteria for patients were a severely hypoplastic or asymmetric mandible, primary or early mixed dentition, the use of an extraoral bicortically fixed distraction device and a follow-up period of at least 1 year after DO. Accordingly, 17 patients (mean age 7.6 years, range 4–10.5 years, eight boys, nine girls) with a diagnosis of hemifacial/craniofacial microsomia (n = 8), Goldenhar syndrome (n = 2), Treacher Collins syndrome (n = 3), Nager syndrome (n = 3) or Pyle–Bakwin–Krida syndrome (n = 1) were included. The dental developmental stage was primary dentition in four patients and early mixed dentition in 13 patients.

Surgical technique and distraction procedure

The surgical procedure was performed by one senior surgeon. The location of tooth germs was preoperatively evaluated by using panoramic tomograms and sometimes also CT scans. The complete osteotomy with mobilization was performed in the gonial area (17). The osteotomy line was aimed to be proximal to the second molar. The pins were inserted bicortically and planned below the tooth germs. The bony segments were distracted uni- (8) or bilaterally (9) by an extraorally fixed multidirectional device (Leibinger Multiguide). The latency period varied from 3 to 5 days. The distraction rate was 0.5 mm/12 h. The mean distraction period was 30 days (range 16–49 days), and the mean consolidation period 9 weeks (range 6–12 weeks). The mean total time with the distraction device attached was 13 weeks (range 8–18 weeks). At the end of distraction the facial and occlusal treatment outcomes were considered good or excellent. Orthodontic treatment was carried out pre- and/or postoperatively in 15 patients. In the preoperative orthodontic treatment fixed appliances were used to align dental arches. Postoperative treatment was performed with fixed or functional appliances to stabilize the achieved occlusion.

Methods

Panoramic tomograms were taken preoperatively, 2–3 days after surgery, after the consolidation period, half a year postoperatively, 1 year postoperatively, 2 years postoperatively and every second or third year after this. The mean total follow-up period was 3.6 years (range 1–7 years). In the analysis of pre- and postoperative dentition, 172 consecutive panoramic tomograms were analysed on a light box using a magnifying glass. In unilaterally distracted cases, the dentition was compared with the contralateral side. In bilaterally distracted cases, the left and right sides were analysed separately. The form and location of 63 mandibular first, second and third molars were examined in a total of 26 gonial areas. Treatment effect on the development of premolars was not evaluated, because these teeth were not located in the operated region. The effects on the molars were described and categorized as structural or positional changes. The causes of dental injuries were categorized as follows: the osteotomy cut, the insertion of fixation pins or the effect of DO traction on tooth germ. The time points for the first sign of the injury were also categorized: during the distraction or consolidation period (0–3 months), 3 months to 1 year postoperatively, 1–2 years postoperatively or more than 2 years postoperatively.

The research protocol was approved by the Ethics Committee of Helsinki University Central Hospital (HUS 223/E6/2000).

Results

Effects of DO on structure, location or development of molars were detected in 13 of the 17 patients (76%) and in 18 of 63 mandibular molars (29%). Structural changes such as root malformations (n = 5), hampered tooth development (n = 4) and destruction of the tooth follicle (n = 2) were found in 11 of 18 injured teeth (Fig. 1). Positional changes such as shifted or tilted teeth were found in seven of 18 cases. Five of 18 injured teeth failed to erupt in long-term follow-up (Fig. 2). The dental injury resulted from splitting of the tooth follicle in the osteotomy (22%) (Fig. 3), piercing of the tooth by the pin (39%) or from shifting of the tooth germ towards the newly created bone (39%, Fig. 4).

Consecutively, four of the 27 first molars studied (15%), 10 of 23 second molars (43%) and four of 13 third molars (31%) were injured by DO. When the operation was performed in deciduous dentition, the teeth most likely to be affected were the first (43%) and second (40%) molars and in mixed dentition the second (44%) and third (40%) molars (Fig. 5).

Nearly half (44%) of the injuries were detected while the appliance was still in place. A further 17% of the injuries were noted between 3 months and 1 year postoperatively and 33% during the second postoperative year (Fig. 6).

Discussion

This long-term study showed structural and positional injuries in 29% of developing lower molars in the

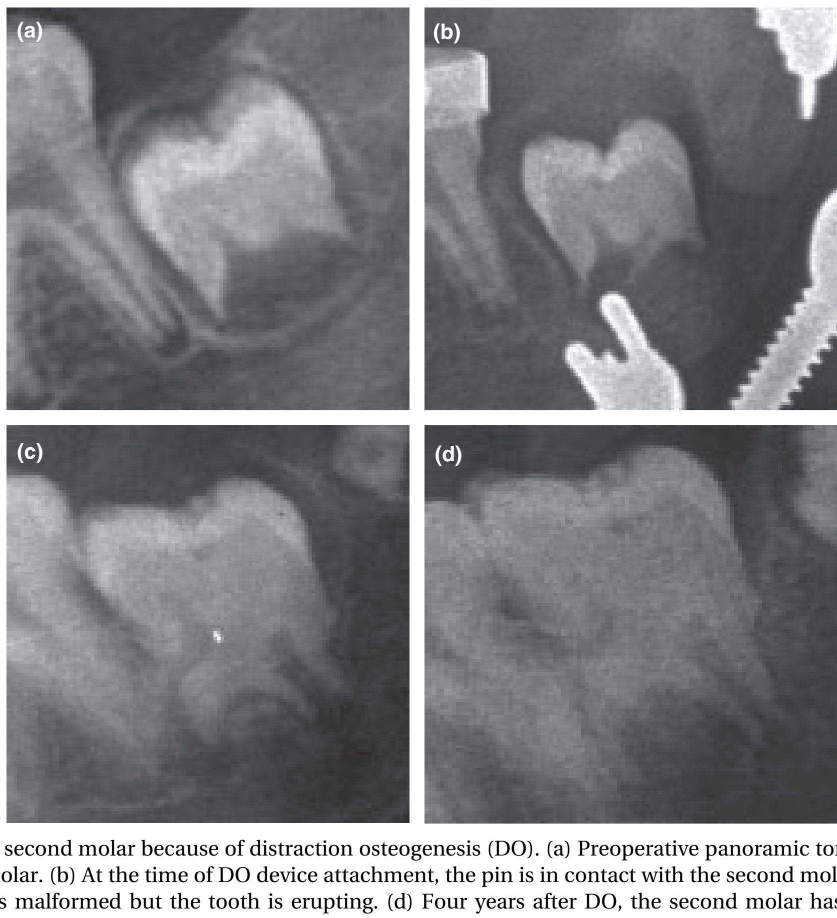

Fig. 1. Root injury of lower second molar because of distraction osteogenesis (DO). (a) Preoperative panoramic tomography shows a normally developing lower second molar. (b) At the time of DO device attachment, the pin is in contact with the second molar tooth germ. (c) Two years after DO, the mesial root is malformed but the tooth is erupting. (d) Four years after DO, the second molar has erupted successfully. Only minor further root development is observed in the mesial malformed root.

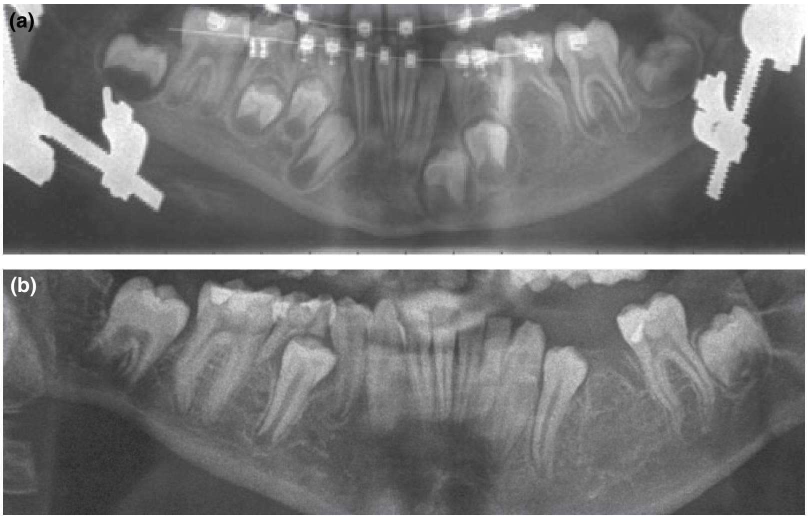

Fig. 2. (a) Panoramic tomography X-ray during distraction osteogenesis (DO). On the left side, development of the lower second molar is somewhat behind schedule compared to the right side. (b) 4 years after DO. Normal tooth development and eruption is observed on the patient's right side. The obscure structure and hindered development of the second molar on the left side is evident.

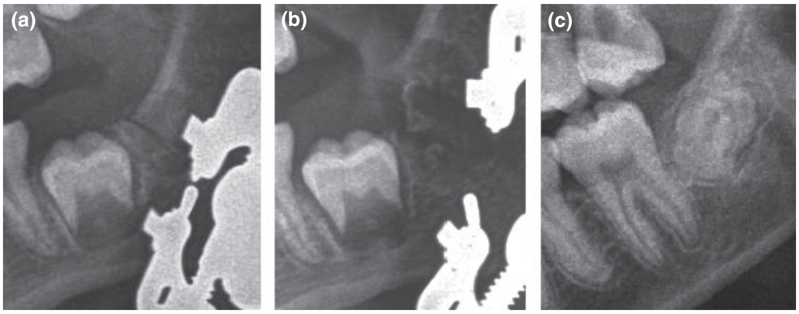

Fig. 3. Panoramic tomography X-rays of the third lower molar. (a) The osteotomy cut can be seen across the developing tooth germ 2 days after distraction osteogenesis surgery. (b) During the consolidation period the tooth germ appears to be divided into two parts. (c) Three and a half years postoperatively the tooth appears to have ceased its development and is unerupted in the bone.

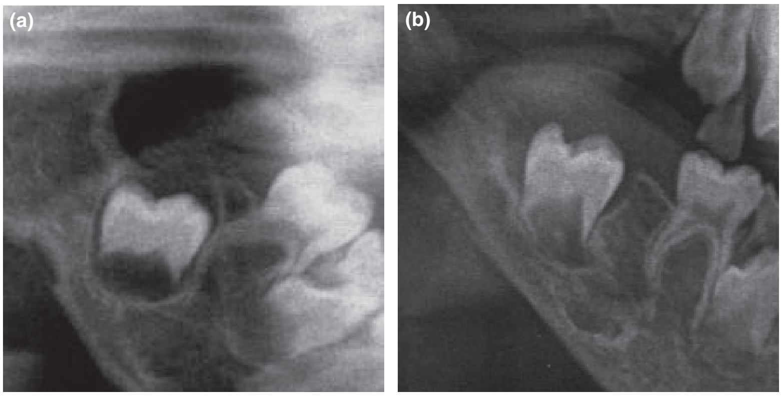

Fig. 4. (a) Panoramic tomography X-rays of the first lower molar preoperatively. (b) Two years after DO root formation is hindered and the tooth has shifted posteriorly.

hypoplastic lower jaw of small children after DO using an extraoral bicortically fixed device. Thirteen of the 17 patients were affected. Most injuries (13/18) were minor structural abnormalities, such as root malformations and hindered tooth development or positional changes such as shifted teeth. These effects can

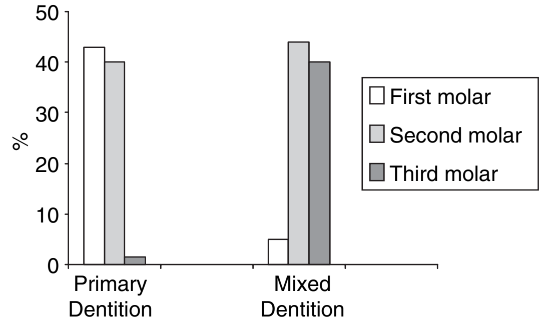

Fig. 5. Different teeth were damaged when distraction osteogenesis surgery was performed in the primary or mixed dentition. The first and second molars were injured most often when surgery was performed in the primary dentition and the second and third molars during mixed dentition surgery. Overall, the second molars had the highest risk of injury.

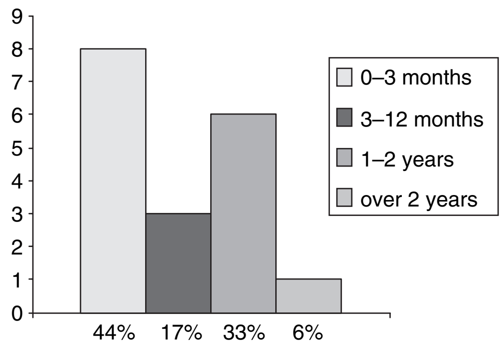

Fig. 6. Examining consecutive panoramic tomograms, nearly half of the tooth injuries (44%) were detected during the first 3 months after surgery when the appliance was in place. The remaining injuries became obvious during further dental development, some up to 2 years postoperatively.

be regarded as either temporary, treatable or non-functional. However, tooth destruction and failed eruption were detected in five of 18 cases. Two of these five cases were third molar buds with minute clinical importance, but long term non-eruption of three second molars were also observed. The effect of DO on the dentition has quite seldom been reported (8, 9). The reason for unreported dental injuries may partly be a lack of diagnosis or trivialization because of their minor importance compared with the main treatment outcome. Moreover, some negative effects of DO on dental development can only be detected in long-term studies such as this. In this study 39% of injuries were detected after the first postoperative year.

Dental injury resulted from splitting of the tooth follicle during the osteotomy in 22% of the cases. This may result from the lack of sufficient bone in young children (mean age 7.6 years) with a hypoplastic mandible. A complete osteotomy was performed in the gonial area, and the cut was aimed proximal to the first or second molar. Some new recommendations for avoiding tooth damage in DO suggest to situate the osteotomy line high in the ramus area and to incline obliquely from the buccal to the lingual region (18). Recovery from the dental injury has been reported. An experimental animal DO study showed that the surgical cut into the tooth did not stop further development or eruption of the tooth.(19). Also, in this study, most injured teeth erupted.

A major cause of the injuries appeared to be related to bicortical fixation of the pins (39%). Use of monocortically fixed distraction devises would presumably reduce the incidence of tooth injuries. However, because of the severity of the mandibular hypoplasia, bicortically fixed extraoral devices were required to provide long range and a multidirectional vector (20). During the course of this study, suitable intraoral unicortically fixed devices for small children were not available. In our study, the incidence of tooth injuries was markedly higher than previously reported findings. This may be due in part to a different set of diagnoses. Furthermore, our material consisted of high-risk patients with severely hypoplastic mandibles, which complicate the treatment. The rate of DO complications has been associated with the experience of the surgeon (9, 21). However, this was not analysed in this study.

Distraction osteogenesis not only affects bony tissue, but also causes tension in associated tissues, initiating an adaptive change termed distraction histogenesis (22). In this study, the teeth close to the osteotomy line migrated into the newly formed regenerate (39%), probably due to tissue pull. This type of positional change is not related to the type of the distractor but rather to the biomechanism of DO. Some of the observed dental disturbances might be related to the syndrome itself.

As conventional sagittal split osteotomy is performed in the mature permanent dentition developmental injuries do not occur. The preoperative removal of unerupted wisdom teeth is accepted as a routine in the sagittal split osteotomy. Also, in DO for children under the age of 4 years, the first molars, and in older children the removal of the second molars 4 months preoperative has been suggested (23). In young children, surgical exposure and orthodontic treatment of unerupted molars were thought to enhance the eruption of molars and to facilitate the DO timing. In this study, the teeth affected most were first and second molars when the procedure was performed in the deciduous dentition. The second and third molars were likely to be affected in the mixed dentition. Regarding tooth development, the optimal time for the DO procedure is after the eruption of molars. The later the operation is performed, the more posterior and less important tooth is at risk of damage.

The decision to operate at an early age is based on individual or functional needs. In the presence of a life-threatening airway problem, dependency on a tracheotomy tube or severe eating and speech problems of a small child, an early intervention is often essential. Minor disadvantages like tooth injuries should be weighed against these benefits. However, recent long-term studies reveal structural instability after mandibular DO (14–16). If the main indication of the procedure is to improve the facial appearance of the growing child, it might be better to defer the operation to a later and safer stage. The majority (61%) of tooth injuries in this study were caused by the osteotomy and fixation. This emphasizes the need for detailed and careful surgical treatment planning including particular attention to tooth buds in collaboration with orthodontist.

Conclusions

Although tooth injury is a relatively minor disadvantage compared with the benefits of DO, it should not be trivialized. Every effort should be made to minimize dental injuries, as in many hypoplastic lower jaws hypodontia is already included in the syndrome. Bicortical fixation of the device should be re-considered, because it seems to induce an additional risk for a tooth injury. To properly evaluate the advantages of DO, it is essential to record all detailed complications occurring during the long-lasting dental development and the entire growth of child.

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