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Author(s)
Sakamoto, T; Ishii, T; Mukai, M; Ueki, A; Sueishi, K; Suga, K; Nakano, Y; Uchiyama, T

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Clinical Report

Application of Interdental Distraction Osteogenesis to Unilateral Cleft Lip and Palate Patients

Teruo Sakamoto, Takenobu Ishii, Miya Mukai, Akinobu Ueki, Kenji Sueishi, Kenichirou Suga*, Yoko Nakano* and Takeshi Uchiyama*

Department of Orthodontics, Tokyo Dental College, 1-2-2 Masago, Mihama-ku, Chiba 261-8502, Japan
* Division of Oral-maxillofacial Surgery, Tokyo Dental College, 1-2-2 Masago, Mihama-ku, Chiba 261-8502, Japan

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Abstract

Distraction osteogenesis is widely used for the treatment of craniofacial deformities. In patients with cleft lip and palate, distraction osteogenesis can be employed to repair the alveolar cleft. In this report, we describe the management of three cases of unilateral cleft lip and palate by interdental distraction osteogenesis. Interdental distraction osteogenesis of the maxillary bone was performed to reduce the width of the alveolar cleft in these patients in conjunction with orthodontic treatment. Tooth-tooth type distraction devices were fabricated and delivered at the same time as osteotomy. Distraction was continued until the midline of the dentition coincided with the facial midline, and until the width of the alveolar cleft was reduced to the width of lateral incisor or had closed. One month after distraction was complete, orthodontic treatment with an edgewise appliance was initiated, and neighboring teeth were moved into the newly created bone. A favorable treatment outcome was achieved in all three cases.

Key words: Interdental distraction osteogenesis (IDO)—Unilateral cleft lip and palate—Alveolar cleft—Orthodontic treatment

Introduction

In recent years, secondary alveolar bone grafting has been widely performed for the repair of the alveolar cleft in patients with cleft lip and palate in the effort to improve the intra-oral environment. This involves bone grafting into the alveolar cleft, which enables teeth to be moved into the graft site and improves stability after orthodontic treatment. In the case of alveolar clefts wider than 11 mm, however, the survival rate of the bone graft is low and the prognosis is reportedly poor.

Distraction osteogenesis (DOG), developed by the Russian orthopedic surgeon Ilizarov, has been widely adopted in the field of orthopedic surgery for lengthening limb bones. The mechanism of DOG involves imposing an external force during the callus formation stage of fracture healing to extend the callus gradually, promoting osteogenesis between
the fracture segments. McCarthy et al. performed mandibular extension for patients with hemi-facial microsomia, the first application of DOG in the oral-maxillofacial region\(^{13}\). Recently, DOG has become a common treatment for craniofacial deformities\(^{4,7,14,16}\). The principle of bone transport has also been applied to reconstruction following mandibular segmental osteotomy, with good results reported\(^{5}\). Bone transport is a method of bone reconstruction that involves performing partial segmental osteotomy of the bone fragment of the segmental defect and extending this segment towards the fragment on the other side. Interdental distraction osteogenesis (IDO) is carried out by applying the principle of bone transport to the alveolar cleft defect in patients with cleft lip and palate\(^{1,5,11,12,15,18,19,21}\).

Here, we report the application of DOG with the aim of reducing the width of the alveolar cleft in patients with cleft lip and palate who had wide alveolar clefts by IDO of maxillary alveolar bone in addition to orthodontic treatment, whereby we achieved good results.

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**Fig. 1** Intraoral photographs before IDO (Case 1)

**Fig. 2** 3D-CT before IDO (Case 1)

**Fig. 3** Panoramic X-ray before IDO (Case 1)
Patients and Methods

We performed IDO on three patients with unilateral cleft lip and palate.

1. Surgery and distraction procedures

Under general anesthesia, vertical osteotomies were performed distal to the transport site, and a horizontal osteotomy from the piriform aperture to around 5 mm above the tooth root apex, using a reciprocating saw. Mobility of the osteotomy sites was confirmed during surgery.

Tooth-tooth type distraction devices were fabricated, comprising an orthodontic expansion screw (cases 1 and 2) and/or a Zurich-type ramus distractor (cases 2 and 3) soldered to an orthodontic band. Distraction devices were delivered in the teeth by using dental cement during surgery (Figs. 4, 11, 18).

Distraction was performed twice a day by 0.5 mm each time, followed by a 1 week latency period. The process was continued until the midline of dentition coincided with the facial midline for the larger segment, and until the width of the alveolar cleft was reduced to the width of lateral incisor (cases 1 and 2) or had closed (case 3) for the lesser segment. The consolidation period lasted for 1 month, and the distraction device was removed 1 month after distraction. Orthodontic treatment with an edgewise appliance was started 1 month after distraction was complete, with neighboring teeth moved to the bone newly created as a result of IDO.

Cases

Case 1 was a boy with unilateral left cleft lip and palate. The midline of the maxillary dentition deviated 5 mm to the right of the facial midline, and the width of the alveolar cleft was 16 mm. The left maxillary lateral incisor was missing, and the bilateral maxillary first premolars were displaced to the palatal side (Figs. 1–3). The patient’s age at surgery was 14 years and 2 months. Vertical osteotomies were performed distally to the lateral incisor on the right side and distally to the

Fig. 4 Distraction devices (Case 1)

Fig. 5 Intraoral photographs after IDO (Case 1)
second premolar on the left (Fig. 5). Bone grafting in the alveolar cleft was performed after distraction. Subsequently, the maxillary midline was brought to coincide with the facial midline by orthodontic treatment. The width of the alveolar cleft was reduced to the width of lateral incisor. This space was planned to be replaced by a fixed bridge or dental implant. The bilateral maxillary first premolars that were palatally displaced were moved into the space created by IDO (Figs. 6, 7).

Case 2 was a girl with unilateral left cleft lip and palate. The midline of the maxillary dentition was shifted 8 mm to the right of the facial midline, and the width of the alveolar

![Fig. 6 Orthodontic treatment after IDO (Case 1)](image1)

![Fig. 7 Frontal cephalogram after IDO (Case 1)](image2)

![Fig. 8 Intraoral photographs before IDO (Case 2)](image3)
cleft was 15 mm. The left maxillary lateral incisor was missing, and the right maxillary lateral incisor was displaced to the palatal side (Figs. 8–10). The patient’s age at surgery was 12 years and 10 months. Vertical osteotomies were performed distally to the canine tooth on the right and distally to the second premolar on the left (Fig. 12). Bone grafting in the alveolar cleft was performed after distraction. Subsequently, the maxillary midline was brought to coincide with the facial midline as a result of orthodontic treatment. The width of the alveolar cleft was reduced to the width of lateral incisor. This space was planned to be replaced by a fixed bridge or dental implant. The right lateral incisor that was palatally displaced was moved into the space created by IDO (Figs. 13, 14).

Fig. 9 Frontal cephalogram before IDO (Case 2)

Fig. 10 Panoramic X-ray before IDO (Case 2)

Fig. 11 Distraction devices (Case 2)
Fig. 12 Intraoral photographs after IDO (Case 2)

Fig. 13 Frontal cephalogram after IDO (Case 2)

Fig. 14 Intraoral photographs after treatment (Case 2)

Fig. 15 Intraoral photographs before IDO (Case 3)
Case 3 was a boy with unilateral right cleft lip and palate. There was no midline shift in the maxillary dentition, but the width of the alveolar cleft was 15 mm. The right maxillary lateral incisor was also missing (Figs. 15–17). The patient’s age at surgery was 16 years and 6 months. Vertical osteotomies were performed distally to the second premolar, and distraction was performed until the canine and premolars came into contact with the

Fig. 16 3D-CT before IDO (Case 3)

Fig. 17 Panoramic X-ray before IDO (Case 3)

Fig. 18 Distraction devices (Case 3)

Fig. 19 Intraoral photographs after IDO (Case 3)
central incisor (Fig. 19). Subsequently, the right first and second molars will be moved proximally into the space created by IDO, closing the gap (Figs. 20, 21). Bone grafting in the narrowed alveolar cleft is also scheduled.

Discussion

Secondary alveolar bone grafting in the alveolar cleft is widely performed and is an established method. Success rates for this procedure, however, are low when the alveolar cleft is wide. Fukuda et al. have indicated a maximal cleft width of <11 mm for successful alveolar bone grafting. IDO is an effective treatment method for wide alveolar clefts and fistulas, as it reduces the alveolar cleft by generating new bone and attached gingiva at points distant from the cleft. This method utilizes DOG, and is therefore also frequently employed in the craniofacial area. Another advantage of IDO is that it can extend not only bone, but also surrounding soft tissues such as periosteum, muscles, nerves, blood vessels, skin and mucosa. It can be used in patients requiring greater distraction compared with conventional jaw surgery, and there is little postoperative relapse because the extended area becomes compact bone.

Bone-bone, bone-tooth, and tooth-tooth types of distraction devices have been reported. Because bone-bone and bone-tooth type distraction devices are firmly fixed, there is no need to take into account their side effect on teeth used for fixation as seen in the tooth-tooth type. However, care must be taken to avoid damage to teeth roots. In the cases presented here, a tooth-tooth type distraction device was used. Although the orthodontist must deliver the distraction device in the operating room, tooth-tooth type distraction devices are advantageous in that they can be fitted while taking the direction of distraction into account and in that there is no need to consider any risk of damage to tooth roots during fitting. When the distraction devices...
were made, the direction of the distraction was taken into consideration. That is, the device in the larger segment was made with an orthodontic fan-type screw for consistency with the direction of distraction of the arch-shaped dentition, and that in the lesser segment was made with a Zurich type ramus distractor or orthodontic expansion screw. One problem, however, is that when fabricating the distraction device, the cast is prepared to resemble the dentition after tooth movement and the distraction device is produced on this post-distraction cast, with effort made to ensure that distraction occurs in the simulated direction. However, because the direction of distraction is predetermined, it is impossible to correct it during distraction, particularly vertically, and post-operative orthodontic correction becomes necessary.

Reported distraction protocols comprise a latency period of from $3^{111}$ to 6 days$^{1,10}$, and distraction speeds of $0.5 \text{ mm/day}^{1,5,15,19}$, or $1.5 \text{ mm}$ in the first week, $1 \text{ mm}$ in the second week, and $0.5 \text{ mm}$ in the third week$^{11}$. We decided on a latency period of 7 days in light of the wound openings along the incision lines, and performed a $0.5 \text{ mm}$ distraction twice a day, in the morning and evening. The reported consolidation period varies: periods of $1^{111}$, $5^{19}$, and 10 weeks$^{1}$ have been reported. Dolanmaz et al.$^{5}$ stated that although the distraction was misdirected vertically upward by $2 \text{ mm}$, initiation of orthodontic treatment from 1 week after the end of distraction guided teeth into the ideal position after approximately 10 days, with a subsequent consolidation period of 1 month. Liou et al.$^{11}$ initiated orthodontic treatment 1 week after distraction, stating that the reason was to preserve new bone and perform orthodontic treatment over a short period. It has also been reported that new bone is maintained if teeth are moved into the new bone by orthodontic treatment immediately after alveolar bone distraction$^{10}$. In our patients, we initiated orthodontic treatment 1 month after distraction.

With respect to the treatment of persistent bone defects at the alveolar cleft site following IDO, Mitsugi et al.$^{15}$ stripped away the mucosa at the docking site under local anesthetic when removing the distraction device, promoting the formation of a bone bridge by transportation of the bone generated by DOG. Sakamoto et al.$^{18}$ promoted bone formation by filling the gap with $\beta$-tricalcium phosphate ($\beta$-TCP), platelet-rich plasma (PRP), and bone marrow aspirate. $\beta$-tricalcium synthetic bone induces bone conduction from neighboring bone and periosteum, while PRP has been reported not only to enhance osteogenesis$^{20}$, but also to play a role in wound healing, and is widely used in bone graft treatment. We performed bone grafting at the site in patients in whom the alveolar cleft was reduced in size without closure. In cases 1 and 2, the alveolar cleft was reduced to the width of the lateral incisor, and the results of bone grafting at the cleft site were good, and the cleft closed in case 3. We also intend to perform bone grafting in case 3, and the prognosis is regarded as good.

Conclusions

Interdental distraction osteogenesis is an effective treatment for orthodontic treatment in cleft lip and palate patients. It has the following advantages:

1. The alveolar cleft can be closed or its width reduced.
2. Midline deviation of the maxillary dentition can be improved.
3. Crowding can be resolved.
4. Post-operative outcomes of secondary alveolar bone grafting can be improved.
5. The use of prostheses at sites of missing teeth can be avoided, or the prosthetic method simplified.

References


Reprint requests to:
Dr. Teruo Sakamoto
Department of Orthodontics,
Tokyo Dental College,
1-2-2 Masago, Mihama-ku,
Chiba 261-8502, Japan
E-mail: tesakamo@tdc.ac.jp