Maxillary segmental distraction in children with unilateral clefts of lip, palate, and alveolus

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Objectives. Alveolar clefts are commonly closed by a bone grafting procedure. In cases of wide clefts the deficiency of soft tissue in the cleft area may lead to wound dehiscence and loss of the bony graft. Segmental maxillary bony transfer has been mentioned to be useful in such cases. Standard distraction devices allow unidirectional movement of the transported segment. Ideally the distraction should strictly follow the dental arch. The aim of this study was to analyze distraction devices that were adapted to the individual clinical situation of the patients. The goal was to achieve a distraction strictly parallel to the dental arch.

Study design. Six children with unilateral clefts of lip, palate, and alveolus between 12 and 13 years of age were included in the study. The width of the cleft was between 7 and 19 mm. Dental cast models were used to manufacture individual distraction devices that should allow a segmental bony transport strictly parallel to the dental arch. Segmental osteotomy was performed under general anesthesia. Distraction was started 5 days after surgery. All distracters were tooth fixed but supported by palatal inserted orthodontic miniscrews.

Results. In all patients, a closure of the alveolar cleft was achieved. Two patients required additional bone grafting after the distraction procedure. The distraction was strictly parallel to the dental arch in all cases. In 1 case a slight cranial displacement of the transported maxillary segment could be noticed, leading to minor modifications of the following distractors.

Conclusion. Distraction osteogenesis is a proper method to close wide alveolar clefts. Linear segmental transport is required in the posterior part of the dental arch, whereas in the frontal part the bony transport should run strictly parallel to the dental arch. An exact guided segmental transport may reduce the postoperative orthodontic complexity. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:688-692)

Secondary autogenous bone grafting is a frequently performed procedure to close alveolar cleft spaces. The closure of wide alveolar clefts is challenging because of the difficulty in achieving complete closure by using local attached gingiva. The deficiency of soft tissue in the cleft region may lead to postoperative wound dehiscence and infection resulting in loss of the cancellous bone graft. A problem after the failure of an alveolar bone graft is the even higher failure rate of the subsequent bone graft, which may be due to the scar tissue. However, a possibility for reducing the width of an alveolar cleft is osteogenesis by a distraction procedure. Distraction osteogenesis is a frequently performed procedure in craniofacial surgery. Unlike extraoral appliances which are mainly used for midface distraction, small distractors can be used intraorally. These distractors have been used to reconstruct bony defects, especially concerning the alveolar ridge. Alveolar bone distraction has been performed vertically to enable the insertion of dental implants in atrophic jaws. The possible field of application for intraoral distractors has increased over the years. Sagittal skeletal discrepancy can be corrected using intraoral distractors. Wang et al. reported anterior maxillary segmental distraction for the correction of maxillary hypoplasia in cleft patients. Bevilacqua et al. published similar cases. Not only sagittal deficits can be corrected using distraction. Henkel et al. reported the closure of alveolar bone defects using guided horizontal distraction osteogenesis. Other authors also reported on this technique. Vertical intraoral distraction devices were modified and fixed horizontally to close alveolar clefts.

However, in most studies straight distraction devices are used, which leads to a linear movement of the alveolar segment. Depending on the clinical situation, linear transport of the segment does not always ensure a proper closure of the cleft space. A straight distraction of a segment does not follow the natural direction of the dental arch, so that the orthodontic complexity in postoperative treatment may be extensive. Yen et al. reported a case of alveolar cleft closure through bony transport of a posterior segment following the dental arch. A lingual holding arch, parallel to the physiologic dental arch, ensured a guidance of the segment in its requested direction. The distraction device was made from ordinary orthodontic wires, springs, and brackets.
Most patients in the reported cases were adults. In the present study, the closure of wide alveolar clefts using customized distraction devices in children with unilateral clefts of the lip, palate, and alveolus is presented.

**METHODS**

Six patients with wide alveolar clefts were treated with individualized distraction devices. The width of the alveolar cleft was between 7 and 19 mm. The patients’ ages were between 12 and 13 years. Four boys and 2 girls were included in the study. A main criterion for inclusion, besides the width of the cleft, was an almost erupted permanent canine tooth to ensure an osteotomy without injuring the canine apex.

In all patients, impressions of the upper and lower dental arch were taken. The dental cast models were analyzed regarding the width of the cleft and the required vector of the segmental bone transport. Furthermore, the dimension of the osteotomized alveolar segment was defined. To minimize the risk of dental impairment during osteotomy, the orthodontist preoperatively released a gap of about 3 mm between the teeth bordering the osteotomy line.

**Distraction devices**

All distractors were customized to the particular clinical situation of the patients. The intraoral distractors were manufactured on the dental cast models. An expansion screw was used as a distraction device and brazed to orthodontic bands as shown in Fig. 1. To ensure a guidance of the segment exactly following the dental arch, a palatal holding wire was positioned deep in the concavity of the palate strictly parallel to the physiologic dental arch (Fig. 2). To enable change of direction during distraction, a hinge was attached to the buccal arch wire (Fig. 2).

**Surgical procedure**

In all patients, osteotomy was performed under general anesthesia. The mucosal incision was performed vestibularly, and the palatal mucoperiostium remained intact to ensure a sufficient blood supply for the alveolar segment. The mucoperiosteal flap was raised, and the nasal aperture and the alveolar cleft were dissected. The horizontal osteotomy was performed ~5 mm away from the dental root apex by using a cutting saw. The vertical interdental osteotomy was performed with a cutting saw as well. Mobilization of the maxillary alveolar segment was carried out using a blunt chisel (Fig. 3). Soft tissues were removed from the alveolar gap to ensure a bony contact after approximation. The width of the cleft was measured using a measuring gauge. After gingivoperioplasty, the customized distraction device was cemented to the teeth by the orthodontist (Fig. 4).
Postoperative period
After surgery, the patients were treated with antiinflammatory drugs and antibiotics.

Distraction protocol
Five days after surgery, activation was started. The activation frequency was 0.5 mm per day (0.25 mm in the morning, 0.25 mm in the evening). The distraction procedure was performed by the parents as instructed by the authors. The procedure was stopped as soon as a subsequent radiograph showed bony contact between the posterior and anterior maxillary segment (Fig. 5). Up to that time, the patients reported increasing pressure in the gap region.

Retention period
The distraction period was followed by retention of 6 weeks. To ensure the stability of the result and the distractor, the expansion screw was blocked using a dry adhesive (Fig. 6). The patients were examined once a week by the authors.

Follow-up period
The orthodontic treatment continued right after the retention period. All patients are routinely controlled: once a week by the orthodontist, once a month by the surgeon. The follow-up period ranged from 7 months for the last to 3 years for the first distraction patient.

RESULTS
In all patients, the surgery and the postoperative period were uneventful. The blood supply for the maxillary segments was adequate in all patients. The width of the alveolar cleft was measured intraoperatively and ranged from 7 to 19 mm (Table I). The customized appliances could be applied easily. There were no oro-nasal fistulas after gingivoperioplasty. In 2 patients (Table I), there was a dehiscence requiring a bone grafting procedure to close the remaining alveolar gap after the distraction period. One of these patients had a cleft of initially 19 mm and the other a cleft of 12 mm. The bone grafting procedure was performed after the retention period. The bone was harvested intraorally.

After the segmental maxillary osteotomy, the patients were prescribed antiinflammatory drugs and antibiotics for 3-5 days. The postoperative swelling was minimal in all patients, as was the amount of pain. The

Fig. 4. Tooth-fixed distractor cemented by the orthodontist.

Fig. 5. Radiograph showing bony contact of the alveolar segments after distraction procedure.

Fig. 6. After the distraction period the expansion screw was blocked to ensure a retention of the achieved result.
Distraction was performed according to the preoperative plan in all patients. The parents of the children were asked to activate the distraction screw twice a day (0.25 mm in the morning and 0.25 mm in the evening). Immediately after activation of the distractor, the patients complained about discomfort in the region of the vertical ostotomy remaining for 20-30 minutes. No patient required additional pain therapy during these phases. The patients were examined by either the surgeon (W.Z.) or the orthodontist (M.P.) on both days. In the first patient a cranial displacement of the transported maxillary segment was observed. Because of this, orthodontic self-drilling anchorage screws were inserted in the palate in the cases that followed to offer additional bony anchorage (Fig. 7). In the remaining cases, there was no cognizable displacement of the transported segments. All patients reported that the distraction devices were easy to handle and that the distraction period was uneventful. The average amount of distraction was 12 mm (range 7-19 mm). Distal movement of the molars on the distraction side was not observed.

DISCUSSION

Alveolar clefts are commonly closed using a bone grafting procedure. In wide clefts the danger of failure is high, owing to the deficit of soft tissue in the cleft region. In addition, the soft tissues may be affected by chronic inflamed oronasal fistulas. Distraction procedures may lighten the closure of alveolar clefts. In the authors’ opinion, distraction is indicated in very wide clefts. An unusual width of an alveolar cleft may be caused by overexpansion or may speak to inadequate primary cleft treatment. Because such cases are rare, the number of analyzed patients was rather small in this study. Liou et al.8 concluded that an alveolar cleft wider than a maxillary canine in unilateral or bilateral cleft lip and palate can be minimized or approximated by interdental distraction. Some authors prefer individualized manufactured distraction devices10,11; others use standard linear devices.6,7 Bone segment transport using standard distractors is linear. Ideally the transportation of the distracted segment should follow the curve of the dental arch. Mitsugi et at.7 considered that manufactured tooth-borne distractors lead to inadequate distraction and therefore suggest bone-fixed distraction devices. To enable segmental transport according to the dental arch, an additional orthodontic arch wire is recommended. A bone-fixed distractor obviously reduces the burden on the teeth, but if the mobilization of the alveolar segment is adequate and the distraction rate is slow (0.25 mm twice a day) the risk of tooth burden should be minimal. Yen et al.10 introduced the use of continuous spring force instead of distractor screws. They argued that the use of continuous forces instead of incremental screw lengthening provides the tension force needed for distraction osteogenesis. On the other hand, solid distractor devices (manufactured or standard devices) may withstand the tractive forces of the extended soft tissues superior to the orthodontic springs. In our first case of maxillary segmental distraction, a small dislocation of the transported segment was observed. A slight cranial shift of the transported segment required a modification of the distractor. By adding 2 palatal orthodontic self-drilling miniscrews, a bony support was achieved. This new distractor was therefore supported by the teeth and the maxillary bone. The risk of tooth burdening, as mentioned in the literature,7 should therefore be eliminated.

Various problems, such as vertical and transversal discrepancies of the dental arch, have to be taken into account before choosing a distraction device. Ideally, dental cast models should be analyzed to identify the requested vector of distraction. If the vector is almost linear, as in the posterior part of the dental arch, standard devices are probably appropriate. In the frontal part of the maxilla the vector of segmental movement changes according to the curve of the dental arch. In the authors’ opinion, the postoperative orthodontic complexity was reduced when using individualized distrac-
tion devices. Mitsugi et al.\(^7\) combined a bone-fixed standard distraction device with an orthodontic arch wire. They indicated that this also allows a distraction almost parallel to the dental arch.

A main advantage of tooth-borne distractors is the removal of the device. There is no need for a second surgical intervention, which lightens the use, especially in children. In addition there is no scarring of the gingiva as found in bone-fixed distractors. A review of the literature shows that most cleft patients who received segmental maxillary distraction were adults or at least beyond their pubertal growth spurt.\(^6,8,10\) In younger patients, as presented in the present paper, it may be difficult to fix a distractor to the maxillary bone without injuring any dental roots.

A manufactured tooth-borne distraction device should be necessarily easy to handle and of graceful design. In the experience of the authors, standard devices are mostly of larger dimension, and not as adaptable to the specific clinical situation of the patient as individualized appliances.

Dentoalveolar distraction creates new alveolar bone and attached gingiva, but in some cases there is no planar contact between the alveolar segments, resulting in small residual bony clefts. Accordingly, in such situations a secondary alveolar bone grafting was performed in 2 patients, not surprisingly the patients with the widest alveolar clefts (Table I). Owing to the small extent of the remaining cleft, the bony graft was harvested intraorally. This is in accordance with other reports on alveolar segmental distraction in cleft patients.\(^1,8\) A gingivoperioplasty is suggested simultaneously with the segmental osteotomy. This allows bony contact after distraction and therefore ossification of the remaining alveolar spaces. In patients with wide clefts, the gingivoperioplasty procedure may fail, as described in the present paper. In such cases a bone grafting is recommended, as mentioned above. Mitsugi et al.\(^7\) grafted possibly remaining cleft spaces when removing the distraction device.

A transmission of pathogenic agents along a bone-fixed distractor may possibly lead to infection of the new bone. A tooth-fixed distraction device may reduce such risks. However, a review of literature did not reveal any reports of infection in maxillary segmental distraction cases. In the present cases also, there was no evidence of any inflammatory process during and after the distraction period.

It has to be taken into account that designing a custom segmental distraction device is time consuming. In cases of tooth-borne devices, the orthodontist has to attend the surgery. On the other hand, the flexibility of custom-made devices is among the best of commercially available distractors and costs less.

**CONCLUSION**

Distraction osteogenesis is a proper method to reduce the width of alveolar clefts. The introduced method is mainly indicated in cases of wide alveolar clefts. The distraction device can be fixed either to the bone or to the teeth. Standard devices mainly allow a linear movement of the maxillary segment, which may not always lead to an adequate result, especially in the frontal part of the dental arch. Individualized distractor devices may be superior in this region, because they allow a bony transport running strictly parallel to the dental arch. An exact guided segmental transport may reduce the postoperative orthodontic complexity.

**REFERENCES**


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