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Case Report

Posterior maxillary alveolar vertical distraction osteogenesis by bi-directional distractor

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ABSTRACT

A patient with severe posterior maxillary hypoplasia was simulated using a 3-dimensional model by rapid prototyping, and segmental vertical distraction osteogenesis was planned to advance the posterior maxillary segment. The bi-directional distractor was adapted to the alveolar ridge and zygomatic buttress. After a 7-day latency period, we started distraction at a rate of 0.35 mm every 12 h. 12 mm of advancement of the posterior maxillary segment was achieved. This distraction osteogenesis using a bi-directional distractor with proper therapeutic planning and good surgical technique will help ensure adequate vector control to predictably regenerate the hard and soft tissues during alveolar distraction.

1. Introduction

Distraction osteogenesis is a surgical technique that utilizes the body's own reparative mechanisms for hard and soft tissue reconstructions [1,2]. This approach has numerous applications in the maxillofacial complex, and has been successfully applied for vertical and horizontal augmentations of the alveolar ridges [3]. In our opinion, this method offers a useful and acceptable alternative to conventional bone grafting techniques in a selected group of patients. Although the concept of alveolar distraction is exciting, and has certain specific benefits, optimal vector control of regeneration in the distraction remains an issue of critical importance. This article represents a novel report of vertical alveolar distraction osteogenesis using a bi-directional distractor. The purpose of this article is to present our experience with some simple techniques in posterior alveolar vertical distraction osteogenesis that we have successfully used with a bi-directional distractor for proper vector control.

2. Case report

A 30-year-old man with severe posterior maxillary hypoplasia was referred to our hospital. Panoramic radiography revealed vertical and horizontal bone loss in the right maxillary alveolar process, loss of the right maxillary canine and first and second premolar teeth, and complete impaction of the first, second, and third molars which were ankylosed around bone and root resorption (Fig. 1). Following cephalometric analysis and surgical simulation using a 3-dimensional (3D) model by rapid prototyping (RP model), segmental vertical distraction osteogenesis was planned to advance the posterior maxillary segment for pre-prosthetic surgery. An extra-osseous distractor (bi-directional alveolar distractor; Synces, Oberdorf, Switzerland) was prepared beforehand on a 3D model. Outline of the impacted tooth crown was drawn on a 3D model to avoid drilling for fixation of device. The device was oriented so that activation would produce vertical movement. The device should be tried on for passive fit, and any adjustment needed should be made before surgery (Fig. 2).

The surgery is performed under general anesthesia with nasoendotracheal intubation. A crestal incision running from the right maxillary tuberosity to the upper right lateral incisor was made with a vertical release incision anteriorly, and a mucoperiosteal flap was elevated. Palatal mucoperiosteal attachment to the bone was maintained. The bi-directional distractor was adapted to the alveolar ridge and zygomatic buttress, and osteotomy lines were marked. An oscillating saw was used to perform the horizontal and vertical osteotomies, leaving the palatal periosteum intact. Segmental osteotomy was performed immediately adjacent to the lateral incisor anteriorly and near the anterior wall of maxillary sinus posteriorly at the pterygomaxillary suture, freeing the segment anteroposteriorly. The superior border of the transport segment was cut at the zygomaticomaxillary suture (Fig. 3A). The bone segment was totally mobilized using chisels. The osteotomy was carefully performed with leaving the completely impacted upper

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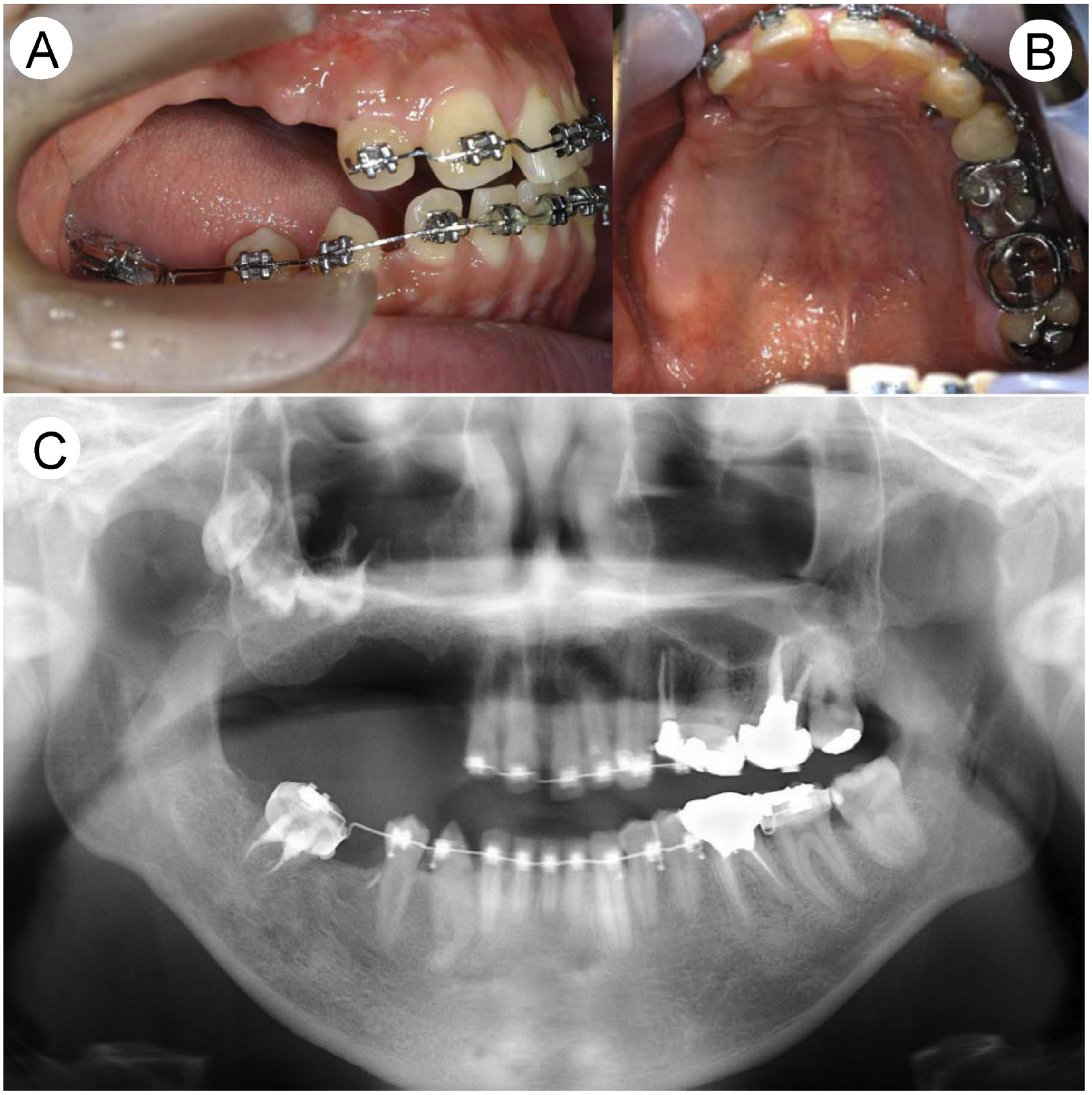

Fig. 1. (A and B) Pre-distraction photographs showed significant hard and soft tissue defects in the posterior maxilla. (C) Pre-distraction radiograph of the same patient showed lack of alveolar bone height for dental prosthesis.

maxillary molars intact. The distractor was adapted to an angle of 50° to the fixed plane for orientation of the transport segment in a forward and downward direction. The device was positioned and fixed into place using monocortical screws (Fig. 3B). After activation to test its function, the device was returned to its initial position. Finally, the surgical site was closed with 5-0 nylon sutures (Fig. 3C).

After a 7-day latency period, we started distraction at a rate of 0.35 mm every 12 h. The sutures were removed on postoperative

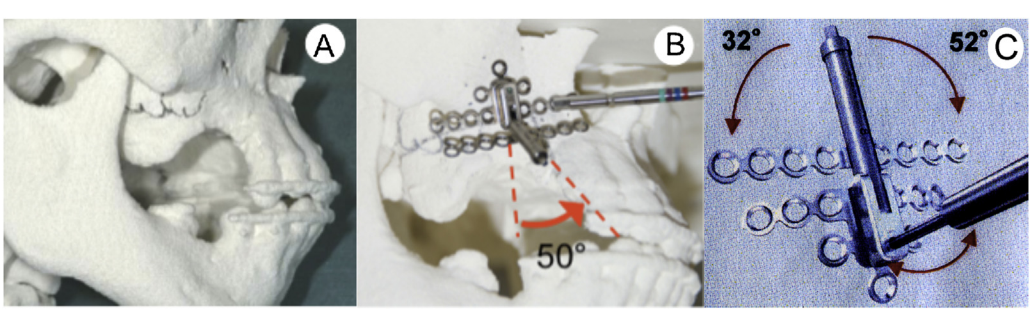

Fig. 2. (A) Rapid prototyping (RP) model reconstructed from computed tomography images by means of the binder jet method. (B) Distraction device was placed on the RP-model. The arrows specify the distraction vector. (C) By activating the inclination screw, maximum angulation of 52° can be performed on the buccal side and maximum angulation of 32° can be performed on the lingual side.

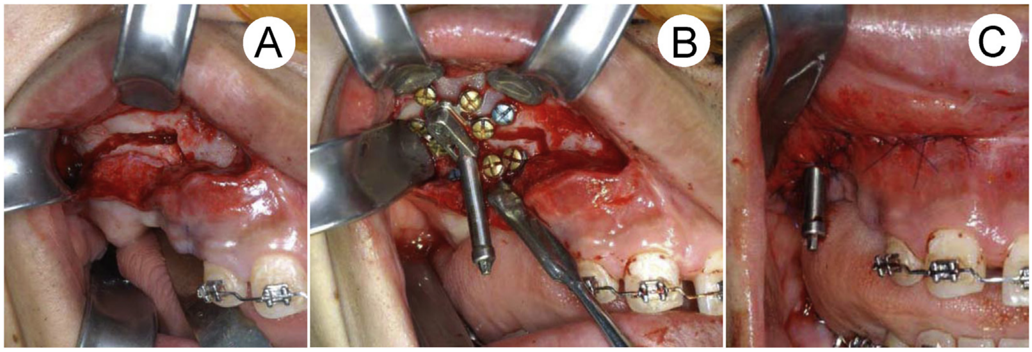

Fig. 3. Intraoperative view of a distractor installation. (A) A distraction device was placed and bent to conform to the alveolar ridge and crista zygomaticum before osteotomy. Then the horizontal and vertical osteotomies were made. (B) The device was fixed by self-tapping screws in each segment. (C) The surgical site was closed with 5-0 nylon sutures.

day 7. Although the procedure and postoperative period were well tolerated by the patient until 10 mm of distraction was achieved, distraction intervals were made 24 h rather than every 12 h because of the pain associated with activation. However the plate which fixed transport segment exposed on alveolar membrane, the newly formed bone was covered mucous membrane. The patient kept good oral hygiene to prevent infection. At the end of the distraction period, 12 mm of vertical and horizontal advancement of the posterior maxillary segment was achieved, and the right maxillary hypoplasia was eliminated. A total of 12 mm of vertical distraction was achieved within 16 days. During the distraction period, the transport segment was not dislocated (Fig. 4A–D). Six months later, cortical bone remodeling was observed and satisfactory bone levels remained (Fig. 4E).

Three years after alveolar distraction osteogenesis, hard and soft tissue regenerations were maintained without significant resorption in the posterior maxilla and removal of orthodontic retainer with fixed partial denture supported prosthetic oral rehabilitation (Fig. 5).

3. Discussion

The principle of distraction osteogenesis is well established in long bones [4], and has been applied to the maxilla [5] and mandible [6]. In the present case, the patient showed a complication of insufficient soft tissue to adequately cover a large bone graft in the right maxillary alveolar ridge, so vertical distraction osteogenesis was the most desirable approach. Vertical distraction osteogenesis as described by Hidding et al. [7] is thought to be a versatile method to increase the vertical height of the mandible by means of an intraoral-extraosseous device placed on the vestibular bony surface. With regard to maxillary vertical distraction osteogenesis, Block and Baugbman [8] reported reconstruction of severe anterior maxillary defects using distraction osteogenesis. However, while good results have been reported with posterior maxillary distraction osteogenesis in animals, to the best of our knowledge, clinical application of maxillary posterior segmental distraction osteogenesis has been limited [9]. The accuracy of distracted bone movement depends on the preoperative clinical assessment, surgical planning,

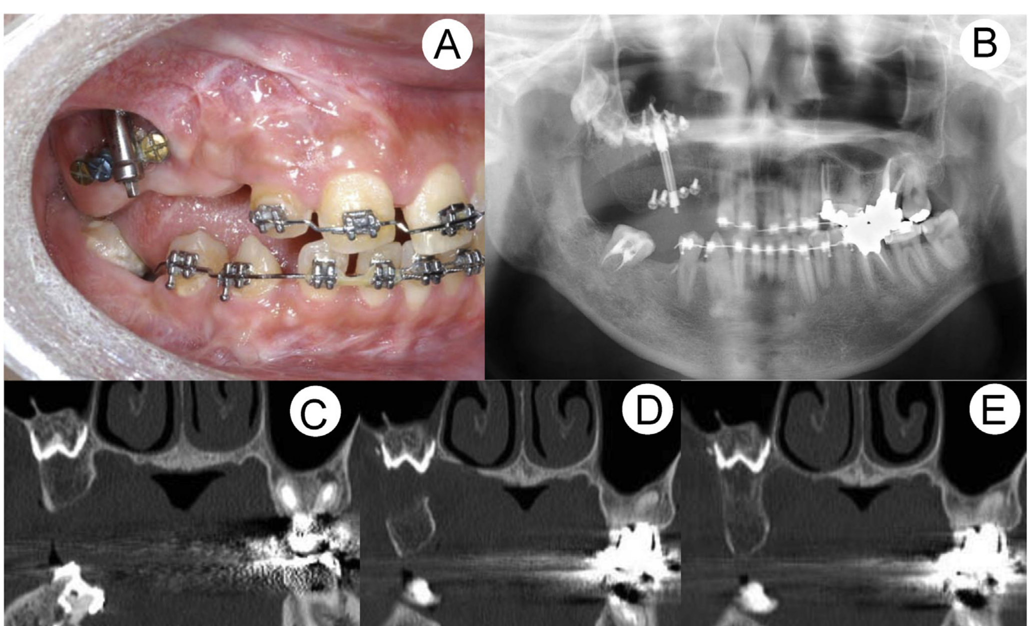

Fig. 4. (A) Postoperative intraoral photograph showed combined correction of hard and soft tissue defects in the posterior maxilla after alveolar distraction. (B) Postoperative panoramic radiograph showed that the superior plate of the distractor has been extended to estimated position. (C) Preoperative computed tomography (CT) scan showed alveolar bone hypoplasia. (D) CT scan at end of the active distraction showed excellent vector control. (E) Six months after distraction, new bone formation in the distraction gap was observable and there was no significant buccal or lingual tipping of the regenerated segment.

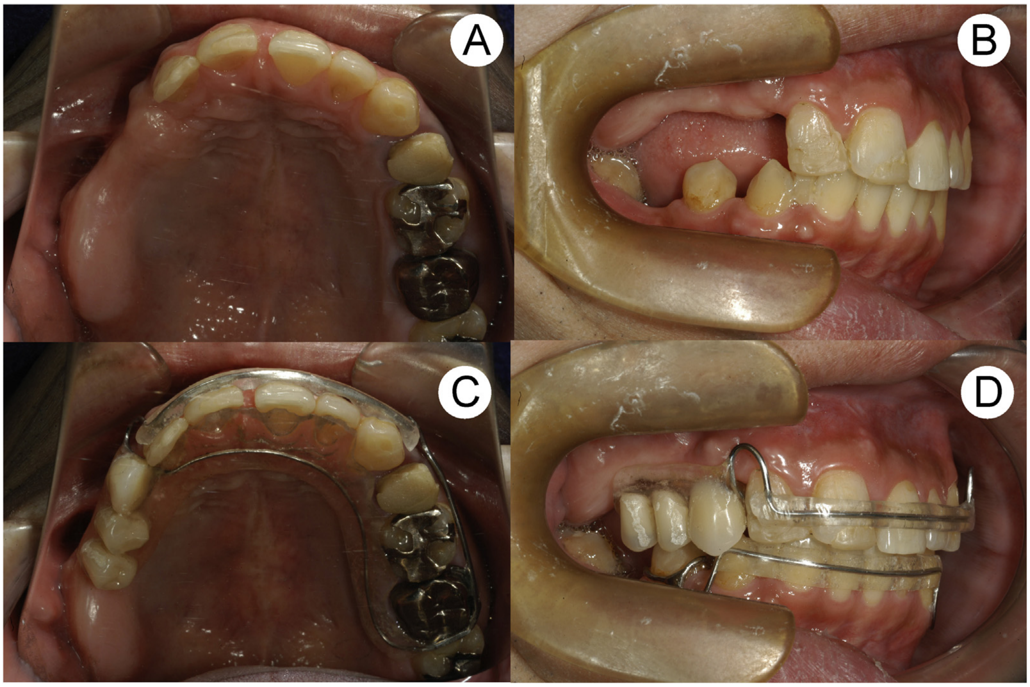

Fig. 5. Three years after alveolar distraction osteogenesis. (A and B) Intraoral photographs showed hard and soft tissue regeneration were maintained without significant resorption in the posterior maxilla. (C and D) Removal of the orthodontic retainer with fixed partial denture supported prosthetic oral rehabilitation.

device, and technique. In the treatment of complex 3D malformations as in this case, exact 3D planning is crucial. Optimal results can be obtained with accurate planning of the osteotomies and accurate positioning of the distraction device using 3D models. In addition, important structures like teeth, nerves, arteries, and the maxillary sinus can be taken into account when positioning the distraction device. RP models using the binder jet method have recently been established and have already produced excellent results in industrial applications. The use of medical models built with RP techniques in medicine creates improved opportunities for planning and simulation of complex surgeries, so higher-quality therapy and faster patient recovery are to be expected [10]. Distraction osteogenesis does not always proceed exactly according to 3D planning in practice. In some cases, accurate prediction is difficult using only skeletal planning, due to soft tissue resistance [11]. One of the limitations of distracting the posterior maxillary alveolus is resisting the palatal displacement of the distracted segment.

Although alveolar distraction osteogenesis has proven to be successful for treating alveolar ridge deficiency, some intra- and postoperative complications must be considered [12,13]. The difficulty in controlling 3D movements during transport osteogenesis has been widely reported [14,15]. Inappropriate direction of distraction may be caused by any of several factors, such as local soft tissue pull, inappropriate device positioning, or poor device trajectory. During maxillary alveolar distraction, the distracted segment may incline palatally because of the thick, inelastic palatal mucosa. Accurate control of the direction of alveolar distraction is a problem that remains unresolved [16]. Modification is needed according to postoperative progress if the transport segment becomes dislocated. To prevent displacement of segments, we need to control displacement by manual repositioning or using direction control equipment or a variable-direction distractor or use of a splint or temporary prosthesis. In the case we described, no dislocation of the transport segment was seen after distraction osteogenesis according to the treatment plan. This result was probably attributable to use of a bi-directional distractor with resistance from surrounding soft tissue. The bi-directional distraction device we used has sufficient strength and allows an inclination up to 52° and use of a distraction rod independently from the inclination of the bone surface. We checked whether sufficient bone for osteosynthesis was present in both the transport segment and the pterygomaxillary buttress on computed tomography, and decided the site at which the distraction device would be fixed. The rod was then adapted to an angle of 50° to the fixed plane for orientation of the transport segment in a forward and downward direction using the RP model. In the severely resorbed case, alveolar distraction in the maxilla is limited by the existing height of bone between the alveolar rim and the maxillary sinus or nasal bone. Only the frontal part of the maxilla will contain sufficient bone volume. For the completion of therapy, augmentation of the lateral part of the maxilla requires another augmentation technique, such as a sinus lift operation. In the present case, impacted molar teeth were present around the bottom of the maxillary sinus, which was not so pneumatized. We did not extract these impacted molar teeth before distraction osteogenesis because these were dentoalveolar ankylosis around the bone and therefore surgical removal of the ankylosed tooth caused damage to the bone for distraction osteogenesis and fixation of device. We could therefore ensure the size of the transport segment as far as possible posteriorly without sinus lifting.

We believe that alveolar distraction osteogenesis is not always a replacement for conventional bone grafting techniques. However, in our experience, distraction osteogenesis using a bi-directional distractor with proper therapeutic planning and good surgical technique will help ensure adequate vector control to predictably regenerate the hard and soft tissues during alveolar distraction.

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