CLINICAL SECTION

A paralleling device and ethylene vinyl acetate baffles for use with mandibular distraction osteogenesis: technical note

N. L. Brown*, K. House*, A. Leach*, K. Page†, G. H. Irvine* and J. R. Sandy*
*Southmead Hospital and †Frenchay Hospital, Bristol, UK

A novel method for planning the placement of intra-oral lengthening devices using a paralleling device is described and illustrated with a case report. Simple radiographic measurements and study models are all that is required to construct a simple acrylic splint with guides, which allows accurate positioning of the distractors at surgery. The construction of ethylene vinyl acetate (EVA) baffles to prevent trauma to the labial mucosa from the intra-oral link arms is a technique that enhances patient comfort during distraction of the mandible. The case report demonstrates the application of the surgical planning technique and the use of EVA baffles for a patient with an overjet of 21.5 mm.

Key words: Distraction osteogenesis, mandible

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Introduction

The surgical technique of distraction osteogenesis is not new. Following corticotomy, gradual callus distraction by separation of the proximal and distal ends of the bone results in bone lengthening. Within the craniofacial complex, distraction osteogenesis has many applications (for review, *see* Mattick[1]). Patients with mandibular hypoplasia, who are inappropriate for functional appliance therapy can be effectively treated using distraction osteogenesis to lengthen the mandible.[2] Compared with the relatively simple unidirectional distraction of long bones as described by Ilizarov,[3] the 3-dimensional distraction of the mandible is complex.[4] Various types of distraction devices are available for correction of hypoplastic mandibles, and they are usually categorized as internal or external, by the direction of distraction or by the site of application. External devices are capable of either unidirectional, bi-directional or multiplanar (3-dimensional) distraction, but internal or intra-oral distractors are capable of unidirectional distraction only.[5]

Accurate surgical placement of the lengthening devices is crucial to minimize post-operative complications. These include potential damage to the teeth, periodontium, inferior alveolar nerve and temporomandibular joint.[6] During bilateral mandibular lengthening, the distraction appliances must be orientated parallel to the axis of distraction to prevent unwanted lateral movement of the condyles and other adverse biomechanical effects.[7]

In order to plan the mandibular cuts and the placement of the lengthening devices at surgery, radiographs, study models, computed tomography (CT), stereolithographic models and computer regeneration programs have all been used in various ways. Stucki-McCormick *et al.* planned surgery using radiographs and CT scans alone,[8] but the detail reported is insufficient to replicate accurate positioning of the distraction device. Some cases have been successfully treated with corticotomy and simply placement of the intra-oral distractor parallel to the occlusal plane,[9] but the majority of reported cases use stereolithography models to plan both mandibular cuts and placement of the lengthening device.[10,11] Troulis *et al.* developed a 3-dimensional treatment planning system based on CT data[12] and, similarly, Gateno *et al.*[4] described the use of 3-dimensional modeling with animation to simulate mandibular distraction using virtual reality. In this, a 3-dimensional computerized scan of the facial skeleton is used to build a 3-dimensional wire-mesh model using animation software. A virtual distractor is built and installed on the wire-mesh model. The osteotomies and the distraction process can then be simulated. Gateno *et al.*[4] also developed a technique to facilitate the precise placement of distractors at surgery. The pin position and orientation of the distractors is

Address for correspondence: Jonathan Sandy, Division of Child Dental Health, Bristol Dental Hospital, Lower Maudlin Street, Bristol BS1 2LY, UK. Email: Jonathan.sandy@bris.ac.uk

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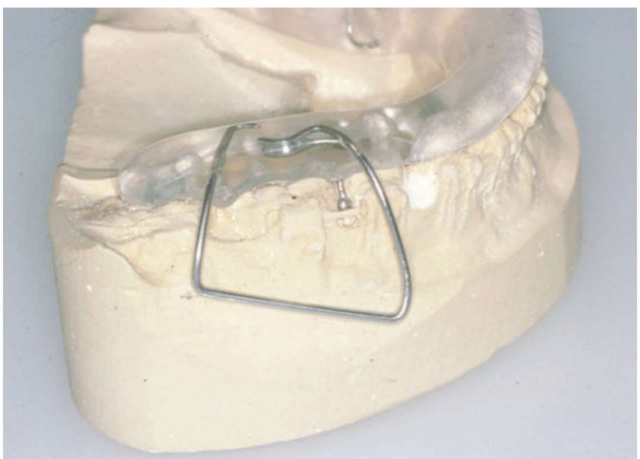
(a)

(b)



(c)

Figure 1 (a) Osteotomy cut on the acrylic mandible. (b) Distractor attachment and opening to the final post-distraction position. (c) Jig designed for parallel placement of distractors at operation

transferred from the computer model to the patient by creating a custom drill guide and surgical template. The template is designed with the computer and fabricated using the principle of stereolithography. Mock surgery can then be performed on the stereolithographic models. The combination of this planning process and surgical technique appears very accurate, but requires complex technology.[13,14] There are few simple and inexpensive aids for positioning intra-oral devices. Cope and Harper[15] used stereolithographic models for fabrication of an intra-oral distraction device and occlusal splints in order to define the osteotomy line, while Van Strijen[2] described the use of an acrylic pointer during surgery to mark the direction of distraction.

This paper describes a simple method for the placement of an intra-oral lengthening device to a pre-planned position at the time of surgery. We also describe the construction of EVA baffles to fit over intra-oral link arms to prevent post-operative trauma to labial mucosa, which may be seen particularly when there is profound post-operative paresthesia.

Technical information

In order to construct an acrylic model the following radiographs were taken: lateral cephalogram, a dental pantomogram and a submento-vertex radiograph. These were all traced paying particular attention to the mandibular condyles, coronoid processes, the lower border of the mandible, the symphysis, the molar cusps and incisal tips. The width and curvature of both the mandible and the condyles were also obtained from the tracings, then transferred to sheets of acetate, and cut to make 2-dimensional left and right mandibular tracings. This information was used to construct a 3-dimensional acrylic template of the patient's mandible. The lower dental arch was reproduced in acrylic resin, and attached to the mandibular acetate template using the anterior and molar teeth as guides for positioning. This ensured that the reference points (namely, the molar cusps and incisal tips) were correctly related to the radiographic tracings. The body of the mandible was then constructed in modeling wax, ensuring that the outlines of the acetate tracings were followed. The curve of the lower border of the mandible was determined from the acetate tracing made from the submento-vertex radiograph. Finally, the mandibular template including the acrylic dental arches was cast into acrylic by constructing a two-part plaster matrix around the wax mandible. The wax was then removed with boiling water; the 2 halves of the mould were coated with a preparatory mould release agent and packed with self-curing ivory-coloured acrylic resin. A bench press was

(a)

(b)

(c)

(d)

Figure 2 (e) Pre-operative lateral cephalogram. (f) Pre-operative dental pantomogram

(e)

(f)

(a)

(b)

Figure 3 (a,b) Pre-surgical intra-oral views

(c)

Figure 3 (c) Pre-distraction lateral cephalogram

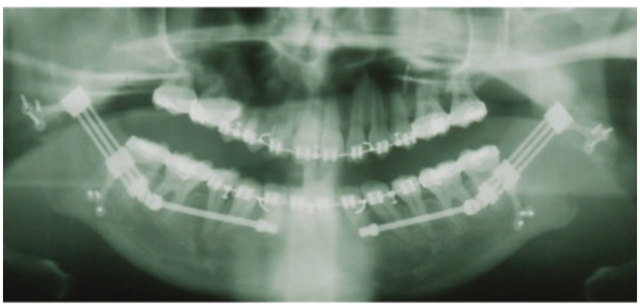
used to bring the 2 halves of the mould together while the acrylic cured. Finally, the plaster matrix was removed from the acrylic mandible and flash was trimmed.

The acrylic mandible was mounted on a semi-adjustable Dinar articulator in centric occlusion together with an acrylic model of the maxillary dental arch. The ideal angle of placement of the intra-oral distractors was determined by trial and error; the mandible was divided at the intended position of the 'live' osteotomy and the distractor repeatedly repositioned until the ideal path of distraction was achieved. At this point, measurements were taken from cusps of adjacent mandibular teeth to the upper border of the distractor to determine the angle at which the distractors were to be placed. Using these measurements, a paralleling device was constructed that comprised two 0.9-mm stainless steel wire carriers made to lie at the same angle as the distractors. The carriers were held in position by means of an acrylic occlusal splint with ball-ended clasps for stability and retention. The use of 0.9-mm stainless steel prevented distortion of the paralleling device. This technique allowed accurate placement of the intra-oral lengthening device in theatre to replicate the position planned on the template (Figure 1).

Baffles were constructed to fit over each arm of the lengthening device to prevent post-operative labial trauma. This was achieved by selecting a stainless steel rod slightly larger in diameter than the arm of the lengthening device. The rod was cut to a length of 20 mm and uncured light cure tray material was shaped over the end to create a round bulbous form. This was placed vertically on the platform of a Dreve Drufomat pressure-forming machine and a 1-mm EVA blank was thermoformed over this. The resultant baffle was trimmed to the required length and finished using a Lisko polishing disc. Once fitted to the link arms of the distraction device, the EVA covers could be removed and replaced by the patient enabling normal oral hygiene to continue.

(a)

(b)



(d)

(c)

Figure 4 (a,b) Post-distraction intra-oral views. (c) Post-distraction lateral cephalogram. (d) Post-distraction dental pantomogram

Case report

A female patient was 15 years 4 months of age when referred for orthodontic treatment. She presented with a Class II division 1 malocclusion and an overjet of 21.5 mm (Figure 2). The SNA and SNB angles of 79 and 65° suggested this case was beyond orthodontic treatment alone. There was significant crowding in both arches. It was felt that a combined orthodontic/orthognathic approach was required. In both arches the first premolars were extracted and fixed appliances used to level, align and co-ordinate the arches prior to orthognathic correction (Figure 3). The residual overjet was 18 mm, which is too large for correction with a single jaw movement and, in addition, the maxilla and upper incisal protrusion were normal. The options considered at the time were an initial sagittal split osteotomy with approximately 10 mm of forward movement. After healing, this would then need to be followed by a further sagittal split osteotomy to correct the residual overjet. Alternatively, an osteotomy with a bone graft may have provided a solution, but we felt that, in this particular case, distraction osteogenesis would provide the optimal treatment.

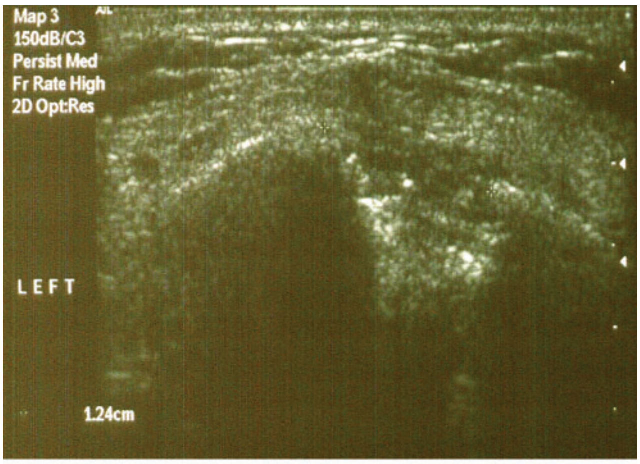
Surgery to place the lengthening devices and split the mandible proceeded without complication, and within 20 days distraction was complete, without the need for elastic moulding of the regenerate during distraction (Figure 4). During this time, the link arms of the lengthening device caused significant trauma to the labial mucosa, which was compounded by profound anaesthesia of the inferior dental nerve. This problem

(a)

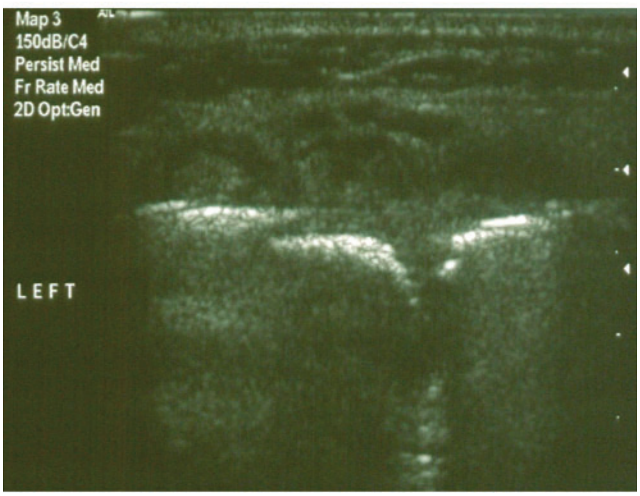
Figure 5 (a) EVA baffles

(b)

Figure 5 (b) Placement of EVA baffles over distractor link arms to prevent oral ulceration



(a)



(b)

Figure 6 (a,b) Ultrasound scans used to monitor healing of the distraction site

was overcome with the use of baffles and, within a few days, the ulceration had healed (Figure 5).

Ultrasound was used in order to monitor the regenerate bone (Figure 6). Two months after initial surgery, the distractors were removed under general anaesthetic. Post distraction, the SNB had increased to 74° and the ANB was 3°. The maxillary-mandibular plane angle remained constant, but as the mandible came forward the facial proportion increased. Before orthodontic treatment the upper incisors were considerably proclined (116°). After orthodontic treatment and distraction the upper incisors were retroclined at 102° (Table 1). Facially, this patient did not appear compromised by this retroclination (Figure 7). The lower incisor angulation to the mandibular plane remained fairly constant throughout treatment. Superimposition of the cephalometric tracings showed that relative to the cranial base the mandible was

Table 1 Pre- and post-distraction cephalometric measurements

Measurement	Pre-distraction	Post-distraction
Skeletal		
SNA (°)	79	77
SNB (°)	65	74
ANB (°)	14	3
Sn/MxP (°)	10	10
MxP/MnP (°)	27	27
LAFH/TAFH (%)	52.5	55
Teeth		
OJ (mm)	21.5	3
OB (mm)	3.5	3
UI/MxP (°)	116.5	102
LI/MnP (°)	99	97

(a)

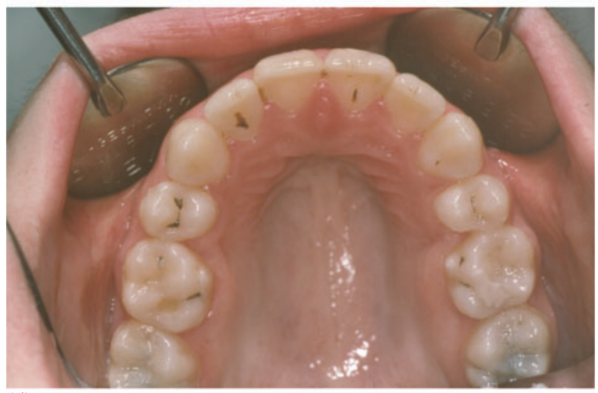
Figure 7 (a) Post-operative face-on facial view

(f)

Figure 7 (f) Post-operative lateral cephalogram

(b)

(c)



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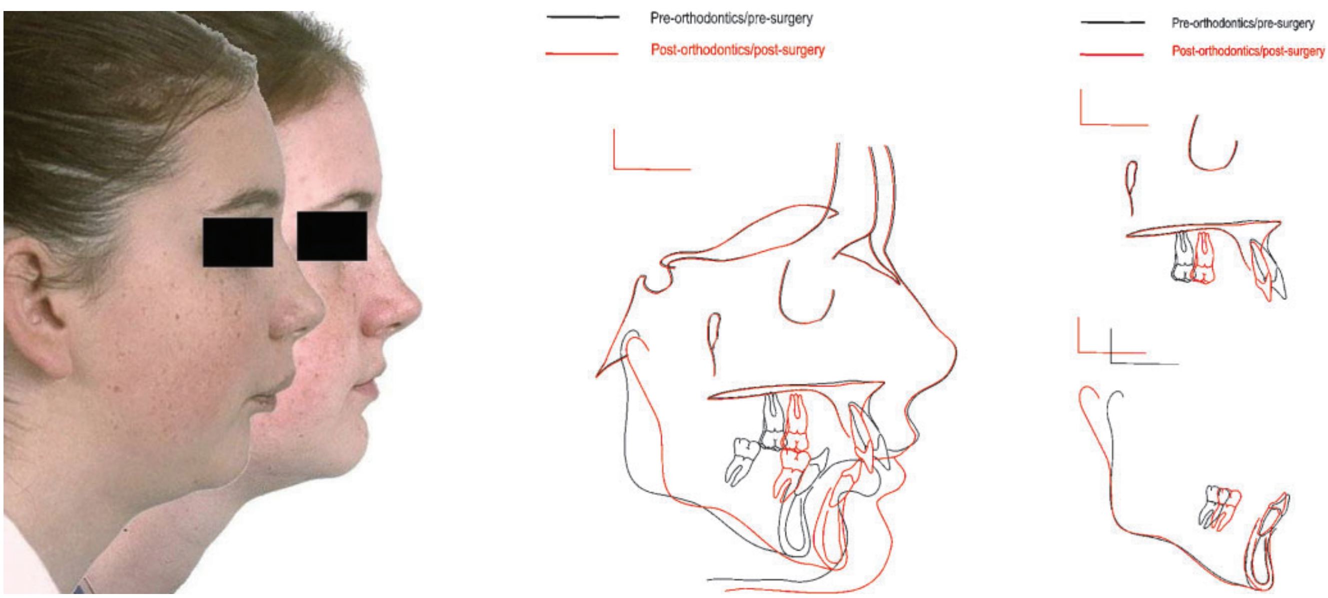
(e)

Figure 7 (b–e) Post-operative intra-oral views



(a) (b) (c)

Figure 8 (a) Pre- and post-distraction profiles superimposed. (b) Pre- and post-distraction lateral cephalogram tracings superimposed. (c) Superimposition of pre- and post-distraction tracings of the maxilla and mandible

significantly advanced (Figure 8). The maxillary superimposition highlights the retroclination of the upper incisors; the forward movement of the molars was by virtue of the premolar loss in the upper arch in order to align these teeth. In the mandibular superimposition there is forward movement of the lower molar and slight retroclination of the lower incisors. The patient has been kept under review and 2 years post-distraction she appears to have a stable occlusal and skeletal result.

Discussion

Planning the position of the mandibular distractors is an important factor in the use of distraction osteogenesis to correct skeletal discrepancies. The alignment of the distractors to produce movement of the segments in the correct direction is critical for a successful outcome in these cases. Accurate placement and identifying appropriate vectors is paramount because of the 3D movement that will be performed. Inappropriate mandibular advancement may lead to facial asymmetry, to an iatrogenic dental lateral or anterior open bite, or unilateral crossbite.[9] The template and paralleling device described here allows accurate placement of the intra-oral distractors in an ideal position for a good final result. This is illustrated by the present case in which the planned result was achieved and there was no need for elastic molding of the regenerate during distraction.

The strength of this method is that it is relatively inexpensive, the planning and placement of the mandibular distractors is simple and the final position of the mandible is predictable. Further cases need to be treated using this technique to determine the reproducibility and accuracy of the surgical planning and distractor positioning, and also to make valid comparisons with other methods such as virtual planning.

As with all distraction procedures, the possibility of adverse effects still exists using this technique, including profound paresthesia. The EVA baffles were simple to construct and prevented post-operative trauma to the labial mucosa, thus minimizing the risk of serious oral ulceration. In the case illustrated, oral ulceration was already present in the mucosa adjacent to the arms of the distractors when the baffles were fitted, but their subsequent construction and placement prevented further trauma and promoted healing of the mucosa.

Ultrasound was also used in order to monitor the regenerate bone. This not only monitored callus formation, it also ensured early detection of complications. The benefits of sonography in distraction osteogenesis cases are that tissues with any degree of mineralization can be visualized in any desired projection, it is non-invasive and can be repeated as necessary. It provides a complete picture of the region, since complications such as fluid retention or abscess formation can be detected early and precisely. It can also be used to measure the length of distraction attained.[16]

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