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SEGMENTAL DISTRACTION OSTEOGENESIS OF THE ANTERIOR MANDIBLE FOR IMPROVING FACIAL ESTHETICS. PRELIMINARY RESULTS

Aim: *To report preliminary results of treatment with gradual repositioning of the anterior mandibular segment using distraction osteogenesis in patients with anterior tooth crowding and/or an unfavorable anteroposterior relationship between the anterior dentoalveolar area and the skeletal base.* ***Methods:*** *The following outcome measures were considered: ability of the technique to achieve the desired skeletal jaw position, resolution of the crowding, periodontal condition (recessions and probing pocket depths), temporomandibular joint symptoms, tooth sensitivity, permanent nerve injury, additional complications, and patient satisfaction. Four patients were treated.* ***Results:*** *All outcome measures indicated that the therapy goal was achieved and the results maintained to date. Periodontal conditions were slightly improved. Two patients were very satisfied; 2 were only partially satisfied with the therapy. In 1 patient the root of the mandibular right first premolar was damaged during the vertical osteotomy procedure and the mandibular right central incisor did not respond to the postoperative sensitivity test. Another patient reported tension at the temporomandibular joint when chewing hard food.* ***Conclusion:*** *The preliminary results are encouraging. However, larger trials are needed to acquire sufficient knowledge of the efficacy, predictability, and ideal indications for the mandibular osteodistraction technique.* World J Orthod 2007;8:19–29.

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Distraction osteogenesis, also called osteodistraction, is a relatively new procedure used to correct skeletal discrepancies when applied to the maxillofacial complex. Osteodistraction can be an alternative to conventional orthognathic procedures. It can be used to correct vertical, sagittal, and transversal discrepancies of both jaws. In comparison to orthognathic surgery, osteodistraction may be easier, less costly since hospitalization is not required, and possibly more acceptable to patients due to fewer complications and postoperative sequelae. The main advantage of osteodistraction is that the risk of permanent damage to the alveolar inferior nerve can be minimized, if not completely eliminated.

Osteodistraction is an interesting option to create intra-arch space for resolving transverse mandibular deficiency.[1–3] In patients with anterior tooth crowding, osteodistraction offers an alternative to tooth extraction and stripping where transverse discrepancies exist.[1,2,4] Preliminary results suggest that the mandibular expansion obtained with osteodistraction can be maintained over time.[4,5]

The use of mandibular segmental osteodistraction, introduced by Triaca et al,[2] has been suggested for the following clinical conditions: skeletal Class I and II cases with anterior tooth crowding; skeletal Class II cases with mandibular retrusion and severe overjet, though prosthetic rehabilitation may be required; and Class III cases requiring decompensation before orthognathic surgery.[2,3] In fact, in patients with anterior crowding, extraction therapy often implies extraction also in the maxilla. The effect is an unfavorable relationship between the mandibular symphysis and the anterior dentition, resulting in a compromised facial profile. In addition, vestibularization of the mandibular anterior teeth may expose buccally the roots of the teeth. Osteodistraction may also be used as an alternative to orthodontic functional therapy in a noncompliant growing child with a skeletal Class II malocclusion and a severe overjet due to mandibular retrusion.

There are some disadvantages associated with the osteodistraction technique; vector control is probably the most challenging aspect.[3] Up to 3 distractors may be needed in patients requiring large mandibular advancements with simultaneous symphyseal widening. Often, elastics are used to control or modify the vector during the distraction phase. Nevertheless, the resulting occlusion at the end of the distraction period seems to be less precise than that obtained after orthognathic surgery. Therefore, final adjustments to the occlusion may be needed while the bone segments are still moldable.

Patient compliance is another aspect to be considered when planning to use osteodistraction techniques, since patients are expected to activate their distractors once or twice a day for a few days. In addition, despite repeated instructions, patients may turn the device in the wrong direction. Therefore noncompliant patients might be poor candidates for osteodistraction.

The aim of this case series is to report the preliminary results achieved in patients treated by gradually repositioning the anterior mandible segment using osteodistraction for the treatment of anterior tooth crowding and/or an unfavorable anteroposterior relationship between the anterior dentoalveolar area and the skeletal base.

OUTCOME MEASURES

The following outcome measures, assessed by independent clinicians, were considered:

Ability to achieve the desired skeletal jaw position

The achievement and maintenance of the desired position of the mandible was evaluated using Dolphin Imaging 9.0 computer software (Dolphin Imaging, Chatsworth, CA, USA). On lateral radiographs, landmarks were identified, digitized, and used to compute the measurements, according to the soft tissue cephalometric analysis (STCA) by Arnett and McLaughlin.[6]

Resolution of the crowding

The total space analysis measured on pre- and posttreatment casts was used to quantify the resolution of the anterior crowding in patients having this problem.

Periodontal condition

Buccal gingival recessions (REC) and probing pocket depths (PPD) were measured, in mm, at 6 points for the teeth in the distracted bone segment and the 2 laterally adjacent teeth. These measurements were taken prior to and after therapy, and were the parameters used for assessing periodontal condition.

Temporomandibular joint (TMJ) symptoms

Preoperative and postoperative physical assessment of the TMJ symptoms included evaluation of functional shifts, clicking, crepitus, popping, joint pain,

Table 1 Characteristics of patients treated with segmental distraction osteogenesis of the anterior mandible

Patient	Age (y)*/ gender	Diagnosis	Operation period	Osteotomies	Number of distractors	Total gain in length (mm)	Complications	Duration of therapy (mo)	Postoperative follow-up (y)
1	18/female	Retrognathic skeletal Class II; severe frontal crowding	06/1999	42-32	1	5.6	None	14	5
2	27/female	Compensated skeletal Class III	03/2001	43-32	1	6.0	None	20	3
3	25/female	Retrognathic skeletal Class II;slight frontal crowding	11/2002	44-34	3	3.2; 6†	None	29	2
4	38/male	Skeletal Class II, deep bite	09/2003	43-33	3	4.8; 5.6†	Yes‡	18	1

*Age at surgical intervention.

†The first figure corresponds to the movement of the distractor at the symphysis; the second refers to the movement of the vestibular distractors

‡Tooth 44 (mandibular right first premolar) was damaged during the vertical osteotomy and extracted.

muscle tenderness, and mouth opening, as well as a thorough history of symptoms, such as joint pain, headaches, clicking, crepitus, popping, and open or closed lock.

Tooth sensitivity

Postoperative sensitivity of the teeth in the distracted bone segment and the 2 laterally adjacent teeth was assessed with an electrical pulp tester or with iced pellets. Results were divided into sensitive or not-sensitive teeth.

Permanent alveolar inferior nerve alteration

The presence of permanent mental nerve paresthesia/alteration was assessed by lightly touching the skin and the oral mucosa of the anterior mandible with a periodontal probe.

Additional complications

Additional complications were reported as recorded on the patient files.

Patient satisfaction

The following questions were asked, either in person or via telephone; the patients were given 5 potential responses (completely yes, partially yes, not sure, unlikely, absolutely not):

1. Did the therapy improve your quality of life?
2. Did the procedure alter your lifestyle?
3. Did this procedure cause excessive discomfort?
4. Did you endure excessive physical pain?
5. Are you satisfied with the esthetic results?
6. Do you feel more confident?
7. Were the results worth it economically?
8. If you could, would you do it over again?
9. Any comments?

INTERVENTIONS AND PROCEDURES

Four patients, 3 females and 1 male, were treated to improve facial esthetics

Table 2 Time chart for the osteodistraction procedure used

Procedure	Time requirement
Preoperative orthodontic therapy	≈ 3 to 6 months
Osteotomy	
Latency	≈ 8 to 13 days
Distraction	≈ 0.6 mm/day
Consolidation	≈ 3 months
Surgical removal of the distractor(s)	
Postoperative orthodontic therapy	≈ 6 to 12 months

and malocclusion. Patients received periodontal and restorative treatment as needed. Patient characteristics and information on the interventions are summarized in Table 1.

The time chart for the osteodistraction procedure used in this study is presented in Table 2. Following is a brief description of the procedure: The new position of the anterior alveolar segment was carefully planned with the help of a lateral cephalogram. The outlines of the maxillofacial region were copied on acetate paper; the anterior segment of the mandible was then cut out and transferred to the desired position to evaluate the required movement/rotation (VTO, visual treatment objective). Brackets (MBT 0.022) were bonded on both dental arches. Orthodontic wires were placed as follows: During the alignment phase, nickel-titanium wires with a diameter of 0.014 inches were placed initially, and progressively increased up to 0.18 or 0.19 × 0.28-inch stainless steel wires. The authors used a maxillary posterior anchorage with a transpalatal arch for 2 of the patients (patient 3 and patient 4). A lingual arch anchorage was used in 2 patients (patient 2 and patient 3). Both straightwire and segmented arch (TMA 0.17 × 0.25 inch) techniques were used. The inter-root space of the teeth adjacent to the planned vertical osteotomies was increased with fixed orthodontic appliances. Whenever possible, the root of the canine was mesialized, with particular emphasis on not moving the body of the tooth. Preferably, the osteotomy was planned between the canine and the first premolar; therefore, whenever possible, the premolar was distalized. For 1 patient (patient 4), 2 soldered appliances were used to apply an orthodontic single force as apically as possible to diverge the roots of the canines from the premolars.

Surgery was performed under local anesthesia/intravenous sedation for 3 cases, and 1 patient (patient 4) was treated under general anesthesia. A horizontal incision was made from canine to canine at about 1 cm below the gingival margin, followed by a subperiosteal dissection to the level of the horizontal osteotomy. The horizontal osteotomy was done about 5 mm below the apices of the mandibular canines, with the help of a thin bur-type bone cutter with a diameter of 1.6 mm (Cutter E0540; Maillefer, Ballaigues, Switzerland). Once the horizontal osteotomy was complete, incomplete vertical osteotomies were made between the canines and premolars or the canines and lateral incisors. Extreme care was taken to maintain the lingual periosteum

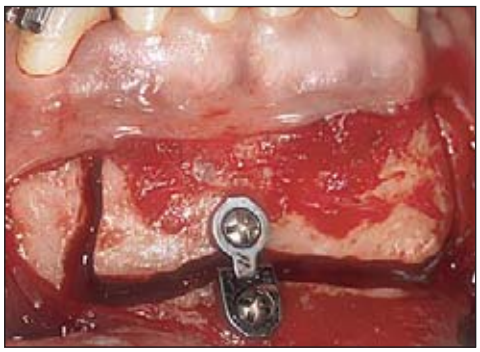


Fig 1 Osteotomies and the application of a hinge plate MDO-H (Ortho-Gnathics, Zurich, Switzerland) in patient 2.

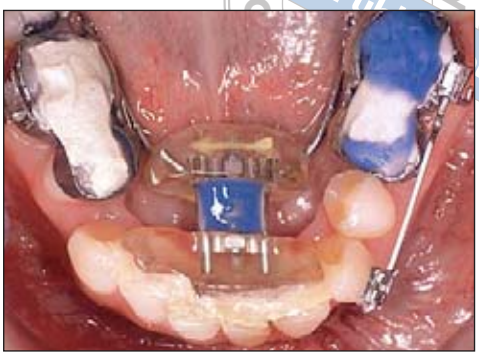


Fig 2 Lingual osteodistractor blocked in a locked position to allow for bone consolidation (patient 2).

and mucosa. The joint plate of the distractor was loosely fixed with screws before the vertical osteotomies were completed. Once the vertical osteotomies were completed, the alveolar process was mobilized with a chisel and free rotation was assured. The bone segment was stabilized by tightening the holding screws (Fig 1) and the flap was sutured. During the first postoperative week, the bone segment was stabilized. After 1 week or slightly more, the distraction device was activated by the clinician turning a screw mechanism and moving the bone block in the desired direction about 0.6 mm per day. In some cases, activations were made twice a day. When possible, activations were performed directly at home by the patients, who were instructed accordingly. Once the planned position of the bone segment was reached, the bone block was stabilized for about 3 months by means of the distractor appliance locked in the final position (Fig 2). The orthodontic treatment was then continued and the teeth were moved into the newly created space. The bone plates were surgically removed 3 to 4 months after the start of treatment, with the exception of patient 1, who refused to have the plate removed. At the end of the active orthodontic phase, a removable retention device was applied to the maxilla. An additional fixed retainer was bonded between the maxillary right and left lateral incisors of patient 3. Fixed 0.19-inch stainless steel lingual retainers were bonded between the first premolars or the canines of the mandible in each patient.

PATIENTS

Patient 1

This patient, a female born in 1981, with a retrognathic skeletal Class II malocclusion and severe crowding of the anterior mandible, was treated with segmental osteodistraction with vertical osteotomies between the mandibular right and left lateral incisors and canines. One lingual osteodistractor, built using a 7-mm rapid expansion screw (Hyrax; Dentaurum, Ispringen, Germany) with a hinge plate (MDO-H; Ortho-Gnathics, Zurich, Switzerland), was used. The osteodistractor was activated 13 days after its placement, with 1 revolution the first day (1 revolution, 0.9 mm), 2 activations (1 activation, 1/4 revolution) for 7 days, and then 1 activation for 7 days. The total gain in length was of 5.6 mm on each side (Figs 3 and 4).

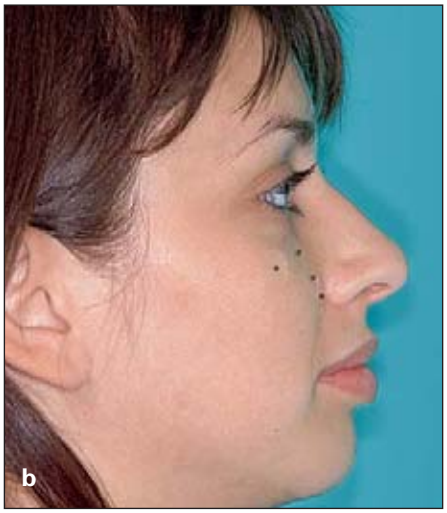
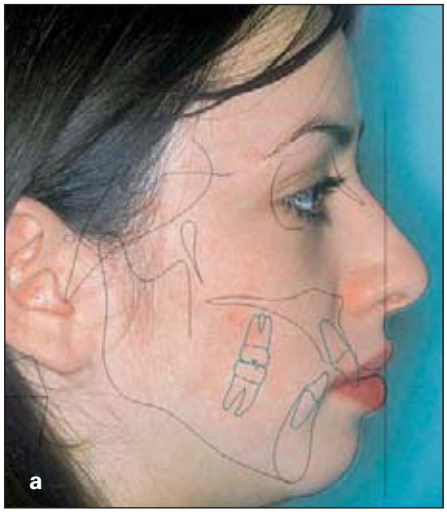


Fig 3 Patient 1. Preoperative and postoperative photographs showing esthetic changes of soft tissue **(a,b)**, skeletal changes **(c,d)**, and resolution of the crowding **(e,f)**.



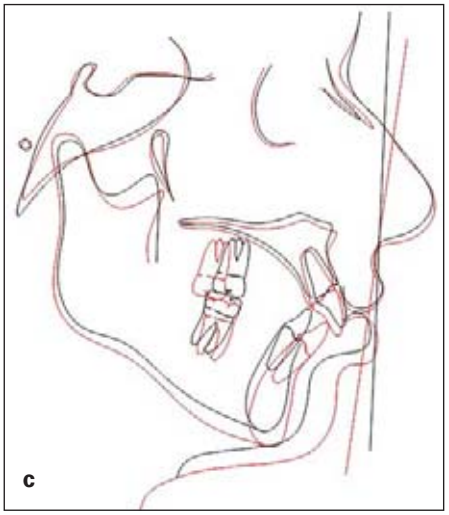
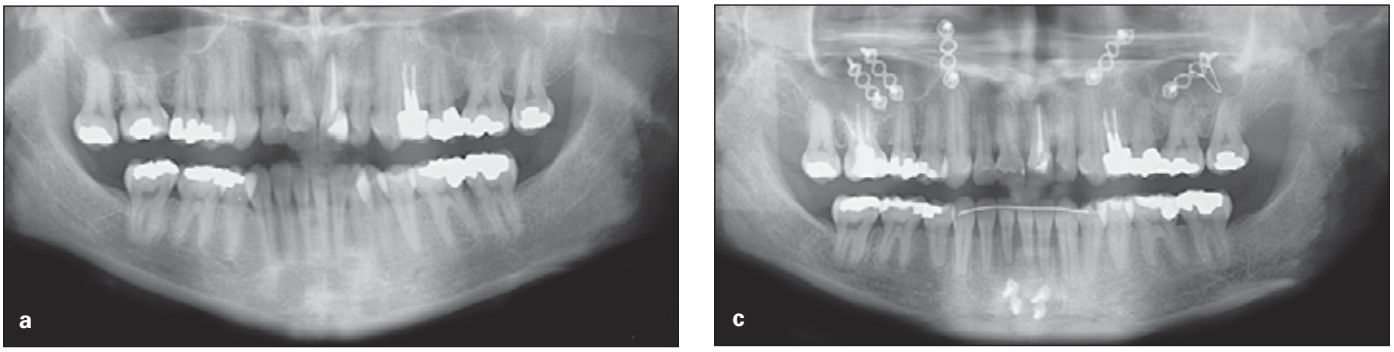


Fig 4 Patient 1. Preoperative **(a)** and postoperative **(b)** soft tissue cephalometric analyses (STCA), according to Arnett and McLaughlin,[6] which are superimposed **(c)** to show the improvement of facial esthetics. Preoperative analysis *(black);* postoperative analysis *(red)*.

Fig 5 Patient 2. Preoperative **(a,b)** and postoperative **(b,c)** views showing esthetic changes of the soft tissue.



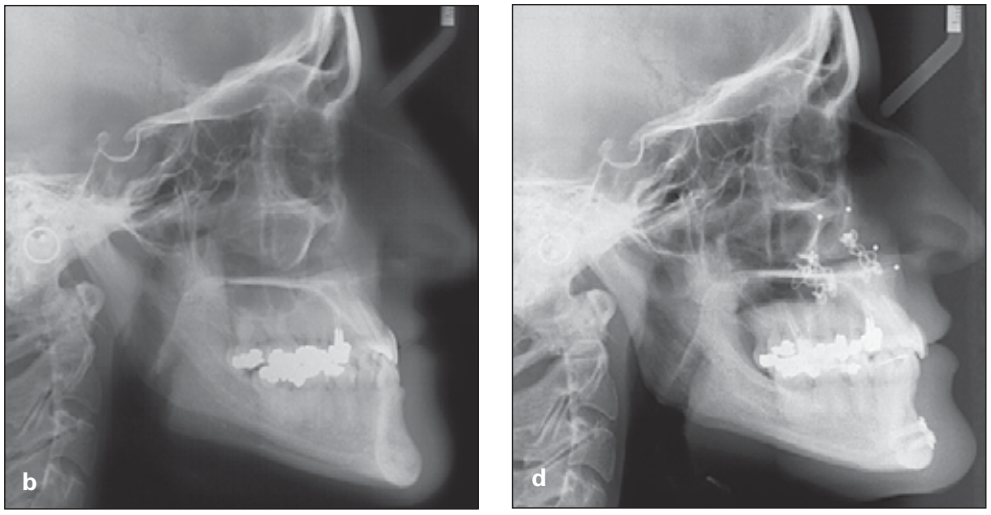


Fig 6 Patient 2. Preoperative **(a,b)** and postoperative **(c,d)** orthopantomographs and lateral cephalometric radiographs showing skeletal changes.

Patient 2

This patient, a female born in 1975, with a compensated skeletal Class III malocclusion, was treated with mandibular segmental osteodistraction with vertical osteotomies between the mandibular right first premolar and canine and the left canine and lateral incisor; in a second stage she was treated with a maxillary Le Fort I osteotomy (Fig 6d). One lingual osteodistractor, built using a 7-mm expansion screw (A0805-11; Leone, Sesto Fiorentino, Italy) (see Fig 2) with a hinge plate (MDO-H, Ortho-Gnathics), was used. The osteodistractors were activated 10 days after placement and thereafter with 1 activation per day for 30 days (1 revolution, 0.8 mm; 1 activation, 0.8 mm), equivalent to about 6 mm. Preoperative and postoperative views are presented in Figs 5 to 8.

Fig 7 Patient 2. Preoperative **(a)**, intraoperative **(b)**, and postoperative **(c)** views showing overjet changes.

Fig 8 Patient 2. Preoperative **(a to c)** and postoperative **(d to f)** photographs of the frontal and lateral occlusion showing occlusal changes.

Patient 3

This patient, a female born in 1974, had a retrognathic skeletal Class II malocclusion and slight anterior crowding in the maxilla and mandible. She was treated with vertical osteotomies between the mandibular right canine and first premolar and left first and second premolars. Two vestibular osteodistractors (1 revolution, 1.2 mm), 1 per side, and 1 H-B distractor (Ortho-Gnathics) were used. The H-B distractor allowed anterior advancement of the base of the alveolar segment independent from the movement of the dental arch (1 revolution, 0.8 mm). The osteodistractors were activated 9 days after placement; the symphysis was pushed forward about 3.2 mm in 3 days, whereas the vestibular mandibular distractors were pushed forward 6 mm on each side in 10 days.

Patient 4

This patient, a male born in 1965, had a skeletal Class II malocclusion with deep bite. He was treated with vertical osteotomies between the mandibular canine and first premolar on the right and left sides. Both jaws were simultaneously distracted. Two vestibular osteodistractors, the Fast Back 9 mm (Leone), 1 per side (1 revolution, 0.8 mm), and 1 H-B distractor (Ortho-Gnathics) were placed in the mandible (1 revolution, 0.8 mm). The osteodistractors were activated 8 days after placement; the symphysis was pushed forward about 4.8 mm in 8 days, whereas the vestibular mandibular distractors were pushed forward 5.6 mm on each side in 15 days.

RESULTS

All interventions were successful and achieved the planned goal of the therapy.

Ability to achieve the desired skeletal jaw position

In all instances, the authors were able to achieve the planned goal of the therapy.

Resolution of the crowding

The total space needed in the mandible to resolve crowding was: 6 mm (patient 1), 8 mm (patient 2), and 5.5 mm (patient 3). In all cases, the space needed was obtained.

Periodontal condition

Before intervention, 3 patients had minor buccal recessions of the soft tissue margins of mandibular teeth: patient 2 (1 mm, left canine), patient 3 (3 mm, right canine; 1 mm, left canine), and patient 4 (1 mm, right and left first premolars; and 2 mm, left canine). Postoperative measurements were the following: patient 2 (no measurable recession of left canine), patient 3 (1 mm, right canine), and patient 4 (1 mm, right central incisor; 3 mm, left canine). These results tend to indicate a slight improvement of the recessions. Only patient 4 had a pocket of 5 mm mesial to the right central incisor that disappeared due to physiologic conditions posttreatment.

TMJ symptoms

Two patients had preoperative TMJ symptoms. Patient 1 had clicking on the right side and a lateral shift toward the left; patient 2 had a history of open lock; there was a total remission of TMJ symptoms postoperatively in patient 1; postoperatively in patient 2, no open lock occurred, but the patient had a small deviation toward the right when opening the mouth and, now and then, clicking on the right TMJ. Patient 2 also stated that the TMJ became tense and painful when eating hard food.

Tooth sensitivity

In patient 4, the mandibular right central incisor did not respond to the sensitivity test. The tooth was not discolored and there were no radiographic signs of pathology.

Permanent alveolar inferior nerve alterations

Apart from some postoperative paresthesia of the oral mucosa, which resolved within a couple of months, no permanent alteration of the mental nerve functionality was detected.

Additional complications

Complications occurred only in 1 patient (patient 4). During the osteotomy procedure, the mandibular right first premolar was damaged, extracted, and later replaced with a dental implant.

Patient satisfaction

Two patients (patients 1 and 3) were, in general, very satisfied with the outcome. Two patients were partially satisfied: patient 2 would undergo the same treatment again, while patient 4 was unsure about undergoing the same treatment again. Patient 2 suffered substantial discomfort and pain during the therapy. All patients were completely (patients 1 and 3) or partially (patients 2 and 4) satisfied with the esthetic results.

DISCUSSION

The osteodistraction procedures achieved the planned results in each of these 4 cases. Complications occurred in 1 patient (patient 4); during the osteotomy, the mandibular right first premolar was damaged. The authors were fully aware of this risk and the patient was duly informed. Unfortunately, it was not possible to move the tooth distally during the orthodontic phase. Although the osteotomy procedure was postponed 3 times to give more time for the teeth to move, sufficient space was not obtained. Despite a careful surgical approach, the tooth was slightly damaged and the operator decided to extract it. The problem was solved with a single dental implant. It may be debatable whether the tooth should have been extracted or left for healing since the amount of damage was minimal. In similar situations, potential risks should be discussed with the patient prior to making a decision on how to proceed. Alternatively, a reciprocating saw blade (as thin as 0.25 mm) could be used to allow for a more precise and thinner osteotomy; this method will be used in future treatments. Another option would have been to insert a short screw in the intraradicular space where the osteotomy was performed and to take an intraoral radiograph to precisely visualize the exact location for cutting the bone without risking damage to the adjacent roots.

The mandibular right central incisor in the same patient did not respond to repeated sensitivity tests. Since the authors did not perform any sensitivity test prior to the surgical intervention, it is possible, though unlikely, that the tooth was not sensitive before the osteotomy procedure. Therefore, routine measurements of tooth sensitivity, to monitor any changes, are suggested for patients to be treated with segmental osteodistraction.

The authors were also interested in the patients' opinions regarding the treatment. All patients were satisfied with the treatment, although to varying degrees. Two patients were completely satisfied and enthusiastic about the outcome; the other 2 patients were also satisfied with the treatment but were unsure whether the treatment was worth the economic cost. One of these 2 patients would repeat the procedure, but the second was unsure. The latter patient had undergone orthodontic treatment for many years in another dental practice and had suffered in terms of physical pain and discomfort. To minimize such problems, careful selection of patients is necessary and detailed explanation of the procedure is recommended. Patient expectations and needs have to be analyzed in detail and discussed with the patients. The authors were pleased with the outcomes and the final esthetic results.

With osteodistraction it is possible to treat cases of severe crowding without extractions, thus preserving or improving facial esthetics. The alternative would be bilateral sagittal split osteotomy, which must be conducted under general anesthesia and risks permanent damage to the alveolar inferior nerve. However, with segmental osteodistraction there is the risk of losing tooth sensitivity.

Another advantage of the anterior segmental distraction technique is that when moving only a segment of bone, it may be easier to control the direction of the vector compared to the mobilization of the entire anterior mandible. In 1 report in which the latter technique was used, 2 of the 5 treated patients showed opening rotations of the anterior mandibular segments along with the advancement.[3]

The anterior segmental distraction technique used in this study, when compared with the mandibular symphyseal

distraction technique introduced by Guerrero et al,[1] has the advantage of allowing correction of transverse, as well as anteroposterior, discrepancy. In fact, with the technique of Guerrero et al,[1] only transverse problems can be correctly modified. The direct effect is that it can become necessary to surgically increase the width of the maxilla as well. Another advantage of the technique presented in this article is that in the presence of a retrognathic mandible, the body of the mandible can be lengthened. This is not possible with symphyseal osteodistraction.

CONCLUSION

The preliminary results showed that facial esthetics, anterior tooth crowding, and unfavorable relationships between the anterior dentoalveolar area and the skeletal base can be improved using the osteodistraction technique. Segmental distraction of the anterior mandible, associated with chin distraction, induced a real lengthening of the body of the mandible. This represents a positive alternative, in cases of a retrognathic mandible, to sagittal split osteotomy. Larger trials are needed to acquire sufficient knowledge of the efficacy, predictability, and ideal indications of the mandibular osteodistraction technique.

ACKNOWLEDGMENTS

The authors wish to thank Ms Heather Dawe for her kind contribution in editing the manuscript and Marco Bonfini for his technical support in producing the images of this article.

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