

Bilateral Distraction Osteogenesis for the Management of Mandibular Hypoplasia

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Abstract

Introduction: Patients with mandibular bilateral hypoplasia usually present with varying degrees of facial deformity, upper airway obstruction and difficulty with feeding. Treatment of such cases is very important. Distraction osteogenesis (DO) using intra and extra-oral devices provides an excellent alternative when other surgical techniques do not prove to be satisfactory.

Aim of the Work: To evaluate the efficacy of bilateral DO in the treatment of mandibular hypoplasia.

Patients and Methods: Ten patients (7 females and 3 males), their ages ranged from 7 years to 23 years (with a mean of 14.45 years). They presented with bilateral mandibular hypoplasia with facial deformity, difficulty in feeding and three of them presented with obstructive sleep apnoea. All patients were treated with bilateral mandibular distraction osteogenesis, using intra and extra-oral unidirectional distractors. The follow-up periods were immediately, 3 months, 6 months and one year post distraction.

Results: The patients were successfully treated using bilateral unidirectional distractors. After completion of distraction, retrognathia was corrected in all patients. The "subjective" symptoms had disappeared completely or had been alleviated with obvious increase of airway space. And good stability of skeletal changes (defined by the lateral cephalograms measurements).

Conclusion: DO is an effective method for management of facial deformity and obstructive sleep apnea with good stability of the results.

Key Words: *Distraction osteogenesis — Obstructive sleep apnoea — Mandibular lengthening — Surgical correction of mandibular hypoplasia.*

Introduction

MANDIBULAR hypoplasia is one of the most common problem that falls into the dentofacial deformity category, patients with the true mandib-

ular deficiency represent about 40% of the total pool of potential dentofacial patients. Mandibular hypoplasia usually leads to facial asymmetry, reduction of oropharyngeal capacity, upper airway obstruction, snoring, in addition to feeding difficulties and gastroesophageal reflux, mandibular hypoplasia can be congenital, developmental, or acquired [1-3].

Techniques such as functional orthopedics and orthodontics alone are inadequate modalities for management of the mandibular deficiency [4].

Different orthognathic surgeries can be used for treatment of mandibular deficiency such as inverted "L" osteotomy, vertical ramus osteotomy and bilateral sagittal split osteotomy, although orthognathic surgeries were gaining wide spread acceptance but they have several problems including intraoperative nerve damage, marked postoperative displacement of bone segments due to inadequate bony contact and insufficient fixation stability and partial or total relapse as a result of acute muscle stretching [5,6].

Nowadays mandibular skeletal deficiency can be corrected successfully by the mandibular distraction osteogenesis which has the potential to overcome the hazards associated with bilateral sagittal split osteotomy. Distraction osteogenesis provide higher stability with more preservation of inferior alveolar nerve than bilateral sagittal split osteotomy specially in cases required larger mandibular advancement [7,8].

In this article, we report our experience in correction of bilateral mandibular hypoplasia and management of obstructive sleep apnea with reporting stability of the results.

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Patients and Methods

Ten patients presented with skeletal mandibular deficiency indicated for bilateral distraction osteogenesis were included in this study. They were selected from the cases received at the Oral surgery Department, Faculty of Dentistry, Suez Canal university from October 2007 to May 2011. Patients included in this study were arranged for topical application of platelet rich plasma (PRP) in the left side of the distraction and the right side selected to be the control one. After admission to the Oral Surgery Department preoperatively every patient was carefully evaluated. Full clinical examination and routine admission laboratory investigation which include complete blood picture, liver function tests, renal function tests, blood sugar and prothrombin time were done. Also study model, photographs were taken, in addition radiographic examination were done using Cephalometric X-ray, panoramic X-ray and computerized tomography. Patient with systematic disorders were excluded from the study, also patients with platelets number and prothrombin level below normal were excluded. The selected cases of this study were arranged for local maxillofacial examination and assessment with documentation of the finding in every patient file and including:

- Facial appearance in posteroanterior and lateral side view.
- Mandibular micrognathia.
- Relation of the mandible to maxilla.
- Occlusion abnormality and oral hygiene.
- Study model to reveal dental relation.
- Panoramic view to determine site of osteotomy.
- Lateral cephalometric to study dental relation, mandibular deficiency; skeletal relation of the mandible.

Surgical procedure and distraction protocol:

All operations were performed with the patient under general anesthesia. At the body of the mandible, a buccal corticotomy and superior and inferior osteotomies with a standard surgical reciprocating saw were performed under sterile saline irrigation. The lingual cortex and medulla bones were disrupted by a "greenstick" maneuver with an osteotome. This procedure can effectively prevent injury to the inferior alveolar nerve. The intraoral distractor was applied and fixed in position using miniscrews on using extraoral distractor trocar was used to retract the cheek and penetrate it for application of the self tapping pins in their positions. The latency period was 6 days. The distraction rate was 1.0 mm with a rhythm of 0.5 mm twice a day. The distraction period was 10 to 23 days. The consol-

idation period was 54 ± 74 week. At the end of consolidation period the distractors were removed using local anesthesia for the extraoral distractors and general anesthesia for removal of the intraoral distractors.

Postoperative follow-up accomplished by the following:

- Clinical and photographic evaluation for aesthetic improvement. Including observation of the subsequent surgical complications as wound dehiscence, infection and scars in addition to observation of aesthetic improvement and occlusion changes.
- Radiographic X-rays including: Panoramic and cephalometric, X-ray films taken immediately postdistraction, 3 months, 6 months and one year postdistraction.

Cephalometric X-ray to assess the position of the mandible according to Burden, et al., (2007) [9]. The cephalometric variables that were measured are shown in (Fig. 1), the maxillary plane was defined as posterior nasal spine to anterior nasal spine, and the mandibular plane was defined as gonion to menton. The Holdway angle was defined as the angle soft tissue nasion to soft tissue pogonion to labrale superius.

A horizontal reference line was constructed by rotating the sella-nasion line downward by 6°. And a vertical line was constructed perpendicularly through sella. The horizontal and vertical movements of point A, point B, and the maxillary and mandibular incisor tips relative to these lines were used to measure the movements of the maxilla, the mandible and the incisors respectively. All cephalometric measurements were determined by specific cephalometric analysis program, (DGIMIZER version 7.3, cephalometric measurements were recorded by the same orthodontist.

Measurement of airway changes:

Objective measurements of changes in airway size (at the tongue base level) were determined from lateral cephalometric radiographs obtained pre- and post-operatively according to the method utilized by Denny et al., (2001) [10]. And Sadaka et al., (2009) [11]. The effective airway space represents a single-plane measurement defined by the following boundaries: A horizontal line from the tip of the odontoid process to the velum, the uvula tip to the tongue base along the shortest line, the tongue base down to the base of the epiglottis, and the "horizontal" line to the posterior pharynx. These lines were traced for each cephalogram, by using special Soft ware program (Digimizer v 7.3) and determined area measured by the soft ware in pixels.

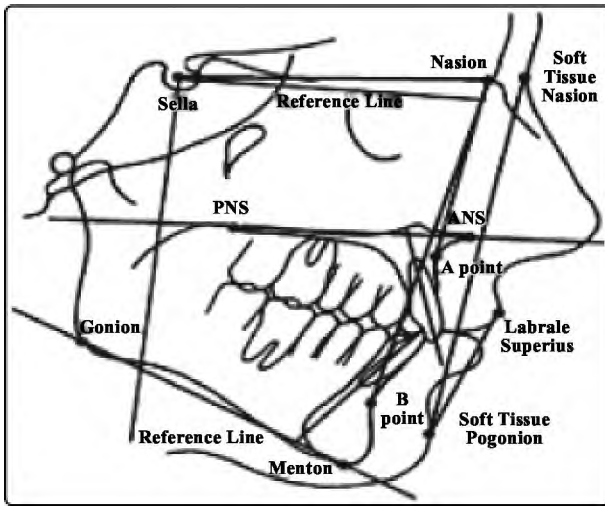


Fig. (1): Landmarks and lines used in cephalometric analysis.

Results

Ten patients sustained bilateral mandibular hypoplasia were included in this study.

The mandibular hypoplasia surgically corrected by distraction osteogenesis, the ages of the studied patients were similar and ranged from 7.5 to 23 years with mean age 14 years, seven patients were females (70%) and the rest were males (30%) these findings.

Mandibular hypoplasia was developmental in nine patients (90%) and was due to facial trauma followed by ankyloses in one patient (10%).

The signs and symptoms were similar in most patients. All the patients have skeletal and dental class 11 relationship, with accentuated labiodental angle, extensive over jet and deep bite were obvious in most patients.

The complain of abnormal facial appearance was common among the patients, snoring during sleep with abnormal respiration along with dysphagia were recorded for three patients (30%). Intraoral distractors were used in four patients (40%) and extraoral distractors were used in six patients (60%). The distraction distance ranged from 10 to 23mm, with a mean of 15.4mm. The postoperative course was uneventful and the patients resumed their activities after they were discharged from the hospital. The complications noticed through this study were little fractured roots occurred in two patients due to thin buccal cortex over the roots and little space between the teeth, in the first case patient suffered from pain related to the tooth of the fractured route and this was managed by endodontic treatment. The affected tooth in the other patient was vital through all periods of the treatment without any complication.

Hyper trophic scar was recorded in all the patients treated by the extraoral distractors, some scars were noticed because they were small and hidden in the submandibular region, other scars was arranged for surgical repair.

Two patients suffered from numbness related to the lower lip after surgery and this sensation disappeared few weeks after surgery. As regard occlusal abnormality only one patient showed open bite which was thought to be due to distractor instability in addition to the downward and backward contraction of the suprahyoid muscles during the consolidation period, the open bite was managed by orthodontic treatment with intermaxillary elastics. Every patient had regained facial symmetry, normal jaw movements. Satisfaction to the results of surgery was reflected from the patients and their families and in turn the cooperation during the course of follow-up was excellent (Fig. 2).

Results of cephalometric analysis:

As regards SNA angle its mean value was 79.20 and $SD \pm 5.11$ preoperatively (TO), its mean value was 79.1 and $SD \pm 4.97$ immediately postdistraction (T1), at the 3rd month postoperatively (T2) the mean of SNA angle was 79.6 and $SD \pm 4.88$, at the sixth month postoperatively (T3) the mean of the the mean of SNA angle after one year postoperatively (T4) was 80.10 and $SD \pm 4.45$ there was no significant difference between TO and T1 and no significant difference between T1 and the other remaining periods (T2,T3,T4) where $p > 0.05$.

As regards SNB angle its mean value was 69.40 and $SD \pm 5.33$ preoperatively (TO), its mean value was 74 and $SD \pm 4.027$ immediately postdistraction (T1), at the 3rd month postoperatively (T2) the mean of SNB angle was 74.2 and $SD \pm 4.15$, at the sixth month postoperatively (T3) the mean of the the mean of SNB angle after one year postoperatively (T4) was 74.20 and $SD \pm 3.22$ there was significant difference between TO and T1 $p < .005$ and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards ANB angle its mean value was 9.50 and $SD \pm 3.47$ preoperatively (TO), its mean value was 5.80 and $SD \pm 2.89$ immediately postdistraction (T1), at the 3rd month postoperatively (T2) the mean of ANB angle was 5.40 and $SD \pm 2.54$, at the sixth month postoperatively (T3) the mean of ANB angle was 5.60 and $SD \pm 3.06$ after one year postoperatively (T4) was 5.60 and $SD \pm 3.06$ there was significant difference between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards mandibular maxillary plane angle (MM) angle its mean value was 35.30 and $SD \pm 8.44$ preoperatively (TO), its mean value was 41.40 and $SD \pm 6.31$ immediately postdistraction (T1), at the 3rd month postoperatively (T2) the mean of MM angle was 37.40 and $SD \pm 6.78$, at the sixth month postoperatively (T3) the mean of MM angle was 37.50 and $SD \pm 5.03$ after one year postoperatively (T4) was 35.80 and $SD \pm 5.99$ there was significant difference between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards lower facial height % (LFH%) its mean value was 56.06% and $SD \pm 2.10$ preoperatively (TO) while its mean value was 57.33% and $SD \pm 1.96$ immediately post-distraction (T1), at the 3rd month postoperatively (T2) the mean of LFH% was 56.94 and $SD \pm 1.85$. At the sixth month postoperatively (T3) the mean of LFH% was 57.67% and $SD \pm 2.49$ after one year postoperatively (T4) was 56.33% and $SD \pm 1.97$ there was significant difference between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards overjet its mean value was 10.85 mm and $SD \pm 0.88$ preoperatively (TO) while its mean value was 2.40mm and $SD \pm 0.40$ immediately post-distraction (T1), at the 3rd month postoperatively (T2) the mean of overjet was 2.90mm and $SD 0.71$. At the sixth month postoperatively (T3) the mean of overjet was 3.20 and $SD \pm 0.67$ after one year postoperatively (T4) was 3.70 and $SD \pm 0.61$ there was significant difference $p < .05$ between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards overbite its mean value was 5mm and $SD \pm 2.44$ preoperatively (TO) while its mean value was 2.50mm and $SD \pm 0.56$ immediately post-distraction (T1). At the 3rd month postoperatively (T2) the mean of overbite was 2.50mm and $SD \pm 0.42$. At the sixth month postoperatively (T3) the mean of overbite was 2.50 mm and $SD \pm 0.50$ after one year postoperatively (T4) was 2.90mm and $SD \pm 0.37$ there was significant difference $p < .05$ between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards lower incisor to mandibular plane angle (LI/Mn angle) its mean value was 93.40 and $SD \pm 7.97$ preoperatively (TO) while its mean value was 100.5 and $SD \pm 7.07$ immediately post-distraction (T1), at the 3rd month postoperatively (T2) the mean of (LI/Mn angle) was 99.80 and $SD \pm 7.531$ at the

sixth month postoperatively (T3) the mean of (LI/Mn angle) was 88 and $SD \pm 9.20$ after one year postoperatively (T4) was 96.40 and $SD \pm 2.83$ there was no significant difference $p > .05$ between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards Holdway angle its mean value was 25.40 and $SD \pm 6.04$ preoperatively (TO) while its mean value was 18 and $SD \pm 3.77$ immediately post-distraction (T1), at the 3rd month postoperatively (T2) the mean of Holdway angle was 19.90 and $SD \pm 3.31$ at the sixth month postoperatively (T3) the mean of Holdway angle was 22.20 and $SD \pm 4.87$ after one year postoperatively (T4) was 22.80 and $SD \pm 4.96$ there was significant difference $p < .05$ between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards upper maxillary incisor to maxillary plane angle (UI/MX angle) its mean value was 116.2 and $SD \pm 6.03$ preoperatively (TO) while its mean value was 112.6 and $SD \pm 7.58$ immediately post-distraction (T1), at the 3rd month postoperatively (T2) the mean of (UI/MX angle) was 110.8 and $SD \pm 5.41$ at the sixth month postoperatively (T3) the mean of (UI/MX angle) was 110.20 and $SD \pm 4.93$ after one year postoperatively (T4) was 111 and $SD \pm 5.35$ there was no significant difference $p > .05$ between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards vertical reference line to man. Incisor (mm) (V.MAN. incisor) its mean value was 70.87mm and $SD \pm 9.28$ preoperatively (TO) while its mean value was 77.60mm and $SD \pm 8.64$ immediately post-distraction (T1), at the 3rd month postoperatively (T2) the mean of V.MAN incisors was 77.60mm and $SD \pm 9.681$ at the sixth month postoperatively (T3) the mean of V.MAN. Incisor was 75.60 mm and $SD \pm 10.12$ after one year postoperatively (T4) was 75.30mm and $SD \pm 3.21$ there was significant difference $p < .05$ between TO and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards horizontal reference line to point B. (mm) (H.point B) its mean value was 54 20mm and $SD \pm 4.51$ preoperatively (TO) while its mean value was 59.80mm and $SD \pm 4.48$ immediately post-distraction (T1), at the 3rd month postoperatively (T2) the mean of (H.point B) was 59 Omm and $SD \pm 4.34$ while at the sixth month postoperatively (T3) the mean of (H.point B) was 57 80mm and $SD \pm 11.09$ after one year postoperatively (T4)

was 57.60mm and $SD \pm 3.52$ there was significant difference $p < 0.05$ between T0 and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$.

As regards vertical reference line to point B. (mm) (V.point B) its mean value was 86.72mm and $SD \pm 5.58$ preoperatively (T0) while its mean value was 94.50mm and $SD \pm 6.03$ immediately post-distraction (T1), at the 3rd month postoperatively (T2) the mean of (V.point B) was 94.10mm and $SD \pm 5.99$ while at the sixth month postoperatively (T3) the mean of (V.point B) was 93.70mm and $SD \pm 6.23$ after one year postoperatively (T4) was 94.10mm and $SD \pm 6.24$ there was no significant difference $p > 0.05$ between T0 and T1 and no significant difference between T1 and the subsequent periods (T2,T3,T4) where $p > 0.05$ (Figs. 3,4).

Pharyngeal airway changes:

The mean of the preoperative pharyngeal airway was 294.9612mm² with $SD \pm 404.1588$ and the mean of the postoperative pharyngeal airway was 404.1588mm² and $SD \pm 154.07958$ and (*t*) value was 4.591 and there is significant difference between the two counts $p < 0.05$ as shown in table (Figs. 5,6).



Fig. (2): Preoperative (left) photograph and postoperative (right) views.



Fig. (3): Preoperative cephalometric showing retruded mandible & excessive overjet.



Fig. (4): Postoperative cephalometric showing good mandibular advancement and normal overjet.



Fig. (5): Preoperative lateral cephalometric showing preoperative pharyngeal airway.



Fig. (6): Postoperative lateral cephalometric showing increased pharyngeal airway.

Discussion

The mandibular distraction process is an effective treatment modality for the correction of craniofacial deformities and is used to obtain stable results. Craniofacial changes in the vertical and horizontal dimensions following distraction can be effectively evaluated by cephalometric radiographic tracing [12]. Severe mandibular hypoplasia can lead to facial asymmetry and reduction of oro-pharyngeal capacity and glossoptosis because of the posterior location of the insertion of the suprahyoid muscles into the mandible, as a result, upper airway obstruction, feeding difficulties, gastroesophageal reflux may occur. Several authors have reported that these conditions could be resolved by the help of mandibular distraction [11,13-15].

Similarly, following the advancement of the mandible, using extra-oral and intra-oral distractors through this study the facial deformity was improved significantly as regards skeletal and soft tissue deformity also respiratory problems and snoring was resolved in our patients, due to increase in the pharyngeal airway and correction of the excessive overjet. And this was in accordance to the study of Ortakoglu et al. [16] and (Sadakah et al. [iii] who stated that During bilateral mandibular distraction of hypoplastic mandible elongation of the corpus length increased the volume of the oral cavity therefore tongue was relieved. Before treatment, tongue tip was positioned over the incisal edges of the lower incisors because of insufficient space. However, following the treatment, it retruded behind these teeth to a normal position. This retrusion decreased the distance between tongue tip and epiglottic base. The tongue accompanied the advancement of the mandible and postural alterations occurred. Since the tongue moved in the anterior direction, the pharyngeal airway increased.

During the distraction of the mandibular body, mandible revealed anterior rotation and probably this rotation affected the hyoid bone through the muscles and caused an elevation at the hyoid so the perpendicular distance from hyoid to mandibular plane decreased after treatment.

Through this study the cephalometric analysis revealed statistically significant increase in the mandibular length as well as correction of the soft tissue profiles, in addition to correction of the dental overjet and overbite, and this indicated a good result of the distraction.

By comparison of the results obtained through cephalometric analysis between the immediate post

distraction and that of the subsequent periods through one year of follow-up in our study there was no significant difference indicating a good stability of the results with a little relapse.

The stability of the results of distraction osteogenesis was also concluded by Andrew and Cheung [17] on comparison between bilateral sagittal split osteotomy and mandibular distraction osteogenesis.

Other authors have found no relapse of the mandible following distraction osteogenesis based on dental occlusion and cephalometry [18] also McTavish [19] stated that the bone formed by distraction osteogenesis in the mandible underwent normal remodelling and was stable through 12 months following distraction.

Stability of the results in our study can be explained because of distraction osteogenesis allows gradual stretching of the paramandibular soft tissue envelope, and through the process of soft tissue histogenesis, this led to expansion of the suprahyoid muscles. Also expansion in the medial pterygoid muscle after distraction was reported. With this soft tissue expansion, along with reasonable period of consolidation the paramandibular soft tissue forces are reduced, contributing to stability of the distracted mandible.

It is to be noted that there was slight increase as regards SNA angle at the last follow-up period and this can be explained as a result of the normal growth of the patients, also there was slight change as regards dental angulations' and this can be explained as a result of dental movement due to dental wiring or compensatory movement after mandibular distraction.

The complications noticed through this study were little, fractured roots occurred in two patients due to thin buccal cortex over the roots and little space between the teeth, in the first case patient suffered from pain related to the tooth of the fractured root and this was managed by endodontic treatment. The affected tooth in the other patient was vital through all periods of the treatment without any complication. However Bremen et al., (2008) [20] recorded fractured roots in two cases in one of them one tooth was extracted because it was hopeless the other one is kept in place because it was vital with normal mobility. Freita et al. [21] recorded the same incidence of dental injury and the fractured roots was resorbed through the period of follow which was 44 months.

Hypertrophic scar was recorded through this study in all the patients treated by the extra-oral distractors, some scars were unnoticed because they were small and hidden in the submandibular region, other scars was arranged for surgical repair. Similarly Mofid et al. [22] stated that It has previously been suggested that there is minimal risk of abnormal scarring associated with external distractors. Despite this impression the rate of hypertrophic scarring, keloid formation, or scars requiring revision associated with the use of external distractors was high (15.6 percent).

Hollier et al. [23]. Reported a scar-revision at rate of 14.3% two of 14 patients who underwent mandibular distraction when using external devices.

As regards inferior alveolar inferior injury two patients in our study suffered from numbness related to the lower lib after surgery and this sensation disappeared few weeks after surgery. Similarly Anderew and Cheung (2009) [24] recorded lower incidence of persistent inferior alveolar nerve disturbance after mandibular distraction osteogenesis and this may be related to several factors.

Makarov et al. [25] and Hu [26] showed that inferior alveolar nerve undergoes gradual stretching during the distraction process, which allows the nerve to adapt better and avoid any permanent damage. This adaptation is influenced by the distraction rate, with a higher rate resulting in more nerve damage. Surgical technique is another contributing factor. The main osteotomy design advocated for mandibular distraction osteogenesis is the vertical body osteotomy between the teeth. In this technique, soft-tissue dissection is minimal and limited to the buccal mucoperiosteum on the lateral body, After performance of the osteotomy, gradual mobilization of the segments is performed to ensure adequate separation. And this insure less traumatic manipulation of the inferior alveolar nerve.

Also the fixation of the intraoral distractors is usually monocortical, and fixation of the pins of the extraoral distractors is near the lower border thereby minimizing the risk of damage to the inferior alveolar nerve.

As regards occlusal abnormality only one patient in our study showed open bite which was thought to be due to distractor instability in addition to the downward and backward contraction of the suprahyoid muscles during the consolidation period, the open bite was managed by orthodontic treatment with inter-maxillary elastics. However Tibesar et

al. [27] stated that anterior open bite deformity was the most frequently encountered complication the anterior open bite deformity typically resulted from inadequate angulation as the distraction process proceeded. This was sometimes as a result of limitations of the distraction device and absence of molding of the distraction osteogenesis regenerate.

Through this study the complications of distraction osteogenesis were little and it is still a good modality for management of mandibular deficiency.

Conclusion:

- Mandibular distraction osteogenesis is an ideal method for treatment of mandibular deficiency and dento-facial deformity.
- Mandibular distraction osteogenesis is valuable method for improvement of pharyngeal airway.
- The effects of distraction osteogenesis are stable through the first postoperative year, and longer follow-up period is recommended to evaluate the stability of these effects.

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