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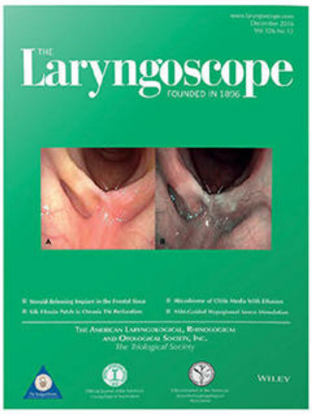

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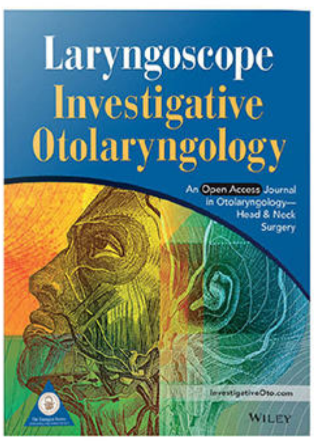

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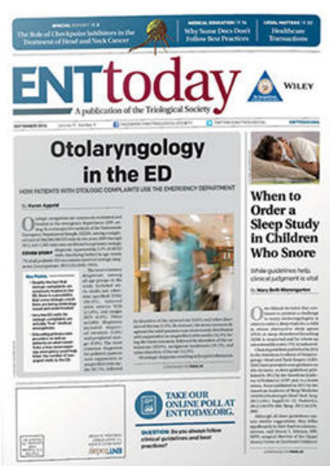

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Maxillomandibular Expansion for the Treatment of Sleep-Disordered Breathing: Preliminary Result

Christian Guilleminault, MD; Kasey K. Li, DDS, MD

Objective: **To assess the outcomes of maxillomandibular expansion (MME) by distraction osteogenesis (DO) for the treatment of sleep-disordered breathing (SDB).** ***Methods:*** **This was a prospective study of six consecutive patients with SDB. All of the patients have maxillary and mandibular constriction and were treated with MME. Variables examined include age, sex, body mass index (BMI), polysomnographic results (PSG), Epworth Sleepiness Scale (ESS), and the extent of the widening of the maxilla and mandible.** ***Results:*** **All six patients (4 males) completed MME for the treatment of SDB. The mean age was 22.2 ± 11.4 years. The mean maxillary expansion was 10.3 ± 3.0 mm, and the mean mandibular expansion was 9.5 ± 2.9 mm. ESS improved from 10.2 ± 1.9 to 5 ± 2.9. The mean apnea/hypopnea index (AHI) improved from 13.2 ± 15.6 to 4.5 ± 5.8 events per hour, and the mean lowest oxygen saturation (LSAT) improved from 88.2 ± 2.9% to 91.3 ± 3.3%. The mean esophageal pressure improved from −20 ± 11.3 cm H_2O to −8 ± 3.6 cm H_2O. No complications were encountered, and the follow-up period was 18.1 ± 9.8 months.** ***Conclusion:*** **The result suggests that MME improves SDB in patients with maxillary and mandibular constriction and can be a valid treatment.** ***Key Words:*** **Obstructive sleep apnea syndrome, sleep-disordered breathing, maxillary constriction, maxillomandibular expansion, mandibular widening.**

***Laryngoscope*, 114:893–896, 2004**

INTRODUCTION

Since the initial description of obstructive sleep apnea syndrome (OSA),[1] several risk factors have been suggested in its development and progression, including male sex, age, and obesity.[2,3] Certain craniofacial features identified by cephalometric analysis have also been suggested as risk factors,[3–5] and the correction of some of the craniofacial deformities, such as mandibular or maxillomandibular deficiency, has been shown to improve OSA.[6,7] Nevertheless, the emphasis of corrective surgery has been primarily limited in the sagittal plane. The correction of transverse deficiency of the maxilla or mandible as a potential treatment of OSA has received little attention.

Constriction of the maxilla has been suggested as a possible risk factor for OSA. In a comparative study between OSA and control subjects by Seto et al.,[8] OSA subjects were found to have narrower, more tapered, and shorter maxillary arches. Kushida et al.[9] found that the intermolar distance of the maxilla is related to the presence of OSA. Cistulli et al.[10] have reported that patients with Marfan's syndrome, in which maxillary constriction is a common finding, have increased incidence of OSA and elevated nasal resistance.

The relationship of nasal resistance and maxillary morphology has long been recognized. The positive impact of maxillary expansion on nasal breathing is also well known in the orthodontic literature. Timms[11–13] has repeatedly demonstrated that patients with constricted maxilla have elevated nasal resistance, and nasal resistance can be improved by maxillary expansion. Other investigators have validated these findings, albeit that the beneficial effect of maxillary expansion on nasal resistance may not be uniformly achieved in all patients, and it appears that patients with greater degrees of nasal resistance tend to have greater improvement after maxillary expansion.[14–17] To the best of our knowledge, there has been only one study examining the effect of maxillary expansion on OSA. Cistulli et al.[18] performed maxillary expansion on 10 OSA patients with maxillary constriction, and improvement was achieved in 9 of the 10 patients. The mean apnea/hypopnea index (AHI) was reduced from 19 events per hour to 7 events per hour, and the mean maxillary expansion achieved was 12.1 mm. It is unknown whether mandibular expansion can be performed with maxillary expansion and whether simultaneous maxillary and mandibular expansion can improve sleep-disordered breathing (SDB).

Maxillary expansion is routinely performed when there is constriction of the maxilla where posterior crossbite often exists. Although the width of the maxilla can be improved by expansion, it usually remains narrowed after expansion because the extent of expansion is limited by the width of the mandible, and mandibular constriction often coexists. Clearly, the extent of maxillary expansion can be augmented if simultaneous mandibular expansion can be performed.

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Recent advances in the technique of distraction osteogenesis (DO), a process of bone lengthening by gradual separation of bone segments performed by simple osteotomy, have improved our ability to expand the mandible.[19] Because mandibular constriction is also frequently found in patients with OSA as well as upper airway resistance syndrome (UARS) (Guilleminault C, Li KK, unpublished results, 2002), mandibular expansion may improve OSA. The purpose of this study was to assess the outcomes of maxillomandibular expansion (MME) in the treatment of OSA and UARS (i.e., SDB).

MATERIALS AND METHODS

This was a prospective study of six consecutive patients with dentofacial deformity as well as documented SDB. All of the patients were found to have maxillary and mandibular constriction by an orthodontic evaluation (posterior crossbite or edge-to-edge occlusion with high arch hard palate). All of the patients were intolerant of nasal continuous positive airway pressure or refused long-term treatment. Surgical correction of the dentofacial deformity was recommended in all patients because of functional and esthetic concerns. Informed consent was obtained from all patients regarding the rationale for the correction of dentofacial deformity as well as the unknown effect on SDB. The potential impact on SDB as a result of the correction of dentofacial deformity was evaluated. All of the patients underwent MME along with simultaneous orthodontic treatment. Variables examined include age, sex, body mass index (BMI), polysomnographic results (PSG), Epworth Sleepiness Scale (ESS), and the extent of the widening of the maxilla and mandible.

Polysomnography

The standard PSG included the following variables: electroencephalogram, electrooculogram, chin and leg electromyelogram, electrocardiogram (modified V2 lead), and body position. Respiration was monitored using a neck microphone (breathing noises), a nasal cannula/pressure transducer system, an oral thermistor, thoracic and abdominal bands for measurement of uncalibrated respiratory plethysmography, esopharyngeal pressure monitoring (Pes), and pulse oximetry. A transcutaneous CO_2 electrode was used for CO_2 analysis. Pes was calibrated in cm H_2O at the beginning and end of the night. All recordings were performed with video monitoring. Oxygen desaturations of 3% or more were noted. The PSG study was performed within 24 months of the operation, and the postoperative study was performed at least 4 months after the operation.

Maxillomandibular Expansion

All of the procedures were performed by the same surgeon in the operating room under general anesthesia. Maxillary widening is achieved by a limited osteotomy in the Le Fort I level without down-fracturing the maxilla, and pterygomaxillary dysjunction was not performed. A limited osteotomy in the midline of the maxilla between the central incisor teeth was performed. Before surgery, the distraction device on the maxilla was placed by the orthodontist, and it was activated for 1.0 mm at the completion of the operation. In the mandible, a midline osteotomy was made between the central incisor teeth, followed by application of the intraoral distraction device, and it was activated for 1.0 mm at the completion of the operation. After 5 to 7 days of latency period, the maxillary and mandibular devices were activated two to four times per day to achieve 0.5 to 1.0 mm of widening per day. After the completion of distraction (approximately 1–3 weeks), the distraction devices were maintained in place for 2 to 3 months to allow healing and bone consolidation (Fig. 1). The orthodontist removed the maxillary distraction device, and the mandibular distraction device was removed in the operating room under intravenous sedation.

In the 9-year-old child, maxillary osteotomy was unnecessary because the skeletal sutures are incompletely fused, thus allowing expansion. However, because of the absence of mandibular sutures, mandibular midline osteotomy was performed to achieve expansion.

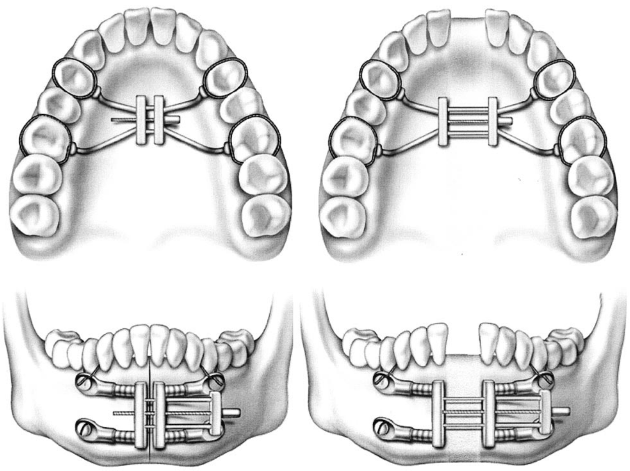

Fig. 1. Schematic drawing demonstrating maxillomandibular expansion by distraction osteogenesis.

RESULTS

Six patients (4 males) completed MME for the treatment of SDB. The mean maxillary expansion (at the distraction device) was 10.3 ± 3.0 mm, and the mean mandibular expansion (at the distraction device) was 9.5 ± 2.9 mm. The

TABLE I.
Patient Data.

Patient No.	Age	Sex	PreBMI	PostBMI	PreESS	PostESS	Expansion Max	Expansion Mand	F/U
1	24	F	21.3	22.1	12	6	7.5 mm	7.0 mm	11 mo
2	18	M	23.4	23.8	7	3	13.0 mm	12.0 mm	25 mo
3	9	M	14.0	14.6	—	—	8.0 mm	7.0 mm	30 mo
4	18	M	23.6	24.0	11	1	12.5 mm	12.0 mm	25 mo
5	21	M	27.2	28.3	11	7	13.5 mm	12.0 mm	13 mo
6	43	F	27.1	26.6	10	8	7.0 mm	7.0 mm	5 mo
Average	22.2	—	22.8	23.2	10.2	5	10.3	9.5	18.1
SD	11.4	—	4.9	4.8	1.9	2.9	3.0	2.7	9.8

BMI = body mass index; ESS = Epworth sleepiness scale; Max = maxillary; Mand = mandibular.

TABLE II.
Polysomnography Data.

Patient No.	PreTST	PostTST	PreREM (%)	PostREM (%)	PreNREM (%)	PostNREM (%)	PreAHI	PostAHI	PreLSAT (%)	PostLSAT (%)	PrePes	PostPes
1	373	471	23	24.9	77	75.1	4.34	0	92	96	−13 cm	−5 cm
2	244	340	9.4	10.7	91.6	89.3	2.2	1.6	89	93	−14 cm	−7 cm
3	470	504	7.0	14.2	93	85.8	9	0.7	88	91	—	—
4	540	537	14.4	17.7	85.6	82.3	0.8	1.9	90	90	−33 cm	−12 cm
5	448	504	14.4	17.7	85.6	82.3	21.4	8.4	84	86	—	—
6	431	428	15.9	21.3	84.1	78.7	41.2	14.6	86	92	—	—
Average	418	464	14.0	17.8	86.2	82.3	13.2	4.5	88.2	91.3	−20	−8
SD	101	71	5.6	5.0	5.7	5.0	15.6	5.8	2.9	3.3	11.3	3.6

Esopharyngeal pressure monitoring (Pes) is measured in cm H_2O, and the maximum Pes pressure is reported.

TST = total sleep time (minutes); REM = rapid eye movement sleep; NREM = nonrapid eye movement sleep; AHI = apnea/hypopnea index; LSAT = lowest oxygen saturation.

consolidation period was 2 to 3 months. All of the patients received orthodontic treatment to close the space created by the DO without problems. Increased airway dimension was evident radiographically. Improvement was seen in all six patients on the basis of ESS and PSG results (Tables I and II).

CASE REPORT

A 21-year-old male (patient 5) presented with OSA despite prior uvulopalatopharyngoplasty. He was found to have significant maxillomandibular narrowing and diminished intraoral space. He underwent MME with improvement of intraoral space as well as the airway space on cephalometric radiograph (Figs. 2 to 4).

DISCUSSION

The technique of DO was used to achieve widening of the maxilla and mandible. DO involves the generation of new bone in the stretched fracture callus between bone fragments. It has demonstrated acceptable feasibility, efficacy, safety, and reproducibility of its treatment results. DO in the maxillofacial region was first investigated by Snyder et al.[20] in the canine mandible. Karp et al.[21] demonstrated that bone formation during DO in the maxillofacial region is similar to that of long bones, which is predominately by intramembranous ossification.

Recently, we have reported on the potential application of DO in maxillomandibular advancement (MMA) for the treatment of SDB instead of traditional surgical techniques.[22] However, although less surgical dissection is necessary for DO, the procedure is highly technique sensitive, especially in achieving the proper alignment of the distraction devices. Parallelism of the distraction vectors is extremely important to avoid malocclusion, which can be quite difficult to avoid in simultaneous MMA with multiple distraction devices. Improper alignment of the maxilla and mandible is a major disadvantage of its use. Another problem with the use of DO in MMA is its treatment time. Because of the weakness of the regenerated bone, the distraction devices (bilateral devices in MMA) may need to be left in place for 3 months, which can affect the patient's mastication and speech. These unfavorable factors have limited the patient's acceptance of DO. On the other hand, MME performed in this series is significantly less complicated and less traumatic for patients because of the simple linear osteotomy design. Only a single distraction device is needed to

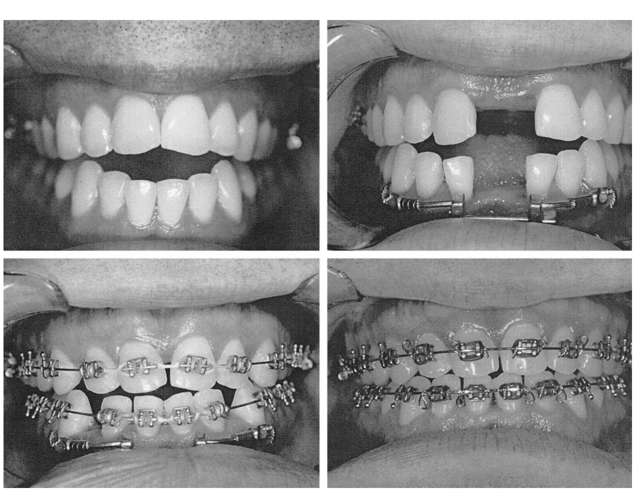

Fig. 2. Clinical progression of maxillomandibular expansion. Note the widening of the maxillomandibular complex.

Fig. 3. Intraoral view of the tongue position pre- and postoperatively. Note the increased intraoral volume for tongue position.

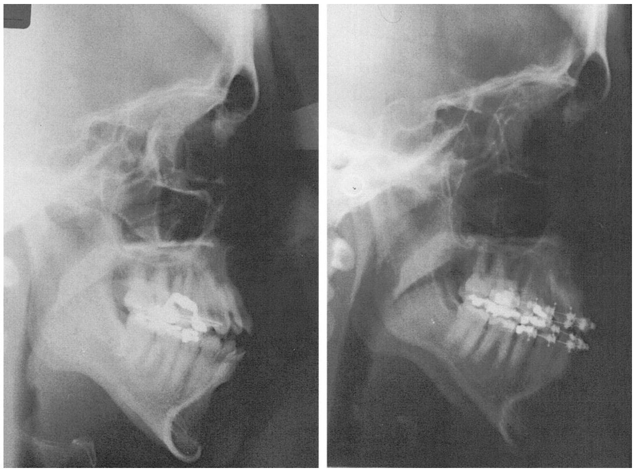

Fig. 4. Pre- and postoperative cephalometric radiographs. Note the increased posterior airway space.

achieve the widening effect, and the placement of the device is much less problematic for the patient's comfort.

Despite the limited numbers of patients in our series, improvement of SDB based on PSG results were seen in all six patients after MME, and no complications were encountered. Our finding is consistent with the prior report on the beneficial effect of maxillary expansion on OSA.[18] It is unknown whether maxillary widening and mandibular widening both improve OSA because they were performed simultaneously in our series. However, the improvement of tongue posture and intraoral volume is clearly demonstrated clinically by mandibular expansion. The ability to expand the mandible also allows greater expansion of the maxilla because proper dental occlusion can be preserved.

MME clearly has limitations. As in any DO procedures, the distraction devices need to be left in place for 2 to 3 months, until the newly generated bone is sufficiently matured. In addition, the necessity of orthodontic treatment deters most adult patients for this treatment. The ideal candidate for this treatment may be an adolescent or young adult with SDB who may be contemplating or already in need of orthodontic treatment. Clearly, larger series will be needed to delineate the patients who may benefit the most from MME. We often see young patients with significant craniofacial risk factors with persistent SDB after adenotonsillectomy (T&A), which can lead to the recurrence of OSA at the time of pubertal tongue growth.[23,24] It is known that T&A will have only a limited and immediate effect on craniofacial morphology,[25] and MME could be a treatment option in patients who are currently being untreated.

CONCLUSIONS

With the increasing awareness of the role of craniofacial abnormalities in the development of SDB, greater attention should be focused on the treatment of skeletal anatomy. Historically, the available surgical treatment options consist of either soft tissue reduction procedures or major maxillofacial surgical procedures. In patients with significant maxillomandibular narrowing or in adolescent and young adult with SDB, MME by DO may be an alternative to the currently available surgical options.

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