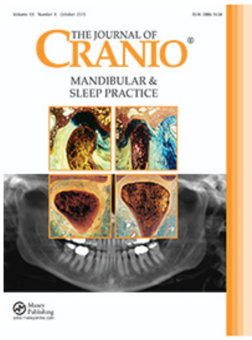

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CASE REPORT

Restoration of sleep using a novel biomimetic protocol for adult OSA: Clinical case report

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ABSTRACT

Background: A sleep study of a 56-year old male with excessive daytime sleepiness demonstrated an AHI of 16.4hr^{-1} with 13% of total sleep time in REM sleep and a mean oxygen desaturation (SpO_2) of 86%.
Clinical presentation: On intra-oral examination, it was found that the patient had maxillary hypoplasia and bilateral torus mandibularis. A 3D cone-beam CT (CBCT) scan was taken, and 28 craniofacial parameters were measured. Surgical reduction of the mandibular tori followed by biomimetic oral appliance therapy (BOAT) was initiated. After 14 months, a post-treatment CBCT scan revealed that 70% of parameters measured had improved. Therefore, another sleep study was performed with no device in the mouth. This follow-up home sleep test demonstrated that the AHI fell to 5.3hr^{-1}hr; with 27% REM sleep, and a mean SpO_2 of 93% without any device in the mouth.
Conclusion: These findings suggest that BOAT might be able to restore sleep in certain adult cases.

KEYWORDS
Oral appliance therapy; palatal expansion; obstructive sleep apnea

Introduction

There are numerous reports in the literature that document upper airway changes in children undergoing various forms of midfacial development. For example, the effects of maxillary protraction on craniofacial structures and the upper airway in children aged about 10 yrs. reported that maxillary growth had a significant effect on the upper airway [1]. Similarly, another study [2] found increased width and area of the upper airway and increased growth of the maxilla in children aged about 11 yrs. Another study [3] noted improved breathing after rapid maxillary expansion in children aged about 7.5 yrs, but it is not known how these approaches might benefit adults diagnosed with sleep disordered breathing. Thus, the purpose of this case report is to examine the potential role of biomimetic oral appliance therapy (BOAT) in the management of adult obstructive sleep apnea (OSA).

Case report

A 56-year old male reported for treatment of persistent snoring and excessive daytime sleepiness. After reviewing the medical history, it was noted that he had been screened for OSA and had scored 15 on an Epworth sleepiness scale (ESS). This screening was followed by overnight polysomnography, which demonstrated an AHI of 16.4hr^{-1}, with approximately 13% of the total sleep time in REM sleep and a mean oxygen desaturation (SpO_2) of 86%. The subsequent diagnosis of moderate OSA had initially been controlled with a mandibular advancement device (MAD), since the patient had declined continuous positive airway pressure (CPAP) therapy. In fact, MADs of different designs were utilized for about three years until they became loose and ineffective, since the patient began to snore again. In addition, despite the use of a morning re-positioner, the patient noticed unwanted changes in the occlusion of the posterior teeth.

On craniofacial and intra-oral examination, it was found that the patient had extensive, bilateral torus mandibularis and maxillary hypoplasia (Figure 1). In addition, the lingual frenum appeared to be short, thin, and blanched, suggestive of tongue restriction. Therefore, a pre-treatment 3D cone-beam computerized tomographic (CBCT) scan (Sirona Technologies, USA) was taken, and 18 craniofacial parameters (Table 1) were measured. Treatment with biomimetic oral appliance therapy

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(BOAT; mRNA appliance®, Vivos BioTechnologies, Inc.) was discussed. This type of oral appliance therapy differs from MADs in that it consists of simultaneous, non-surgical, midfacial redevelopment [4–6] in combination with mandibular repositioning [7,8]; but it does not include an anterior headgear component that might pull on the cervical spine. After written informed consent was obtained, the patient elected to undergo surgical reduction of the mandibular tori [9,10] followed by BOAT, since these devices are FDA-cleared for use in mild to moderate cases of OSA in adults.

Discussion

After 14 months of combined BOAT, the patient reported that his sleep quality had improved, and he was no longer snoring. The ESS score fell from 15 to 2 on a follow-up assessment. There were also changes in the midfacial morphology (Figure 2). On the post-treatment CBCT scan, the following craniofacial parameters showed improvements: the minimum, mid-sagittal, retropalatal distance; the minimum, medio-lateral, retropalatal width; the minimum retropalatal area in the axial plane; the minimum, mid-sagittal, retroglossal distance; the minimum, medio-lateral, retroglossal width; the minimum retroglossal area in the axial plane; the surface area of the posterior nasal apertures at level of the posterior nasal spine in the axial plane; the minimum inferior nasal concha distance from the nasal septum on the left side; the transpalatal bone width at cervical margin of the mesio-palatal cusps of the first molars, and the 3D airway volume, measured from the level of the posterior nasal spine to the inferior border of C3/hyoid bone. Table 1 and Figures 3 and 4 summarize these analyses. In view of these findings, an ambulatory, type III, home sleep study (HST; WatchPAT, Itamar Medical Ltd, Framingham, MA, USA) was performed with no device in the mouth while the patient was sleeping. This

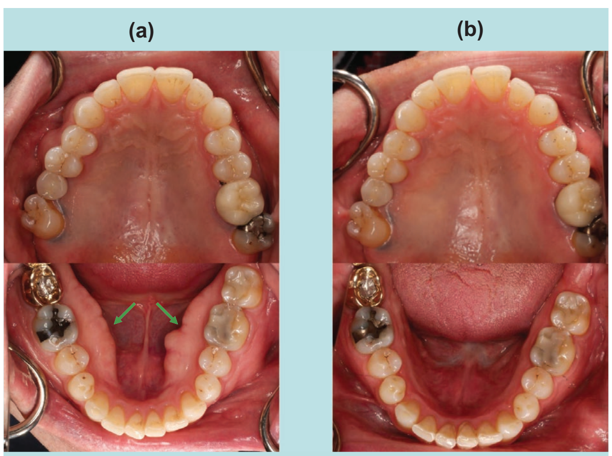

Figure 1. a. Pre-treatment intra-oral appearance, showing maxillary hypoplasia with a transpalatal bone width of 36 mm and extensive, bilateral torus mandibularis (arrows). b. Post-treatment intra-oral appearance, showing a transpalatal bone width of 39 mm and absence of torus mandibularis.

Figure 2. a. Pre-treatment intra-oral appearance from anterior aspect, showing extensive, maxillary buccal exostoses (arrows). b. Post-treatment intra-oral appearance, showing absence of buccal exostoses in the absence of surgical intervention.

Table 1. Comparison of pre- and post-treatment CBCT parameters.

	Pre-treatment	Post-treatment
Cranial base length	108 mm	107 mm
Anterior cranial base length	70 mm	69 mm
Posterior cranial base length	48 mm	47.5 mm
Cranial base angle	129.5°	132°
Minimum retropalatal mid-sagittal distance	**3.4 mm**	**8.4 mm**
Soft palate length	52 mm	52 mm
Minimum medio-lateral retropalatal width	**20 mm**	**31.5 mm**
Minimum retropalatal area in the axial plane	**117.5 mm²**	**301 mm²**
Minimum mid-sagittal retroglossal distance	**11 mm**	**18 mm**
Minimum medio-lateral retroglossal width	**20 mm**	**34 mm**
Minimum retroglossal area in the axial plane	**223 mm²**	**561.5 mm²**
Surface area of posterior nasal apertures at level of posterior nasal spine in axial plane	**507.5 mm²**	**533.5 mm²**
Minimum inferior nasal concha distance from nasal septum: Right	1.8 mm	1.8 mm
Minimum inferior nasal concha distance from nasal septum: Left	**0.65 mm**	**1.65 mm**
Angle of upper central incisor to cranial base plane	81°	83°
Angle of lower central incisor mandibular plane	74°	71°
Transpalatal bone width at cervical margin of mesio-palatal cusps of first molars	**36 mm**	**39 mm**
3D airway volume from posterior nasal spine to inferior border of C3/hyoid bone	**18.9 cm³**	**29.7 cm³**

Note: CBCT: Cone Beam Computed Tomography.

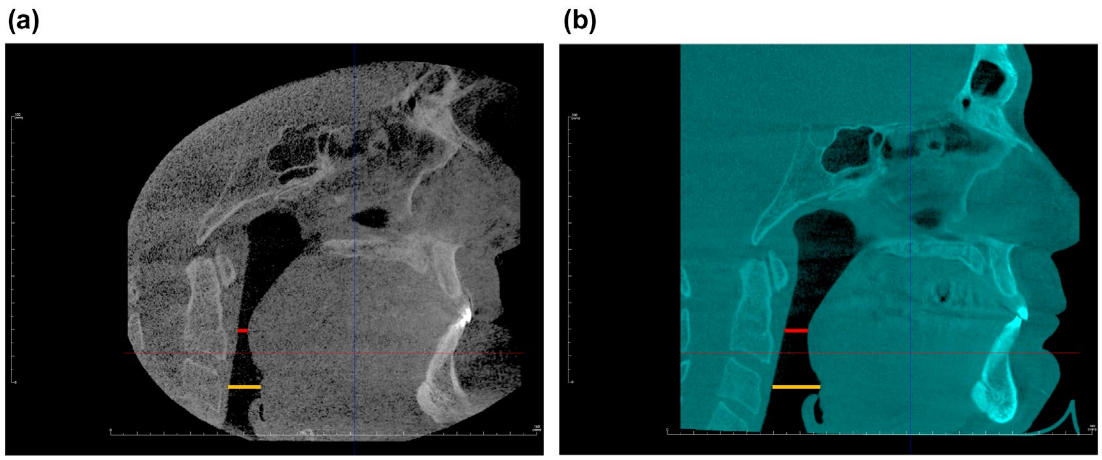

Figure 3. a. Pre-treatment mid-sagittal slice from 3D CBCT scan, showing minimum, mid-sagittal retropalatal distance of 3.44 mm (red line) and the minimum mid-sagittal retroglossal distance of 10.77 mm (orange line). b. Post-treatment mid-sagittal slice from 3D CBCT scan, showing improvements in the minimum, mid-sagittal retropalatal distance to 8.44 mm (red line); and the minimum mid-sagittal to 17.97 mm (orange line).

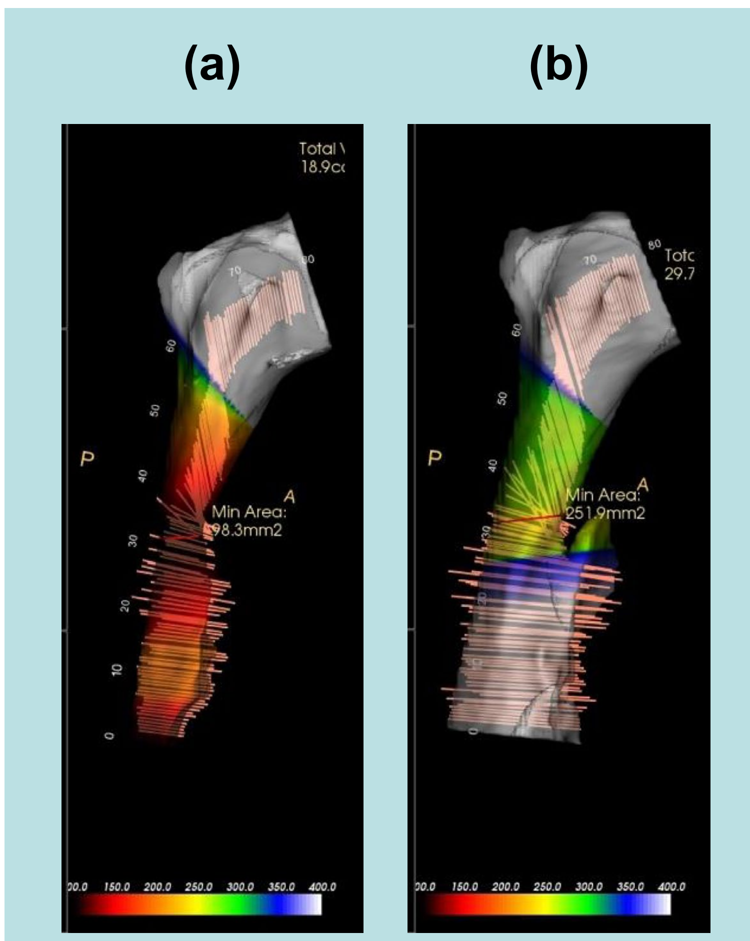

Figure 4. a. Pre-treatment 3D upper airway reconstruction from 3D CBCT scans, showing minimum surface area of 98.3 mm^2 and upper airway volume of 18.9 cm^3. b. Pre-treatment 3D upper airway reconstruction from 3D CBCT scans, showing minimum surface area of 251.9 mm^2 and upper airway volume of 29.7 cm^3.

follow-up HST demonstrated that the sleep architecture appeared to be good: the AHI fell to 5.3hr^{-1}hr; and he spent 27% of sleep time in REM sleep, with a mean SpO_2 of 93% without any appliances in the mouth at night when the sleep study was performed.

Conclusion

These findings are similar to previous studies [11,12], which suggest that BOAT might be able to restore the subjective quality of sleep in certain adult cases of

OSA [13]. However, a limitation of this study is that post-treatment polysomnography would have been preferred since portable devices can underestimate the severity of the condition. In addition, while the impact of surgical reduction of the mandibular tori is not clear in achieving the improvement in breathing during sleep, previous studies suggest that it may be of lower importance [9,10] with respect to BOAT. Therefore, long term follow-up is warranted to ensure that the current craniofacial findings and sleep quality are maintained.

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Disclosure statement

GDS has disclosed those interests fully to Taylor & Francis, and have in place an approved plan for managing any potential conflicts arising from this arrangement.

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