

## SLEEP DISORDERS

# Efficacy and safety of maxillomandibular advancement in treatment of obstructive sleep apnoea syndrome

## *Risultati dell'avanzamento maxillo-mandibolare nel trattamento della sindrome delle apnee ostruttive del sonno*

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## SUMMARY

To assess the effectiveness of maxillomandibular advancement for treatment of adults with obstructive sleep apnoea, we report the results obtained after maxillomandibular advancement. A group of 16 patients were studied before surgery, at 6 months after surgery and at follow-up. The analysis included: upper airway endoscopy during Mueller's manoeuvre, lateral cephalometry, polysomnography and Epworth Sleepiness Scale. The results of surgical treatment were divided into "surgical success" and "surgical cure". The former was defined as an AHI < 20 events/hour and a > 50% reduction in AHI after surgical procedure, while the latter was defined as an AHI < 5 events/hour after surgical procedure. At follow-up, all patients had AHI < 20 events/hour with a surgical success rate of 100%. The surgical cure rate was 37.5%, with 6 patients having an AHI < 5 events/hour. Surgical success and long term stability of outcomes confirm the efficacy and safety of MMA for treatment of obstructive sleep apnoea syndrome. However, a continuous follow-up of these patients is necessary to control their lifestyle and to detect possible relapse.

**KEY WORDS:** Maxillomandibular advancement • Obstructive sleep apnoea syndrome • Surgery treatment in OSAS

## RIASSUNTO

*Obiettivo del nostro studio è stato valutare l'efficacia dell'avanzamento maxillo-mandibolare come trattamento dell'apnea ostruttiva del sonno negli adulti. Sedici pazienti sono stati studiati prima dell'intervento chirurgico, a sei mesi dopo l'intervento ed al follow-up. L'analisi includeva: l'endoscopia delle vie aeree superiori durante la manovra di Mueller, la cefalometria laterale, la polisonnografia e la scala della sonnolenza di Epworth. I risultati del trattamento chirurgico sono stati riportati in termini di successo chirurgico (riduzione superiore al 50% dell'AHI con valori inferiori a 20 eventi / ora) e successo terapeutico (AHI <5 eventi / ora dopo l'intervento chirurgico). Al follow up (T<sub>2</sub>) tutti i pazienti avevano AHI <20 eventi / h con un "successo chirurgico" del 100%. Il tasso di "successo terapeutico" è stato del 37,5%, con 6 pazienti con un AHI <5 eventi / h. Il successo chirurgico e la stabilità a lungo termine dei risultati confermano l'efficacia e la sicurezza dell'avanzamento maxillo-mandibolare per il trattamento della OSAS. Tuttavia, un continuo follow-up di questi pazienti è necessario per controllare il loro stile di vita e di rilevare eventuali possibili recidive.*

**PAROLE CHIAVE:** Avanzamento maxillo-mandibolare • Sindrome delle apnee ostruttive del sonno • Trattamento chirurgico dell'OSAS

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## Introduction

Continuous positive airway pressure therapy (CPAP) is first line treatment for patients with obstructive sleep apnoea syndrome (OSAS). CPAP prevents upper airway collapse, relieves symptoms such daytime sleepiness and decreases cardiovascular events<sup>1,2</sup>. However, for various reasons this treatment has poor compliance<sup>3</sup>.

An alternative approach to the OSAS is upper airway surgery, with the goal of increasing the posterior airway space and decreasing resistance to airflow, removing the site or sites of upper airway collapse<sup>4</sup>.

Different surgical approaches have been proposed, includ-

ing tracheostomy, uvulopalatopharyngoplasty, velouvulopharyngeal lift, hyoid suspension, partial glossectomy, lingual suspension, tongue base resection, genioglossus advancement and maxillomandibular advancement<sup>5-8</sup>.

Tracheostomy is the surgical treatment for OSA with a success rate of 100% because of by-pass of the site of collapse; it is indicated as a treatment of last resort after the failure of other surgical procedures. Other surgical procedures have given results that are not always positive. The reported surgical success rate for soft tissue surgical procedures is approximately 40-60%<sup>9</sup>.

Maxillo-mandibular advancement (MMA) enlarges the pharyngeal space by expanding the skeletal framework

so that the soft tissue pharyngeal structures and tongue attach, resulting in reduced pharyngeal collapsibility<sup>10</sup>. MMA is currently the most effective surgical treatment for management of OSA in adults<sup>11,12</sup>. Herein, we report the results obtained after MMA in a group of adult patients affected by OSAS.

## Materials and methods

Between 2004 and 2009, 16 patients (13 males and 3 females) with a mean age of 49.31 years (SD 8.22) diagnosed with OSAS underwent MMA. Maxillary and mandibular advancements were obtained by Le Fort I osteotomy and bilateral sagittal split osteotomy, respectively. Surgery was always performed by the same surgical team.

Concomitant to bimaxillary surgery, 5 patients underwent septoplasty/turbinoplasty; 1 was subjected to uvulopalatopharyngoplasty and 3 patients underwent simultaneously septoplasty/turbinoplasty and uvulopalatopharyngoplasty. Additional procedures included (1) piriform rim recontouring, (2) anterior nasal spine modelling and (3) alar base cinch suture. No patients underwent genioplasty.

Osteosynthesis was performed using plates and monocortical/bicortical screws, as dictated by the magnitude of the advancements and the anatomic variations. To assess surgical success and outcomes, we evaluated both objective and subjective parameters before surgery (T0), at 6 months after surgery (T1) and at follow-up (T2). The average length of follow-up was 48.6 months (SD 25.1 months).

Objective examinations were evaluated by upper airway fibroscopy during Mueller's manoeuvre, lateral cephalometry and polysomnography. Subjective examinations were evaluated by the Epworth Sleepiness Scale (ESS) questionnaire. With upper airway endoscopic evaluation, performed using a flexible fibre optic endoscope in the supine position during Mueller's manoeuvre, we assessed the localization of site/sites of collapse (N: nose, O: oropharynx, H: oropharynx), pattern of collapse (c: circular, t: transversal, ap: antero-posterior) and grade of collapse (grade 0, 1, 2, 3, 4) (NOH classification)<sup>13</sup>.

With lateral cephalometry, performed on latero-lateral telerradiography by the same operator, we evaluated skeletal relationship by angular measurements (SNA, SNB) as well as the posterior air space (PAS) between the base of the tongue and the posterior wall of the pharynx<sup>14</sup>.

Using polysomnography, we evaluated the average number of apnoeas and hypopnoeas per hour during sleep (AHI), the average number of oxyhaemoglobin desaturation per hour during sleep (ODI) and the average time spent with oxyhaemoglobin saturation below 90% during sleep ( $\text{SaO}_2 < 90$ ).

Data were analyzed using the paired Student's t-test and ANOVA post hoc analysis with Bonferroni's correction considering  $p < 0.001$  as statistically significant.

This research was approved by our institution.

## Results

Presurgical upper airway fibroscopy with Mueller's manoeuvre identified oropharyngeal and hypopharyngeal collapse in all patients. The most frequent pattern of oropharyngeal collapse was the circular type (O: c), and was observed in 14 patients (87.5%), while the most frequent pattern of hypopharyngeal collapse was the transversal type (H: t) and was observed in 10 patients (62.5%). At T1, we observed a reduction of the grade of collapse in all patients. From T1 to T2, we observed a worsening of the grade of collapse in 4 patients, although the T2 grade of collapse was less than the preoperative grade (T0); these patients had significant improvement in clinical outcomes (Table I). We referred these patients to sleep endoscopy.

For the cephalometric skeletal measurements (SNA and SNB), no statistically significant changes ( $p > 0.001$ ) were observed from T1 to T2 (Table II). These data confirmed long-term skeletal stability.

The posterior airway space (PAS) was increased in length from T0 to T1, respectively, from 3.73 mm (SD 2.1 mm) to 9.7mm (SD 2.7 mm) ( $p < 0.001$ ). From T1 to T2, the differences in the PAS were not statistically significant ( $p > 0.001$ ) (Table III).

In Table IV, polysomnographic data is shown; from T0 to T1, there was a statistically significant decrease of AHI, respectively, from 47.1 events/h (SD 22.5 events/h) to

**Table I.** Upper airway endoscopic evaluation during Mueller's manoeuvre. NOH (nose oropharynx hypopharynx) classification.

Pt.	N			O			H		
	T0	T1	T2	T0	T1	T2	T0	T1	T2
1	0	0	0	1ap	1ap	1ap	2ap	2ap	1c
2	2	1	0	4c	2c	2c	3t	1t	1t
3	1	0	0	3-4c	2c	2c	2t	1t	1t
4	1	0	0	3-4c	1c	2c	3c	1c	1t
5	0	0	0	4c	2t	2t	4c	2c	2t
6	0	0	0	2c	0	0	3c	1c	1c
7	1	0	0	3c	1c	1t	2t	1t	1t
8	1	0	0	3t	2t	2c	3t	2t	2t
9	2	1	1	1t	1t	1t	2t	1t	1t
10	2	1	1	3c	1c	2c	4t	1t	1t
11	3	0	0	2c	2t	0	1t	1t	1t
12	2	0	0	4c	2ap	2ap	1ap	2ap	2ap
13	1	0	0	2c	1c	1ap	3c	1c	1c
14	3	0	0	4c	2c	2c	2t	1t	2c
15	3	0	0	4c	2c	3c	2c	2c	3c
16	2	0	0	3c	1c	1ap	3t	1c	2c

**Table II.** Cephalometric skeletal measurements.

	SNA			SNB		
	T0	T1	T2	T0	T1	T2
Average	80.86	86.69	86.45	77.92	81.11	81.23
SD	3.95	4.32	3.95	3.41	3.43	3.91

Data are the angle of measure (°)

**Table III.** Cephalometric PAS measurements.

	PAS		
	T0	T1	T2
Average	3.73	9.7	10.3
SD	2.1	2.7	2.3

Data are number (mm).

**Table IV.** Polysomnographic data.

	T0	T1	T2
AHI	47.1 ± 22.5	16.1 ± 17.5	10.4 ± 5.4
Supine AHI	41.1 ± 16.2	17.1 ± 24.2	12.6 ± 5.6
Lateral AHI	11.7 ± 14.0	5.2 ± 9.4	3.2 ± 4.7
ODI	20.4 ± 21.4	7.3 ± 10.1	6.6 ± 6.0
Sa < 90%	25.0 ± 7.0	10.0 ± 18.0	19.3 ± 39.3

**Table V.** ESS scores.

	ESS		
	T0	T1	T2
Average	12.93	2.56	4.12
SD	1.69	1.99	2.52

16.1 events/h (SD 17.5 events/h) ( $p < 0.001$ ). Moreover, from T1 to T2 we observed a decrease in AHI, but this change was not statistically significant ( $p > 0.001$ ). The postoperative result remained stable over time. The ODI also maintained the same trends.  $\text{SaO}_2 < 90\%$  worsened from T1 to T2, ( $10 \pm 18\%$  vs  $19.3 \pm 39.3\%$ ). Comparing the saturation during wake before and after surgery, this result can be explained as a worsening of the clinical picture and not just as worsening of the sleep disorder.

From T0 to T1, the ESS score had a statistically significant reduction ( $12.93 \pm 1.69$  vs.  $2.56 \pm 1.99$ ) ( $p < 0.001$ ), while from T1 to T2 the difference in ESS score was not statistically significant ( $2.56 \pm 1.99$  vs  $4.12 \pm 2.52$ ) ( $p > 0.001$ ) (Table V).

## Discussion

MMA is currently considered to be the craniofacial surgery that is most effective in treatment of OSAS in adults<sup>11,12</sup>. The results of surgical treatment of OSAS are divided into “surgical success” and “surgical cure”. Surgical success is defined as an AHI < 20 events/hour and a > 50% reduction in AHI 50% after surgical procedure.

Surgical cure is defined as an AHI < 5 events/hour after surgical procedure<sup>15</sup>.

Holty and Guilleminault performed a meta-analysis and systematic review to estimate the clinical efficacy of MMA in treating OSAS involving 627 adults with OSAS undergoing MMA<sup>15</sup>. The mean AHI decreased from 63.9 events/hour to 9.5 events/hour following surgery. The surgical success and cure rates were  $86.0 \pm 30.9\%$  and  $43.2 \pm 11.7\%$  respectively. They also observed the maintenance of surgical success at 44 months after surgery.

In our study, at follow up (T2) all patients had AHI < 20 events/hour with a “surgical success” rate of 100%. The surgical cure rate was 37.5%, with 6 patients having an AHI < 5 events/hour. These results are in agreement with data reported in the above-mentioned meta-analysis and confirm the efficacy of MMA. Improvements in AHI were stable over time. There were no significant changes between the data collected at 6 months (T1) and at follow-up (T2). At follow-up, AHI sufferers had further a reduction in AHI registered at T1; this trend, although not statistically significant, could be explained by oedema of the soft tissue that persists for several months after surgery.

We observed a significant improvement in daytime sleepiness, and all patients had subjective benefits of MMA (Table V).

The analysis of skeletal cephalometric values (SNA and SNB) at T1 and T2 did not show any statistically significant differences ( $p > 0.001$ ), confirming the long-term stability of skeletal advancement. No patient had skeletal relapse.

In agreement with literature reports, postoperative PAS (T1) showed a significant increase ( $3.73 \pm 9.07$  mm vs.  $2.1 \pm 2.7$  mm). At T2, PAS maintained stable values; the differences between measurements performed at T1 and at T2 were not statistically significant ( $p > 0.001$ ).

Even the endoscopic data are encouraging; in fact, all patients showed a reduction in the grade of collapse at T1. At T2, we observed a worsening of the grade of collapse in 4 patients, despite the resolution of symptoms and significant reduction in AHI. However, in these patients the T2 grade of collapse was less than the T0 grade. One probable explanation lies in the extreme subjectivity of the assessment method, and we referred these patients to sleep endoscopy. Skeletal advancement was  $9.1 \text{ mm} \pm 1.3 \text{ mm}$  for the maxilla and  $8.9 \text{ mm} \pm 1.8 \text{ mm}$  for the mandible. Lye et al. found a statistically significant correlation between the degree of maxillary advancement and reduction in AHI<sup>12</sup>. However, others have reported no association between the degree of maxillary advancement and improvement in AHI after MMA<sup>16</sup>. In our study, MMA was personalized to the facial characteristics of each patient, and probably a MMA of 1 cm protects patients from relapse in both skeletal soft tissues. Initially, MMA was practiced as a second stage of treatment, after failure of previous nasal and/or oropharyngeal surgery<sup>14</sup>, and as a first stage of treatment in patients with substantial craniofacial deformities<sup>5,17</sup>. Our study under-

lines the possibility to extend MMA, as first stage treatment, even in patients without dento-facial anomalies. However, this choice should also be guided by the severity of the disorder, severity of daytime symptoms, degree of pharyngeal collapse and restriction of PAS.

MMA is generally safe with a major surgical complication maxillary (ischemic necrosis, cardiac complication) rate of 1%<sup>15</sup>, a minor complication (mandibular relapse, facial paraesthesia, tempor-mandibular joint disease)<sup>15 18 19</sup> rate of 3.1% and no reported deaths. Immediately after surgery, facial paresthesia was observed in 4 patients. At follow-up however, no patients reported facial paraesthesia. To reduce the excessive protrusion of maxilla and upper lip, we performed piriform rim recontouring, anterior nasal spine modelling and alar base cinch suture. In our study, no patients reported worsening of their appearance; 13 patients showed a degree of rejuvenation after MMA and 3 reported no postoperative change.

## Conclusions

OSAS is a chronic disease, and the goal of treatment is control of symptoms and control of OSAS-related risks by reducing the severity of the disorder. Surgical success and long-term stability of outcomes confirm the efficacy and safety of MMA for treatment of OSAS. However, continuous follow-up of these patients is necessary to control their lifestyle and detect possible relapse.

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