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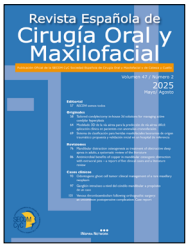

Revisión

Mandibular distraction osteogenesis as treatment of obstructive sleep apnea in adults, a systematic review of the literature

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ABSTRACT

Purpose: This study evaluated the application of mandibular distraction osteogenesis for management of adult patients with obstructive sleep apnea (OSA).
Methods: International databases were searched from January 2000 to June 2025, for articles that reported polysomnographic outcomes after treatment of adult OSA patients with mandibular distraction osteogenesis (MDO).
Results: 399 articles were screened and 8 met the inclusion criteria. A total of 101 patients with a mean age of 35 years (66 male- 24 female), were treated by MDO. 55 of which did not suffer from Temporomandibular joint ankylosis (TMJA). Follow up period ranged from 4 to 45 months. The average distraction distance achieved was 14.8 mm. Global cure and success rates were 80.34 % and 94.27 % respectively with a mean preoperative AHI of 44.03 events per hour and a mean postoperative AHI of 4.8 events per hour. Most frequent complications were neurosensory disturbance of inferior alveolar nerve and local wound infection.
Conclusions: Distraction osteogenesis has shown to safely lengthen mandibular bone and generate new soft tissue that minimizes skeletal relapse and limits neurosensory complications. It is a valid treatment option for adult OSA, that offers high cure rates as well as acceptable aesthetic and functional results with minimal complications. Studies must be performed to assess the long-term effects of this treatment method.

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Distracción osteogénica mandibular como tratamiento del síndrome de apnea obstructiva del sueño en adultos: revisión sistemática de la literatura

Palabras clave:
Apnea del sueño, adulto, avance mandibular, distracción osteogénica, resultados.

R E S U M E N

Objetivo: Evaluar los resultados de la distracción ósea mandibular en el tratamiento de la apnea obstructiva del sueño en adultos.
Método: Se realizó una búsqueda en bases de datos internacionales para incluir artículos publicados entre enero de 2000 y diciembre de 2022, que reportaran resultados con estudio de polisomnografía tras el tratamiento de apnea obstructiva del sueño mediante distracción mandibular.
Resultados: Se revisaron 471 artículos y 8 cumplieron los criterios de inclusión. Se incluyeron 101 pacientes con una edad media de 35 años (66 hombres y 24 mujeres), de los cuales 55 pacientes no estaban diagnosticados de anquilosis temporomandibular. El tiempo de seguimiento fue de 4 a 45 meses. La distracción mandibular media fue 14,9 mm. Los índices globales de cura y éxito quirúrgico fueron 80,34 % y 94,27 % respectivamente, con un AHI preoperatorio medio de 44,03 eventos por hora y un AHI postoperatorio medio de 4,8 eventos por hora. Las complicaciones más frecuentes fueron la alteración sensitiva del nervio dentario inferior y la infección de la herida quirúrgica.
Conclusión: La distracción osteogénica mandibular ha demostrado ser un procedimiento seguro, capaz de generar hueso y tejido blando, minimizando la tasa de recidiva y daño neurosensorial. Es una opción válida para el tratamiento de la apnea obstructiva del sueño en adultos que ofrece una alta tasa de curación, así como buenos resultados estéticos y funcionales con mínimas complicaciones. Se deben estudiar los efectos de esta técnica a largo plazo.

INTRODUCTION

Obstructive sleep apnea (OSA) is a common disorder that causes episodes of upper airway narrowing or total collapse during sleep, limiting the airflow to the lungs, which causes intermittent tissue hypoxia, hypercapnia, recurrent arousals and an increase in respiratory efforts, leading to secondary sympathetic activation, oxidative stress and systemic inflammation[1]. The mechanism of this augmented collapsibility is multifactorial and not yet fully understood. It is estimated that 425 million (range 399-450) of adults aged 30-69 years have moderate to severe obstructive sleep apnea globally, according to AASM 2012 diagnostic criteria for moderate sleep apnea (Apnea Hypopnea Index (AHI) of 15 or more events per hour)[2].

The gold standard treatment of obstructive sleep apnea is Continuous Positive Airway Therapy (CPAP)[3], a non-invasive but only-symptomatic approach. Current society needs, such as frequent travelling or limited living space demand other alternatives. Two main techniques have been described to surgically treat Sleep Apnea: Conventional one step maxillomandibular advancement (MMA) and mandibular distraction osteogenesis (MDO) followed, if necessary by a LeFort I maxillary advancement. Maxillomandibular advancement (MMA) cure rate for OSA has been accounted for in Systematic reviews and Meta-analysis ranging from 38.5 % to 43.2 %[4,5].

Although Sleep Apnea published information has increased in the past 10 years by 20-fold, most studies performed on surgical treatment have a small simple size and describe a very specific patient group: newborns with micrognathia and severe respiratory obstruction before their first year of age. Limited experience using MDO as a treatment tool for adult OSA was at our disposal, until now. During the last two years the clinical use of bilateral internal ramus distraction (BIRD) in adults has gained momentum. A prospective series has demonstrated a marked improvement in disease-especific quality of life after mandibular advancement[6], while two further observational studies from the same study group have confirmed the feasibility of home respiratory polygraphy to titrate distraction length and the stability of combined BIRD + Le Fort I protocols[7,8]. A threedimensional volumetric analysis has also documented significant enlargement of the upper airway following BIRD[9]. Hence, this study was designed to systematically review all international publications on adult MDO, its effectiveness and potential morbidities.

The American Academy of Sleep Medicine (AASM) has issued its 2024 guideline on surgical referral for OSA[10] and released the third edition (2023) of the *Manual for the Scoring of Sleep and Associated Events*, which refines hypopnoea scoring criteria and oxygendesaturation thresholds[11]. These documents define the current diagnostic and therapeutic framework within which the present review should be interpreted.

MATERIALS AND METHODS

Information Sources and search strategy

The databases that were searched included Pubmed/Medline, Ovid, Scopus, the Cochrane library and Science Direct. The following key words and their combinations were used: *Apnea, obstructive sleep* AND *distraction osteogenesis*. Electronic database search was limited by date, from January 1st 2000 to June 1st 2025 included, race was limited to humans. The term "adult" was not included in the search equation to maximize the result number. Language limitations were imposed to English, Spanish and French. An example of search strategy would be as follows: *(sleep apnea, obstructive [MeSH Terms]) AND (distraction osteogenesis [MeSH Terms]) Filters: Humans, from 2000/01/01 - 2025/06/01*.

We formulated a PICO question following PRISMA guidelines: Patients: any adult patients diagnosed with Obstructive Sleep Apnea; Intervention: distraction osteogenesis; Comparison: polysomnography data before and after surgery; Outcomes: surgical cure and success rates.

Study selection

A protocol sheet was developed to simplify the selection of studies, two reviewers identified studies for inclusion. Three rounds of research were performed as showed in the flowchart (Figure 1). First potentially relevant articles were selected, abstracts were reviewed and when information was insufficient, the full text was retrieved. We also performed a manual inquiry into two relevant international journals: International Journal of Oral and Maxillofacial Surgery and Oral and Maxillofacial Clinics of North America and reference lists of included articles and other related systematic literature reviews were manually searched.

Evaluation of full texts was performed according to the following inclusion criteria: study type (clinical trial and case series), treatment outcome reported after MDO on patients diagnosed with OSA, distraction protocol and adjunctive surgeries clearly described, preoperative and postoperative polysomnography (PSG) data specified as AHI or respiratory disturbance index (RDI) and either follow-up period or date of postoperative PSG specified.

Variable description and data collection

Sample size and study design. Randomized controlled trials and case series were included. The studies with adult and children population were selected to include only the adult data (> 18 years) and these had to be reported independently.

Description of treatment. The indication of MDO had to be the diagnosis of OSA by PSG, with or without temporomandibular joint (TMJ) ankylosis. The type of distraction device and vector, details of the protocol (latency, activation and consolidation periods), and the quantity of the final and adjunctive surgeries had to be detailed.

Description of outcome. AHI/RDI had to be clearly stated. Surgical cure was defined as AHI post-treatment (< 5 e/h). Treatment success was defined as AHI post-treatment (< 20 e/h) and 50 % decrease in AHI. Surgical cure rates were calculated for those studies that did not specify it.

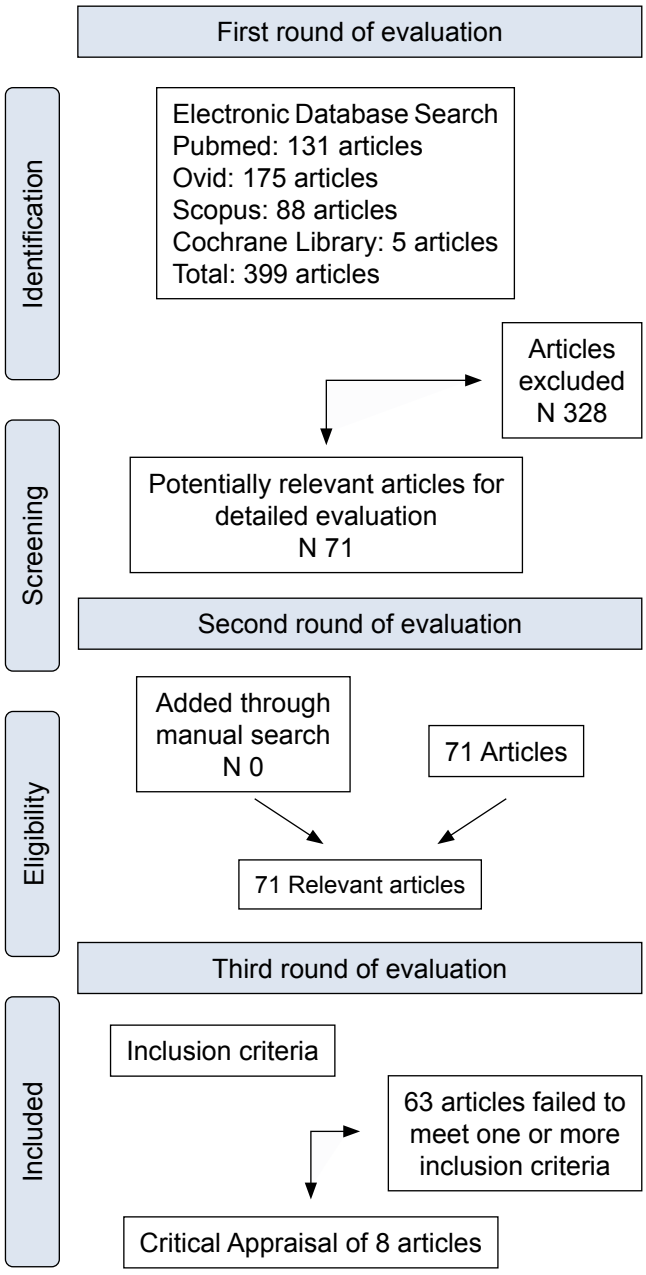

Figure 1. Flow chart.

Patient follow-up. Either patient follow-up or date of the post-treatment PSG had to be specified. When multiple post-surgical PSG measurements were available, the 6-month post PSG was used.

Global weighted means of age, pre/postop AHI and lowest oxygen saturation rates were calculated. Weighted means were calculated by multiplying each data point by its weight and summing these products. Then sum the weights for all data points. Finally, divide the weight*value products by the sum of the weights.

Due to the small sample of most of the studies, a meta-analysis was not conducted.

Evidence Quality was evaluated by using the quality assessment tool from National Institute of health and clinical excellence (NICE). Available checklist for case series was applied to all publications. *Yes* answers are granted 1 point and *No* answers 0 points, appointing a maximum score of 8 points for best quality. Adaptations were made when applying question number 8. *Are outcomes stratified*, to respond yes if there was specific mention to making comparable groups. Evaluations available in Table S1.

RESULTS

The search strategy yielded 399 studies of which 71 were potentially relevant and were downloaded. During the third round of evaluation 63 articles were excluded, reasons for exclusion are recorded in table 1. A total of 8 articles[12-19] are included in this systematic review accounting for 101 patients. General characteristics of the studies are shown in Table II.

Table S1. Quality assesment tool for case series studies from National Institute of health and clinical excellence (NICE). www.NICE.org.

	Paoli 2001	Karakasis 2001	Li 2002	Thompson 2006	Andrade 2006	Feiyun 2010	Brevi 2011	Jihua 2012	Yadav 2014	Andrade 2018	Tsui 2019	Rubio-Bueno 2021
Case series collected in more than one centre	No	No	No	No	No	No	No	No	No	No	No	No
Hypothesis/aim/ objective of the study clearly described?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Inclusion and exclusion criteria (case definition) clearly reported	Yes	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes
Is there a clear definition of the outcomes reported	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were data collected prospectively	No	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Is there an explicit statement that patients were recruited consecutively	No	No	Yes	No	No	No	No	No	No	No	No	No
Are the main findings of the study clearly described	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Are outcomes stratified	No	No	No	No	No	No	No	No	No	Yes	Yes	No
Total score	4	4	6	3	3	4	3	4	4	6	6	5

Table I. Reasons for exclusion of studies.

Database	Population (children)	Inadequate outcome report	Total
Pubmed (34)	10	19	29
Ovid (12)	6	6	12
Cochrane (0)	0	0	0
Scopus (25)	11	11	22
Total (71)	27	36	63

Table II. Description of studies main characteristics. PCS (prospective case series), RCS (retrospective case series), RTC (randomized controlled trial), OAST (one-arm surgical trial), Sex (male/female/not specified), OSA (Obstructive sleep apnea), TMJA (temporomandibular joint ankylosis), Adult MDO (adult mandibular distraction osteogenesis patients), RDI (respiratory disturbance index), Lsat (lowest oxygen saturation during sleep study), CT90 (percentage of time spent with saturation under 90%), mean O2sat (mean oxygen saturation throughout the PSG), AHI (Apnea-hypopnea index), PAS (posterior airway space), SBN angle (sella-nasion supramental angle), ODI (Oxygen desaturation index), ESS (Epworth sleepiness scale).

Year	Author	Tipe of study	Total N	Adult MDO	Sex (N)	Age (mean,range)	Main Diagnosis	Reported outcome
2002	Li	PCS	5	5	3m/2f	54,5 y (44-68)	OSA	RDI, Lsat
2010	Feiyun	PCS	16	16	10m/6f	28,8 y (18-34)	TMJA	Cure, RDI, Lsat, SBN angle
2011	Brevi	RCS	44	9	9m	48 y (37-67)	OSA	ODI, AHI, PAS
2012	Jihua	PCS	12	11	6m/5f	18-27 y	TMJA	RDI
2014	Yadav	PCS	15	8	5m/3f	25,5 y (18-46)	TMJA	AHI, ESS, Lsat, mean O2sat
2018	Andrade	PCS	25	11	NS	21,8 y (18-26)	TMJA	PAS, AHI, mean O2sat
2019	Tsui	RCT	18	9	5m/4f	40,7 y (SD14,3)	OSA	AHI, Lsat, cure, sucess
2021	Rubio-Bueno	OAST	32	32	28m/4f	41 y (SD13,3)	OSA	AHI, ODI, cure

Preoperative Assessment and study population

Of the 101 patients only 90 were identified by sex (66 males and 24 females), with a mean weighted age of 35 years. The preoperative Body Mass Index (BMI) was reported in 4 studies, 2 reported normal weight (≥ 18,5kg/m^2), 2 reported overweight (≥ 25kg/m^2). All patients suffered moderate to severe OSA. As to the main diagnosis, of the selected 8 studies, 4 treated OSA secondary to micrognathia in TMJ ankylosis (46 patients) and 4 treated OSA patients without other probable cause (55 patients).

Surgical intervention

All patients were treated using internal devices for bilateral mandibular distraction osteogenesis except for Li[12] who applied unilateral MDO to one of the five patients described. The most frequent distraction target site was the mandibular body in 60 patients, followed by the vertical ascendant ramus and the mandibular angle. Distraction protocols are detailed in table 3. A 7-day latency period with distractor activation rhythm of 0,5 mm every 12 hours was the most reported protocol. Consolidation periods ranged from no time to 6 months. Mandibular distraction was the initial surgical intervention in 7 of the 8 papers. Jihua et al. initiated treatment by TMJ arthroplasty and then continued with MDO. Two surgeons performed other interventions as simultaneous first stage surgeries: maxillary advancement[12] and transport disc arthroplasty to reconstruct the condyle[13]. In all cases there was a second intervention to remove the distraction device, most frequently accompanied by a Le Fort I maxillary advancement or an arthroplasty. Two teams reported to have needed a third surgery to complete treatment. The average mandibular advancement was 14.8 mm (range 8.1-20.7).

Outcomes after mandibular distraction

1. Functional Airway Outcomes. Polysomnography data is available in table 4. The postoperative study was performed between 3 and 12 months after treatment, in all cases after the last surgery, except for Yadav[16] who performed the control PSG before the arthroplasty. The global AHI pre and postoperatively were 44 (range 14.5-87.9) and 4.8 (range 0-12.4) events per hour respectively. When segregated by main diagnosis, AHI pre and post-treatment results were in 48 and 6.6 events per hour in OSA group and 40.05 and 3 events per hour in TMJ ankylosis + OSA patient group. Lowest Oxygen saturation during PSG was documented in 5 studies, with an average of 69.7 % pre-MDO and 88.2 % post-MDO.
2. Surgical cure and success. When average cure rate is adjusted by weight, the pooled result is 80.34 %. On the other hand, the success rate was 91.67 % in patients with primary OSA and 96.87 % in those patients with TMJA + OSA.

Table III. Surgical intervention details. Dx (diagnosis), OSA (obstructive sleep apnea), TMJA (Temporomamdibular joint ankylosis), MDO (mandibular distraction osteogenesis), MxDO (maxillar distraction osteogenesis), DR (distractor removal), BL (bilateral), UL (unilateral).

Author (N)	Main Dx	1st Surgery	2nd Surgery	3rd Surgery	Device Side Osteotomy	Latency (days)	Rythm (mm/h)	Consolidation (months)	Average advancement (mm) (range or SD)
Li K.K (6)	OSA	MDO (4) MDO+ MxDO (1)	Le Fort I DR		Internal BL (4), UL (1) Body	7 d	0,25/ 6	3 m	8,1 (5,5-12,5)
Brevi (8)	OSA	MDO	Le Fort I DR		Internal BL Angle	3 d	0,5/ 12	0	aprox 20 mm
Tsui (12)	OSA	MDO	Le Fort I (8/9) Md subapical osteotomy (8/9) Genioplasty (9/9) DR		Internal BL Body	5-7 d	1/ 24	6 m	11,5 (SD 1,9)
Rubio-Bueno (13)	OSA	MDO	Le Fort I (28/32) DR		Internal BL Ramus	5 d	1/ 24	2-3 m	16,6 (SD4,9)
Feiyun (7)	TMJA +OSA	MDO+ Arthroplasty	DR		Internal BL Body	7 d	0,8/ 24	4 m	18,9 (12-28)
Jihua (9)	TMJA +OSA	Arthtoplasty	MDO +genioplasty	DR	Internal BL Body	7 d	0,5/ 12	3 m	12,9 (SD 2,4)
Yadav (10)	TMJA +OSA	MDO	DR	Arthroplasty	Internal BL Body	5 d	1/ 24	2 m	20,65 (15-30)
Andrade (11)	TMJA +OSA	MDO	Arthroplasty DR		Internal BL Body	4 d	0,5/ 12	3-4 m	9,36

Table IV. Polisomnographic data. OSA (obstructive sleep apnea), TMJA (Temporomandibular joint ankylosis), MDO (mandibular distraction osteogenesis), MxDO (maxillar distraction osteogenesis.

Author (N)	Main Dx	Advancement (mm) (range or SD)	AHI/RDI Pre	AHI/RDI Post	Lsat Pre	Lsat Post	Cure rate (%)	Success rate (%)
Li K.K (6)	OSA	8,1 (5,5-12,5)	49,3	6,6	79,8	85,8	60	100
Brevi (8)	OSA	aprox 20 mm	53,4	12,4	No	No	22	77,77
Tsui (12)	OSA	11,5 (SD 1,9)	41,5	2,8	72,8	85,8	88,9	88,9
Rubio-Bueno (13)	OSA	16,6 (SD4,9)	47,9	4,7	No	No	81,2	100
Average		14,05	48,02	6,6			63,02	91,67
Feiyun (7)	TMJA + OSA	18,9 (12-28)	47,3	2,1	75,4	98,2	100	Un-available
Jihua (9)	TMJA + OSA	13,27 (SD 2,4)	43,3	3,45	67	92,9	91,6	100
Yadav 10)	TMJA + OSA	20,65 (15-30)	38,13	5,36	67,8	86,68	62,5	87,5
Andrade (11)	TMJA + OSA	9,36	31,5	1,4	No	No	100	Un-available
Average		15,54	40,05	3,07			88,5	96,87
Average global		14,8	44,03	4,8	69,7	88,2	80,34	94,27

3. Facial Aesthetics. Improvement in asymmetry and retrognathia was reported in all TMJ ankylosis patients. No study reports outcomes of facial imbalance or aesthetic negative perception from the patients.
4. Stability and complications. The most commonly reported complications were temporary hypoesthesia of lip and chin, pin site infection and malocclusion. Delayed union or non-union of distraction site was reported in four articles. Tsui[18] reported to have stopped the study recruitment after two major complications in the MDO group. Major complications were reported twice: submental hematoma[13] and pneumonia[18.] Patient follow up after control PSG was documented in all the studies and ranged from 12 to 32 months. The longest follow-up period is reported in Rubio-Bueno[19], with stable outcomes after 32 months. Skeletal relapse was only reported by Tsui[18] comparing the MDO and the sagittal split ramus osteotomy groups after 2 years, being 0.32 mm and 1 mm respectively.

DISCUSSION

OSA is a chronic disease, highly prevalent in productive age. Current public awareness of disease combined with early diagnosis has resulted in a substantial increase of young OSA patients. It is unrealistic to think that this population will willingly accept a lifelong machine-time dependent treatment which compromises their quality of life. Therefore, it is necessary to investigate and provide alternative treatment modalities.

Traditional MMA to treat OSA usually consist of a combination of Le Fort I osteotomy and sagittal split mandibular osteotomy, and have a physical limit of 10-13 mm. Two meta-analysis have demonstrated that traditional orthognathic procedures have modest cure rates[4,5]. These authors have also identified that younger age, lower preoperative weight and AHI, and greater degree of maxillary advancement are predictive of increased surgical success. Five systematic reviews and four meta-analysis have found good results when advancing the mandible by distraction osteogenesis in upper airway obstruction in newborn and children, the most recent one being Leonard et al in 2024 finding a mean AHI reduction of 30 e/h after MDO[20]. The systematic review published by Tsui[21] is the only one with a specific reference to MDO in adult patients, reporting a pooled cure rate from three studies of 82-100 %. The publication by Wang[22] was excluded because it did not present adult and children results separately.

Respiratory outcomes

The global pre- and postoperative AHI found in this study were 44 events per hour and 4.8 events per hour calculated by weighted mean. With a pooled cure rate of 80.3 % (22-100 % range), similar to the 82-100 % reported by Tsui[21]. The success rate was 91.67 % in patients with primary OSA and 96.87 % in those patients with OSA associated with TMJA. When comparing oximetry measures, lowest Oxygen saturation (Lsat) was reported in 5 studies with an average increase from 69.7 % to 88.2 %. CT90 was reported by Rubio-Bueno[19] with an improvement from 44.1 % to 3.4 %. There is undoubtedly an enormous benefit for the patient with severe OSA. The encouraging figures reported in our pooled analysis are in line with the newer prospective data: Verde et al. obtained a mean postoperative AHI of 3.9 ± 1.8 events h after BIRD with simultaneous qualityoflife gains[6], while HernandoMartín et al. documented sustained normalisation of AHI six months after distraction and subsequent Le Fort I advancement, monitored exclusively with home polygraphy[7].

The authors find it critical to present these results stratified depending on the original diagnosis due to the selective criteria applied in the studies included. Brevi[14] specified that OSA other than secondary to TMJA, fibrous ankylosis, non compliants and medically compromised patients could not be included in their study. Whereas Tsui[18] for example excluded patients with facial asymmetry due to differential mandibular growth, patients with TMJ pre-surgical pathology and patients requiring more than 15 mm of mandibular advancement among others, so they specifically select opposite patients. TMJA patients are clearly younger (mean age 28 years versus 45 years at the primary OSA group) and they have a low BMI because of the feeding difficulties, so Yadav reports an increase in BMI after treatment as a success indicator, while patients treated by MDO usually lose weight because of ingestion difficulties in the immediate postop.

With similar advancements (15.5 mm in TMJA and 14 mm in primary OSA), the cure rates calculated were 88.5% and 63% respectively, so TMJA patients will specifically benefit further from MDO, treating primarily the main collapse site. As has already been reported in children[23], MDO increases PAS by pulling forward the muscles adhered to the mandible and asides from increasing the oral cavity.

An advantage of performing MDO is the possibility of titration of respiratory outcomes with sleep studies or radiology tests. Andrade[17] did so by controlling posterior airway space (PAS), while Rubio Bueno[19] performed polygraphy studies until AHI under 5 or and advancement of 20 mm were accomplished. This group reported that the minimum advancement needed for an individual to be cured was 9.8 mm, but it was not until 14 mm of advancement were reached that 50 % of the sample was consider healed. Perhaps this explains the modest cure rate reported by Li[12]. Other authors mention aesthetic limits to the advancement in terms of facial harmony.

Technical variations and adjunctive procedures

The most commonly distracted site in this study was the mandibular body, reported in all the TMJA cases and 50 % of the primary OSA patients. The abnormal mandibular anatomy of severe micrognathia increases the difficulty of performing traditional osteotomies. Rubio Bueno[24] has published the bilateral internal mandibular ramus distraction technique (BIRD), emphasizing that advancement and counter-clockwise rotation are both key factors during the distraction, this permits the correction of the mandibular occlusal plane angle, pulling the tongue and the hyoid bone forward and additionally enlarging the oral cavity to accommodate the tongue[25].

All the primary OSA patients also had a maxillary advancement performed simultaneously or after MDO, this produces an additional increase in the oropharyngeal space and allows correction of the crossbite and facial imbalance[26,27]. Jihua[15] and Tsui[18] also performed advancement genioplasties, which also increase volume in the hypopharynx by pulling the genial tubercle forward[28]. Arthroplasty, even if performed by transport disc osteogenesis, does not interfere with respiratory results.

Aesthetic, stability and complications

An average mandibular advancement of 15 mm requires in most cases a maxillary advancement to correct facial harmony and occlusion. Skeletal advancement generally produces soft tissue lifting effect with a pleasant facial result that when mentioned, ranged from good to excellent. Customized surgical 3D planning will help minimize surgical duration, predict the skeletal changes and inform the patient of the intervention and aesthetic consequences as emphasized Feiyun[13].

Transitory lower lip and chin numbness was reported in 5 studies with incidences as high as 100 %[15], 90 %[14] or 88 %[18]. Local site (pin) infection was the second most frequent complication, also with high incidence in some series: 75% reported by Rubio Bueno[19], and 66 % reported by Tsui[18]. Malocclusion was also reported in all the studies, with frequent references to the need of orthodontic treatment. Nonunion of the distraction site was reported in 5 patients, they hypothesized it was due to the restricted healing capacity and blood supply in older sicker patients, and extended the latency period up to 6 months. Major complications were only reported by Tsui[18], ending their clinical trial due to this reason.

Relapse is typically referred drawback of treating OSA by traditional MMA, due to the large mandibular advancement needed. In a report by McDonald[29], an average relapse of 3.5 mm was showed after mandibular advancement of 12.2 mm, due to acute stretching of soft tissue components. Contrary to this finding, a metanalysis performed by Al Moraissi[30] didn´t find any statistical difference in relapse rates for an average advancement of 8,4 mm when comparing traditional MMA, and MDO although MDO significantly reduced the injury to the inferior alveolar. In our systematic review the longest follow up periods reporting stability is observed in Rubio Bueno[19], specifying 7 years with no evidence of disease relapse.

MDO has two main disadvantages: it requires patient compliance and the need for a minimum of two interventions to insert and remove the device. It also has some very strong aspects such as being able to create new tissue without the need for grafting or a donor site.

Surgeon MDO indication

A secondary goal of this systematic review was to analyze the current indication of MDO to treat OSA. On one hand we find the classic micrognathic patient with OSA secondary to TMJA, that would be treated by MDO aside from having OSA. On the other hand, we found OSA patients with no evident skeletal pathology. These patients were in average: middle aged, obese (average BMI of 27) and most frequently suffering from severe OSA. All studies mentioned previously failed treatment with CPAP and a significant level of mandibular advancement need anticipated by the surgeon in order to treat OSA. Various occlusion profiles are described, especially Class II and biretrusive contour. Successful skeletal correction was proven in obese patients by Holty and Guilleminault[5]. In our opinion, the average OSA patient candidate for surgical treatment is well represented by the inclusion and exclusion criteria applied by Rubio Bueno[19]: AHI > 15/h, refusal of CPAP treatment, health conditions compatible with surgery, no alcohol or smoking dependence, no central sleep apnea, good dental hygiene and without other ENT diagnosis that contraindicate MDO as primary treatment. Previous procedures for OSA should not affect our indication.

Although there are numerous papers reporting excellent results of MDO on children airway obstruction, there is currently no systematic review that investigates it effects on OSA adult patients. The strengths of this study include consistency of efficacy of this technique as a treatment option for adult severe OSA, with good safety profile and long-term maintained successful respiratory outcomes. We also found evidence of excellent cure rates in patient phenotype of micrognathia due to TMJA, especially performing distraction first and then arthroplasty.

Nevertheless, some limitations have been found. Publication byass could not be ruled out and due to the limited number of publications at our disposal, we could not perform a meta-analysis. We have also found significant heterogeneity due to reporting methods of patient characteristics and PSG data among other examples. Most of the literature is comprised of case reports and small case series. As recently stated by Noller[31], the paucity of randomized trials on MDO in OSA patients is difficult due to its clearly demonstrated efficacy on specific target patients. However, the surgical technique should be homogenized to include specific steps of maxillar or mandibular advancement and counterclockwise rotation, with concrete consolidation periods, so conclusions can be generalized.

Statistical analysis would be interesting to test if greater advancements are associated with higher cure rates when stratified by severity of OSA or primary diagnosis.

Lastly, future recommendations should be given to homogenize study reporting methods and perform scientific investigation that provides high quality evidence in surgery, such as randomized controlled trials. It would also be interesting to perform long-term follow up on patients and a timely-designation added to the surgical cure term, since OSA is to become more severe with age.

CONCLUSION

Mandibular distraction osteogenesis is a safe and biologically sound option for treating severe adult obstructive sleep apnea. In our systematic review encompassing 101 patients, the technique lowered the weighted mean apnea-hypopnea index from 44.0 to 4.8 events h^{-1}, delivered an 80.3 % cure rate and a 94 % overall success rate, and did so with predominantly minor, transient complications. The procedure therefore offers substantial and durable airway improvement

while preserving facial aesthetics and function. Future multicentre studies with standardised protocols and longterm surveillance are needed to validate these outcomes and define optimal patient selection.

ETHICS DECLARATIONS

Ethics committee review was not needed since this is a Systematic Review.

CONFLICT OF INTERESTS

The author declares no competing interests.

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