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Endorsement of "European Respiratory Society guideline on non-CPAP therapies for obstructive sleep apnoea" by World Sleep Society

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A B S T R A C T

Guidelines for management of sleep disorders from national or regional societies provide recommendations that may be regionally appropriate but may not always be practical or relevant in other parts of the world. A task force of experts from the World Sleep Society's (WSS) International Sleep Medicine Guidelines Committee and Sleep and Breathing Disorders Task Force reviewed the European Respiratory Society's guideline on non-CPAP therapies for obstructive sleep apnea (OSA) with respect to its relevance and applicability to the practice of sleep medicine by sleep specialists in various regions of the world. The task force and the WSS guidelines committee endorsed the European Respiratory Society's guideline with respect to the utilization of bariatric surgery, mandibular advancement devices, positioning devices, myofunctional therapy, hypoglossal neurostimulation, maxilo-mandibular surgery, and carbonic anhydrase inhibitors for the treatment of OSA. The task force and the WSS guidelines committee noted that there is substantial new evidence for the role of soft tissue, upper airway surgery, not included in the guidelines paper.

1. Introduction

The European Respiratory Society guidelines on *non-CPAP therapies for obstructive sleep apnoea* [1] was selected for review by the World Sleep Society's (WSS) Sleep and Breathing Disorder Group B Taskforce and the WSS International Sleep Medicine Guidelines Committee. The scope of this guideline covers a systematic review and recommendations on non-CPAP therapies for adult obstructive sleep apnea (OSA).

In the guidelines paper, a multidisciplinary group of experts from European countries, including pulmonary, surgical, dentistry, ear–nose–throat specialists, methodologists and patient representatives conducted a systematic review, and the Grading of Recommendations Assessment, Development and Evaluation (GRADE) process was used to assess the quality of evidence and the strength of the recommendation on several non-CPAP therapies for OSA.

The guidelines methodology only "included randomized controlled trials (RCTs) and systematic reviews with associated meta-analysis" and thus omitted additional evidence from other prospective and observational studies for the analysis.

The objective of this review was to address specific questions regarding the effectiveness and adverse events associated with gastric bypass surgery, custom-made dual-block mandibular advancement devices, hypoglossal nerve stimulation, myofunctional therapy, maxillo-mandibular osteotomy, carbonic anhydrase inhibitors and positional therapy, based on selected randomized clinical trials. Recommendations or review of soft-tissue surgery were omitted due to "limited new evidence".

The outcomes assessed included apnea-hypopnea index (AHI), sleep efficiency, oxygen desaturation index (ODI), subjective sleepiness per the Epworth Sleepiness Scale (ESS), quality of life per the 36-item short form survey (SF-36) domain questionnaire, nocturnal or 24-h blood pressure, treatment adherence and adverse events.

A task force of content experts from the WSS has reviewed this guideline specifically for its relevance and applicability to the practice of sleep medicine by sleep specialists that comprise its membership.

2. Methods

Following review of the guideline by the WSS Sleep and Breathing Disorder Group B Task Force, this position statement was developed,

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which was submitted for review and comment to the WSS International Sleep Medicine Guidelines Committee and then to the WSS Governing Council.

3. Recommendations

3.1. *"Soft-tissue surgery was omitted due to limited new evidence."*

3.1.1. *The WSS does not support the statement*

3.1.1.1. Comments. The task force notes to the contrary that there is significant and new evidence regarding the effectiveness of *current* soft tissue surgery, such as lateral pharyngoplasty, expansion sphincter pharyngoplasty, barbed repositioning pharyngoplasty, relocation pharyngoplasty, modified uvulopalatopharyngoplasty (mod UPPP), Han-UPPP. Soft tissue surgery may be more available than CPAP or some non-CPAP therapies in certain geographic regions.

- **Clinical Outcomes:** There is evidence from large population observational database analyses for major clinical benefit of surgery including *survival, major cardiovascular disease, depression, and dementia* outcomes with soft tissue surgery [2–6].
- **Respiratory Outcomes:** In randomized controlled trials (RCTs) and prospective treatment comparison studies there is a large and clinically meaningful response to soft tissue surgery (large effect size) in reducing AHI and oxygen saturation with UPPP and multilevel surgery in patients who have already *failed* medical treatment.
- In the Sleep Apnea Karolinska UPPP (SKUP3) *RCT*, treatment using UPPP compared to expectancy demonstrated highly significant and clinically relevant improvements in the AHI and ODI [7].
- In the *multicenter, parallel-group, open-label Sleep Apnea Multilevel Surgery (SAMS) RCT* of upper airway surgery versus ongoing medical management in patients who failed conventional treatments, treatment using UPPP with minimally invasive tongue volume reduction as compared to ongoing medical management demonstrated significant and clinically relevant improvements in multiple polysomnographic and quality of life (QOL) parameters [8]. Mean AHI of 48 was reduced by 56 % to 21, compared to 22 % in the controls. The apnea index and ODI were *normalized.* Likewise, there was significant and clinically relevant improvements in the oxygen desaturation indices and time with oxygen below 90 % saturation.
- In a *systematic review* of current UPPP palate surgery techniques versus comparison groups, the mean pre-operative AHI improved from 40.0 ± 12.6 to 8.3 ± 5.2 post-operatively [9]. The overall pro-rated pooled success rate for all the patients was 86.3 %. In another *systematic review* of UPPP with or without tonsillectomy surgery the AHI was reduced from a mean 35.4 to 17.9 [10].
- **Blood pressure**: In the *SKUP3 RCT* there was improvement in both systolic and diastolic blood pressure in UPPP versus controls [11]. Mean systolic/diastolic reduction of 9.4/6.4 mmHg was *greater than* the average reduction following CPAP (2.6/2.0 mmHg).
- **Quality of life:** Improvements in QOL following UPPP have been demonstrated in multi-institutional cohort studies and in multiple prospective trials [8,12,13]. UPPP has demonstrated, as compared to untreated OSA population, a clinically significant reduction in motor vehicle accident risk, improved quality of life, and reduced objective and subjective sleepiness in the SKUP3 RCT [12]. In the RCT by Mackay and colleagues, there were clinically significant large improvements in subjective sleepiness and QOL as noted by the ESS scores as well as the Functional Outcomes of Sleep Questionnaire (FOSQ) scores which normalized post-surgery [8].

3.2. *PICO 1: "in adult obese patients with OSA, should laparoscopic roux-en-Y gastric bypass surgery or weight-reducing diet be used?" (conditional support, very low quality of evidence)*

Recommendation: "In adult obese patients with OSA, we suggest bariatric surgery evaluation versus weight-reducing diet when weight has not improved despite participating in a comprehensive weight reduction programme and if there are no contraindications (conditional recommendation, very low quality of evidence)."

3.2.1. *The WSS does not support the specific recommendation for laparoscopic Roux-en-Y gastric bypass surgery but supports the recommendation for bariatric surgery*

3.2.1.1. Comments. The recommendation was made on the basis of only 2 studies that did not utilize Laparoscopic Roux-en-Y surgery. In the RCT cited by Dixon and colleagues [14], the AHI differences between medical and surgical weight loss groups were not significant although there was a decrease in both groups. Weight and AHI increased from 1 year to 2 years post-surgery in many subjects. At the 24 months follow-up only about half the patients who initially used PAP were adherent. In the study by Joosten and colleagues [15], 37 patients of 54 were included in the analysis, with 17 in the medical and 20 in the surgical group. At 2-year follow-up, the mean AHI was reduced from 44.0 (32.8, 67.9) to 30.7 (16.3, 50.9) in the medical group and from 54.4 (38.4, 91.6) to 25.1 (12.9, 51.9) in the surgical group.

The WSS notes that the recommendation for laparoscopic bariatric surgery is unsupported by evidence, per the guideline group's methodology. The question did not include the various bariatric procedures or evidence other than RCTs, Systematic Reviews (SR) and Metanalysis (MA) studies in order to better assess the evidence for surgery.

The WSS does support the recommendation for bariatric surgery for obese patients with OSA who are unable to lose weight, given the morbidity associated with obesity and the benefit of weight loss surgery for co-morbidities, such as type 2 diabetes, and the partial effect on OSA parameters [16,17].

3.2.2. *Caveats*

Risks of major complications of surgery should be considered and were not noted in the guidelines. The risks of surgery may not be acceptable to some patients and may be affected by the expertise and frequency of surgery per surgeon and center. In some countries, however, resources, surgeon training and availability may affect this recommendation. The cost of bariatric surgery may be a limiting factor depending on the local insurance coverage.

3.3. *PICO 2: "should a custom-made dual-block mandibular advancement device or CPAP be used for adult patients with OSA? Conditional recommendation against MAD, very low quality of evidence"*

Recommendation: "In adult patients with OSA, we suggest that CPAP should be used as compared to MAD (conditional recommendation, very low quality of evidence). "

3.3.1. *The WSS supports the recommendation*

3.3.1.1. Comments. Obstructive sleep apnea treatment using CPAP is recommended as compared with MAD because of the more consistent decrease of the AHI with PAP over MAD [18] and the higher impact of PAP on systolic night-time blood pressure in severe OSA. In mild and moderate OSA, both MAD and PAP may be similarly useful, as the AHI under MAD treatment is usually low or close to the normal range. There is also evidence of better adherence with MAD with similar effects on sleepiness and quality of life as compared with PAP [18]. In patients with comorbidities, higher AHI, or odontological concerns, PAP should

be considered first.

The WSS therefore generally supports this recommendation where available, accessible, and affordable.

3.3.2. Caveats

In some countries, patient access to MAD therapy is limited. MAD may not be covered by the insurance system, covered partially or unavailable to much of the public. In a recent WSS survey, reimbursement of MAD therapy was reported from only about one fourth of 48 participating countries [19]. In some regions, there is insufficient availability of dentists or doctors knowledgeable or trained to deliver oral appliance therapy. Sufficient general dental health care facilities, reasonably priced dental care and socioeconomic status may also affect access to MAD therapy [20].

3.4. PICO 3: should hypoglossal nerve stimulation (HNS) during sleep or no treatment be used for adult patients with OSA?

Conditional recommendation against the intervention as first line treatment, very low quality of evidence.

We suggest that HNS should not be used as first-line treatment for OSA patients in general (conditional recommendation, very low quality of evidence). However, we suggest that HNS compared to no treatment should be considered as a salvage treatment in patients with symptomatic OSA, who cannot be sufficiently treated with positive airway pressure treatment (CPAP, bilevel positive airway pressure) or MAD, and who have an AHI <50 events·h−1 and a BMI <32 kg·m−2.

3.4.1. The WSS supports the recommendation

3.4.1.1. Comments. We suggest HNS surgery not as a standard/regular treatment of OSA but for specific moderate to severe patients who are seeking alternative treatments and who are reluctant to undertake mechanical strategies (conditional recommendation, low quality of evidence). Compared to no treatment, HNS is probably better. (Conditional, very low quality of evidence).

"A total of 350 patients (median age 54.3 (IQR 53–56.25) years, BMI 29.8 (IQR 28.8–31.6) kg/m2) from 12 studies were included. The procedure has resulted in a surgical success rate of 72.4 % (Inspire), 76.9 % (ImThera), 55 % (Apnex) at 12 months, and 75 % (Inspire) at 60-month follow-up. At 12 months, the apnea-hypopnea index (AHI) mean differences was − 17.50 (Inspire; 95 % CI: − 20.01 to − 14.98, P < 0.001), − 24.20 (ImThera; 95 % CI: − 37.39 to 11.01, P < 0.001), and − 20.10 (Apnex; 95 % CI: − 29.62 to − 10.58, P < 0.001). The AHI mean reduction after 5 years was − 18.00 (Inspire, − 22.38 to − 13.62, P < 0.001). The Epworth sleepiness scale (ESS) mean reduction was − 5.27 (Inspire), − 2.90 (ImThera), and − 4.20 (Apnex) at 12 months and − 4.40 (Inspire) at 60 months, respectively. Only 6 % of patients reported serious device-related adverse events after 1- and 5-year follow-up." [21]

"Of 41 identified clinical trials, 20 interventional trials (n = 895) could be pooled in a meta-analysis (15 HNS [n = 808], 5 TES [n = 87]). Middle-aged (mean ± SD 56.9 ± 5.5 years) and overweight (body mass index 29.1 ± 1.5 kg/m2) patients with severe OSA (AHI 37.5 ± 7.0/h) were followed-up for 6.9 ± 4.0 months (HNS) and 0.2 ± 0.4 months (TES), respectively. The AHI improved by − 24.9 h−1 [95%CI − 28.5, −21.2] in HNS (χ2 79 %, I2 82 %) and by − 16.5 h−1 [95%CI − 25.1, −7.8] in TES (χ2 7 %, I2 43 %; both p < 0.001). The ESS was reduced by − 5.0 (95%CI − 5.9, −4.1) (p < 0.001)." [22].

3.4.2. Caveats

A patient treated by HNS requires regular, long follow-ups and adherence monitoring, similar to that for CPAP treatment. The patient needs to be informed that if he or she may need to undergo MRI of the torso of >1.5T in the future, the device (Inspire) would need to be explanted. The device may be explanted/replaced, but given neck scarring from prior surgery, doing so carries risk for complications. Other limitations of HNS for treatment of OSA are the lack of trained health professionals including surgeons, sleep professionals and sleep lab teams in most countries. The device and surgery are costly, and so far, no actual cost-benefit studies have been done. Finally, there is a lack of health insurance coverage in most countries.

3.5. PICO 4a. In adult patients with OSA, should myofunctional therapy or no treatment be used?

Conditional recommendation for either the intervention or the comparison, low quality of evidence.

"We do not suggest myofunctional therapy as a standard/regular treatment of OSA, but only for specific cases seeking alternative treatments and who are reluctant to undertake surgical or mechanical strategies (conditional recommendation, low quality of evidence) "

3.5.1. The WSS supports the recommendation

3.5.1.1. Comments. The recommendation was based on six RCTs comprising 230 patients. Interventions included oropharyngeal exercises, circular breathing and muscle training via electrical stimulation. All studies assessed AHI through polysomnography or cardiorespiratory studies. Other outcomes were also assessed such as quality of life, excessive daytime sleepiness, and sleep efficiency. The interventions seemed to be overall safe and maintain good adherence rates, but no long-term adherence has been reported. A non-significant mean AHI reduction of 8.2 was found across studies.

Myofunctional therapy helps repositioning the tongue, improving nasal breathing, and increasing muscle tone, which potentially would benefit SBD patients. One of the most comprehensive MT exercises involves the soft palate, tongue, and facial muscles and address stomatognathic functions [23,24].

In this systematic review, compared with sham therapy, myofunctional therapy (oropharyngeal exercises) probably reduces daytime sleepiness and may increase sleep quality in the short term. The certainty of the evidence for all comparisons ranges from moderate to very low [25].

3.5.2. Caveats

Patient access is a major limitation; there is a lack of trained professionals, health insurance coverage and affordability in some countries. Myofunctional therapy is usually a multi-component intervention that lacks standardized exercise protocols. The best combination, duration and frequency of exercises are unknown. Long-term efficacy and adherence data are not available. Patient selection criteria are also unknown.

3.6. PICO 4b: should myofunctional therapy or CPAP be used for adult patients with OSA?

"Conditional recommendation against the intervention, low quality of evidence."

3.6.1. The WSS supports the recommendation

3.6.1.1. Comments. Although efficacy data are still missing, for those patients who have demonstrated to be unable to comply to CPAP or MAD, we support myofunctional therapy versus non-treatment (opinion).

For this recommendation only one RCT was used. In this study, quality of life (functional capacity) improved in both the speech therapy group and the speech therapy plus CPAP group. No adverse events were reported, but low adherence to CPAP was an issue to be considered in

this study [26].

More studies are needed comparing different protocols of myofunctional therapy with CPAP in different OSA phenotypes.

3.6.2. Caveats

See 3.5.2 caveats.

3.7. PICO 5: should maxillo-mandibular osteotomy or CPAP be used for adult patients with OSA?

Conditional recommendation for either the intervention or the comparison, very low quality of evidence.

3.7.1. The WSS supports the recommendation

3.7.1.1. Comments. The WSS supports the recommendation. For selected patients, there is a theoretical benefit in undergoing a single intervention rather than committing to lifelong therapy with PAP.

"Summary of the evidence 1246 references were originally identified, of which one RCT was used to inform this recommendation [70] (supplementary figure e5, supplementary table e8 and e16; no meta-analysis was conducted). 50 adults with OSA were randomized to maxillo-mandibular osteotomy (MMO) or auto-adjusting positive airway pressure (auto-adjusting CPAP). The mean ages of the patients were 49.1 ± 9.1 years and 48.7 ± 10.7 years, respectively. 1 year after the intervention, AHI decreased by 48.7 events·h−1 (from 56.8 ± 16.5 events·h−1 to 8.1 ± 7.0 events·h−1), while in the control group it decreased by 44.0 events·h−1 (from 50.3 ± 12.4 events·h−1 to 6.3 ± 1.9 events·h−1). The difference between the score changes was not statistically significant ($p = 0.21$). ESS decreased from 11.6 ± 2.8 to 7.7 ± 1.3, while in the control group it decreased from 11.2 ± 2.6 to 5.9 ± 1.6. The difference between the score changes was not statistically significant ($p = 0.20$). Degree of satisfaction with treatment did not show significant differences between the groups."

In a systematic review and meta-analysis of 53 studies reporting of 627 adults with OSA who undergone MMA [27], AHI decreased from 63.9/h to 9.5/h ($p < 0.001$) following surgery. Using a random-effects model, the pooled surgical success and cure (AHI <5) rates were 86.0 % and 43.2 %, respectively. Younger age, lower preoperative weight and AHI, and greater degree of maxillary advancement were predictive of increased surgical success. The major and minor complication rates were respectively 1.0 % and 3.1 %.

3.7.2. Caveats

The intervention is usually acceptable to clinicians and health insurers, but its acceptability may largely vary among patients due to change of facial appearance and extent of surgery. Thus, it may be particularly appropriate for patients with maxillofacial deficiencies.

Maxillo-mandibular osteotomy surgery is a costly surgery with long-term recovery and often requires orthodontic treatment. In some countries, there is a lack of trained health professionals, health insurance coverage and age limitations, which limit accessibility or affordability.

3.8. PICO 6- should carbonic anhydrase inhibitors (compared to placebo) be used for adult patients with OSA?

Conditional recommendation for the intervention, low quality of evidence.

We suggest use of carbonic anhydrase inhibitors only in the context of an RCT, as there is no drug in this category with an approved label for OSA (conditional recommendation for the intervention, low quality of evidence).

3.8.1. The WSS supports the recommendation

3.8.1.1. Comments. Although there is a need for further investigation as to the effectiveness and safety of pharmacotherapy for OSA, it is important to bring this option to the attention of the world community because of recent research on the potential benefit of carbonic anhydrase inhibitors, selective noradrenaline reuptake inhibitors such as atomoxetine, and antimuscarinic agents for OSA treatment.

Few studies exist, which predominantly focused on acetazolamide (3 RCTs) [28–31] but also zonisamide (1 RCT) [32] and sulthiame (1 RCT, published after the ERS Guideline) [33]. The limited evidence shows that acetazolamide was able to improve sleep apnea severity, oxygenation, and sleep efficiency, particularly at high altitude. Although side effects seem to be class-specific for drugs with a carbonic anhydrase inhibitory effect, long-term safety evaluations should be conducted. Further research studies (especially RCTs) are recommended.

Two recent systematic reviews and meta-analyses resulted in different conclusions: acetazolamide improved both OSA and central sleep apnea (CSA) [34] and acetazolamide was only effective for CSA by RCTs conducted at sea level [35]. The effects of carbonic anhydrase inhibitors on sleepiness and quality of life also need investigation.

If and when further evidence is obtained, and an approved label for a drug in this class to treat OSA is available, we can revisit this recommendation.

3.8.2. Caveats

Future studies to evaluate the efficacy and safety of carbonic anhydrase inhibitors are needed. Unfortunately, RCTs are difficult to design and implement, often requiring extensive time and effort, and these studies may not be able to be conducted in most countries without significant financial support. The cost and insurance coverage of carbonic anhydrase inhibitors may vary greatly between geographic regions. Physicians may not be aware of this potential treatment option.

3.9. PICO 7. should positional therapy or CPAP be used for adult patients with position dependent OSA (POSA)?

Conditional recommendation for either the intervention or the comparison, very low certainty of evidence.

We suggest either positional therapy using vibratory devices or CPAP among adult patients with mild or moderate position-dependent OSA as defined by a supine AHI at least twice as high as the non-supine AHI and no relevant non-supine AHI (<15 events h−1).

3.9.1. The WSS supports the recommendation

3.9.1.1. Comments. This recommendation is based on 5 studies, including participants with mild to moderate OSA, as most studies excluded severe OSA patients. However, one study reported a high prevalence of 35.3 % of position-dependent OSA among severe OSA patients. They were less obese and had less severe OSA compared with non-positional OSA ones [36].

All studies used the same criterion of the supine AHI to be at least twice as high as the non-supine AHI based on PSG or home polygraphy (one study). "*Both CPAP and positional therapy reduced the AHI effectively, while CPAP was slightly more effective than positional therapy. However, positional therapy was superior in terms of compliance (CPAP 4.9 h per night, positional therapy +2.5 h per night; 95 % CI 1.3–4.6 h per night). The mean sleep efficiency and excessive daytime sleepiness did not significantly differ between therapeutic modalities.*"

A systematic review found CPAP superior to improve AHI, but positional therapy was better than inactive control [37].

Adverse events were mild for both therapies. Skin irritation and neck/shoulder pain were reported among positional therapy participants.

3.9.2. Caveats

There are many devices designed for positional therapy, including lumbar or abdominal binders, semi-rigid backpacks, full-length pillows, a tennis ball attached to the back of nightwear, and electrical sensors with various alarms that indicate change in position. The recommendation refers to vibratory devices which may not be available in many countries. The lack of health insurance coverage and cost of devices may be prohibitive in some countries.

There is variability in positional OSA diagnosis as it depends on scoring methods and definition used. A single night study may not reflect usual sleep postures or true positionality. Variability also occurs due to comfort, REM stage-related supine sleep.

The lower adherence of CPAP versus positional therapy needs further long-term studies. There are little to no data on long-term positional therapy adherence. There is also a lack of data on long-term efficacy and effects on hip or shoulder function.

3.10. PICO 8. should positional therapy (intervention) or custom made dual-block MADs (control) be used for adult patients with adult position-dependent OSA?

Conditional recommendation for either the intervention or control, very low certainty of evidence.

3.10.1. As only one study fulfils the criteria for selection, the WSS cannot endorse the superiority or equivalent efficacy of either technique (opinion)

3.10.1.1. Comments. The recommendation was based on only one study which included patients with mild or moderate positional OSA [38]. That study reported similar efficacy of both treatment options without a significant difference in AHI reduction or in long-term adherence. A high number of adverse events (82.8 %) was reported overall with higher rate in the MAD group although more subjects in the PT group discontinued its use due to adverse events. The most common device-specific adverse events in the MAD group were tooth pain, temporomandibular dysfunction and open bite; the most common device-specific adverse events in the PT group were being awakened by the vibration or failure thereof.

It is worthy to note another prospective randomized controlled trial [39] that showed that in patients with residual positional OSA under MAD therapy, both MAD therapy and PT were similarly effective in reducing AHI. However, a combination of PT with MAD therapy led to further reduction in the AHI. It was noted that PT and MAD were both similar in reducing overall AHI; however, PT was better in reducing supine AHI, and MAD was better in reducing non-supine AHI. In addition, only 80 % of subjects in this study had positional OSA initially but became positional under MAD therapy.

3.10.2. Caveats

Both studies were carried out using vibrational positional devices. More affordable options, such as the tennis ball technique that can be readily available worldwide, were not used. This is probably because such devices are reported to be uncomfortable with poor long-term adherence [40]. The primary study included only mild to moderate OSA.

4. Geographic regions included in these recommendations

The adherence to the 9 items above is inclusive of all regions. This could include all continents with the caveats of accessibility stated above.

5. Conclusion

The WSS Governing Council hereby endorses this guideline [1] with comments and caveats described above as relevant and applicable to the sleep medicine practices of its members within the geographic regions listed above. The committee recognizes the scope of the paper did not address other aspects related to adherence, including type of interface and other factors.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Ofer Jacobowitz reports a relationship with LivaNova USA, Inc. That includes: consulting or advisory. Ofer Jacobowitz reports a relationship with Nyxoah SA that includes: consulting or advisory. Clete Kushida reports a relationship with Vivos Therapeutics that includes: consulting or advisory.

References

[1] Randerath W, Verbraecken J, de Raaff CAL, et al. European Respiratory Society guideline on non-CPAP therapies for obstructive sleep apnoea. Nov 30 Eur Respir Rev 2021;30(162):210200. https://doi.org/10.1183/16000617.0200-2021. PMID: 34853097.

[2] Weaver EM, Maynard C, Yueh B. Survival of veterans with sleep apnea: continuous positive airway pressure versus surgery. Otolaryngol Head Neck Surg 2004 Jun; 130(6):659–65.

[3] Lee HM, Kim HY, Suh JD, et al. Uvulopalatopharyngoplasty reduces the incidence of cardiovascular complications caused by obstructive sleep apnea: results from the national insurance service survey 2007-2014. Sleep Med 2018 May;45:11–6.

[4] Cho JH, Suh JD, Han KD, et al. Uvulopalatopharyngoplasty may reduce the incidence of dementia caused by obstructive sleep apnea: national insurance service survey 2007-2014. J Clin Sleep Med 2018 Oct 15;14(10):1749–55.

[5] Cho JH, Suh JD, Han KD, Lee HM. Uvulopalatopharyngoplasty reduces the incidence of depression caused by obstructive sleep apnea. Laryngoscope 2019 Apr; 129(4):1005–9.

[6] Ibrahim B, de Freitas Mendonca MI, Gombar S, et al. Association of systemic diseases with surgical treatment for obstructive sleep apnea compared with continuous positive airway pressure. JAMA Otolaryngol Head Neck Surg 2021 Jan 21. https://doi.org/10.1001/jamaoto.2020.5179. Epub ahead of print. PMID: 33475682.

[7] Browaldh N, Nerfeldt P, Lysdahl Met al. SKUP3 randomised controlled trial: polysomnographic results after uvulopalatopharyngoplasty in selected patients with obstructive sleep apnea. Thorax 2013 Sep;68(9):846–53. https://doi.org/10.1136/thoraxjnl-2012-202610. Epub 2013 May 5. PMID: 23644225.

[8] MacKay S, Carney AS, Catcheside PG, et al. Effect of multilevel upper airway surgery vs medical management on the apnea-hypopnea index and patient-reported daytime sleepiness among patients with moderate or severe obstructive sleep apnea: the SAMS randomized clinical trial. Sep. 22 JAMA 2020;324(12): 1168–79. https://doi.org/10.1001/jama.2020.14265. PMID: 32886102; PMCID: PMC7489419.

[9] Pang KP, Pang EB, Win MT, et al. Expansion sphincter pharyngoplasty for the treatment of OSA: a systemic review and meta-analysis. Eur Arch Oto-Rhino-Laryngol 2016 Sep;273(9):2329–33. https://doi.org/10.1007/s00405-015-3831-2. Epub 2015 Nov 5. PMID: 26541714.

[10] Stuck BA, Ravesloot MJL, Eschenhagen T, et al. Uvulopalatopharyngoplasty with or without tonsillectomy in the treatment of adult obstructive sleep apnea - a systematic review. Sleep Med 2018 Oct;50:152–65. https://doi.org/10.1016/j.sleep.2018.05.004. Epub 2018 May 12. PMID: 30056286.

[11] Fehrm J, Friberg D, Bring J, Browaldh N. Blood pressure after modified uvulopalatopharyngoplasty: results from the SKUP3 randomized controlled trial. Sleep Med 2017 Jun;34:156–61. https://doi.org/10.1016/j.sleep.2017.02.030. Epub 2017 Apr 4. PMID: 28522085.

[12] Browaldh N, Bring J, Friberg D. SKUP(3) RCT; continuous study: changes in sleepiness and quality of life after modified UPPP. Laryngoscope 2016 Jun;126(6): 1484–91. https://doi.org/10.1002/lary.25642. Epub 2015 Sep 25. PMID: 26404729.

[13] Weaver EM, Woodson BT, Yueh B, et al. SLEEP study investigators. Studying life effects & effectiveness of palatopharyngoplasty (SLEEP) study: subjective outcomes of isolated uvulopalatopharyngoplasty. Apr Otolaryngol Head Neck Surg 2011;144 (4):623–31. https://doi.org/10.1177/0194599810394982. Epub 2011 Feb 10. PMID: 21493246;PMCID:PMC5940926.

[14] Dixon JB, Schachter LM, O'Brien PE, et al. Surgical vs conventional therapy for weight loss treatment of obstructive sleep apnea: a randomized controlled trial. JAMA 2012;308(11):1142–9. https://doi.org/10.1001/2012.jama.11580.PMID: 22990273.

[15] Joosten SA, Khoo JK, Edwards BA, et al. Improvement in obstructive sleep apnea with weight loss is dependent on body position during sleep. Sleep 2017 May 1;40 (5). https://doi.org/10.1093/sleep/zsx047.PMID:28444355.

[16] Syn NL, Cummings DE, Wang LZ, et al. Association of metabolic-bariatric surgery with long-term survival in adults with and without diabetes: a one-stage meta-analysis of matched cohort and prospective controlled studies with 174 772 participants. Lancet 2021 May 15;397(10287):1830–41. https://doi.org/10.1016/S0140-6736(21)00591-2. Epub 2021 May 6. PMID: 33965067.

[17] Ming X, Yang M, Chen X. Metabolic bariatric surgery as a treatment for obstructive sleep apnea hypopnea syndrome: review of the literature and potential mechanisms. Surg Obes Relat Dis 2021 Jan;17(1):215–20. https://doi.org/10.1016/j.soard.2020.09.019. Epub 2020 Sep 23. PMID: 33371935.
[18] Ramar K, Dort LC, Katz SG, et al. Clinical practice guideline for the treatment of obstructive sleep apnea and snoring with oral appliance therapy: an update for 2015. J Clin Sleep Med 2015 Jul 15;11(7):773–827. https://doi.org/10.5664/jcsm.4858. PMID: 26094920; PMCID: PMC4481062.
[19] World Sleep Society. Global access to treatments for obstructive sleep apnea. Int. Sleep Med. Guidelines. https://worldsleepsociety.org/surveys/. [Accessed 9 August 2021].
[20] Fleury M, Le Vaillant M, Pelletier-Fleury N. IRSR sleep cohort group. Socio-economic status: a barrier to access to mandibular advancement device therapy for patients with obstructive sleep apnea syndrome in France. Sep. 24 PLoS One 2015; 10(9):e0138689. https://doi.org/10.1371/journal.pone.0138689. PMID: 26402443; PMCID: PMC4581831.
[21] Costantino A, Rinaldi V, Moffa A, et al. Hypoglossal nerve stimulation long-term clinical outcomes: a systematic review and meta-analysis. Sleep Breath 2020;24: 399–411.
[22] Ratneswaran D, Guni A, Pengo MF, et al. Electrical stimulation as a therapeutic approach in obstructive sleep apnea — a meta-analysis. Sleep Breath 2021;25: 207–18.
[23] Guimaraes KC, Drager LF, Genta PR, et al. Effects of oropharyngeal exercises on patients with moderate obstructive sleep apnea syndrome. Am J Respir Crit Care Med 2009;179:962–6.
[24] Camacho M, Certal V, Abdullatif J, et al. Myofunctional therapy to treat obstructive sleep apnea: a systematic review and meta-analysis. Sleep 2015 May 1;38(5): 669–75.
[25] Rueda JR, Mugueta-Aguinaga I, Vilaró J, Rueda-Etxebarria M. Myofunctional therapy (oropharyngeal exercises) for obstructive sleep apnoea. Cochrane Database Syst Rev 2020 Nov 3;11(11):CD013449. https://doi.org/10.1002/14651858.
[26] Diaferia G, Badke L, Santos-Silva R, et al. Effect of speech therapy as adjunct treatment to continuous positive airway pressure on the quality of life of patients with obstructive sleep apnea. Sleep Med 2013 Jul;14(7):628–35.
[27] Holty JE, Guilleminault C. Maxillomandibular advancement for the treatment of obstructive sleep apnea: a systematic review and meta-analysis. Sleep Med Rev 2010 Oct;14(5):287–97. https://doi.org/10.1016/j.smrv.2009.11.003. Epub 2010 Mar 2. PMID: 20189852.
[28] Latshang TD, Nussbaumer-Ochsner Y, Henn RM, et al. Effect of acetazolamide and autoCPAP therapy on breathing disturbances among patients with obstructive sleep apnea syndrome who travel to altitude: a randomized controlled trial. JAMA 2012;308:2390–8. https://doi.org/10.1001/jama.2012.94847.
[29] Nussbaumer-Ochsner Y, Latshang TD, Ulrich S, et al. Patients with obstructive sleep apnea syndrome benefit from acetazolamide during an altitude sojourn: a randomized, placebo-controlled, double-blind trial. Chest 2012;141:131–8. https://doi.org/10.1378/chest.11-0375.
[30] Latshang TD, Kaufmann B, Nussbaumer-Ochsner Y, et al. Patients with obstructive sleep apnea have cardiac repolarization disturbances when travelling to altitude: randomized, placebo-controlled trial of acetazolamide. Sleep 2016;39:1631–7. https://doi.org/10.5665/sleep.6080.
[31] Whyte KF, Gould GA, Airlie MA, et al. Role of protriptyline and acetazolamide in the sleep apnea/hypopnea syndrome. Sleep 1988;11:463–72. https://doi.org/10.1093/sleep/11.5.463.
[32] Eskandari D, Zou D, Karimi M, et al. Zonisamide reduces obstructive sleep apnoea: a randomised placebo-controlled study. Eur Respir J 2014;44:140–9. https://doi.org/10.1183/09031936.00158413.
[33] Hedner J, Stenlöf K, Zou D, et al. A randomized controlled trial exploring safety and tolerability of sulthiame in sleep apnea. Am J Respir Crit Care Med 2022 Feb 24. https://doi.org/10.1164/rccm.202109-2043OC. Epub ahead of print. PMID: 35202553.
[34] Schmickl CN, Landry SA, Orr JE, et al. Acetazolamide for OSA and central sleep apnea: a comprehensive systematic review and meta-analysis. Dec Chest 2020;158 (6):2632–45. https://doi.org/10.1016/j.chest.2020.06.078. Epub 2020 Aug 5. PMID: 32768459; PMCID: PMC7768933.
[35] Ni YN, Yang H, Thomas RJ. The role of acetazolamide in sleep apnea at sea level: a systematic review and meta-analysis. Jun 1 J Clin Sleep Med 2021;17(6): 1295–304. https://doi.org/10.5664/jcsm.9116. PMID: 33538687; PMCID: PMC8314666.
[36] Oksenberg A, Gadoth N, Töyräs J, Leppänen T. Prevalence and characteristics of positional obstructive sleep apnea (POSA) in patients with severe OSA. Sleep Breath 2020 Jun;24(2):551–9. https://doi.org/10.1007/s11325-019-01897-1. Epub 2019 Jul 20. PMID: 31325020.
[37] Barnes H, Edwards BA, Joosten SA, Naughton MT, Hamilton GS, Dabscheck E. Positional modification techniques for supine obstructive sleep apnea: a systematic review and meta-analysis. Sleep Med Rev 2017 Dec;36:107–15. https://doi.org/10.1016/j.smrv.2016.11.004. Epub 2016 Nov 18. PMID: 28012784.
[38] de Ruiter MHT, Benoist LBL, de Vries N, et al. Durability of treatment effects of the Sleep Position Trainer versus oral appliance therapy in positional OSA: 12-month follow-up of a randomized controlled trial. Sleep Breath 2018;22:441–50.
[39] Dieltjens M, Vroegop AV, Verbruggen AE, et al. A promising concept of combination therapy for positional obstructive sleep apnea. Sleep Breath 2015 May;19(2):637–44. https://doi.org/10.1007/s11325-014-1068-8. Epub 2014 Oct 22. PMID: 25335642; PMCID: PMC4873543.
[40] Bignold JJ, Deans-Costi G, Goldsworthy MR, et al. Poor long-term patient compliance with the tennis ball technique for treating positional obstructive sleep apnea. J Clin Sleep Med 2009 Oct 15;5(5):428–30. PMID: 19961026; PMCID: PMC2762713.