



Photobiomodulation for pediatric hypertrophic tonsils: a clinical case report

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Background: Photobiomodulation and low level laser therapy have multiple clinical applications across medicine and dentistry and has been used, with varying degrees of success, in sleep medicine and dental sleep medicine.

Case Description: This case report describes the use of low level laser therapy with an Er:YAG laser for the immediate treatment of hypertrophic tonsils in a child with symptoms of a sleep airway disorder as recorded through pre-intervention screening with the pediatric sleep questionnaire and BEARS sleep screening tool. Immediate, 3-month post-intervention, and 1 year post-intervention clinical photos showed significant tonsil size reduction from the low level laser therapy with maintenance of tonsillar shrinkage over the following year. Post-intervention results on the pediatric sleep questionnaire and BEARS sleep screening tool showed a significant change in reported symptoms. No negative side effects were noted by the clinician or reported by the patient. The results of this case report indicate that low level laser therapy may be a potential treatment option for hypertrophic tonsils, with potential applications into the fields of sleep medicine and otolaryngology for both adults and children.

Conclusions: Further research into the applications of low level laser therapy on hypertrophic tonsils should be conducted, with appropriate clinical protocols and patient selection criteria studied in detail.

Keywords: Hypertrophic tonsil; photobiomodulation; laser; pediatric obstructive sleep apnea; case report

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Introduction

Photobiomodulation (PBM) has been used for the treatment of surgical wounds, nerve regeneration, chronic pain, and sports injuries with evidence of its efficacy continuing to accumulate (1-16). However, the use of PBM for the treatment of snoring and obstructive sleep apnea (OSA) is a relatively recent new development, with the first literature review on PBM and sleep breathing disorders published in 2020 (17). While there are case reports of PBM resulting in improvement in OSA patients, the research is both new and controversial (17-20). This is likely from current clinical data showing that PBM intervention does not necessarily reduce the Apnea-Hypopnea Index, commonly used in the diagnosis of OSA, for every patient and that it is not yet

known which patients may benefit and/or what selection criteria should be used to predict which patients may respond favourably to PBM as a treatment for OSA. This is not surprising given the relative youth of this modality of treatment, and further research to more thoroughly investigate PBM for OSA is already underway.

OSA is not a disease limited to adults; pediatric obstructive sleep apnea (POSA) has different etiology from adult OSA (21-25). While impaired anatomy is essential for adult OSA, a majority of children who suffer from POSA present with hypertrophic tonsils (26-31). This difference in etiology explains why first line treatment for adult OSA is usually the use of positive airway pressure machines, while for POSA first line treatment is usually surgical removal of

Pre-Photobiomodulation PSQ (De-Identified)

Please answer the following questions as they pertain to your child in the past month.

	YES	NO	Don't Know
1. While sleeping, does your child: Snore more than half the time?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Always snore?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Snore loudly?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Have "heavy" or loud breathing?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Have trouble breathing, or struggle to breath?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Have you ever seen your child stop breathing during the night?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
3. Does your child: Tend to breathe through the mouth during the day?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Have a dry mouth on waking up in the morning?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Occasionally wet the bed?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
4. Does your child: Wake up feeling unrefreshed in the morning?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Have a problem with sleepiness during the day?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
5. Has a teacher or other supervisor commented that your child appears sleepy during the day?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
6. Is it hard to wake your child up in the morning?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
7. Does your child wake up with headaches in the morning?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
8. Did your child stop growing at a normal rate at any time since birth?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
9. Is your child overweight?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
10. This child often: Does not seem to listen when spoken to directly.....	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Has difficulty organizing tasks and activities.....	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Is easily distracted by extraneous stimuli.....	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Fidgets with hands or feet, or squirms in seat	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Is "on the go" or often acts as if "driven by a motor"	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interrupts or intrudes on others (eg butts into conversations or games)	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Post-Photobiomodulation PSQ (De-Identified)

Please answer the following questions as they pertain to your child in the past month.

	YES	NO	Don't Know
1. While sleeping, does your child: Snore more than half the time?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Always snore?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Snore loudly?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Have "heavy" or loud breathing?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Have trouble breathing, or struggle to breath?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
2. Have you ever seen your child stop breathing during the night?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Does your child: Tend to breathe through the mouth during the day?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Have a dry mouth on waking up in the morning?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Occasionally wet the bed?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
4. Does your child: Wake up feeling unrefreshed in the morning?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Have a problem with sleepiness during the day?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
5. Has a teacher or other supervisor commented that your child appears sleepy during the day?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
6. Is it hard to wake your child up in the morning?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
7. Does your child wake up with headaches in the morning?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
8. Did your child stop growing at a normal rate at any time since birth?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
9. Is your child overweight?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
10. This child often: Does not seem to listen when spoken to directly.....	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Has difficulty organizing tasks and activities.....	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Is easily distracted by extraneous stimuli.....	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Fidgets with hands or feet, or squirms in seat	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Is "on the go" or often acts as if "driven by a motor"	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interrupts or intrudes on others (eg butts into conversations or games)	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Figure 1 Pre-treatment and post-treatment PSQ responses.

hypertrophic tonsils and adenoids (28,32-37).

Tonsil and adenoid (T&A) surgery, both partial removal (tonsillotomy) and complete removal (tonsillectomy) presents with its own risks, both short- and long-term. Short-term risks of T&A surgery include secondary hemorrhage, complications with surgical anesthesia, and tonsillar regrowth from partial removal (37-39). Long-term risks include the development of respiratory infections and infectious diseases (36). Therefore, any treatments that would reduce the risks of T&A surgery should be explored, including the possibility of using PBM to treat pediatric hypertrophic tonsils.

We present the following case in accordance with the CARE reporting checklist (available at <https://pm.amegroups.com/article/view/10.21037/pm-21-18/rc>).

Case presentation

A 12-year-old male presented for routine dental examination in February 2019. The patient's mother reported the patient suffered from snoring, poor sleep, nocturnal bruxism, chronic mouth breathing, and persistent ear infections. Visual intraoral examination showed the patient with bilateral grade 3 tonsillar swelling. The patient's mother was informed of the clinical findings and

reported that the child was already referred and scheduled for an otolaryngology consult for evaluation and potential treatment of the child's hypertrophic tonsils. Upon further discussion the child's mother indicated that the child had not undergone any formal overnight sleep testing for sleep disordered breathing; despite the child scoring positive for sleep disorders on the BEARS Sleep Screening Tool and 9/22 on the PSQ (Figure 1) for a high likelihood for pediatric sleep apnea, no consultation with a pediatric sleep specialist or a pediatric sleep study had yet been performed or ordered (40,41). The child's mother requested to know other treatment options, including whether the use of PBM methods for adult OSA and snoring would be effective for POSA. The child's mother was informed no research into this area existed and that PBM for the child's hypertrophic tonsils could be attempted, but that clinical evaluation by an appropriate physician was still necessary. The child's mother requested and consented to the use of PBM for the child's hypertrophic tonsils.

The child and child's mother were provided information about the procedure and informed consent was obtained. The child was reclined supine in a dental chair, no sedation or topical anesthetic was necessary. PBM treatment with a Fotona LightWalker laser was provided using a fractional laser beam delivered with a R30 and PS04 handpiece at

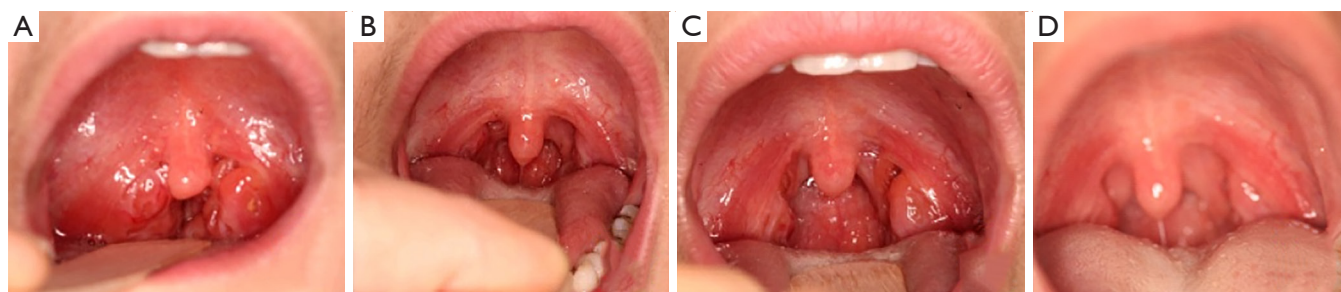


Figure 2 Clinical photos of the patient before and after intervention. (A) The patient’s tonsils grade 3 bilaterally prior to intervention; (B) the patient’s tonsils grade 1 bilaterally immediately after intervention; (C) the patient’s tonsils grade 1/2 bilaterally at follow-up three months after intervention; (D) the patient’s tonsils grade 1 bilaterally at annual follow-up after intervention.

Table 1 Pre-treatment and post-treatment symptoms

Mother reported symptoms pre-treatment	Mother reported symptoms post-treatment
Chronic snoring while asleep (every night)	Quiet sleep (no noise heard in room while asleep)
Grinding noises while asleep	Quiet sleep
Hyperactivity, poor attention, restless behaviour	Better concentration, less inattentiveness
Chronic mouth breathing	Notable lips together during daytime

minimally invasive settings according to manufacturer’s instructions modified for pediatric delivery. The laser therapy was manually delivered transorally directly targeted at the hypertrophic tonsillar tissue at 10 Hz in LP mode. The laser was delivered in slow horizontal and vertical passes ensuring significant delivery overlap. Treatment took a total of ten minutes. The child reported feeling no ill effects to treatment. The child returned for re-evaluation three months after treatment, and also reported feeling no ill effects from treatment during the 3-month interval.

Clinical photos were taken immediately before, immediately after, at a three month follow-up appointment, and one year after the intervention. Pre-treatment visual grading showed tonsils to be grade 3 bilaterally (*Figure 2A*). Immediate post-treatment visual grading showed tonsils to be grade 1 bilaterally (*Figure 2B*). Follow-up visual grading at the three month interval showed tonsils to be grade 1/2 bilaterally (*Figure 2C*). Follow-up visual grading one year after intervention showed tonsils to be grade 1 bilaterally (*Figure 2D*).

Immediately after treatment, the child reported “mom, I can breathe now”.

At the three month follow-up, the child’s mother reported that the child was sleeping better, less hyperactive, no longer mouth breathing, better able to concentrate, and

that she could no longer hear the child bruxing during the night (*Table 1*). Follow-up screening on the BEARS Sleep Screening Tool was negative and scoring on the PSQ was 1/21, with 1 non-response (*Figure 1*).

All procedures were performed in accordance with the ethical standards of the institution and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). The mother provided written consent for de-identified information related to this treatment on her child to be used for educational and research purposes.

Discussion

PBM has been shown to be an effective treatment for certain diseases including inflammatory conditions such as chronic pain, to upregulate the immune system, and to aid in wound closure (1-11). PBM is now also being used for sleep breathing disorders; specifically for snoring and, more controversially, for OSA (17-20). This therapy is primarily being delivered by dentists using the Fotona LightWalker laser, and is targeted specifically at the soft palate. The mechanism of action has been studied histologically in animal studies with soft palate tissue appearing to undergo immediate mucosal contraction and keratinization (42,43). Studies also indicate that these effects are not life-long and

may begin to taper within three weeks of treatment (42). This may be the reason that “top up” treatments for the treatment of snoring in humans are necessary with the Er:YAG lasers.

POSA is a significant medical problem linked with permanent cognitive functional loss, decreased emotional regulation, and growth stunting if not treated in children (26,36,37,39,44-50). First line treatment for POSA involves surgical excision of tonsils and adenoids (T&A), which brings with it both short- and long-term risks (36-39). As well, some children undergoing T&A surgery for POSA have been shown to require additional treatment even after T&A excision (51-53).

PBM appears to be a potential adjunctive treatment for children suffering from hypertrophic tonsils. However, insufficient research exists into its utility for appropriate patient selection, delivery, and long-term outcomes. Despite this lack of research, this case study appears to indicate PBM is a possible minimally invasive therapy for children with hypertrophic tonsils suffering from symptoms of POSA as noted on the PSQ, at least within the short term. The lack of a pre-intervention and post-intervention Level 1 polysomnogram (PSG), the gold standard for diagnosing POSA, makes any interpretation of the actual effects of PBM on presumed POSA in this child speculative at best. PBM presents a non-painful low risk treatment option for children requiring urgent therapy with symptoms of POSA presenting with hypertrophic tonsils who are unable to see an appropriate physician immediately. For the child in this case report, the reduction in PSQ score of 9/22 (0.409) down to 1/21 (0.048) is a significant drop, indicating the child dropping from high risk of POSA (PSQ pretreatment above cutoff of 0.33) to low risk of POSA as measured by the PSQ (40,41). However, the lack of pre-intervention and post-intervention PSG is a critical limitation in any potential extrapolation of this intervention as a treatment for POSA. The use of PBM may shrink hypertrophic tonsils, immediately opening the airway and allowing for other pediatric airway treatments, such as facial orthopedics/orthodontics and myofunctional therapy, while patients are waiting for other appropriate consultation and evaluation (25,51-57). Clinical research into appropriate patient selection and exclusion criteria, PBM effect duration, and appropriate clinical delivery protocols should be explored.

Conclusions

PBM is a potentially safe and effective treatment for pediatric

hypertrophic tonsils in patients presenting with symptoms of POSA as revealed on the PSQ. Further research into this non-invasive painless treatment option is necessary.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at <https://pm.amegroups.com/article/view/10.21037/pm-21-18/rc>

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://pm.amegroups.com/article/view/10.21037/pm-21-18/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures were performed in accordance with the ethical standards of the institution and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). The mother provided written consent for de-identified information related to this treatment on her child to be used for educational and research purposes.

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References

1. Cassano P, Petrie SR, Hamblin MR, et al. Review of transcranial photobiomodulation for major depressive disorder: targeting brain metabolism, inflammation, oxidative stress, and neurogenesis. *Neurophotronics* 2016;3:031404.
2. Cassano P, Tran AP, Katnani H, et al. Selective

- photobiomodulation for emotion regulation: model-based dosimetry study. *Neurophotonics* 2019;6:015004.
3. Gonzalez-Lima F, Barrett DW. Augmentation of cognitive brain functions with transcranial lasers. *Front Syst Neurosci* 2014;8:36.
 4. Hamblin MR. Shining light on the head: Photobiomodulation for brain disorders. *BBA Clin* 2016;6:113-24.
 5. Keszler A, Lindemer B, Weihrauch D, et al. Red/near infrared light stimulates release of an endothelium dependent vasodilator and rescues vascular dysfunction in a diabetes model. *Free Radic Biol Med* 2017;113:157-64.
 6. Kuryliszyn-Moskal A, Kita J, Dakowicz A, et al. The influence of Multiwave Locked System (MLS) laser therapy on clinical features, microcirculatory abnormalities and selected modulators of angiogenesis in patients with Raynaud's phenomenon. *Clin Rheumatol* 2015;34:489-96.
 7. Silverman R. Getting athletes back in the game: Low-level laser therapy for sports injuries. *Dynamic Chiropract*. 2014;32:22-9.
 8. Liu TC, Cheng L, Su E, et al., Randomized double-blind, and placebo-controlled clinic report of intranasal low-intensity laser therapy on vascular diseases, *Int J Photoenergy* 2012;2012:489713.
 9. Vallone F, Benedicenti S, Sorrenti E, et al. Effect of diode laser in the treatment of patients with nonspecific chronic low back pain: a randomized controlled trial. *Photomed Laser Surg* 2014;32:490-4.
 10. Wong-Riley MT, Liang HL, Eells JT, et al. Photobiomodulation directly benefits primary neurons functionally inactivated by toxins: role of cytochrome c oxidase. *J Biol Chem* 2005;280:4761-71.
 11. Yadav A, Gupta A. Noninvasive red and near-infrared wavelength-induced photobiomodulation: promoting impaired cutaneous wound healing. *Photodermatol Photoimmunol Photomed* 2017;33:4-13.
 12. Kui A, Tisler C, Ciomasu A, et al. Effect of low level laser therapy (LLLT) on muscle pain in temporomandibular disorders – an update of literature, *Balneo Res J* 2020;11:14-9.
 13. Barolet D, Boucher A. Prophylactic low-level light therapy for the treatment of hypertrophic scars and keloids: a case series. *Lasers Surg Med* 2010;42:597-601.
 14. Ezzati K, Fekrazad R, Raoufi Z. The Effects of Photobiomodulation Therapy on Post-Surgical Pain. *J Lasers Med Sci* 2019;10:79-85.
 15. Ide Y. Phototherapy for chronic pain treatment. *Masui* 2009;58:1401-6.
 16. Avci P, Gupta A, Sadasivam M, et al. Low-level laser (light) therapy (LLLT) in skin: stimulating, healing, restoring. *Semin Cutan Med Surg* 2013;32:41-52.
 17. Neruntarat C, Khuancharee K, Shoowit P. Er:YAG laser for snoring: a systemic review and meta-analysis. *Lasers Med Sci* 2020;35:1231-8.
 18. Cetinkaya EA, Turker M, Kiraz K, et al. Er:Yag Laser Treatment of Simple Snorers in an Outpatient Setting. *ORL J Otorhinolaryngol Relat Spec* 2016;78:70-6.
 19. Frelich H, Ścierański W, Marków M, et al. Minimally invasive erbium laser treatment for selected snorers. *Lasers Med Sci* 2019;34:1413-20.
 20. Storchi IF, Parker S, Bovis F, et al. Outpatient erbium:YAG (2940 nm) laser treatment for snoring: a prospective study on 40 patients. *Lasers Med Sci* 2018;33:399-406.
 21. Baweja R, Calhoun S, Baweja R, et al. Sleep problems in children. *Minerva Pediatr* 2013;65:457-72.
 22. Guilleminault C. Sleep and its disorders in children. Raven Press, New York, 1987.
 23. Hoban TF. Sleep and its disorders in children. *Semin Neurol* 2004;24:327-40.
 24. Lam JC, Mason TB. Treatment of sleep disorders in children. *Curr Treat Options Neurol* 2007;9:404-13.
 25. Walter L, Horne R, Nixon G. Treatment of obstructive sleep apnea in children. *Clinical Practice* 2013;10:519-33.
 26. Katz ES, D'Ambrosio CM. Pathophysiology of pediatric obstructive sleep apnea. *Proc Am Thorac Soc* 2008;5:253-62.
 27. Section on Pediatric Pulmonology, Subcommittee on Obstructive Sleep Apnea Syndrome. American Academy of Pediatrics. Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics* 2002;109:704-12.
 28. Darrow DH. Surgery for pediatric sleep apnea. *Otolaryngol Clin North Am* 2007;40:855-75.
 29. Hoban TF. Sleep disorders in children. *Ann N Y Acad Sci* 2010;1184:1-14.
 30. Osman AM, Carter SG, Carberry JC, et al. Obstructive sleep apnea: current perspectives. *Nat Sci Sleep* 2018;10:21-34.
 31. Eckert DJ. Phenotypic approaches to obstructive sleep apnoea - New pathways for targeted therapy. *Sleep Med Rev* 2018;37:45-59.
 32. Epstein LJ, Kristo D, Strollo PJ Jr, et al. Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. *J Clin Sleep Med* 2009;5:263-76.
 33. American Sleep Apnea Association. Sleep apnea

- treatment options. Available online: <https://www.sleepapnea.org/treat/sleep-apnea-treatment-options/>. Accessed April 22, 2020
34. Veasey SC, Guilleminault C, Strohl KP, et al. Medical therapy for obstructive sleep apnea: a review by the Medical Therapy for Obstructive Sleep Apnea Task Force of the Standards of Practice Committee of the American Academy of Sleep Medicine. *Sleep* 2006;29:1036-44.
 35. Patil SP, Ayappa IA, Caples SM, et al. Treatment of Adult Obstructive Sleep Apnea With Positive Airway Pressure: An American Academy of Sleep Medicine Systematic Review, Meta-Analysis, and GRADE Assessment. *J Clin Sleep Med* 2019;15:301-34.
 36. Contencin P, Guilleminault C, Manach Y. Long-term follow-up and mechanisms of obstructive sleep apnea (OSA) and related syndromes through infancy and childhood. *Int J Pediatr Otorhinolaryngol* 2003;67 Suppl 1:S119-23.
 37. Tan HL, Gozal D, Kheirandish-Gozal L. Obstructive sleep apnea in children: a critical update. *Nat Sci Sleep* 2013;5:109-23.
 38. Chandrakantan A, Musso MF, Floyd T, et al. Pediatric obstructive sleep apnea: Preoperative and neurocognitive considerations for perioperative management. *Paediatr Anaesth* 2020;30:529-36.
 39. Capdevila OS, Kheirandish-Gozal L, Dayyat E, et al. Pediatric obstructive sleep apnea: complications, management, and long-term outcomes. *Proc Am Thorac Soc* 2008;5:274-82.
 40. Chervin RD, Hedger K, Dillon JE, et al. Pediatric sleep questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems. *Sleep Med* 2000;1:21-32.
 41. Chervin RD, Weatherly RA, Garetz SL, et al. Pediatric sleep questionnaire: prediction of sleep apnea and outcomes. *Arch Otolaryngol Head Neck Surg* 2007;133:216-22.
 42. Unver T, Aytugan E, Ozturan O, et al. Histological Effects of Er:YAG Laser Irradiation with Snoring Handpiece in the Rat Soft Palate. *Photomed Laser Surg* 2016;34:321-5.
 43. Wang Z, Rebeiz EE, Shapshay SM. Laser soft palate "stiffening": an alternative to uvulopalatopharyngoplasty. *Lasers Surg Med* 2002;30:40-3.
 44. Schneider HE, Lam JC, Mahone EM. Sleep disturbance and neuropsychological function in young children with ADHD. *Child Neuropsychol* 2016;22:493-506.
 45. Cha J, Zea-Hernandez JA, Sin S, et al. The Effects of Obstructive Sleep Apnea Syndrome on the Dentate Gyrus and Learning and Memory in Children. *J Neurosci* 2017;37:4280-8.
 46. Gozal D. Obstructive sleep apnea in children: implications for the developing central nervous system. *Semin Pediatr Neurol* 2008;15:100-6.
 47. Nachalon Y, Lowenthal N, Greenberg-Dotan S, et al. Inflammation and growth in young children with obstructive sleep apnea syndrome before and after adenotonsillectomy. *Mediators Inflamm* 2014;2014:146893.
 48. Operto FF, Precenzano F, Bitetti I, et al. Emotional Intelligence in Children with Severe Sleep-Related Breathing Disorders. *Behav Neurol* 2019;2019:6530539.
 49. Smith DL, Gozal D, Hunter SJ, et al. Impact of sleep disordered breathing on behaviour among elementary school-aged children: a cross-sectional analysis of a large community-based sample. *Eur Respir J* 2016;48:1631-9.
 50. Xanthopoulos MS, Gallagher PR, Berkowitz RI, et al. Neurobehavioral functioning in adolescents with and without obesity and obstructive sleep apnea. *Sleep* 2015;38:401-10.
 51. Guilleminault C, Huang YS, Monteyrol PJ, et al. Critical role of myofascial reeducation in pediatric sleep-disordered breathing. *Sleep Med* 2013;14:518-25.
 52. Guilleminault C, Huang YS. From oral facial dysfunction to dysmorphism and the onset of pediatric OSA. *Sleep Med Rev* 2018;40:203-14.
 53. Huang YS, Hsu SC, Guilleminault C, et al. Myofunctional Therapy: Role in Pediatric OSA. *Sleep Med Clin* 2019;14:135-42.
 54. Aroucha Lyra MC, Aguiar D, Paiva M, et al. Prevalence of sleep-disordered breathing and associations with malocclusion in children. *J Clin Sleep Med* 2020;16:1007-12.
 55. Camacho M, Chang ET, Song SA, et al. Rapid maxillary expansion for pediatric obstructive sleep apnea: A systematic review and meta-analysis. *Laryngoscope* 2017;127:1712-9.
 56. Villa MP, Rizzoli A, Miano S, et al. Efficacy of rapid maxillary expansion in children with obstructive sleep apnea syndrome: 36 months of follow-up. *Sleep Breath* 2011;15:179-84.
 57. Pirelli P, Saponara M, Guilleminault C. Rapid maxillary expansion (RME) for pediatric obstructive sleep apnea: a 12-year follow-up. *Sleep Med* 2015;16:933-5.

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