Midline posterior glossectomy and lingual tonsillectomy in children with refractory obstructive sleep apnoea: factors that influence outcomes

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Background: Tongue base reduction (TBR) can be performed by lingual tonsillectomy (LT) or midline posterior glossectomy (MPG) or a combination of these procedures. MPG is less commonly performed and there is a paucity of data regarding the outcomes of this procedure. The aim of this study was to identify factors that influence surgical outcomes in TBR for the treatment of paediatric refractory obstructive sleep apnoea (rOSA).

Methods: A retrospective analysis of all consecutive TBR cases from 1st January 2007 to 30th June 2021 was conducted at Perth Children's Hospital in Western Australia. Fifteen patients (73.3% male; age, 10 months–15 years) met the inclusion criteria: children under 16 years of age who underwent MPG and/or LT for rOSA after failing adenotonsillectomy (AT) and/or positive airway pressure (PAP) therapy.

Results: Thirteen patients had moderate to severe OSA prior to TBR. Eleven patients had a recognised syndrome. One-third of the patients were obese [body mass index (BMI) ≥95th percentile]. Most patients (12/15) in this study had MPG. Ten patients (66.7%) demonstrated complete resolution of rOSA after TBR. Mean obstructive apnoea hypopnoea index (OAHI) reduced by 11.75 [standard deviation (SD), 28.8; range, −56.1 to 57.3]. Children with healthy weight had the greatest improvements in OAHI (P=0.0682). Gender and the presence of a syndromic diagnosis did not affect changes in OAHI.

Conclusions: TBR appears to be a safe and effective treatment option for paediatric rOSA. A healthy BMI was associated with a positive outcome. We recommend a multidisciplinary approach to preoperative weight loss and medical optimization to maximise the benefit of TBR.

Keywords: Tongue base reduction (TBR); midline posterior glossectomy (MPG); lingual tonsillectomy (LT); paediatric; obstructive sleep apnoea (OSA); down syndrome (DS)

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Introduction

Paediatric obstructive sleep apnoea (OSA) is seen in 1–3% of children, particularly in the pre-school years (1). Long term, it can lead to failure to thrive, pulmonary hypertension, and learning and behavioral difficulties (2). Adenotonsillectomy (AT) is the first-line therapy for children with OSA and the first-stage treatment for complex OSA patients with evidence of adenotonsillar hypertrophy. In otherwise healthy children, 80% will improve clinically and normalize their polysomnogram (PSG) after AT (1,3).

However, those who fail first-line therapy may require additional intervention such as positive airway pressure (PAP) therapy and further surgery.

Persistent or refractory OSA (rOSA) in children can be defined as airway obstruction on PSG despite first-line therapy (4). It is a difficult condition to treat due to its multi-modal aetiology and requires a multidisciplinary approach to improve patient outcomes. Multiple studies have shown when rOSA is associated with obesity, asthma, craniofacial abnormalities and neuromuscular diseases, the rate of complete resolution of OSA after AT drops to 25–45% (2,4-11).

Furthermore, syndromic patients are likely to have multi-level obstruction, including nasoseptal obstruction, macroglossia, retrognathia with glossoptosis, lingual tonsil hypertrophy, lateral pharyngeal collapse, laryngomalacia and vocal cord paralysis (2). Clinically, the causative level and degree of obstruction can be assessed using a combination of history and examination, drug induced sleep endoscopy (DISE) and Cine magnetic resonance imaging (MRI) (12). Therefore, surgical options can be tailored to the level of obstruction, which may include turbinoplasty, tongue base reduction (TBR), supraglottoplasty or tracheostomy.

The current gold standard management for paediatric rOSA is PAP therapy (1,2). However, its tolerance in syndromic children is poor and long-term adherence is made more difficult by the need for frequent refitting of masks due to the rapid growth of children (13,14). This, in conjunction with evidence supporting the use of Cine MRI and DISE, has resulted in an increase in individualized, resistance-based surgical management (12).

TBR can be performed by lingual tonsillectomy (LT) or midline posterior glossectomy (MPG) or a combination of these procedures. LT treats hypertrophied lymphoid tissue on the surface of the posterior one-third of the tongue and is relatively common. MPG involves the partial excision of lingual musculature for patients with glossoptosis or macroglossia, where LT alone is unlikely to be successful. MPG is a more complicated procedure and not universally performed. As such, there is a paucity of data regarding the outcomes of this procedure.

International studies have assessed the benefit of TBR in rOSA with LT and MPG (15-26).

LT

Lin and Koltai first described endoscopic-assisted Coblation™ LT in 2009 and found a trend towards reduced mean obstructive apnoea hypopnoea index (OAHI) from 14.7 to 8.1 in children with rOSA (15). Abdel-Aziz *et al.* conducted a retrospective study of 16 children with rOSA who underwent LT and observed an improvement on post-operative PSG in all patients, but persistence of snoring in 37.5% of patients (16). DeMarcantonio *et al.* demonstrated a statistically significant reduction in median apnoea-hypopnoea index (AHI) and OAHI, and improved median oxygen saturation in 18 patients who had pre- and postoperative PSG (17). Two studies examined outcomes of LT in DS children: Skirko *et al.* found no appreciable change in mean OAHI, whereas Prosser *et al.* found significant improvements in AHI, OAHI and oxygen saturation (18,19).

MPG

Only a handful of studies have examined the outcomes of MPG in paediatric rOSA. Propst *et al.* conducted a retrospective study of 13 children with down syndrome (DS) and rOSA who underwent MPG with or without LT, where they found a statistically significant reduction in mean OAHI in normal-weight children but not in obese children (20). Wootten *et al.* conducted a retrospective study of 31 consecutive children with rOSA, of which 16 underwent MPG (21). They found a statistically significant reduction in OAHI and improved symptomatology. However, results were confounded by multiple other concurrent procedures, and it was difficult to isolate the outcomes of MPG alone. More recently, Ulualp conducted a retrospective study of 10 children who underwent MPG and LT and found a statistically significant reduction in OAHI in all children, with resolution of apneic events in children with normal weight (22). To date only 52 cases of MPG in children have been reported in the literature (20-24).

Two meta-analyses on TBR in paediatric rOSA were published in 2017. One evaluated the efficacy of LT only, which included 73 patients from 4 studies (25). The overall success rate of LT was 17% for a postoperative AHI less than 1 and 51% for a postoperative AHI less than 5. This study also identified the lack of evidence regarding factors influencing surgical outcome. Another meta-analysis included 11 studies with a total of 114 patients, of which only 24 had MPG (26). AHI improved by 48.5%. There was a greater improvement in AHI in non-syndromic children (59.2% OAHI reduction) compared to syndromic children (40.0% OAHI reduction). Children with DS had less improvement compared to children with other syndromes, but this finding was confounded by the increased mean body

Table 1 Scoring of paediatric sleep apnoea† (children less than 13 years of age‡)

Severity	OAHI
Normal	OAHI ≤1/hr TST
Mild OSA	OAHI >1/hr to ≤5/hr TST
Moderate OSA	OAHI >5/hr to ≤10/hr TST
Severe OSA	OAHI >10/hr TST

†, according to the ASA/ASTA Paediatric Working Party's Guidelines for Recording and Scoring of Paediatric Sleep, which is based on the AASM 2007 manual; ‡, paediatric OSA severity criteria. OSA, obstructive sleep apnoea; OAHI, obstructive apnoea hypopnoea index; TST, total sleep time; ASA, Australasian Sleep Association; ASTA, Australasian Sleep Technologists' Association; AASM, American Academy of Sleep Medicine.

mass index (BMI) in the DS group (27 kg/m^2 compared to 18 kg/m^2).

The aim of the present study is to determine the efficacy of MPG and/or LT in the treatment of paediatric rOSA and to identify the factors that influence surgical outcome. We present the following article in accordance with the STROBE reporting checklist (available at https://www.theajo.com/article/view/10.21037/ajo-21-35/rc).

Methods

A retrospective study of all consecutive TBR cases was conducted at a single tertiary paediatric centre (Perth Children's Hospital) in Western Australia. Data was obtained from review of an electronic operating theatre database and patient case files from 1st January 2007 to 30th June 2021. Inclusion criteria were: (I) paediatric patients aged ≤16 years, (II) patients who underwent TBR by MPG and/or LT and (III) patients with OSA who had failed AT and/or PAP therapy. Patients who underwent TBR for a primary indication other than OSA were excluded. Patients who underwent TBR with concurrent AT, revision adenoidectomy, cautery of inferior turbinates and turbinoplasty were included in this study.

Data on patient demographics, comorbidities, surgical procedures, and pre- and postoperative PSG results were collected.

Polysomnography

PSG was conducted according to the Australasian Sleep Association/Australasian Sleep Technologists' Association (ASA/ASTA) Paediatric Working Party's Guidelines for Recording and Scoring of Paediatric Sleep, which is based on the American Academy of Sleep Medicine (AASM) 2007 manual (27,28). All patients were scored according to the paediatric OSA severity criteria (*Table 1*).

Surgical technique

All procedures were performed under general anaesthesia by a single consultant otolaryngologist (senior author). All patients received a prophylactic dose of intravenous dexamethasone (0.25 mg/kg) on induction. Patients were positioned supine with shoulder roll and head ring. MPG was performed with the patient suspended with a laryngoscope *in situ* and using a Hopkins rod lens telescope and video camera to visualize the epiglottis and central tongue base. The Coblation™ Evac 70 Xtra or the Procise EZ Wand (ArthroCare Corp., Smith and Nephew, Sunnyvale, CA, USA) were used depending on surgical access. The central portion of the tongue base was resected up to the width of the epiglottis to avoid injury to the lingual arteries and deep to the point where the hyoid bone was palpable but not exposed. LT was performed with a Boyle-Davis mouth gag or suspension laryngoscope to expose the lingual tonsils. The tissue was then ablated using the Coblation™ wands.

Postoperatively, most patients were extubated in theatre and observed for at least 24 hours in the intensive care unit (ICU). Analgesia was managed with a combination of paracetamol and ibuprofen, and oxycodone or tramadol as needed.

Outcome measures

The primary outcome of the study was postoperative resolution of rOSA, defined by postoperative OAHI <5, ≥50% reduction in preoperative OAHI or symptomatic improvement with complete cessation of PAP therapy.

Secondary analyses were performed to investigate whether gender, BMI, and the presence of a syndromic diagnosis influenced the primary outcome.

Statistical analysis

Data was analysed using IBM SPSS Statistics for Windows, version 20 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the study population.

Figure 1 Rational for the number of included cases. OSA, obstructive sleep apnoea.

Comparison of pre- and postoperative PSG results and secondary analyses were performed using paired sample *t*-tests. P value <0.05 was considered statistically significant.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the local research ethics committee (approval number: 26695). Informed consent was waived in this study as it was a retrospective review of de-identified data only.

Results

Twenty-two consecutive patients underwent tongue base surgery from 1^{st} January 2007 to 30^{th} June 2021 and seven were excluded based on the eligibility criteria (*Figure 1*). A total of 15 patients (73.3% male; median age, 8 years; age range, 10 months–15 years) were included in this study.

Most patients (80%) had moderate to severe OSA prior to TBR. Eleven patients had a syndromic diagnosis, seven had a history of cardiopulmonary disease and two had a history of endocrine disorder (*Table 2*). The median preoperative BMI of the group was 20.2 [standard deviation (SD), 8.17; range, 15.5–45.1] kg/m^2. According to the Centers for Disease Control and Prevention (CDC) Clinical Growth Charts (29), 13.3% of patients were overweight (BMI 85^{th} to $<95^{th}$ percentile) and 33.3% were obese (BMI $\geq 95^{th}$ percentile). The most common clinical presentations were snoring (93.3%), restlessness (93.3%) and daytime fatigue or inattention (60.0%) (*Table 3*).

Pre- and postoperative PSG were performed in 12 patients. Two patients did not have PSG: one had preoperative inpatient overnight oximetry with significant desaturations, suggestive of severe OSA; the other had obstructive symptoms consistent with severe OSA, requiring urgent surgery; both had dramatic clinical resolution of symptoms postoperatively and a postoperative PSG was not required. One patient had mild OSA on preoperative PSG

Table 2 Preoperative patient demographics

Patient characteristics	Data
Number of patients	15
Gender (M/F), n (%)	11 (73.3)/4 (26.7)
Age† (years), median (SD) [range]	8 (4.66) [0.83–15]
BMI‡ (kg/m^2), median (SD) [range]	20.2 (8.17) [15.5–45.1]
BMI percentile, median (SD) [range]	71 (35.2) [3–99]
BMI risk, n (%)	
Underweight (BMI <5th percentile)	1 (6.67)
Healthy weight (BMI 5th to <85th percentile)	7 (46.7)
Overweight (BMI 85th to <95th percentile)	2 (13.3)
Obese (BMI ≥95th percentile)	5 (33.3)
ASA, n (%)	
I	0
II	4 (26.7)
III	11(73.3)
IV	0
Syndromic diagnosis, n (%)	11 (73.3)
DS	6
Rubenstein-Taybi syndrome	2
Beckwith-Wiedemann syndrome	1
Chromosome 6q duplication	1
Prader-Willi syndrome	1
Cardiac/pulmonary disorders, n (%)	7 (46.7)
AVSD/VSD/ASD	5
Repaired tetralogy of Fallot	1
Bicuspid AV	1
Endocrine/metabolic disorders, n (%)	2 (13.3)
T2DM	1
Primary growth hormone deficiency on hormone replacement	1
Craniofacial abnormalities, n (%)	2 (13.3)
Retrognathia	2

†, age at time of operation; ‡, BMI as calculated by CDC's BMI Percentile Calculator for Child and Teen ≥2 years of age; BMI was not applicable in children under 2 years old, whose weight plotted against age on an age-appropriate growth chart. M, male; F, female; SD, standard deviation; BMI, body mass index; ASA, American Society of Anesthesiologists' Physical Status Classification System; DS, down syndrome; AVSD, atrioventricular septal defect; VSD, ventricular septal defect; ASD, atrial septal defect; AV, atrioventricular; T2DM, type 2 diabetes mellitus; CDC, Centers for Disease Control and Prevention.

Table 3 Clinical presentation

Presenting history	Frequency
Common clinical presentation, n (%)	
Snoring	14 (93.3)
Restlessness	14 (93.3)
Daytime fatigue or inattention	9 (60.0)
Pauses	8 (53.3)
Mouth breathing	6 (40.0)
Gasping	3 (20.2)
Prior AT, n (%)	12 (80.0)
Prior trial of PAP, n (%)	10 (66.7)
Preoperative PAP tolerant, n (%)	5 (33.3)

AT, adenotonsillectomy; PAP, positive airway pressure.

and did not require a postoperative PSG due to clinical resolution of symptoms. Individual patient demographics, comorbidities, surgical procedures, and pre- and postoperative PSG results are summarized in *Table 4*. Pre- and postoperative OSA scores are summarized in *Table 5*.

Ten patients (66.7%) had complete resolution of rOSA (postoperative OAHI <5, ≥50% reduction in preoperative OAHI or complete cessation of PAP therapy). Three patients had persistent OSA and were referred for further PAP therapy, of which, two had improved PAP tolerance and one (patient 2) had worse OSA due to 15 kg weight gain (*Figure 2*). One patient (patient 11) was referred for surgically assisted rapid maxillary expansion for correction of retrognathia and narrow maxilla, and one (patient 13) was decannulated after a repeat PSG with capped tracheostomy tube that demonstrated mild OSA.

Statistical analysis was performed to compare the pre- and postoperative PSG results in 12 (*Table 6*). The preoperative mean OAHI was 21.2 (SD, 16.3; range, 3.6–57.6) and the postoperative mean OAHI was 15.2 (SD, 22.6; range, 0–62.8). The mean percentage reduction in OAHI was 83.9 and the decrease in postoperative OAHI was not statistically significant (P=0.480).

Subgroup analysis was performed to compare the PSG results based on BMI, gender, and the presence of a syndromic diagnosis. Patients were divided into four groups based on their BMI risk category: underweight (BMI <5th percentile, n=1), healthy weight (BMI 5th to <85th percentile, n=4), overweight (BMI 85th to <95th percentile, n=2), and obese (BMI ≥95th percentile, n=4). Patients in the healthy

Table 4 Individual patient demographics, comorbidities, and pre- and postoperative polysomnography results

No.	Age[†] (years)	Gender	Preoperative BMI[‡] percentile (BMI risk)	Co-morbidities (ASA grade)	Procedures	Preoperative OAHI (LSAT)	Postoperative OAHI (LSAT)	Change in OAHI	Percentage reduction in preoperative OAHI (%)	Successful outcome[§], comments
1	12	F	93 (overweight)	Nil (ASA II)	MPG, LT, RA, CIT	N/A (inpatient overnight oximetry suggestive of severe OSA)	N/A (Significant clinical improvement, no residual symptoms, no PAP requirement)	N/A	N/A	Yes
2	12	F	99 (obese)	DS, T2DM, intellectual disability, GDD, recurrent laryngeal papilloma, congenital sensorineural hearing loss (ASA III)	MPG, LT	30.9 (68%)	55.2 (52%) (postoperative weight gain of 15 kg)	–24.3	–78.6	No, referred for PAP therapy
3	13	M	97 (obese)	DS, AVSD repair, recurrent bronchitis (ASA II)	MPG, LT, turbinoplasty	7.0 (87%)	24.9 (80%)	–17.9	–256	No, referred for PAP therapy, improved PAP tolerance
4	10 months	M	5 (healthy)	DS, PDA and VSD repair, pulmonary hypertension, choanal atresia repair, Hirschsprung disease, duodenal atresia, PEG fed, hepatitis C, GDD (ASA III)	MPG, AT	10.4 (64%)	0.2 (93%)	10.2	98.1	Yes
5	5	M	93 (overweight)	Rubenstein-Taybi, congenital single kidney, undescended testes orchidopexy, ureteric reimplantation, GDD (ASA III)	MPG, AT, CIT	33.5 (76%)	1 (86%)	32.5	97.0	Yes
6	2	M	18 (healthy)	Beckwith-Wiedemann, bicuspid AV valve, anterior cerebral artery infraction with left encephlomalacia and frontal focal epilepsy, GMFCS III spastic diplegic cerebral palsy, tracheomalacia, right duplex kidney with vesicoureteric reflux, GDD (ASA III)	MPG	20.9 (73%)	0.5 (98%)	20.4	97.6	Yes

Table 4 *(continued)*

Table 4 *(continued)*

No.	Age† (years)	Gender	Preoperative BMI‡ percentile (BMI risk)	Co-morbidities (ASA grade)	Procedures	Preoperative OAHI (LSAT)	Postoperative OAHI (LSAT)	Change in OAHI	Percentage reduction in preoperative OAHI (%)	Successful outcome§, comments
7	7	F	98 (obese)	DS, small unrepaired muscular ASD, laryngomalacia, GDD (ASA II)	MPG	39.8 (82%)	26.5 (84%)	13.3	33.4	No, referred for PAP therapy, improved PAP tolerance
8	8	M	54 (healthy)	Prader-Willi, primary growth hormone deficiency on Genotropin, hypotonia, GDD, autism spectrum disorder (ASA III)	MPG, RA	10.1 (85%)	0.3 (72%)	9.8	97.0	Yes
9	9	M	40 (healthy)	Nil (ASA III)	LT, RA	N/A (symptoms consistent with severe OSA, urgent elective surgery)	N/A (significant clinical improvement, mild residual symptoms, no PAP requirement)	N/A	N/A	Yes
10	8	M	95 (obese)	Rubenstin-Taybi, small unrepaired VSD, chronic cough, bilateral undescended testes, GDD (ASA III)	LT	20.9 (79%)	6.1 (86%)	14.8	70.8	Yes
11	15	M	94 (overweight)	Refractory epilepsy with corpus callostomy, intellectual disability, retrognathia, narrow maxilla (ASA III)	MPG + turbinoplasty	6.7 (88%) (underestimated hypopnoeic and apnoeic events due to epileptiform activity)	62.8 (79%)	N/A	N/A	No, some clinical improvement, subsequent SARME
12	15	F	71 (healthy)	DS, tetralogy of Fallot repair (ASA III)	MPG	13.5 (66%) (underestimated due to many sub-criterion events)	0 (81%)	13.5	100	Yes

Table 4 *(continued)*

Table 4 *(continued)*

No.	Age† (years)	Gender	Preoperative BMI‡ percentile (BMI risk)	Co-morbidities (ASA grade)	Procedures	Preoperative OAHI (LSAT)	Postoperative OAHI (LSAT)	Change in OAHI	Percentage reduction in preoperative OAHI (%)	Successful outcome§, comments
13	1.5	M	3 (underweight)	Chromosome 6q duplication, ex premature twin 32/40, laryngotracheobronchomalacia, tracheostomy and ventilator dependent, retrognathia and macroglossia, deep laryngeal cleft, immune deficiency, recurrent LRTI, PEJ fed, right ureteropelvic junction malrotation and obstruction, bilateral hernia repair, GDD (ASA III)	MPG	3.6 (81%) (sleep study performed with NPA due to severity of OSA)	4.1 (81%) (sleep study performed with tracheostomy capped)	N/A	N/A	Decannulated
14	8	M	57 (healthy)	DS, incomplete AVSD and membranous subaortic stenosis repair, immune deficiency, recurrent croup, tracheomalacia, severe anxiety (ASA III)	LT + RA	2.1 (82%)	N/A (significant clinical improvement, mild residual symptoms, no PAP requirement, will not tolerate repeat PSG due to severe anxiety)	N/A	N/A	Yes
15	5	M	60 (healthy)	FASD, ex premature 35/40, central hypotonia, recurrent aspiration pneumonia, PEG fed, laryngomalacia (ASA II)	MPG	57.6 (45%)	0.3 (97%)	57.3	99.5%	Yes

†, age at time of operation; ‡, BMI as calculated by CDC's BMI Percentile Calculator for Child and Teen ≥2 years of age; BMI was not applicable in the 10 months old patient, whose weight plotted against age on an age-appropriate male growth chart was in the 5th percentile; §, successful outcome was postoperative resolution of rOSA, defined by postoperative OAHI <5 or ≥50% reduction in preoperative OAHI or complete cessation of PAP therapy. F, female; M, male; BMI, body mass index; ASA, American Society of Anesthesiologists' Physical Status Classification System; DS, down syndrome; T2DM, type 2 diabetes mellitus; GDD, global developmental delay; AVSD, atrioventricular septal defect; PDA, patent ductus arteriosus; VSD, ventricular septal defect; PEG, percutaneous endoscopic gastrostomy; AV, atrioventricular; GMFCS, Gross Motor Function Classification System; ASD, atrial septal defect; LRTI, lower respiratory tract infection; PEJ, percutaneous endoscopic jejunostomy; FASD, fetal alcohol spectrum disorders; MPG, midline posterior glossectomy; LT, lingual tonsillectomy; RA, revision adenoidectomy; CIT, cautery of inferior turbinates; AT, adenotonsillectomy; OAHI, obstructive apnoea hypopnoea index; LSAT, low oxyhaemoglobin desaturation; N/A, not applicable; OSA, obstructive sleep apnoea; NPA, nasopharyngeal airway; PAP, positive airway pressure; PSG, polysomnography; SARME, surgically assisted rapid maxillary expansion; CDC, Centers for Disease Control and Prevention; rOSA, refractory obstructive sleep apnoea.

group had the greatest reduction in mean OAHI postoperatively (P=0.0682). Neither gender nor the presence of a syndromic diagnosis appeared to be significant factors.

Successful outcome was achieved in 66.7% (10/15) of patients in this study: 33.3% (1/3) patients who underwent MPG with LT, 66.7% (6/9) patients who underwent MPG, and all (3/3) patients who underwent LT.

There was no mortality among the patients in this study. Patient 9 had a prolonged ICU admission due to traumatic intubation (grade IV view on laryngoscopy) and intraoperative desaturations and had a planned extubation in theatre 3 days after surgery. No significant complications such as injury to lingual or hypoglossal nerves, significant vascular injury, postoperative bleeding requiring re-intervention, or obstructive airway symptoms requiring tracheostomy occurred in this study.

Table 5 Pre- and postoperative OSA severity scores

OSA severity score	Preoperative (n=15), n (%)	Postoperative (n=15), n (%)
Normal	0	9 (60.0)
Mild	2 (13.3)	1 (6.67)
Moderate	2 (13.3)	1 (6.67)
Severe	11(73.3)	4 (26.7)

OSA, obstructive sleep apnoea.

Discussion

Within the limitations of a retrospective study with a small patient cohort, this study found that children with healthy weight (BMI 5th to <85th percentile) demonstrated consistent improvement in rOSA after TBR, whereas children with

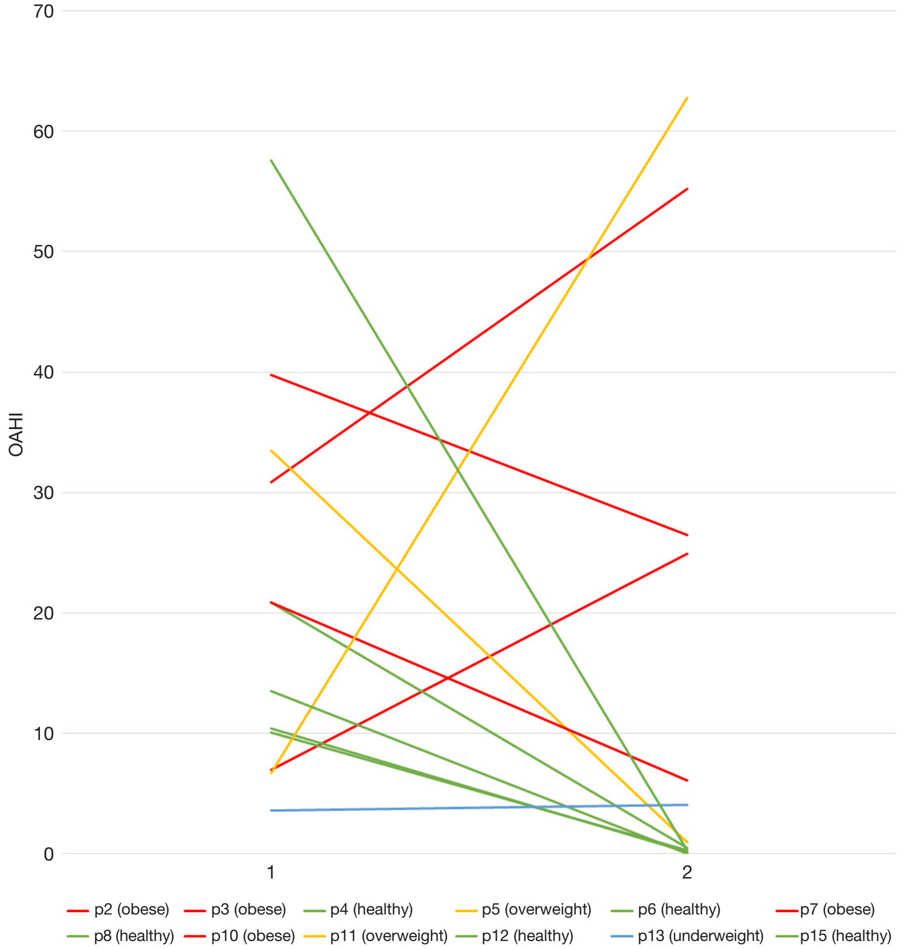

Figure 2 Pre- and postoperative polysomnography results after TBR. OAHI, obstructive apnoea hypopnoea index; P, patient; TBR, tongue base reduction.

Table 6 Comparison of pre- and postoperative polysomnography results and subgroup analysis of patient variables using paired sample *t*-test

Patient variables	Preoperative	Postoperative	t value	P value
OAHI (n=12), median	17.2	2.55	N/A	N/A
OAHI (n=12), mean (SD) [range]	21.2 (16.3) [3.6–57.6]	15.2 (22.6) [0–62.8]	2.20	0.480
Change in OAHI (n=12), mean (SD) [range]	–	11.75 (28.8) [–56.1 to 57.3]	N/A	N/A
Percentage reduction in OAHI (n=12), mean (SD) [range]	–	83.9 (272.4) [–837.3 to 100.0]	N/A	N/A
Subgroup analyses				
Obese OAHI (n=4), mean (SD) [range]	25.9 (17.0) [7–39.8]	35.5 (17.1) [6.1–55.2]	3.18	0.753
Overweight OAHI (n=2), mean (SD) [range]	20.1 (17.9) [6.7–33.5]	31.9 (36.0) [1–62.8]	12.7	0.834
Healthy OAHI (n=5), mean (SD) [range]	35.6 (31.2) [13.5–57.6]	0.15 (0.212) [0–0.3]	2.78	0.0682
Underweight OAHI (n=1), median	3.6	4.1	N/A	N/A
Male OAHI (n=9), mean (SD) [range]	10.4 (9.22) [3.6 – 57.6]	24.33(33.3) [0.3-62.8]	2.31	0.481
Female OAHI (n=3), mean (SD) [range]	35.33 (20.9) [13.5 – 39.8]	40.85 (27.6) [0-55.2]	4.30	0.953
Syndromic OAHI (n=10), mean (SD) [range]	8.55 (7.00) [3.6–13.5]	2.05 (2.90) [0–4.1]	2.26	0.218
Non syndromic OAHI (n=2), mean (SD) [range]	6.7 (4.74) [6.7–57.6]	62.8 (44.4) [0.3–62.8]	12.7	0.993

OAHI, obstructive apnoea hypopnoea index; SD, standard deviation; N/A, not applicable.

abnormally increased or decreased BMI had variable outcomes. This appears to be independent of patients' gender and syndromic diagnoses.

BMI and TBR in rOSA

The finding of healthy BMI as a positive predictor of outcome in rOSA after TBR surgery is consistent with current evidence (16,18,24,26,30). Obesity is independently correlated to lingual tonsil hypertrophy in children, thereby contributing to rOSA (31-33). Additionally, the oropharyngeal space is compressed by adipose tissue, resulting in a decrease in its cross-sectional area and an exponential increase in airway resistance. In the present study, we divided patients into four BMI risk categories according to the CDC Clinical Growth Charts (29). We found that obese and overweight children had less favorable outcomes with MPG and/or LT, which is consistent with the findings of Propst *et al.* (20). The worsening of rOSA symptoms in patient 2 in the setting of significant postoperative weight gain supports this finding.

We recommend that BMI be taken into consideration in the preoperative workup and counselling of children with rOSA and aggressive weight loss programs in a multidisciplinary setting be encouraged prior to surgery.

Safety and efficacy of LT and MPG

LT has been found to be an effective surgical option for children with rOSA due to lingual tonsil hypertrophy (25). A recent meta-analysis of LT in the treatment of paediatric OSA found that it resulted in significant improvements in minimum oxygen saturation by 6% [95% confidence interval (CI): 2.7–9.2%] and mean AHI by 8.9/hr (95% CI: –12.6/hr to –5.2/hr) (25). While data on the complications of LT are limited, the rate of serious complications appear to be low. The same study found an overall complication rate of 6.84%, including three patients with airway obstruction, postoperative bleeding, and pneumonia (25).

All studies on MPG have included other airway procedures in paediatric rOSA patients (20-24). This makes the interpretation of complications such as postoperative bleeding and airway obstruction difficult. However, MPG appears to be a safe option for treating paediatric patients with rOSA due to tongue base obstruction (20-24).

We found TBR involving MPG and LT to be safe and effective with a success rate of 66.7% for all procedures combined and no significant complication was observed in this series. While all patients with rOSA should be considered for a trial of PAP, patients with definite tongue base obstruction as demonstrated on DISE or Cine MRI may benefit from targeted surgical therapy. Even among patients with partial improvement, the reduction in tongue base resistance has been shown to improve tolerance of PAP therapy (20). This was observed in patients 3 and 7.

As demonstrated in *Table 4*, many of our patients have a complex list of comorbidities as well as social and psychological issues that impede their tolerance and/or compliance with PAP therapy. The clinical decision tree in these patients is complex and require extensive multidisciplinary input and discussion. At our institution, children with rOSA are referred to a Complex Airway Team service that includes otolaryngologists, sleep physicians, paediatricians, craniofacial surgeons, speech pathologists, dietitians, social workers, and advanced scope nurse practitioners. Syndromic children with rOSA particularly benefit from this model of care, in which they are referred early for multidisciplinary discussion, coordination of care and intervention.

Limitations

This study has several limitations. First, the study was retrospective and not all patients had pre- and postoperative PSG. Second, the inclusion of other concurrent procedures such as revision adenoidectomy, cautery of inferior turbinates and turbinoplasty may contribute to the degree of improvement seen in our cohort. Finally, the study was limited by the small sample size. However, MPG and LT are uncommon procedures and there are only 52 cases of MPG reported in the literature. Large, multi-institutional studies are required to confirm the findings of this study.

Conclusions

TBR using MPG and/or LT appears to be a safe and effective treatment option in paediatric rOSA. A healthy weight (BMI 5th to <85th percentile) was associated with a positive outcome and larger studies are required to confirm this finding. A multidisciplinary approach to weight loss and preoperative medical optimization is recommended to maximise the benefits of surgery.

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Footnote

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