

## Nasal Obstruction in Children with Sleep-disordered Breathing

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### Abstract

**Introduction:** Nasal obstruction secondary to pathological enlargement of inferior nasal turbinates contributes to sleep-disordered breathing (SDB) in prepubertal children, but treatments designed to address turbinate enlargement are often not performed. The aims of these studies are: (1) to appreciate the contribution to SDB of untreated enlarged nasal turbinates in prepubertal children; and (2) to report our experience with treatment of enlarged nasal turbinates in young children with SDB. **Materials and Methods:** Children with enlarged nasal turbinates who underwent adenotonsillectomy (T&A) had significantly less improvement in postoperative apnoea-hypopnoea index (AHI) compared to those treated with concomitant turbinate reduction. Children in the untreated turbinate hypertrophy group subsequently underwent radiofrequency ablation of the inferior nasal turbinates; following this procedure, AHI was no different than AHI of those without hypertrophy. **Results:** In an analysis of safety and effectiveness of radiofrequency treatment of the nasal turbinates, we found the procedure to be a well-tolerated component of SDB treatment. **Conclusions:** We conclude that radiofrequency (RF) treatment of inferior nasal turbinates is a safe and effective treatment in young prepubertal children with SDB. When indicated, it should be included in the treatment plan for prepubertal children with SDB. However, the duration of effectiveness is variable and therapy may need to be repeated if turbinate hypertrophy recurs.

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**Key words:** Nasal inferior turbinates, Obstructive sleep apnoea, Pre-pubertal, Radiofrequency

### Introduction

Nasal breathing is critical in infants and children; for example, neonatal choanal atresia often leads to respiratory distress and may require urgent intervention in the newborn nursery. Later, during development in the first years of life, abnormal nasal breathing has important consequences for facial growth. Persistent impairment of nasal breathing leads to chronic mouth-breathing and subsequent facial growth abnormalities. This is demonstrated by experiments performed on newborn rhesus monkey at the School of Dentistry at the University of California, San Francisco in the 1970s, which established the considerable impact of abnormal nasal breathing on facial and dental development. The study involved placement of soft, hollow, cone-shaped silicon plugs, 10-mm long, into the nares. The plugs, designed to increase nasal resistance, were sutured to the nasal septum. In these young monkeys, elevated nasal resistance had the dramatic effect of halting maxillo-mandibular skeletal growth.<sup>1-3</sup>

The mechanisms leading to these marked skeletal growth changes include adaptive changes in soft tissues that are

associated with deviations in jaw posture and tongue activity, as well as obstruction-induced functional changes that impact the naso-maxillary complex and the mandible. Disuse of the nasal airway leads to poor maxillary development, restricting the nose and upper jaw. Associated mouth breathing leads to displacement of the mandible and yields a narrow, often long-appearing facial skeleton. Abnormal nasal breathing in children during the period of facial development leads to narrowing of the dental arches, decreased maxillary arch length, an anterior crossbite, maxillary overjet, and increased anterior face height. These changes further favour abnormal breathing, especially during sleep. Often obstructive sleep apnoea (OSA) develops, and nocturnal breathing abnormalities reinforce oral breathing; thus a vicious cycle of breathing problems and impaired facial growth develops.

It is critical to address the problem of nasal obstruction when approaching sleep-disordered breathing (SDB) in children. This can be challenging, since the nasal septum is recognised as a facial growth centre and septal surgery in childhood is controversial. For children within the proper

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age range, rapid maxillary distraction may be able to resolve the problem<sup>4,6</sup> but we shall not consider this question here.

Instead, we shall consider treatments for enlarged inferior nasal turbinates, which can cause significant narrowing of the functional nasal airway and increase nasal resistance dramatically. While nasal steroid sprays are often used, it can take months to have a sufficient response, and at times nasal steroids are not effective enough to eliminate increased resistance. Such a prolonged steroid treatment trial period may allow ongoing nasal obstruction and facial growth impairment to persist for some time. Since 60% of adult facial structure is formed by 4 years of age, delays in diagnosis and interventions to correct nasal obstruction can have deleterious consequences.

In this report, we investigate both the impact of failure to treat increased nasal resistance in children with SDB from data collected on children seen at our centre; and the results of treatment using radiofrequency (RF) for enlarged inferior turbinates in children with SDB.

## I. Failure to Treat Enlarged Inferior Nasal Turbinates

### Methods

To investigate the impact of failure to treat enlarged nasal inferior turbinates, we performed a retrospective review of 500 prepubertal (Tanner stage 1,<sup>7</sup> mean age  $6.2 \pm 1.2$  years) children successively seen and diagnosed with SDB between 1996 and 2005 at our sleep disorders clinic. Four hundred and forty-one subjects in the group were recommended for T & A as the primary therapy for SDB. Of this group, 75 subjects were also diagnosed with abnormal enlargement of inferior nasal turbinates, and it was recommended that RF reduction of the turbinates be performed at the time of adenotonsillectomy.

Follow-up evaluation 3 to 4 months post-surgery was obtained in 399 of these children. All parents completed a validated paediatric sleep questionnaire,<sup>8</sup> had clinical evaluation, and underwent polysomnography (PSG) recording at entry and at follow-up.

### Results

Of the 75 subjects in whom both adenotonsillectomy and treatment of inferior nasal turbinate hypertrophy were recommended, 74 were seen at follow-up and turbinate reduction had been performed in only 27 subjects.

In the overall group of 399, the mean apnoea-hypopnoea index (AHI) at entry was  $8.6 \pm 9$  events per hour. At follow-up, the mean AHI was  $1.8 \pm 2$  events per hour.

Of the 74 individuals who were recommended to undergo the RF treatment, the mean AHI was  $9.85 \pm 8.1$  events per hour at entry and  $2.9 \pm 2.5$  at follow-up.

As a whole, the group of children identified as having concomitant inferior nasal turbinate hypertrophy with SDB had significantly less improvement with adenotonsillectomy (Wilcoxon signed rank test,  $P = 0.01$ ) than those without initially identified hypertrophy. To understand this reduced AHI improvement, we divided the 74 children with pre-operatively identified hypertrophy into RF-treated and RF-untreated groups. There was a significant difference ( $P = 0.02$ ) in post-treatment AHI between those who had adenotonsillectomy alone and those who had combined adenotonsillectomy with RF treatment. Those with added RF turbinate treatment had an AHI of  $1.9 \pm 2.2$  events per hour (results not different from overall results), while those without added RF treatment had an AHI of  $3.5 \pm 2.1$  events per hour.

Interestingly, out of the 47 patients identified with turbinate hypertrophy who did not receive RF treatment initially, 39 had subsequent RF treatment, and post-treatment polysomnography demonstrated further significant improvement in AHI. In these subjects, the AHI went from an AHI of  $3.4 \pm 1.1$  events per hour after adenotonsillectomy alone, to an AHI of  $1.6 \pm 0.8$  events per hour after subsequent RF treatment ( $P = 0.05$ ).

## II. Turbinate Reduction by RF in a Paediatric Population – Initial Clinical Experience

### Methods

We undertook a prospective, non-randomised study of 86 consecutively treated paediatric patients (age range, 1 to 17 years) between January 2003 and August 2005. All patients were diagnosed with SDB based on polysomnographic recordings. The diagnosis of nasal obstruction was made either by subjective complaint or caregiver observation, plus PSG. Turbinate hypertrophy was confirmed on clinical examination. The examination consisted of anterior rhinoscopy with direct visual inspection of the anterior nasal cavity using a nasal speculum and fiberoptic headlight. The severity of nasal obstruction at the anterior end of the inferior turbinate was graded based on a 4 point scale per nostril: 0 (turbinates not visible), 1 (0 to 25% blockage), 2 (25 to 50% blockage), 3 (50 to 75% blockage), 4 (75 to 100% blockage).<sup>9</sup> The scores were added for a composite nasal score.

Radiofrequency treatment: All RF procedures were performed by the same surgeon. When concomitant T and A was done, the procedures were performed in the operating room under general anaesthesia. A local anaesthetic injection of 1 to 2 mL (depending on the size of the turbinate) of 0.5% marcaine without epinephrine using a 30 gauge needle was administered just prior to treatment. In patients with isolated transcutaneous RF (TCRF) treatments, topical anaesthetic (cotton swab saturated with

2% lidocaine without epinephrine) was applied to the anterior edge of the inferior turbinate for 1 minute followed by a local anaesthetic injection. The Somnoplasty™ turbinate probe was inserted submucosally into the anterior head of the inferior turbinate (medial to the conchal bone) until the 10 mm active tip was completely buried. Care was taken not to breach the mucosa posterior to the puncture site. The RF setting was 85°C and the amount of energy delivery was dependent on the size of the turbinate (range, 200 to 550 Joules -J-, Somnoplasty Radiofrequency Generator, Gyrus, TN, USA). The probe was removed after completion of the energy delivery and T & A was then performed. The patient was awakened at the end of the procedure without any special care of the turbinate. In the 2 patients treated under local anaesthesia, immediately following the procedure, a cotton applicator saturated with oxymetazoline was placed over the puncture site for 2 minutes, and each patient was observed for 5 minutes then discharged without restrictions to normal daily activities. No nasal packing, topical ointment, steroids or nasal spray were administered.

The patients were examined between postoperative day 1 and 3, at 1 week, 2 weeks and 6 weeks. All patients were examined to assess the degree of nasal obstruction, bleeding, crusting, or other side effects. Any adverse effects reported by the patients were recorded at each visit.

Paired *t*-tests were used to determine whether changes from the baseline to the final measurements were significant. Results are expressed as mean, plus or minus standard deviation, and generated using a SAS computerised statistical package.

**Results**

Eighty-six patients (59 males) with a mean age of 9.4 ± 4.4 years (range, 1 to 17) were enrolled and completed the study.

One hundred and seventy-two inferior turbinates were treated with a mean of 338 ± 130 J of RF energy per turbinate. The mean temperature at the lesion site was 80 ± 5.1°C.

Eighty-one patients (>3 years old) reported minimal postoperative discomfort. The caregivers of the 5 patients less than 3 years old reported no obvious discomfort associated with the nasal/premaxillary region. Oedema was noted either by clinical examination or by subjective patient report in all patients but was of short duration (24 to 72 hours). Two turbinates (2 patients) were noted to have a small area of crusting at the puncture site. In each case, this area was completely healed at 2 weeks. At the completion of the study (6 weeks post-treatment), improvement of nasal breathing by either subjective reporting or caregiver observation was noted in all patients.

The extent of obstruction, as determined by clinical examination, demonstrated a severity score improvement from 5.7 ± 0.72 to 2.6 ± 0.58 (complete turbinate scoring data available in 79 patients); this difference was significant (Wilcoxon signed rank test, *P* = 0.00).

**Discussion**

In these 2 studies, we show that overlooking treatment of nasal obstruction in children leads to persistence of clinical complaints and abnormal polysomnographic findings. While parents always report symptomatic improvement following adenotonsillectomy, as we have previously shown in a smaller group,<sup>10</sup> persistent residual symptoms and PSG-documented SDB was amenable to further treatment with a procedure aimed specifically at nasal obstruction. We were able to establish that radiofrequency reduction of the turbinates is effective in further improving SDB in patients with turbinate hypertrophy.

In addition to being effective, we also demonstrate that treatment of enlarged inferior turbinates is safe when performed appropriately. Nonetheless, this treatment alone will not solve the problem of paediatric SDB. Tonsillectomy and adenoidectomy is the first-line treatment of sleep

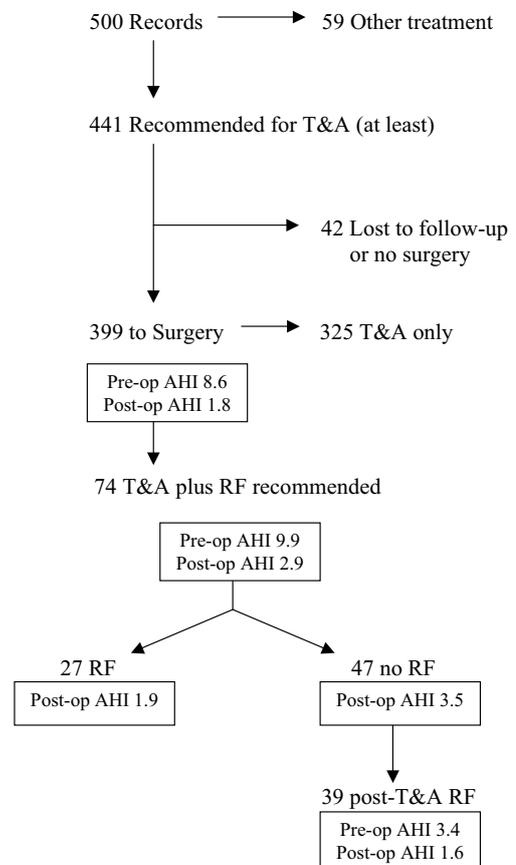


Fig. 1. Treatment of 500 prepubertal children with SDB.

disordered breathing (SDB) in the paediatric population. Despite the success of this surgical procedure, many children continue to have residual SDB following surgery.<sup>11,12</sup> Success has been reported with respect to the use of nasal steroids to improve sleep in children with allergic rhinitis, and safety has been demonstrated,<sup>13-15</sup> but we have found that some parents are reluctant to use these medications long term because of concerns of possible systemic side effects with continual use. Moreover, the likely long duration of therapy necessary to produce sufficient elimination of nasal resistance is a handicap. This is an important consideration in the growing child since nasal obstruction leads to an increase in nasal resistance and mouth breathing, which negatively affect the facial growth<sup>16-18</sup> as demonstrated both in the rhesus monkey experiments<sup>1,2</sup> and in long-term orthodontic follow-up studies examining the consequences of mouth breathing.<sup>17,18</sup> One must remember the rapidity of facial growth in childhood when making decisions regarding treatment modalities for nasal obstruction.

The advantages of the RF procedure are that it is minimally invasive, it is not an ablation, and it respects the role of the inferior turbinates in humidification of inspiratory air. Based on this set of studies, we can now add an additional advantage: turbinate reduction can be safely performed in the paediatric population. Kezirian et al<sup>19</sup> recently reported 1 minor complication of crusting in 89 adult patients treated with RF to the turbinates. The same authors also reported 0% of moderate and major complications after TCRF turbinate reduction from a review of published literature results,<sup>19-24</sup> which distinguishes this technique from other modalities used to reduce turbinates in children.<sup>25-29</sup>

One word of caution: the duration of effectiveness of this treatment modality in children is unknown, particularly in children with a history of chronic allergies. It is possible that RF reduction of the turbinates will need to be repeated in the future in some patients. Nonetheless, with an increasing understanding of the progression of SDB,<sup>30,31</sup> and the interplay between nasal obstruction and facial maldevelopment which further predisposes to OSA, maximising nasal patency quickly and safely should be considered in children with SDB and turbinate hypertrophy.

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