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Comparison of treatment outcomes between intracapsular and total tonsillectomy for pediatric obstructive sleep apnea

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ABSTRACT

Background: Intracapsular tonsillectomy (IT) has been advocated as a treatment for pediatric obstructive sleep apnea (OSA). However, evidence in the literature utilizing polysomnography (PSG) is limited.
Objective: To examine the experience at a tertiary children's hospital to evaluate the effectiveness and risks of intracapsular tonsillectomy compared to total tonsillectomy (TT) for treating pediatric OSA.
Methods: A retrospective study was undertaken of pediatric tonsillectomy cases performed for OSA at a tertiary children's hospital from 2005 to 2010. Patients with recurrent tonsillitis, craniofacial abnormalities, chromosomal abnormalities, neuromuscular disease, and congenital malformations were excluded. Main outcome measures were apnea-hypopnea index (AHI), minimum oxygen saturation ($minO_2$), and surgical complications.
Results: Of the 1583 patients reviewed in this study, there were 75 IT and 93 TT patients with pre- and post-operative PSG results. The IT patients were younger, had lower BMI, larger tonsil size, lower pre-operative (AHI) and lower post-operative AHI ($p < 0.05$). There was a similar percentage of patients that showed improvement in AHI and minimum oxygen saturation between the IT and TT groups. There were statistically similar average change in AHI and minimum oxygen saturation between the IT and TT groups at 5.6 ± 8.6 and 8.6 ± 12.9, respectively ($p = 0.8$) as well as similar improvement in minimum oxygen saturation between the two groups at $3.3\% \pm 4.3\%$ and $3.0\% \pm 5.2\%$, respectively ($p = 0.66$). Of TT patients, 2.9% experienced post-operative bleeding with 1.6% requiring OR for control of hemorrhage. Of IT patients, 2.2% were found to have tonsillar regrowth with 2.0% returning to the OR for secondary tonsillectomy.
Conclusions: Intracapsular tonsillectomy, like total tonsillectomy, is effective in improving polysomnogram results in appropriately selected children. Intracapsular tonsillectomy is a suitable option for the surgical treatment of pediatric OSA consequent to its demonstrated efficacy in relieving OSA and its favorable safety profile.

1. Introduction

Tonsillectomy is one of the most common procedures performed in the United States in the pediatric population, and obstructive sleep apnea (OSA) is the primary indication for this surgery [1,2]. Total tonsillectomy (TT) has been traditionally the procedure of choice and shown to be effective in treating pediatric obstructive sleep apnea [3]. Complications are uncommon but can lead to significant morbidity. Known risks of TT include post-operative oropharyngeal hemorrhage and dehydration, requiring admission for observation, pain control, and rehydration, or a return to the operating room for control of bleeding. The rates of post-tonsillectomy hemorrhage varies but has generally been reported to range from 1% to 3% [1,4].

In light of the risks of total tonsillectomy, we developed the concept of intracapsular tonsillectomy [5–7]. Rather than an extracapsular dissection in traditional TT, this technique removes tonsillar tissue but spares the capsule overlying the pharyngeal muscles and preserves them as a biologic dressing. This approach results in less post-operative pain and a quicker recovery with a more favorable safety profile consequent to reduced rates of post-operative bleeding [7–14]. The risk of post-operative hemorrhage has been reported from 1 to 3% with total tonsillectomy while bleeding after intracapsular tonsillectomy is usually reported to be

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much less than 1% [1,4].

Nevertheless, the question remains whether intracapsular tonsillectomy is as effective as TT in treating sleep apnea. Previous studies have shown improvements in sleep apnea symptoms after intracapsular tonsillectomy to be on par with total tonsillectomy [15–17]. However, there are relatively few studies comparing pre-operative and post-operative polysomnograms (PSG), which is the current standard for the diagnosis of obstructive sleep apnea. These studies have shown improvements in sleep study results for intracapsular tonsillectomy to be comparable to total tonsillectomy with potential for cure [17–20].

Our objective was to examine the experience at a tertiary children's hospital in terms of surgical outcomes after intracapsular tonsillectomy (IT) and compare them to total tonsillectomy (TT) as our control group. We hypothesize that intracapsular tonsillectomy produces similar improvements in sleep apnea measured by polysomnography while minimizing significant post-operative complications when the children are appropriately selected.

2. Methods

A retrospective study was conducted of pediatric tonsillectomy cases performed for OSA at a tertiary children's hospital from 2005 to 2010. The study protocol was approved by the Institutional Review Board at Stanford University. The Stanford Translational Research Integrated Database Environment (STRIDE) was utilized for selection of the cohorts and data acquisition. The STRIDE database is a clinical data warehouse integrating clinical data from pediatric patients cared for at our institution since 1995 and provides clinical and demographic data, clinical encounters and documents, ICD9-coded diagnosis, clinical procedures, radiology reports, surgical pathology reports, and laboratory results. The patient electronic charts were reviewed to clarify or supplement the STRIDE data. Patients under the age of 18 years, diagnosed with OSA either clinically or by polysomnography, and undergoing total or intracapsular tonsillectomy were included. All available post-operative events captured in the medical records up until the time of this report were included. Diagnosis of obstructive sleep apnea was made when AHI was greater than 1. Total tonsillectomies were performed using coblation, electrocautery, or cold technique by multiple surgeons operating at the children's hospital. Intracapsular tonsillectomies were performed either with coblation or microdebrider. Children with recurrent tonsillitis, craniofacial abnormalities, chromosomal abnormalities, neuromuscular disease, or congenital malformations were excluded.

All patient charts were reviewed for procedure performed, tonsillectomy indication, age, gender, and body mass index (BMI), tonsil size on exam, pre-operative and post-operative polysomnography results, and complications. The primary outcome measures were the change in polysomnogram results in terms of apnea-hypopnea index (AHI) and minimum oxygen saturation ($minO_2$). The change in AHI and minimum oxygen saturation after surgery was calculated by subtracting the pre-operative value from the post-operative value. The percentage of patients who showed improvement in AHI and minimum oxygen saturation were calculated by taking the number who improved divided by total patients. Secondary outcome measures were post-operative complications, namely oropharyngeal bleeding, dehydration, tonsillar regrowth, velopharyngeal insufficiency (VPI), and subsequent need for admission and surgery.

SPSS IBM software (Armonk, NY) was utilized for statistical analysis. Linear regression was performed for comparison of patient characteristics and PSG results between intracapsular tonsillectomy and total tonsillectomy. Adjustments were made for age, gender, BMI, and tonsil size, and pre-operative PSG results. Chi square and logistic regressions were utilized for statistical comparisons of complications between intracapsular tonsillectomy and total tonsillectomy. The Fisher exact test was used in instances where counts were less than 5. P-value < 0.05 was used for statistical significance.

3. Results

There were 1583 patients who underwent total or intracapsular tonsillectomy for obstructive sleep apnea from 2005 to 2010 at our institution who met inclusion criteria. Of these patients, 168 patients had both pre-operative and post-operative polysomnograms and were included in the primary PSG outcomes comparison. Ninety-three patients underwent total tonsillectomy while seventy-five patients underwent intracapsular tonsillectomy. Comparisons of the patient groups in Table 1 show that the children obtaining intracapsular tonsillectomies were younger (5 vs 9, $p < 0.001$), had lower BMI (16.6 vs 20.9, $p < 0.001$), but larger tonsil size (3.3 vs 2.7, $p < 0.001$). Post-operative AHI was lower in the partial intracapsular tonsillectomy group (4.5 vs 6.7, $p = 0.047$) but also started with lower pre-operative AHI (10.1 vs 15.3, $p = 0.008$).

Table 2 shows a comparison of the improvements in sleep study results after tonsillectomy. The relative number and percentage of patients showing improvement in AHI and minimum oxygen saturation after surgery was similar between the two groups. In the intracapsular tonsillectomy group, 76% of the children showed improvement in AHI and 79% showed improvement in their minimum oxygen saturation. For the total tonsillectomy group, 77% showed improvement in AHI and 70% showed improvement in minimum oxygen saturation. Despite the average change in AHI at 5.6 for intracapsular tonsillectomy cases being less than the change in AHI at 8.6 for total tonsillectomy, this was not statistically significant. Likewise, the actual changes in minimum oxygen saturation (3.3% and 3.0%, for IT and TT, respectively) after tonsillectomy were not statistically different between the two groups.

A total of 1583 patients were reviewed for complications. The percentage of complications between the IT and TT groups were statistically similar, but the complication profile for the two groups was significantly different (Table 3). In all, 2.6% of the patients who underwent IT (12 out of 455 patients) and 3.8% of the TT group (43 out of 1128 patients) experienced complications. Of these 12 IT patients with complications, 9 patients (2% of total) required return to the operating room for total tonsillectomy due to recurrent sleep apnea symptoms with regrowth of tonsils. Of the 43 patients in the TT complications group, 34 patient (3% of total) required re-admission and 18 patients (1.6% of total) required return to the operating room for control of oropharyngeal bleeding. The most

Table 1
Comparison of patient groups.

	Intracapsular tonsillectomy	Total tonsillectomy	p-value
Total patients	75	93	
Age	4.9 ± 2.8	8.5 ± 3.8	<0.001
Gender (M/F)	44/31	62/31	0.833
BMI	16.6 ± 2.7	20.9 ± 6.4	<0.001
Tonsil size	3.3 ± 0.7	2.7 ± 0.9	<0.001
PSG			
Pre-operative AHI	10.1 ± 9.9	15.3 ± 13.9	0.008
Pre-operative min O_2 (%)	88.8 ± 4.1	88.3 ± 5.9	0.789
Post-operative AHI	4.5 ± 5.3	6.7 ± 7.7	0.047
Post-operative min O_2 (%)	92.1 ± 3.0	91.3 ± 3.9	0.365

Abbreviations: m = male; f = female; PSG = polysomnogram; min = minimum; AHI = apnea hypopnea index; O_2 = oxygen saturation.
Values are provided as mean ± STD.

Table 2
Effects on sleep study after treatment.

	Intracapsular tonsillectomy (n = 75)	Total tonsillectomy (n = 93)	p-value
Pts w/improved AHI (%)	76%	77%	0.93
Pts w/improved $minO_2$ (%)	79%	70%	0.21
ΔAHI (±STD)	5.6 ± 8.6	8.6 ± 12.9	0.80
Δ$minO_2$ (% ± STD)	3.3 ± 4.3	3.0 ± 5.2	0.66

Abbreviations: Pts = patients; $MinO_2$ = minimum oxygen saturation; AHI = apnea hypopnea index; ΔAHI = change in AHI; Δ$minO_2$ = change in minimum O_2 saturation.
Values are provided as percentage or mean ± STD.

Table 3
Comparison of complications after treatment.

	Intracapsular tonsillectomy	Total tonsillectomy	p-value
Total patients	455	1128	
Total complications (%)	12 (2.6%)	43 (3.8%)	0.54
Oropharyngeal bleed (%)	1 (0.2%)	33 (2.9%)	0.02
Dehydration (%)	1 (0.2%)	9 (0.8%)	0.41
Tonsillar regrowth (%)	10 (2.2%)	0 (0%)	<0.001
VPI (%)	0 (0%)	3 (0.3%)	0.56

Abbreviations: VPI = velopharyngeal insufficiency.
Values are provided as number of patients (% of total).

common complications experienced by children undergoing TT were oropharyngeal bleeding (2.9%) and dehydration (0.8%) while only occurring in 0.2% in the IT group. The main complication for children undergoing IT was tonsillar regrowth at 2.2% ($p < 0.001$).

4. Discussion

Intracapsular tonsillectomy has been referred to in the literature as partial tonsillectomy, subtotal tonsillectomy, and tonsillotomy. The technique involves removal of tonsillar tissue only, while leaving the capsule intact over the pharyngeal muscles. In our study population intracapsular tonsillectomy was effective in improving obstructive sleep apnea when measured by polysomnography. This efficacy was comparable to total tonsillectomy, but our patients undergoing intracapsular tonsillectomy were on average younger with larger tonsils. There was no difference in the percentage of children who improved after surgery and also no difference in the magnitude of improvement in sleep study results. This is consistent with studies describing improvements in sleep symptoms and quality of life measures such as snoring and sleep disturbance for intracapsular tonsillectomy comparable to total tonsillectomy [14,16,17,21]. There are fewer comparisons made when examining sleep study results. Reilly et al. [20] showed improvement in AHI after intracapsular tonsillectomy. Tunkel et al. [17] showed that intracapsular tonsillectomy can cure sleep apnea, achieving an AHI<1. Mangiardi et al. [19] in a retrospective study with a small group of patients, showed no difference between partial and total tonsillectomy in regards to change in AHI, minimum oxygen saturation, and percentage of patients with post-operative AHI <5.

The technique of intracapsular tonsillectomy has its advantages over traditional total tonsillectomy in terms of post-operative recovery and complications. Patients undergoing intracapsular tonsillectomy experience less post-operative pain, utilize less pain medication, and are quicker to resume normal activity and diet [6,10,12,21]. Inadequate pain control, dehydration, and oropharyngeal bleeding can all result in telephone calls, visits to the clinic, visits to the emergency room, admissions, and potential returns to the operating room. Dehydration and oropharyngeal bleeding with return to the operating room have been shown to be more likely in total tonsillectomies and were confirmed in our study. We found significantly less postoperative oropharyngeal bleeding in the children undergoing intracapsular tonsillectomy. Only 1 patient, or 0.2%, experienced self-limited bleeding and this was assessed in the outpatient clinic without need for further intervention. Bleeding occurred in 2.9% of the total tonsillectomy group. A total of 1.6% required control of bleeding in the operating room. This is in line with reports in the literature for post total tonsillectomy hemorrhage in the range of up to 3% [1,4]. Windfuhr et al. [4] pooled data in the literature for intracapsular tonsillectomy compared to the control group of total tonsillectomy. Of the intracapsular tonsillectomy group, 0.26% required return to the operating room. This was in contrast with 2.1% of control patients who returned to the operating room for bleeding control.

There is strong anatomical evidence why intracapsular tonsillectomy is less likely to bleed. Lee et al. [22] measured the diameters of vessels around the surgical plane of tonsillectomy to investigate an anatomical basis to reduce hemorrhage. The diameters of the vessels in the intracapsular plane were significantly smaller than those at the capsular plane; and likewise, the diameters of the vessels at the capsular plane were significantly smaller than those at the extracapsular plane. The authors conclude that the differential diameter of the vessels across the tonsillar capsule are an important factor for minimizing postoperative hemorrhage after intracapsular tonsillectomy.

Opponents of intracapsular tonsillectomy point to the potential for regrowth and risk of tonsillitis in the patients who undergo intracapsular tonsillectomy. Because episodes of tonsillitis would not necessarily be treated in our clinic, this could not be accurately addressed in our retrospective study. Tonsillar regrowth was found in 2.2% of the intracapsular tonsillectomy cases, which is likely underestimated in our study given that not all patients were specifically seen in follow-up for evaluation of regrowth. Chan et al. [21] showed in a multi-site, randomized, controlled study that there was more residual tonsil tissue in patients who underwent intracapsular tonsillectomy compared to total tonsillectomy. This was not clinically significant since the frequency of pharyngitis and antibiotics use was comparable up to 12 months after surgery. Only 2% of the intracapsular tonsillectomy patients ultimately required a secondary total tonsillectomy for regrowth and recurrent symptoms. Windfuhr et al. [4] reviewed the literature on intracapsular tonsillectomy and found after pooling data that 3.2% of the 5630 patients were found to have tonsillar regrowth, 2.5% of 4169 patients experienced at least 1 episode of tonsillitis, and 1.5% of 5615 patients underwent secondary tonsillectomy. Therefore, while tonsillar regrowth leading to secondary tonsillectomy and episodes of tonsillitis can occur, these are infrequent.

Although polysomnography is the preferred adjunct for the diagnosis of obstructive sleep apnea, sleep studies are not always needed for the diagnosis of sleep apnea when the symptoms and anatomy are consistent with the diagnosis. Many children who are otherwise healthy, above the age of three, with no comorbidities, with strong reliable histories of OSA, and with large tonsils on exam can benefit from tonsillectomy without the need for a polysomnogram. Similarly, the clinical improvement seen postoperatively with tonsillectomy will often preclude the need for a follow up polysomnogram. Thus, there is likely a component of selection bias that complicated the analysis and influenced our results, but most likely without changing the outcome.

The proper terminology for the “partial” tonsillectomy” also bears comment. Tonsillotomy actually means “making a hole in the tonsil” [23]. This was a historical procedure done without anesthesia where the portion of the tonsil that was removed was that medial to the pillars. This was a very different operation than the

contemporary technique. When we developed the technique of "partial tonsillectomy", we emphasized the removal of the bulk of tonsil tissue from the fossa out to but within the capsule. Based on the insight of the importance of the capsule as well as the fact that total tonsillectomy is done deep to the capsule, in other words "subcapsular", we have continued to advocate the nomenclature of "intracapsular" tonsillectomy. Consistency in nomenclature would benefit professional communication.

5. Conclusions

Compared to total tonsillectomy, intracapsular tonsillectomy is less painful, has a shorter recovery, is quicker, and has greatly reduced rates of postoperative bleeding while remaining as effective in improving polysomnogram results in appropriately selected children. Because of the efficacy and favorable safety profile relative to total tonsillectomy, intracapsular tonsillectomy should be considered a suitable option for the surgical treatment of pediatric OSA.

Conflicts of interest

Dr. Peter Koltai is a design consultant for Acclarent. There are no disclosures for Dr. David Chang or Dr. Allison Zemek.

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