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Analyzing factors associated with major complications after adenotonsillectomy in 4776 patients: Comparing three tonsillectomy techniques

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ABSTRACT

OBJECTIVE: To compare the rates of major complications (postoperative hemorrhage requiring return to the operating room or cauterization in the emergency department and dehydration requiring intravenous fluids or readmission) in a large cohort of children undergoing adenotonsillectomy by three different techniques.

STUDY DESIGN: Case series with chart review, case-controlled study.

SETTING: Regional children's hospital.

SUBJECTS AND METHODS: Subjects comprised patients aged 1 to 18 years undergoing adenoidectomy, tonsillectomy, or adenotonsillectomy by microdebrider, coblator, or Bovie over a 36-month period. Major complications identified were compared to two case-matched controls to try to identify patients at risk for major postoperative complications.

RESULTS: The overall complication rate was 80 of 4776 (1.7 ± 0.4% [percent ± 95% confidence interval]). Of the 3362 patients who received either an adenotonsillectomy or tonsillectomy alone, 80 had a complication (2.3 ± 0.5%). Major complication rates differed among tonsil removal techniques: 34 of 1235 (2.8 ± 0.9%) coblation; 40 of 1289 (3.1 ± 0.9%) electrocautery; six of 824 (0.7 ± 0.7%) microdebrider ($P < 0.001$). Postoperative hemorrhage occurred in older children (8.5 vs 5.5 years; $P < 0.001$), while age did not influence postsurgical dehydration (5.33 vs 5.49 years). The case-control portion of the study did not find any reliable way to identify patients at risk for complications during adenotonsillectomy. Identity of the surgeon was not a confounding independent variable, nor was participation by resident surgeons.

CONCLUSION: In this "real life" teaching hospital surgical setting in which three different techniques of tonsillectomy are routinely performed by a variety of resident and attending surgeons, microdebrider intracapsular tonsillectomy is associated with lower rates of post-tonsillectomy hemorrhage and dehydration when compared to coblation and electrocautery complete tonsillectomy technique.

Tonsillectomy is among the oldest and most commonly performed procedures in the pediatric population. Approximately 530,000 outpatient pediatric adenotonsillectomies are performed annually in U.S. hospitals.[1] Despite the frequency of this procedure, there continues to be no universally accepted "ideal" method. Popular techniques include standard "cold steel" tonsillectomy as well as electrocautery techniques. Over the last decade, newer technologies have been introduced, such as coblation, Harmonic scalpel (Ethicon, Cincinnati, OH), CO_2 laser, bipolar scissors, PlasmaKnife (Gyrus, Tuttlingen, Germany), and microdebrider intracapsular tonsillectomy (MIT) (Medtronic, Jacksonville, FL). A surgeon may use these different techniques and technologies to perform either a complete tonsillectomy (extracapsular) or an intracapsular tonsillectomy, also referred to as a tonsillotomy.

The primary indication for tonsillectomy has changed over the years. Initial indications were mainly for recurrent pharyngitis, despite there being little conclusive support from the literature.[2,3] Anecdotal evidence throughout the professional and lay communities supported its continued use. Blakley and Magit[3] performed a meta-analysis in 2009, demonstrating that tonsillectomy reduced the incidence of recurrent pharyngitis by 43 percent. A Cochrane review of the effectiveness of adenotonsillectomy by Burton and Glasziou[4] in the same year concluded that the benefits of surgery were the greatest for those patients fulfilling the "Paradise criteria." Less severely affected children benefited from 1.3 fewer sore throat episodes and four fewer days of sore throat in the first year.

It has become clear that extreme hypertrophy of the adenoids and/or tonsils could obstruct the upper airway and result in obstructive sleep apnea (OSA). Over the past few decades, an increased awareness of the potential harm of OSA has developed, leading to OSA replacing recurrent pharyngitis as the most common indication for removal of the tonsils and adenoids in children.[5,6]

Despite generally being considered a safe procedure, tonsillectomy has significant morbidity and potential for

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complications, especially in the pediatric population. Potential complications include postoperative hemorrhage, anesthetic and airway risks, aspiration, pulmonary edema, atlantoaxial subluxation, mandible fracture/dislocation, eustachian tube injury, nasopharyngeal stenosis, velopharyngeal insufficiency, and psychological trauma.[7] Common postoperative complaints such as odynophagia, otalgia, fever, dehydration, and uvular edema tend to prolong the pediatric patient's recovery. Additionally, there is a less tangible toll on the parents who lose sleep and miss work to care for their convalescing children. In younger children, these risks from tonsillectomy are more critical, due to their smaller airways and lower blood volume.[6] With increased levels of awareness of OSA in the younger age groups has come an increased rate in which tonsillectomy is being performed in these groups, and consequently, the method of tonsillectomy has become even more important.

The objective of this study was to determine if surgical technique was associated with a patient experiencing a postsurgical complication when undergoing adenotonsillectomy at our institution, a regional children's hospital with an otolaryngology training program and both academic and private practice attending otolaryngologists. Additionally, we tried to identify patients "at risk" for major complications after their adenotonsillectomies.

Methods

Permission was obtained from the Institutional Review Board (IRB#08-03-WC-0049) at Eastern Virginia Medical School to perform a dual-institution case series with chart review of pediatric patients undergoing tonsillectomy, adenoidectomy, or adenotonsillectomy between February 2005 and February 2008 (consecutive). Patients were recruited from the senior author's (C.S.D.) academic practice and a collaborating private practice that performs surgeries at the same children's hospital.

Patients were identified using the hospital's electronic medical record (EMR) system utilizing the Current Procedural Terminology (CPT) codes for tonsillectomy and adenoidectomy. The EMR was then utilized to identify any postoperative complications during the 21-day postoperative period; specifically, the International Classification of Disease-9th Revision codes for dehydration, tonsillar bleeding, hematemesis, hemoptysis, and postoperative bleeding were used. Repeat admission and/or treatment in the emergency department for the above diagnoses or return trips to the operating room were also recorded.

Patients included in the study were children, aged 1 to 18 years, who had tonsillectomy, adenoidectomy, or adenotonsillectomy performed by coblation, electrocautery, or microdebrider over the three-year study period. Included subjects were patients of either the academic pediatric otolaryngology practice or the private otolaryngology practice at the hospital. A major postoperative complication was defined as an episode of postsurgical hemorrhage requiring a visit to the emergency department, postsurgical hemorrhage requiring surgical intervention, or hospitalization/emergency department visit for intravenous fluids secondary to dehydration.

The case-control portion of the study utilized the cohort of patients with complications identified from the above-described process and matched them with two control subjects based on age, gender, surgery performed, and the technique of removal. Demographic data, indications for surgery, comorbidities, surgical history, surgical information, and postsurgical information were recorded for each of the patients.

Independent sample *t* tests were performed to determine differences in number of complications by age when there were two variables, and one-way analysis of variance was used to determine differences in age when there were three variables. When P was < 0.05, least significant difference (LSD) post hoc testing was done to further clarify group differences. Rates of complication were compared by type of surgery and method of surgery using Fisher exact tests when there were more than two variables, and χ^2 analyses were used when there were only two variables. When P was < 0.05, relative risk was calculated for the case-control portion, and odds ratios were calculated for all else.

Results

From February 2005 to February 2008, 4776 consecutive adenotonsillectomy, adenoidectomy, and tonsillectomy procedures were performed at Children's Hospital of the King's Daughters (Table 1). Using the criteria established for defining major complications, a total of 80 patients were identified, for a 1.7 $\pm$ 0.4 percent (percent $\pm$ 95% confidence interval) overall complication rate. Table 2 breaks down the complications reported for each type of surgery performed. Males outnumbered females 2534 to 2242. There was not a statistically significant difference in the likelihood of a patient having any particular complication based on gender ($P = 0.437$).

Table 1
Patient characteristics

Total no. of patients (%)	4776 (100)
Male	2534 (53.1)
Female	2242 (46.9)
Tonsillectomy	262 (5.5)
Adenoidectomy	1414 (29.6)
Adenotonsillectomy	3100 (64.9)
Total no. tonsillectomy (%)	3362 (100)
Coblation	1235 (36.7)
Electrocautery	1289 (38.4)
Microdebrider	824 (24.5)
Other technique	14 (0.4)
Total no. adenoidectomy (%)	4514 (100)
Microdebrider	2559 (56.7)
Electrocautery	371 (8.2)
Coblation	272 (6.0)
Curette/adenotomes	1312 (29.1)

Table 2
Complications by surgery performed using coblation, electrocautery, or microdebrider

	Dehydration, n (%)	Hemorrhage, n (%)	Dehydration and/or hemorrhage, n (%)
Tonsillectomy and adenoidectomy (3100)	34 (1.1)	37 (1.2)	67 (2.2)*
Tonsillectomy (262)	6 (2.3)	9 (3.4)	13 (5.0)*
Adenoidectomy (1414)	0 (0)	0 (0)	0 (0)
Total (4776)	40 (0.8)	46 (1.0)	80 (1.7)*

*Six patients had both bleeding and dehydration.

Patient age proved to be a more significant factor in their treatment and outcome. The age distribution of patients demonstrated that younger patients underwent more adenotonsillectomies and adenoidectomies, while older children underwent more tonsillectomies. The mean age of the total group was 5.6 years. The mean age for patients undergoing tonsillectomy was 8.9 years, versus 6.2 years for patients undergoing adenotonsillectomy ($P < 0.001$). Adenoidectomy had the youngest mean age: 3.9 years. There was a statistically significant difference in the distribution of the age of patients who underwent adenotonsillectomies versus the age of those patients who had major complications. The mean age of children with a major postsurgical complication was 7.1 years, versus 5.5 years (mean age of children who underwent adenotonsillectomies) ($P = 0.012$). Further analysis demonstrated that there was a difference in the mean age of children who experience a postsurgical hemorrhage versus postsurgical dehydration: 8.5 years versus 5.3 years, respectively. Of the 40 patients with postsurgical dehydration, the average age was 5.3 years. This was not significantly different from the average age of children without dehydration: 5.5 years ($P = 0.484$). This differed from the average age of children with and without postoperative hemorrhage. The mean age of those with hemorrhage was 8.5 years, versus 5.5 years for those without hemorrhage ($P < 0.001$). The mean ages for tonsil removal by technique were six years for coblation, six years for electrocautery, and five years for MIT.

There were 3362 patients who underwent either an adenotonsillectomy or tonsillectomy alone. Adenoidectomy alone was performed in 4514 patients (including adenotome/curette); however, when looking only at the three techniques studied, this number was reduced to 3202 patients. Table 1 summarizes the breakdown by instrument. Our data demonstrated that adenoidectomy is an extremely safe procedure no matter the technique employed, with only two complications for all patients, both in the adenotome/curette group. There were no major complications reported in any of the children who underwent an adenoidectomy alone using coblation, electrocautery, or microdebrider.

There was a statistically significant difference in the risk of developing a major complication based upon having a tonsillectomy with coblation, electrocautery, and microdebrider ($P = 0.001$). The microdebrider had the lowest overall complication rate at 0.7 percent, versus 2.8 percent for the coblator and 3.1 percent for the electrocautery (Fig 1). We found those who had tonsillectomies via coblation were 3.9 (95% CI, 1.6-9.2) ($P = 0.001$) times more likely than those who had tonsils removed via microdebrider to have complications, and that patients who had tonsillectomies via electrocautery were 4.4 (95% CI, 1.8-10.3) ($P < 0.001$) times more likely than those who had tonsils removed via microdebrider to have complications. Interestingly, there was not a statistically significant difference in odds ratio between tonsillectomy by coblation or electrocautery and complication: 0.9 (95% CI, 0.6-1.4) ($P = 0.638$).

Overall, six subjects returned to the operating room for postsurgical hemorrhage (0.13%). Of those, five had adenotonsillectomy and one had tonsillectomy only. Four of the six had electrocautery tonsillectomy, and two had coblation tonsillectomy. There were no return trips to the operating room for any of the microdebrider tonsillectomy patients. Of note, there were no deaths, and no patients required transfusions due to intraoperative blood loss or postoperative hemorrhage. None of the episodes of post-tonsillectomy hemorrhage were primary in nature. Identity of the surgeon was not a confounding independent variable, nor was participation by resident surgeons.

The second part of this project was to perform a case-control study utilizing the data from the case series to try to identify patients at risk for postsurgical complications. The

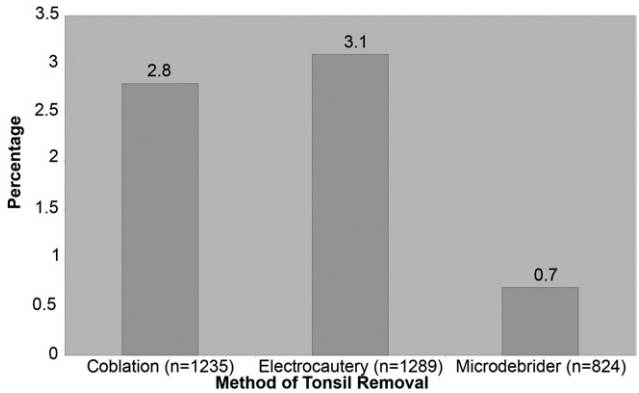

Figure 1 Major complications after tonsil removal.

Table 3
Tonsillectomy complications by technique

	Proportion (percent ± 95% confidence interval)		
	Dehydration	Hemorrhage	Dehydration and/or hemorrhage
Coblation	19/1235 (1.5 ± 0.7%)	19/1235 (1.5 ± 0.7%)	34/1235 (2.8 ± 0.9%)*
Electrocautery	18/1289 (1.4 ± 0.8%)	24/1289 (1.9 ± 0.7%)	40/1289 (3.1 ± 1.0%)*
Microdebrider	3/824 (0.4 ± 0.4%)	3/824 (0.4 ± 0.4%)	6/824 (0.7 ± 0.6%)
Total	40/3348 (1.2 ± 0.4%)	46/3348 (1.4 ± 0.4%)	80/3348 (2.4 ± 0.5%)

*Six patients undergoing tonsillectomy had both dehydration and hemorrhage.

80 patients identified with major postoperative complications from adenotonsillectomy, adenoidectomy, and tonsillectomy were matched to two control subjects based on the criteria listed in the Methods section. The data obtained did not reliably predict which children were at risk of having a complication. They did, however, allow us to determine that surgical indication was not statistically significant between techniques for those patients who had a major complication.

Discussion

MIT was introduced by Koltai et al in 1997 for adenoidectomy and in 2002 for the indication of tonsillectomy.[8-10] Multiple studies have demonstrated the safety and efficacy of MIT, making it a valuable treatment option in children with tonsillar hypertrophy.[11-14] Derkay et al[15] performed the first prospective, randomized, controlled trial evaluating perioperative outcomes and demonstrated the superiority of MIT to low-wattage electrocautery technique for tonsillectomy in children with OSA. The "biologic dressing" has been theorized as the reason for these improved perioperative surgical outcomes when using intracapsular tonsillectomy.[8,12] Johnson et al[16] used a canine model to substantiate this theory on a histopathological level. They found that MIT demonstrated significantly faster healing scores when compared to a total tonsillectomy performed using low-wattage electrocautery.

Our main objective in this study was to try to determine how surgical technique affects a child's risk of developing a major postsurgical complication when undergoing an adenotonsillectomy. Our regional children's hospital has both academic and private otolaryngology practices utilizing its operating rooms. The academic practice comprises two pediatric otolaryngologists and numerous supervised resident surgeons, while the private practice group consists of six board-certified general otolaryngologists. The tonsillectomy techniques used at the academic practice include either low-wattage electrocautery total tonsillectomy or microdebrider intracapsular tonsillectomy/adenoidectomy for the indication of OSA, and electrocautery complete tonsillectomy for the indication of recurrent tonsillitis. The private practice otolaryngologists use either low-wattage electrocautery or coblation for their tonsillectomy patients, regardless of the indication. Techniques for adenoidectomy vary among physicians for both practices. Since our results showed that adenoidectomy is an extremely safe procedure at our institution, no matter the technique employed, it appears that the method of tonsil removal is the critical factor when trying to determine the risk of developing a major postsurgical complication. Table 3 demonstrates that patients in the microdebrider group (0.7 ± 0.7%) had significantly fewer major complications when undergoing tonsillectomy than those patients who had either electrocautery (3.1 ± 0.9%) or coblator (2.8 ± 0.9%). This statistical significance between techniques remained consistent when looking at each major complication individually (Figs 2 and 3).

Additionally, patient age proved to be a significant factor in treatment and outcome following tonsillectomy. When looking at the average age of dehydration and post-tonsillectomy hemorrhage, we observed that the younger patients had more episodes of dehydration (5.3 years), and the older patients tended to have more episodes of post-tonsillectomy hemorrhage (8.5 years, $P = 0.001$). When we compared the average ages of those patients who had complications to those who had none, there was a statistically significant difference in the mean age of those with post-tonsillectomy hemorrhage. However, there was no statistically significant difference between the average ages of those who had dehydration and those who did not (Table 4). Mean age by technique was found to be six, six, and five years for coblation, electrocautery, and MIT, respectively. This was not clinically significant and represents similar patient groupings.

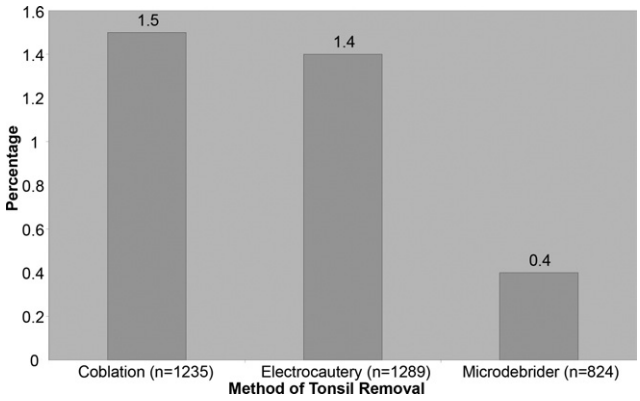

Figure 2 Dehydration after tonsil removal.

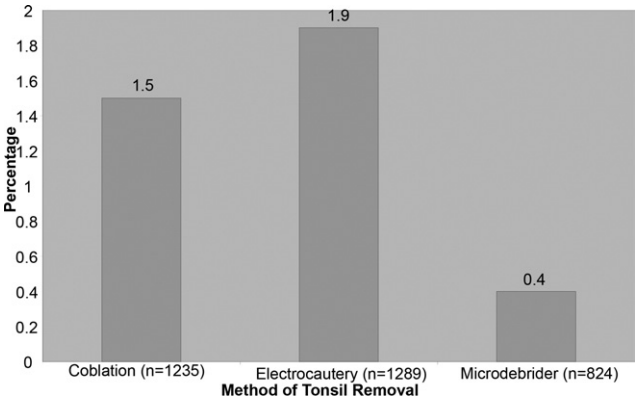

Figure 3 Hemorrhage after tonsillectomy.

The mean age for patients undergoing tonsillectomy alone was 8.9 years, versus 6.2 years for patients undergoing adenotonsillectomy ($P < 0.001$). Erickson et al[17] recently studied the changes in incidence and indications of tonsillectomy and adenotonsillectomy. In their cross-sectional survey of 35-year trends in over 8000 patients, they saw a surge in the incidence of adenotonsillectomy in young children (6.8 years), whereas the mean age for tonsillectomy was 15.9 years. The indication for surgery is one potential explanation for the difference in postoperative complications. Although we did not record the indication for surgery when collecting our data for the case series, we did record indication for our case-control portion of the study. In our review of those patients with a major complication, we found no significant association between having the indication of recurrent tonsillitis and having postoperative hemorrhage, nor did we find a significant association between having the indication of OSA and having dehydration.

A review of recent studies comparing postoperative bleeding and dehydration rates among tonsillectomy techniques supported our data. In 2005, Solares et al[12] performed a retrospective, multicenter review of postoperative complications with tonsillectomy in 1991 children, 870 of whom underwent MIT for relief of OSA. They reported that children who underwent MIT had significantly less postoperative bleeding (0.8% vs 3.3%) and readmission for dehydration (1.1% vs 3.6%) and a decrease in overall major complications (1.9% vs 6.9%) compared to patients who had a total tonsillectomy. Additionally, they found regrowth requiring reoperation in four of the 870 patients (0.46%). Sorin et al[11] studied complications of MIT and found an overall complication rate of 3.9 percent (11 of 278) when looking retrospectively at return of preoperative symptoms, snoring, tonsillar regrowth, bleeding, velopharyngeal insufficiency, and readmission. The study included 278 children and excluded patients with the diagnosis of recurrent tonsillitis. The majority of the complications listed in this study were due to tonsillar regrowth (9 of 11 patients, 3.2% of total), while only 0.7 percent of these patients had post-tonsillectomy hemorrhage. Due to the retrospective nature of our study, tonsillar regrowth was not one of the outcomes.

Other criticisms of MIT include increased intraoperative blood loss (IBL). Although measurement of IBL was not an objective of this study, there is some literature regarding the relationship of MIT and IBL. In an article evaluating post-tonsillectomy morbidity and quality of life, Derkay et al[15] evaluated estimated IBL in a prospective, single-blinded, randomized controlled trial. They reported that electrocautery had statistically significantly less estimated IBL than MIT. The authors concluded, however, that this was not clinically significant. A definitive, prospective study measuring the difference in IBL between electrocautery tonsillectomy and MIT was published this past year.[18] Using actual, not estimated, IBL measurements, as well as volume lost as a fraction of each child's weight, electrocautery again had significantly less IBL than MIT (0.2 mL/kg vs 1.2 mL/kg, $P < 0.001$). The authors' conclusion was similar: although statistically significant, the difference in IBL was not clinically significant.

There are several weaknesses to our study that center primarily on the retrospective, observational nature of our data. The design limits our ability to substantiate our results. Second, our data rely on the accuracy of EMR coding. Any errors in data entry could skew our results in either direction. Additionally, it is possible that patients with complications did not return to our institution for management of their complications and therefore were missed by our data collection technique. However, we are the only children's hospital in the region, and very few of our surrounding adult hospitals provide otolaryngology coverage capable of managing a post-tonsillectomy bleed or dehydration episode in a child. Even so, we would expect that treatment at outside facilities would occur with the same frequency among all the techniques.

There are a total of nine attendings and numerous residents performing tonsillectomies at our institution. Virtually all of the attending/supervised residents routinely used low-

Table 4
Comparison of average ages in post-tonsillectomy complication

	Average age, yrs (median)		
	Complication	No complication	*P* value
Hemorrhage and/or dehydration	7.1 (6)	5.5 (5)	0.012
Dehydration	5.3 (5)	5.5 (5)	0.484
Hemorrhage	8.5 (8)	5.5 (5)	<0.001

wattage cautery to some degree, while only the private practice otolaryngologists used coblation on a regular basis. Only the academic attending/supervised residents used the microdebrider routinely. We thought this could potentially bias the results toward worse, not better, outcomes with the microdebrider technique. One final weakness is that this study indirectly compares complications of intracapsular versus complete tonsillectomy techniques. Chang, in 2008,[19] compared intracapsular coblation tonsillectomy and subcapsular (complete) coblation tonsillectomy for OSA in 69 children. Children with intracapsular tonsillectomy had less pain at days five and six and better oral intake than the patients in the subcapsular arm of the study. In this study, the same instrument was used for each tonsillectomy technique, demonstrating that technique, not instrument, may be responsible for better outcomes.

It should be mentioned that no matter which surgical technique was used for removal of the tonsils at our institution, our results demonstrate an acceptable level of safety. Specifically, looking at microdebrider bleeding rates (Fig 2), we found three patients out of 824, for a 0.4 ± 0.4 percent (percent ± 95% confidence interval) postoperative bleeding rate. Electrocautery had a postoperative bleeding rate of 1.9 ± 0.7 percent (24 of 1289), and coblation had a postoperative bleeding rate of 1.5 ± 0.7 percent (19 of 1235). No postoperative bleeds were primary in nature. Blakley published a recent commentary[20] evaluating the rate of post-tonsillectomy bleeding cited in the literature. He reviewed 63 articles that met his inclusion criteria and found an average post-tonsillectomy bleeding rate of 4.5 percent. All three techniques performed at our institution are well below this rate. Additionally, the rate for return to the operating room for operative control of post-tonsillectomy hemorrhage was only 0.13 percent.

Conclusion

Questions remain regarding what is the best procedure for tonsillectomy. However, in this "real life" surgical setting, in which three popular techniques of tonsillectomy were routinely performed by a variety of resident/attending surgeons, MIT was associated with lower rates of post-tonsillectomy hemorrhage and dehydration when compared to the coblation and electrocautery complete tonsillectomy techniques. Although our study has inherent weaknesses associated with its retrospective design, our results in this large cohort of patients add to the body of literature supporting the safety of intracapsular tonsillectomy.

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