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Cost-Utility Analysis of Intracapsular and Extracapsular Techniques for Pediatric Tonsillectomy

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ABSTRACT

Objectives: To determine the incremental cost-effectiveness of intracapsular pediatric tonsillectomy.

Methods: A prospective cohort with cost-utility analysis included all ambulatory and observation tonsillectomies on pediatric patients (< 18 years) at a tertiary children's hospital between 2020 and 2024. Intracapsular coblation tonsillectomy (ICT) or extracapsular tonsillectomy (ECT) was performed with 30-day outcomes used for model inputs. Costs were expressed in US dollars from the perspective of a hospital system. Utility was based on published ranges.

Results: There were 5425 tonsillectomies performed (604 ICT [11%] and 4821 ECT [89%]). Among 2614 ambulatory procedures, ICT was associated with lower costs (β: −426.6, 95% CI: −631.7 to −221.4, $p < 0.001$). Mean ambulatory ICT costs were $4716 with a quality-adjusted life year (QALY) of 0.94 yielding a cost-effectiveness (C/E) ratio of $5008/QALY. For ambulatory ECT, mean costs were $5400 with a QALY of 0.93 yielding a C/E ratio of $5777/QALY. Ambulatory ICT had an incremental cost-effectiveness ratio (ICER) of −$100,141/QALY. Among 2811 observation tonsillectomies, ICT did not impact costs with an ICT C/E ratio of $10,067/QALY and ECT C/E ratio of $10,209/QALY. The ICER for observation ICT cases was −$16,453/QALY. One-way sensitivity analysis determined that ICT revision rates less than 14.5% for ambulatory or 0.9% for observation cases produced lower costs than a single ECT.

Conclusions: ICT dominates ECT for cost-effectiveness after pediatric tonsillectomy with greater advantages in ambulatory cases. Even when considering the rare potential for revision, offering ICT can substantially reduce the economic impact of this common childhood surgery.

Level of Evidence: III.

1 | Introduction

Modern evidence for pediatric intracapsular tonsillectomy was championed by the work of Koltai et al. describing reduced pain, dehydration, and delayed bleeding after partial tonsillectomy with a microdebrider [1, 2]. Intracapsular tonsillectomy avoids exposing the pharyngeal musculature [3] and has been performed using a variety of techniques and equipment [4, 5]. While high-quality studies have shown improved outcomes with a combination of approaches [6–8], more recent evidence has specifically confirmed lower pain and bleeding after intracapsular coblation tonsillectomy (ICT) [9–12].

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The coblator results in less intraoperative blood loss and allows for a cleaner field that improves precision in tissue removal [13]. Coblation employs radiofrequency bipolar electrical current through a medium of isotonic sodium chloride and creates a plasma field of sodium ions. These charge-carrying ions have sufficient energy to break down intercellular bonds and dissolve tissue at a temperature between 40°C and 70°C (degrees Celsius). The presence of saline irrigation limits the thermal energy delivered to surrounding structures and thus minimizes postoperative pain seen with electrocautery that can exceed 100°C [14, 15]. Coblation has several advantages beyond microdebrider-assisted intracapsular tonsillectomy including the avoidance of electrocautery for hemostasis. There is also no fire risk and it should be considered when blood loss needs to be kept at a minimum during surgery. ICT has a learning curve and the potential for injuring the pharyngeal mucosa or tonsillar pillars needs to be monitored. Nonetheless, the coblator is well-suited for intracapsular tonsillectomy in children.

The American Academy of Otolaryngology—Head and Neck Surgery Foundation (AAO-HNSF) has not commented on intracapsular techniques for children in their latest tonsillectomy clinical practice guideline [16]. Given the strong comparative data with regards to pain, bleeding, and regrowth, the AAO-HNSF encouraged prospective studies on effectiveness, quality-of-life, and very long-term outcomes to support inclusion in subsequent guidelines [17]. Even with growing interest in this approach [18], the concern for tonsillar regrowth and potential revision surgery leads to only 20% of otolaryngologists adopting intracapsular tonsillectomy in a recent survey [19]. Revision has been needed after 1.39%–2.6% of intracapsular tonsillectomies depending on technique and follow-up length [9, 20–22].

Improving pediatric tonsillectomy outcomes can have dramatic effects from a health economic perspective. In 2019, an estimated 560,000 ambulatory pediatric tonsillectomies were performed in the United States [23]. The substantial resource utilization for this common surgery justifies cost-effectiveness analyses whenever alternative options exist. These analyses have been performed across a variety of healthcare choices to support judicious, efficient, and fair decisions regarding the use of healthcare resources [24]. In fact, the AAO-HNSF recognized the need for research determining the direct and indirect cost-effectiveness of different tonsillectomy techniques [16]. Evidence on cost-effectiveness of intracapsular versus extracapsular tonsillectomy (ECT) has been limited and modeling suggests an advantage for ECT driven primarily by the potential need for revision surgeries [25, 26]. Unfortunately, these studies were based on cost estimations from nationwide data, used a variety of studies to approximate frequency of events, and did not specifically focus on coblation.

An economic analysis determining the effectiveness of ICT based on actual cost data using prospectively captured outcomes is required to meet this research need. This information would allow key stakeholders to reconsider tonsillectomy techniques from a perspective that incorporates the health economic impact. The primary objective of this study is to determine the incremental cost-effectiveness of ICT and ECT. Prospectively captured data from a large hospital system offers a more precise measure of model inputs than studies utilizing a variety of data sources. Secondary objectives included a comparison of posttonsillectomy bleeding, readmissions, caregiver-reported outcomes, polysomnogram data, and factors correlated with total costs after pediatric tonsillectomy. A sensitivity analysis exploring the impact of possible revision intracapsular surgeries on estimated costs was also performed. We hypothesized that ICT would have improved outcomes with reduced cost and a near-equivalent utility benefit that results in a measurable cost-effectiveness over ECT.

2 | Materials and Methods

A prospective cohort study of all tonsillectomy surgeries performed at a large and urban tertiary children's hospital included cases between January 1, 2020, and April 1, 2024. Only patients younger than 18 years of age that met the indication for tonsillectomy were included. The enrollment into a tonsillectomy database commences at the conclusion of surgery based on the documentation of tonsillectomy or tonsillectomy with adenoidectomy by operating room (OR) staff into the Electronic Medical Record (EMR). All cases are entered daily from any OR location within the hospital system, and the database automatically refreshes every 24 hours. A detailed report of all patients and outcomes is published every 30 days. The review and dissemination of this data for research purposes was approved by the institutional review board with exemption.

Several exclusion criteria were applied. First, patients that had an inpatient (IP) tonsillectomy (planned hospitalization greater than 23 h) were excluded due to long and costly admissions associated with these cases. Second, cases performed outside of the main hospital and the associated ambulatory surgery center were excluded to maintain consistent patient populations. Third, any tonsillectomy case not captured by the Children's Hospital Association (CHA) Pediatric Health Information System (PHIS) Database was also excluded. The PHIS is a comparative database with clinical and resource utilization data for IP, ambulatory surgery, emergency department (ED), and observation unit encounters for more than 49 children's hospitals. This institution participates in the PHIS and receives reports based on abstracted discharge information with 30-day outcomes. Of note, children receiving additional procedures at the time of their tonsillectomy, such as ear tube placement, nasal cautery, or laryngoscopy, were included in this analysis.

The tonsillectomy database collects the following patient characteristics: age at surgery (years), sex (male/female), race (Asian, Black, or African American, White, other, unknown/refused), ethnicity (Hispanic/Non-Hispanic), surgical indication (obstructive/sleep apnea, infectious, other/unknown), payor category (government, commercial, other/unknown), and median household income based on zip code in US dollars (USD). Patient race and ethnicity are self-identified by caregivers, with additional characteristics from the EMR. Several comorbidities are recorded based on *International Classification of Diseases, 10th Revision—Clinical Modification* (ICD-10-CM) terminology present or diagnosed during the initial surgical admission. This includes: Trisomy 21, obesity, obstructive sleep apnea, congenital defects, complex chronic diagnosis, or complicated patient (which includes a diagnosis of reactive airway, craniofacial diagnosis, neuromuscular disorder, prematurity, or congenital cardiac disease).

2.1 | Primary Objective

The primary objective of this study was to determine the incremental cost effectiveness ratio (ICER) within 30 days after tonsillectomy between children obtaining ICT and ECT. Children obtaining an ICT performed by an individual fellowship-trained pediatric otolaryngologist were compared to children receiving ECT from a team of 12 pediatric otolaryngologists. The ICT technique was consistent across all procedures and was performed using coblation technology for both the tonsillectomy and adenoidectomy. A small number of adenoidectomy procedures from early cases included the use of suction electrocautery but did not impact the tonsillectomy technique. All patients obtaining adenotonsillectomy by this surgeon received ICT and there was no randomization to technique within or across surgical groups. A near total removal of the tonsil was performed leaving less than 10% of residual tissue. For the ECT group, most surgeons utilized electrocautery, with lesser numbers using coblation or bipolar electrocautery for removal of the entirety of the tonsillar tissue. Perioperative steroids and narcotics are routinely administered by anesthesia providers at our institution, whereas incisional lidocaine and prophylactic antibiotics are not used by surgeons for tonsillectomy. Residents and fellows were involved in a comparable subset of cases across both the ICT and ECT groups.

From a cost perspective, the PHIS database identifies costs for each index admission based on abstracted discharge documents. In addition, total costs are captured for each subsequent readmission within 30-days to the ED or as an IP at this same institution. Total costs were then calculated as the sum of index admission and any subsequent 30-day admissions. Actual costs were standardized in USD to allow for comparison across institutions and did not include any collected physician fees. Total hospital costs included all direct expenses such as equipment use or disposable instruments (e.g., microdebrider blades or coblation wands).

2.2 | Secondary Objectives

Several secondary objectives were included to further compare ICT and ECT surgeries. Postoperative outcomes within 30 days of surgery are prospectively captured by the institutional tonsillectomy database and were cross-validated by the retrospective data from the PHIS. This included: length of index admission (days), return to the hospital for bleeding (yes/no), return to the hospital for vomiting (yes/no), return to the hospital for pain (yes/no), surgical complication (yes/no), ED readmission (yes/no), IP readmission (yes/no), or OR control of bleeding (yes/no). The otolaryngology department offers a 24-h nursing line service for parents to contact should there be questions or concerns. Calls to the nursing line within 30 days of surgery were recorded, including the primary reason for call as documented by the triage nurse. The number of calls related to a postoperative problem was specifically noted.

Approximately 6 weeks after surgery, the nurses within the otolaryngology department contact caregivers to assess recovery. This occurs via telephone, email, or text message based on caregiver preference. Results are prospectively recorded by the tonsillectomy database based on documentation within the medical record. Parents are asked the following yes or no questions: "Has their child's appetite returned to normal?," "Does their child tolerate the same foods as before?," "Is their child back to normal activity?," "Are there concerns about their child's voice?," "Is their child still requiring pain medication?," "Is their child still snoring or mouth breathing?," "Have there been any visits to the hospital or ED?," and "Was there any bleeding within 3 weeks of surgery?" If a family could not be contacted after three attempts, then these questions remained unanswered. Additionally, patients who had a scheduled follow-up visit around the 2–3-months range would not be contacted given the appointment.

A subset of children obtained preoperative and postoperative polysomnograms (PSG) for OSA. Studies obtained at this institution were able to be prospectively captured by the tonsillectomy database with respiratory disturbance index (RDI) used as a single metric. The following information was captured: preoperative RDI (events/h), preoperative RDI > 5 events/h (yes/no), days PSG obtained before surgery, postoperative RDI (events/h), postoperative RDI < 5 events/h if initially > 5 events/h (yes/no), preoperative RDI < 1 event/h (yes/no), RDI reduced (yes/no), and days after surgery PSG obtained. Only children with preoperative and postoperative PSG and with an initial RDI > 1.0 events/h were analyzed.

2.3 | Economic Evaluation

A health economic analysis plan was not established at the onset of prospective enrollment but was developed using the results from collected data. The study perspective is from the hospital system and includes direct medical costs. No indirect costs or estimated charges were included. The time horizon was set at 30 days after tonsil surgery to capture the maximal amount of postoperative costs. No discounting was performed due to the lack of long-term economic impact and since tonsillectomy outcomes are realized over a short period of time.

A decision-tree model was created for children that met indication and underwent ambulatory (no planned 23-h admission) or observation (planned 23-h admission) tonsillectomy. Procedures were separated into ambulatory and observation to reflect differences in patient comorbidities and postoperative course that would impact costs and outcomes. Decision pathways were created for ICT and ECT cases based on three possible outcomes with varied admission states. A recovery could either proceed uncomplicated without readmission; result in a posttonsillectomy bleed or hemorrhage requiring an ED visit, IP admission, or both; or result in pain or dehydration requiring an ED visit, IP admission, or both. The actual costs from the patients developing these events were calculated, and the frequency of patients in the prospective database that sustained these specific outcomes was determined.

Outcomes were then associated with utility values to estimate quality adjusted life years (QALY). Prior studies have offered values for utility after varied posttonsillectomy states and were used for the basis of this model [25, 26]. Notably, the impact of bleeding was more heavily weighed as a negative outcome in this analysis given the impact on patient, family, and the potential for mortality [27]. As a result, an uncomplicated recovery yields a QALY value of 0.95 with a reduction of 0.15 for an ED readmission, 0.30 for an IP readmission, or 0.45 reduction for both ED and IP readmissions due to bleeding. Pain or dehydration resulted in a reduction of 0.05, 0.10, and 0.15 for ED, IP, or ED and IP readmissions from an uncomplicated QALY baseline, respectively.

Finally, several steps were taken to interpret the results of the cost-utility analysis. An ICER curve was created for both ambulatory and observation cases. A willingness to pay (WTP) threshold of $100,000/QALY was selected to compare with the ICER and determine the cost-effectiveness of ICT. As a method to assess the uncertainty in these results, 1000 Monte Carlo simulations were performed to estimate the percent of iterations that would be cost effective across varied WTP thresholds. Given concerns over the potential need for revision of ICT, a one-way sensitivity analysis was conducted to compare estimated costs between a single ECT and ICT with a range of theoretical second ICT.

Several assumptions were made in creating this model:

1. All costs are incurred in the first 30 days after surgery and no readmissions occurred outside of this hospital system. Any complication not resulting in a revisit would not have a meaningful cost.
2. A child would only have a readmission for bleeding or pain/dehydration, but not both, and each of these could result in only a single ED visit, single IP visit, or both a single ED or IP visit. Multiple revisits were not recorded nor modeled.
3. The assigned utility values would be consistent for all patients within each outcome pathway, and the utility level at a given outcome would be the same for both techniques.
4. The potential for a revision ICT procedure reflected the small subset that had clinically significant regrowth and not any amount of residual tonsillar tissue. Further, the costs, effects and proportions of a revision ICT would be identical to that of the initial surgery.

2.4 | Statistical Analysis

All statistics were performed with Stata (StataCorp. 2023. *Stata Statistical Software: Release 18*. College Station, TX: StataCorp LLC.). Simple logistic regression was used to compare ICT with ECT across a variety of categorical data. These results are presented in odds ratios (OR) with 95% confidence intervals (95% CI) and p values. Reference variables were identified for variables with more than one group. To determine factors associated with total costs, simple linear regression was used, and β coefficients were obtained with 95% CI. Variables strongly significant on simple analysis ($p < 0.001$) were added to a multivariable linear regression model for total costs. Stepwise removal of nonsignificant variables was performed until the strongest model remained. Categorical variables were also compared using Fisher's exact testing, while student's t testing was utilized for continuous variables. Statistical significance was set at $p < 0.05$. All economic analyses were performed using TreeAge Pro (Healthcare Version) Version: 2024. (*TreeAge Software*: *LLC*, Williamstown, MA). Actual cost data with means and standard deviations (SD) were calculated from the prospective database. Total costs were assessed for normality using descriptive statistics (mean [SD] and median with interquartile range [IQR]) along with formal testing of skewness/kurtosis. If data was skewed, the skewness/kurtosis test would be significant ($p < 0.001$). While the primary analysis used linear regression models for ease of interpretation, a sensitivity analysis using a generalized linear model (GLM) with a gamma distribution and log link was conducted, which is well-suited for positively skewed cost data. Probabilities of events were also determined. Categorical data were presented as counts with percentages. This cost-utility analysis followed recommendations from the Second Panel on Cost-Effectiveness in Health and Medicine [24] and utilized the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) 2022 statement guidelines [28].

3 | Results

3.1 | Baseline Characteristics

Between 2020 and 2024, a total of 5425 pediatric tonsillectomy procedures were performed with 604 ICT cases (11%) and 4821 ECT cases (89%). There were 2614 ambulatory tonsillectomies including 367 ICT (14%) and 2247 ECT (86%) cases. Simple logistic regression comparing ICT and ECT patient characteristics is shown in Table 1. Differences included a lower odds of Black or African American patients in the ICT group (OR: 0.64, 95% CI: 0.48–0.87, $p = 0.004$), more unknown/refused ethnicity in the ICT group (OR: 2.10, 95% CI: 1.04–4.22, $p = 0.04$), and greater commercial payors among ICT cases (OR: 1.44, 95% CI: 1.14–1.92, $p = 0.002$). A greater odds of ambulatory ICT cases were for other/unknown indications (OR: 3.85, 95% CI: 2.54–5.85, $p < 0.001$) and were less likely to have an OSA diagnosis (OR: 0.50, 95% CI: 0.37–0.67, $p < 0.001$). The groups were otherwise similar and Table S11 provides detailed values.

There were 2811 observation tonsillectomies during that same period with 237 ICT (8.4%) and 2574 ECT (92%) cases. On simple logistic regression (Table 2), the ICT patients were more likely to be younger (OR: 0.94, 95% CI: 0.90–0.97, $p < 0.001$), more likely to be unknown/refused race (OR: 2.47, 95% CI: 1.06–5.72, $p = 0.04$), and more likely to be unknown/refused ethnicity (OR: 3.92, 95% CI: 1.77–8.66, $p = 0.001$). Further, surgical indication was often for other/unknown (OR: 4.08, 95% CI: 2.70–6.18, $p < 0.001$) for ICT cases, with these children being diagnosed with Trisomy 21 (OR: 1.78, 95% CI: 1.08–2.95, $p = 0.02$), a congenital defect (OR: 1.78, 95% CI: 1.13–2.80, $p = 0.001$), or a complex chronic diagnosis (OR: 1.65, 95% CI: 1.19–2.29, $p = 0.002$) more often than ECT patients. The children receiving ICT procedures were less likely to be obese

TABLE 1 | Simple logistic regression comparing patient characteristics of ambulatory intracapsular coblation tonsillectomies to extracapsular tonsillectomies.

Characteristic	Odds ratio	SE	z	*p*	95% CI
Age	0.97	0.02	−1.82	0.07	0.93–1.00
Sex					
Male			[reference]		
Female	1.08	0.12	0.71	0.48	0.87–1.35
Race					
White			[reference]		
Black or African American	0.64	0.10	−2.86	0.004	0.48–0.87
Asian	1.64	0.49	1.64	0.10	0.91–2.96
Other	0.88	0.17	−0.67	0.50	0.60–1.28
Unknown/refused	1.58	0.58	1.26	0.21	0.77–3.23
Ethnicity					
Non-Hispanic			[reference]		
Hispanic	1.03	0.12	0.23	0.82	0.82–1.29
Unknown/refused	2.10	0.75	2.08	0.04	1.04–4.22
Indication					
Obstructive/sleep apnea			[reference]		
Infectious	0.93	0.21	−0.35	0.73	0.60–1.43
Other/unknown	3.85	0.82	6.33	< 0.001	2.54–5.85
Payor category					
Government			[reference]		
Commercial	1.44	0.17	3.08	0.002	1.14–1.82
Other/unknown	0.76	0.26	−0.81	0.42	0.39–1.48
Median household income	1.00	0.00	−0.71	0.48	1.00–1.00
Complicated patient flag	0.90	0.25	−0.39	0.70	0.52–1.56
Obesity	0.76	0.23	−0.90	0.37	0.42–1.38
Trisomy 21			Omitted because of collinearity		
OSA	0.50	0.08	−4.59	< 0.001	0.37–0.67
Congenital defect			Omitted because of collinearity		
Complex chronic diagnosis	0.82	0.29	−0.56	0.58	0.40–1.66

(OR: 0.72, 95% CI: 0.53–0.97, $p = 0.03$) or have OSA (OR: 0.68, 95% CI: 0.51–0.90, $p = 0.007$). For more detailed values, see Table S2.

3.2 | Postoperative Events

After ambulatory tonsillectomy surgeries, 30-day postoperative events are compared between ICT and ECT techniques in Table 3. Returns to the hospital for pain (OR: 0.12, 95% CI: 0.02–0.87, $p = 0.04$), ED readmissions (OR: 0.54, 95% CI: 0.33–0.91, $p = 0.02$), and IP readmissions (OR: 0.42, 95% CI: 0.21–0.88, $p = 0.02$) were all lower for ICT cases. All nursing calls were significantly lower for ICT cases (OR: 0.52, 95% CI: 0.40–0.69, $p < 0.001$) including calls regarding postoperative problems (OR: 0.47, 95% CI: 0.33–0.67, $p < 0.001$). Of note, operative control of posttonsillectomy bleeding was not statistically significant (OR: 0.18, 95% CI: 0.02–1.34, $p = 0.10$). For observation cases (Table 4), there were no 30-day postoperative events that were statistically different between ICT and ECT cases on simple logistic modeling, including operative control of bleeding (OR: 0.20, 95% CI: 0.03–1.44, $p = 0.11$). Specific values for each outcome are compared in Tables S3 and S4.

TABLE 2 | Simple logistic regression comparing patient characteristics of observation intracapsular coblation tonsillectomies to extracapsular tonsillectomies.

Characteristic	Odds ratio	SE	z	*p*	95% CI
Age	0.94	0.02	−3.45	< 0.001	0.90–0.97
Sex					
Male			[reference]		
Female	1.22	0.17	1.49	0.14	0.94–1.60
Race					
White			[reference]		
Black or African American	0.83	0.13	−1.16	0.25	0.61–1.14
Asian	0.73	0.44	−0.52	0.60	0.22–2.38
Other	0.75	0.20	−1.09	0.27	0.45–1.25
Unknown/refused	2.47	1.06	2.10	0.04	1.06–5.72
Ethnicity					
Non-Hispanic			[reference]		
Hispanic	0.80	0.11	−1.61	0.11	0.61–1.05
Unknown/refused	3.92	1.59	3.38	0.001	1.77–8.66
Indication					
Obstructive/sleep apnea			[reference]		
Infectious	0.57	0.30	−1.08	0.28	0.21–1.58
Other/unknown	4.08	0.86	6.64	< 0.001	2.70–6.18
Payor category					
Government			[reference]		
Commercial	1.33	0.22	1.73	0.08	0.96–1.84
Other/unknown	2.03	0.75	1.92	0.06	0.98–4.19
Median household income	1.00	0.00	−0.41	0.68	1.00–1.00
Complicated patient flag	1.31	0.19	1.85	0.07	0.98–1.74
Obesity	0.72	0.11	−2.15	0.03	0.53–0.97
Trisomy 21	1.78	0.46	2.25	0.02	1.08–2.95
OSA	0.68	0.10	−2.69	0.007	0.51–0.90
Congenital defect	1.78	0.41	2.50	0.01	1.13–2.80
Complex chronic diagnosis	1.65	0.27	3.04	0.002	1.19–2.27

3.3 | Caregiver-Reported Outcomes

Approximately 6 weeks after tonsillectomy, caregiver-reported outcomes were obtained following 822 ambulatory procedures representing 31% of the total group. This included 73 ICT patients (20% of total) and 749 ECT patients (33% of total). As shown in Table 5, ICT cases did not have a significant difference in odds of a response to the questions that could be assessed by simple logistic regression. This included any subjective persistence of snoring or mouth breathing (OR: 0.67, 95% CI: 0.26–1.70, $p = 0.40$). A more detailed comparison is shown in Table S5.

For observation cases, caregiver-reported outcomes at 6 weeks after tonsillectomy are shown in Table 6. Responses were obtained from 997 caregivers (35% of total), with 63 from ICT patients (27% of total) and 934 from ECT patients (36% of total). Like ambulatory procedures, there was no difference in the odds of a response for the questions that could be assessed by simple logistic regression. Any subjective persistence of snoring or

TABLE 3 | Simple logistic regression comparing 30-day postoperative events for ambulatory intracapsular coblation tonsillectomies to extracapsular tonsillectomies.

Postoperative event	Odds ratio	SE	z	*p*	95% CI
Length of stay	1.31	0.31	1.14	0.26	0.82–2.07
Return for bleeding	0.83	0.29	−0.53	0.60	0.43–1.63
Return for vomiting	0.52	0.24	−1.39	0.17	0.21–1.31
Return for pain	0.12	0.12	−2.10	0.04	0.02–0.87
Surgical complication flag	Omitted because of collinearity				
ED readmits	0.54	0.14	−2.34	0.02	0.33–0.91
IP readmits	0.42	0.16	−2.31	0.02	0.21–0.88
OR control bleeding	0.18	0.19	−1.67	0.10	0.02–1.34
Any nursing call	0.52	0.07	−4.73	< 0.001	0.40–0.69
Postop problem calls	0.47	0.08	−4.22	< 0.001	0.33–0.67

TABLE 4 | Simple logistic regression comparing 30-day postoperative events for observation intracapsular coblation tonsillectomies to extracapsular tonsillectomies.

Postoperative event	Odds ratio	SE	z	*p*	95% CI
Length of stay	1.06	0.04	1.79	0.07	0.99–1.14
Return for bleeding	0.30	0.22	−1.65	0.10	0.07–1.25
Return for vomiting	Omitted because of collinearity				
Return for pain	0.86	0.52	−0.26	0.80	0.26–2.79
Surgical complication flag	1.93	1.21	1.04	0.30	0.56–6.63
ED readmits	0.68	0.19	−1.35	0.18	0.39–1.19
IP readmits	0.92	0.27	−0.26	0.79	0.52–1.66
OR control bleeding	0.20	0.20	−1.60	0.11	0.03–1.44
Any nursing call	1.13	0.17	0.82	0.41	0.85–1.50
Postop problem calls	0.77	0.15	−1.37	0.17	0.53–1.12

TABLE 5 | Simple logistic regression comparing 6-week reported outcomes for ambulatory intracapsular coblation tonsillectomies to extracapsular tonsillectomies.

Reported outcome	Odds ratio	SE	z	*p*	95% CI
Appetite returned to normal	0.48	0.53	−0.66	0.51	0.06–4.20
Tolerates same foods as before	0.48	0.53	−0.66	0.51	0.06–4.20
Back to normal activity	Omitted because of collinearity				
Concerns about voice	2.98	2.42	1.34	0.18	0.61–14.61
Still requiring pain medication	Omitted because of collinearity				
Snoring/mouth breathing	0.67	0.32	−0.85	0.40	0.26–1.70
Visits to hospital/ED	Omitted because of collinearity				
Reported bleeding within 3 weeks	Omitted because of collinearity				

TABLE 6 | Simple logistic regression comparing 6-week reported outcomes for observation intracapsular coblation tonsillectomies to extracapsular tonsillectomies.

Reported outcome	Odds ratio	SE	z	*p*	95% CI
Appetite returned to normal	0.33	0.37	−0.99	0.32	0.04–2.90
Tolerates same foods as before	0.40	0.44	−0.84	0.40	0.05–3.38
Back to normal activity	Omitted because of collinearity				
Concerns about voice	Omitted because of collinearity				
Still requiring pain medication	Omitted because of collinearity				
Snoring/mouth breathing	1.64	0.50	1.65	0.10	0.91–2.97
Visits to hospital/ED	0.62	0.33	−0.91	0.36	0.22–1.74
Reported bleeding within 3 weeks	Omitted because of collinearity				

TABLE 7 | Simple logistic regression comparing polysomnogram data for coblation tonsillectomies to extracapsular tonsillectomies.

Polysomnogram data	Odds ratio	SE	z	*p*	95% CI
Preop RDI	0.99	0.01	−0.89	0.37	0.97–1.01
Preop RDI > 5 events/h	3.32	3.40	1.17	0.24	0.44–24.78
Days PSG before surgery	1.00	0.002	−1.43	0.15	0.99–1.00
Postop RDI	1.03	0.02	1.69	0.09	0.99–1.07
Postop RDI < 5 events/h	0.82	0.27	−0.60	0.55	0.42–1.58
Post-RDI < 1 events/h	0.48	0.23	−1.51	0.13	0.18–1.24
RDI improved	0.57	0.29	−1.12	0.26	0.21–1.53
Days PSG after surgery	1.00	0.002	0.97	0.33	1.00–1.01

mouth breathing (OR: 1.64, 95% CI: 0.91–2.97, $p = 0.10$) was no different after ICT and ECT cases. Table S6 compares outcomes in more detail.

3.4 | Polysomnogram Data

In Table 7, polysomnogram data for the children with preoperative and postoperative sleep studies were compared using simple logistic regression. Of the total study population, there were 462 children (8.5%) obtaining PSG before and after tonsillectomy. This included 43 ICT cases (7.1% of total) and 419 ECT cases (8.7% of total). Sleep studies were obtained at a mean of 90 days (SD: 61) before surgery, with postoperative studies obtained at a mean of 122 days (SD: 68) after surgery. ICT and ECT cases were comparable with regard to mean preoperative RDI and were no less likely to achieve improvements in postoperative RDI (OR: 0.57, 95% CI: 0.21–1.53, $p = 0.26$). Additional polysomnogram details can be found in Table S7.

3.5 | Total Costs

The total costs of caring for children within 30 days after tonsillectomy were compared among ambulatory and observation procedures regardless of technique. Mean cost for ambulatory ICT surgeries was $4670 (SD: $2045) (median: $4725 [IQR: $2885–$5710]) while mean cost for ambulatory ECT surgeries was $5400 (SD: $2485) (median: $5241 [IQR: $4384–$6015]). The skewness/kurtosis test confirmed non-normality ($p < 0.001$). Among all ambulatory tonsillectomies, simple linear regression was performed by technique, patient characteristics, and postoperative events. This regression output yielded numerous factors significantly associated with total costs after tonsillectomy (Table S8). Multivariable linear regression model output is shown in Table 8. ICT was associated with lower total costs (β: −426.6, 95% CI: −631.7 to −221.4, $p < 0.001$). In increasing cost impact, the following factors were significant in the final regression model: nursing call (β: 280.6, 95% CI: 125.2–436.0, $p < 0.001$), OSA diagnosis (β: 410.2, 95% CI: 247.6–572.8, $p < 0.001$), complicated patient (β: 958.5, 95% CI: 616.1–1300.9, $p < 0.001$), return for vomiting (β: 1045.8, 95% CI: 548.1–1543.5, $p < 0.001$), return for pain (β: 1422.6, 95% CI: 905.4–1939.7, $p < 0.001$), IP readmission (β: 5239.5, 95% CI: 4796.5–5702.6, $p < 0.001$), and OR control of bleeding (β: 6004.9, 95% CI: 5268.6–6741.2, $p < 0.001$). The sensitivity analysis using a GLM with gamma distribution and log link produced consistent findings. Therefore, the linear regression results were presented as primary analysis for clarity and interpretability. Results from the GLM were consistent with the linear model, supporting the robustness of our findings.

TABLE 8 | Multivariable linear regression for total costs after ambulatory tonsillectomies.

Characteristic	Coefficient	SE	t	p	95% CI
ICT	−426.6	104.6	−4.08	< 0.001	−631.7 to −221.4
Complicated patient flag	958.5	174.6	5.49	< 0.001	616.1–1300.9
OSA	410.2	82.9	4.95	< 0.001	247.6–572.8
Return for vomiting	1045.8	253.8	4.12	< 0.001	548.1–1543.5
Return for pain	1422.6	263.7	5.39	< 0.001	905.4–1939.7
IP readmits	5239.5	231.1	22.72	< 0.001	4796.5–5702.6
OR control bleeding	6004.9	375.5	15.99	< 0.001	5268.6–6741.2
Any nursing call	280.6	79.3	3.54	< 0.001	125.2–436.0

TABLE 9 | Multivariable linear regression for total costs after observation tonsillectomies.

Characteristic	Coefficient	SE	t	p	95% CI
Complicated patient flag	1680.6	136.1	12.35	< 0.001	1413.8–1947.5
Obesity	−509.1	127.9	−3.98	< 0.001	−759.9 to −258.2
OSA	357.6	133.5	2.68	0.007	95.8–619.5
Return for bleeding	−2098.1	436.0	−4.81	< 0.001	−2953.0 to −1243.3
Surgical complication flag	2391.0	702.2	3.40	0.001	1014.0–3767.9
IP readmits	8177.8	313.0	26.12	< 0.001	7564.1–8791.5
OR control bleeding	5052.1	512.2	9.86	< 0.001	4047.7–6056.5
Any nursing call	402.0	131.2	3.06	0.002	144.7–659.3

Total costs within 30 days after observation tonsillectomies were analyzed by simple linear regression regardless of technique. Mean cost for observation ICT surgeries was $9462 (SD: $2771) (median: $8785 [IQR: $7742–$10,262]) while mean cost for observation ECT surgeries was $9545 (SD: $4017) (median: $8600 [IQR: $7688–$10,196]). The skewness/kurtosis test confirmed nonnormality ($p < 0.001$). Table S9 shows several variables with significant association with total costs. When included in a multivariable linear regression model (Table 9), there was no association with surgical technique. Both obesity (β: −509.1, 95% CI: −759.9 to −258.2, $p < 0.001$) and returns for bleeding (β: −2098.1, 95% CI: −2953.0 to −1243.3, $p < 0.001$) had negative impacts on cost. However, increased costs were found with a diagnosis of OSA (β: 357.6, 95% CI: 95.8–619.5, $p = 0.007$), any nursing call (β: 402.0, 95% CI: 144.7–659.3, $p = 0.002$), complicated patients (β: 1680.6, 95% CI: 1413.8–1947.5, $p < 0.001$), surgical complication (β: 2391.0, 95% CI: 1014.0–3767.9, $p = 0.001$), operative control of bleeding (β: 5052.1, 95% CI: 4047.7–6056.5, $p < 0.001$), and IP readmissions (β: 8177.8, 95% CI: 7564.1–8791.5, $p < 0.001$). Like observation cases, the sensitivity analysis using a GLM produced consistent findings to the linear model.

3.6 | Cost-Effectiveness Modeling

A detailed cost-effectiveness analysis was performed comparing ICT and ECT for ambulatory and observation tonsillectomy procedures. Based on the analysis of the study population, Table 10 includes the model input values for mean costs and probabilities of 30-day events after tonsillectomy. Effectiveness was measured using utility values and is shown for each group where applicable.

The decision-tree model with output values comparing ICT and ECT is shown for ambulatory tonsillectomies in Figure 1. The result is a cost for ICT of $4716.38 and a utility value of 0.94 QALY leading to a C/E ratio of $5008.38/QALY. For ECT, the costs were $5400.38 and a utility ratio of 0.93 QALY for a C/E ratio of $5776.63/QALY. Ambulatory ICT dominates ECT with an incremental cost-effectiveness ratio (ICER) (Figure 2) of $-100,140.63/QALY, which is less than the WTP threshold of $100,000/QALY.

The decision-tree model with output values comparing ICT and ECT is shown for observation tonsillectomies in Figure 3. The result is a cost for ICT of $9461.64 per case and a utility value of 0.94 QALY, leading to a C/E ratio of $10,066.81/QALY. For ECT, the costs were $9544.14 per case and a utility value of 0.93 QALY for a C/E ratio of $10,209.06/QALY. Observation ICT dominates ECT, where the cost-effectiveness plot (Figure 4) yielding an ICER of $−16,452.70/QALY, is less than the WTP threshold of $100,000/QALY.

Graphic representation of the uncertainty with these cost-utility results was performed across a variety of willingness-to-pay thresholds. Using 1000 Monte Carlo simulations, the percent of iterations that would be cost-effective for ICT were always

TABLE 10 | Cost-effectiveness model inputs.

	Ambulatory tonsillectomies		Observation tonsillectomies	
Variable	**ICT**	**ECT**	**ICT**	**ECT**
Cost, mean US$ (SD)				
Uncomplicated recovery	$4577 (1746)	$4935 (1480)	$9010 (2088)	$8879 (2100)
Bleeding ED admit	$4702 (1649)	$6598 (2668)	—	$9011 (1394)
Bleeding IP admit	$8971 (4462)	$12,531 (4478)	$14,325 (3652)	$14,950 (3978)
Bleeding ED and IP admits	—	$12,109 (4641)	—	$18,188 (3157)
Dehydration/pain ED admit	$4895 (1719)	$5900 (1576)	$10,057 (2681)	$9888 (3261)
Dehydration/pain IP admit	$11,911 (5693)	$12,720 (5202)	$16,445 (4035)	$20,552 (11703)
Dehydration/pain ED and IP admits	—	$14,109 (5004)	—	$22,037 (12274)
Utility value, QALY				
Uncomplicated recovery	0.95	0.95	0.95	0.95
Bleeding ED admit	0.80	0.80	—	0.80
Bleeding IP admit	0.65	0.65	0.65	0.65
Bleeding ED and IP admits	—	0.50	—	0.50
Dehydration/pain ED admit	0.90	0.90	0.90	0.90
Dehydration/pain IP admit	0.85	0.85	0.85	0.85
Dehydration/pain ED and IP admits	—	0.80	—	0.80
Probability				
Uncomplicated recovery	0.932	0.876	0.886	0.863
Bleeding ED admit	0.016	0.008	—	0.007
Bleeding IP admit	0.011	0.022	0.008	0.017
Bleeding ED and IP admits	—	0.003	—	0.003
Dehydration/pain ED admit	0.030	0.066	0.059	0.071
Dehydration/pain IP admit	0.011	0.020	0.046	0.036
Dehydration/pain ED and IP admits	—	0.005	—	0.003

greater than ECT cases for both ambulatory (Figure S1) and observation tonsillectomies (Figure S2). As the willingness-to-pay increased, the percent of ICT cases that were more cost-effective diverged greater than ECT cases.

Finally, a one-way sensitivity analysis was performed looking at expected costs when various probabilities of revision ICT procedures would be needed. Of note, there were no cases of revision tonsillectomy after ICT in this series. Figure 5 describes the expected costs after ambulatory tonsillectomies and shows that until a revision ICT rate of 14.5%, ICT results in lower costs than ECT. In Figure 6, observation ICT is less costly than ECT until a rate of revision ICT exceeds 0.9%.

4 | Discussion

This 5-year prospective cohort study of pediatric tonsillectomies provides evidence to support the cost-effectiveness of ICT. After ambulatory and observation cases, ICT dominated ECT in this economic analysis and was the more cost-effective approach. No prior study has been able to identify a similar finding, which demonstrates a unique advantage of intracapsular tonsillectomy. As advocates continue to emphasize the benefits of intracapsular tonsillectomy, having clarity and precision in the economic impact of this approach is invaluable. While utility was similar, the cost reduction reflects an ability to avoid readmissions in the weeks after surgery. An uncomplicated recovery occurred in 93% of ambulatory and 89% of observation ICT cases. However, 88% of ambulatory and 86% of observation ECT procedures were uncomplicated. The cost savings was approximately $700 per ambulatory case and $80 per observation case when ICT was performed. Considering the annual volume of pediatric tonsillectomies, these savings can yield substantial health economic advantages.

Economic assessments of intracapsular tonsillectomy have previously been limited. The first cost-utility analysis published on this topic estimated an ICT cost of $4177.92 and an ECT cost of

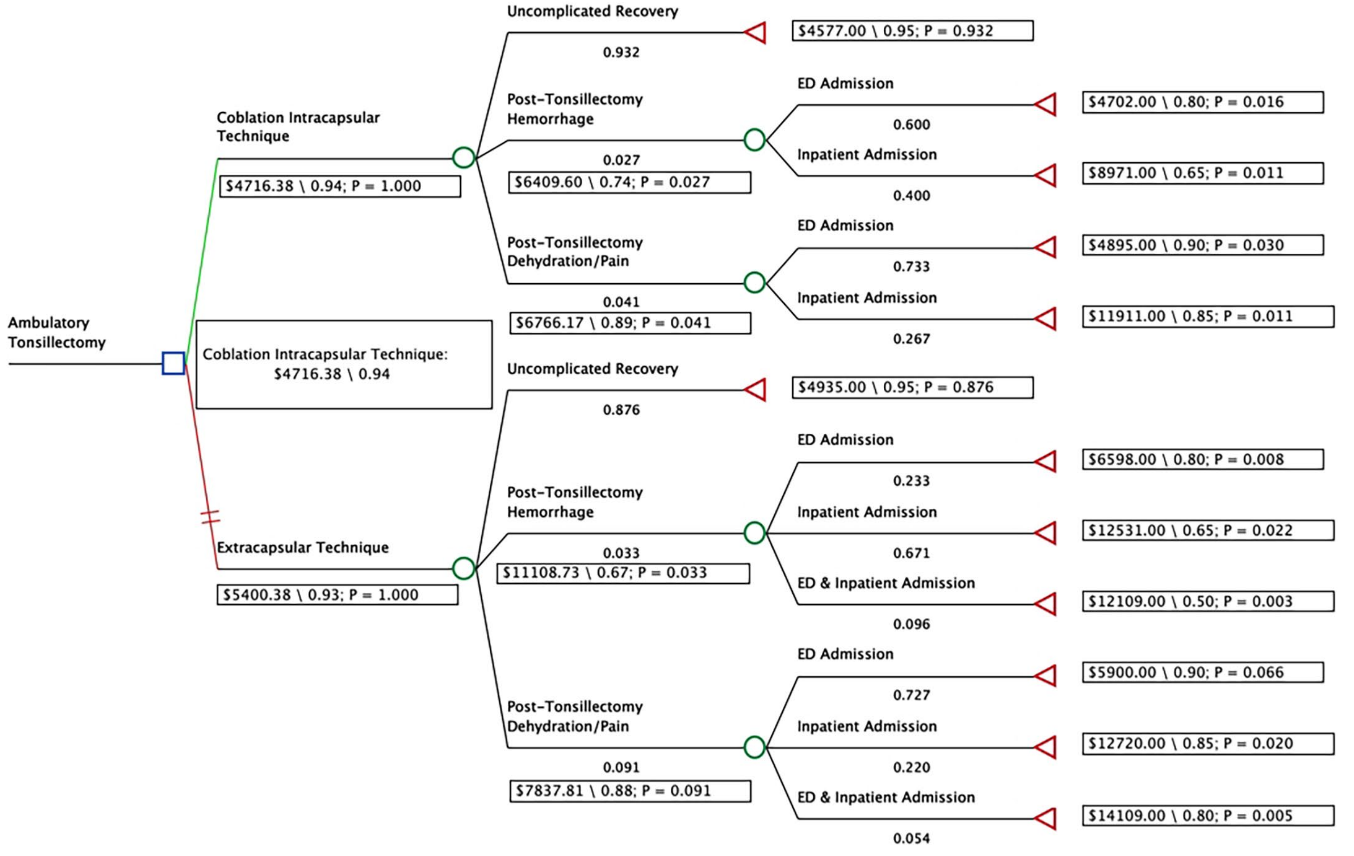

FIGURE 1 | Decision-tree model for ambulatory tonsillectomies.

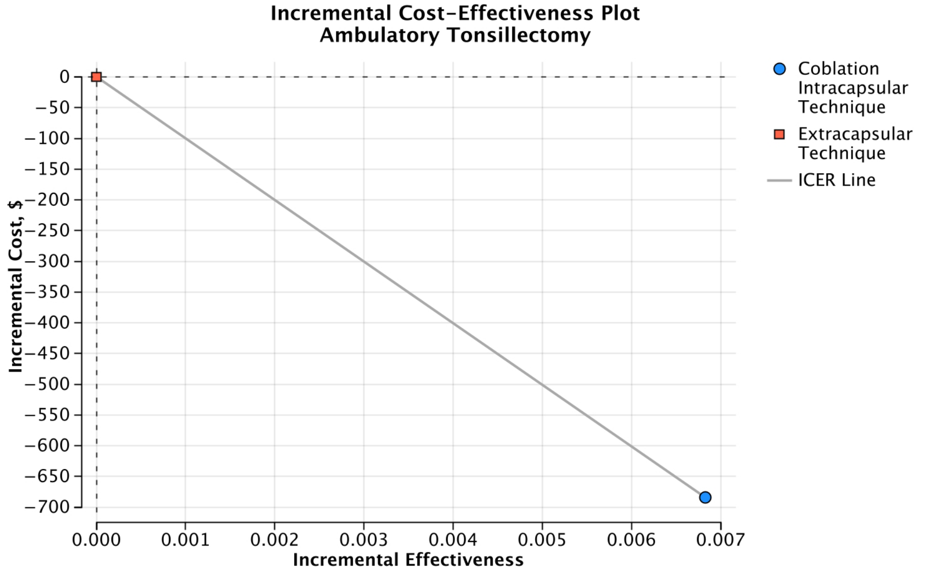

FIGURE 2 | Incremental cost-effectiveness plot for ambulatory tonsillectomies.

$4546.91. However, utility outcomes favored ECT beyond a regrowth rate of 1.64%, and total costs were $8393.91 with a second ICT if more than 17.8% of cases required a revision. These varied utility and cost results were highly dependent on regrowth rates and recovery times [25]. While the model suggested comparable costs to the results shown here, inputs were based on selections from assorted studies, and costs were estimated using a consumer health calculator. Applying actual costs and probabilities with separation by ambulatory or observation procedures improves model precision. The second analysis on this topic also used a variety of published rates for outcomes after intracapsular approaches with Medicare reimbursement values applied for costs. In that model, total tonsillectomy was more cost effective at $12,453.40 per QALY gained, but suggested intracapsular tonsillectomy could be more effective when OSA recurrence is less than 3.12% and failure rate is less than 1.0%. The authors

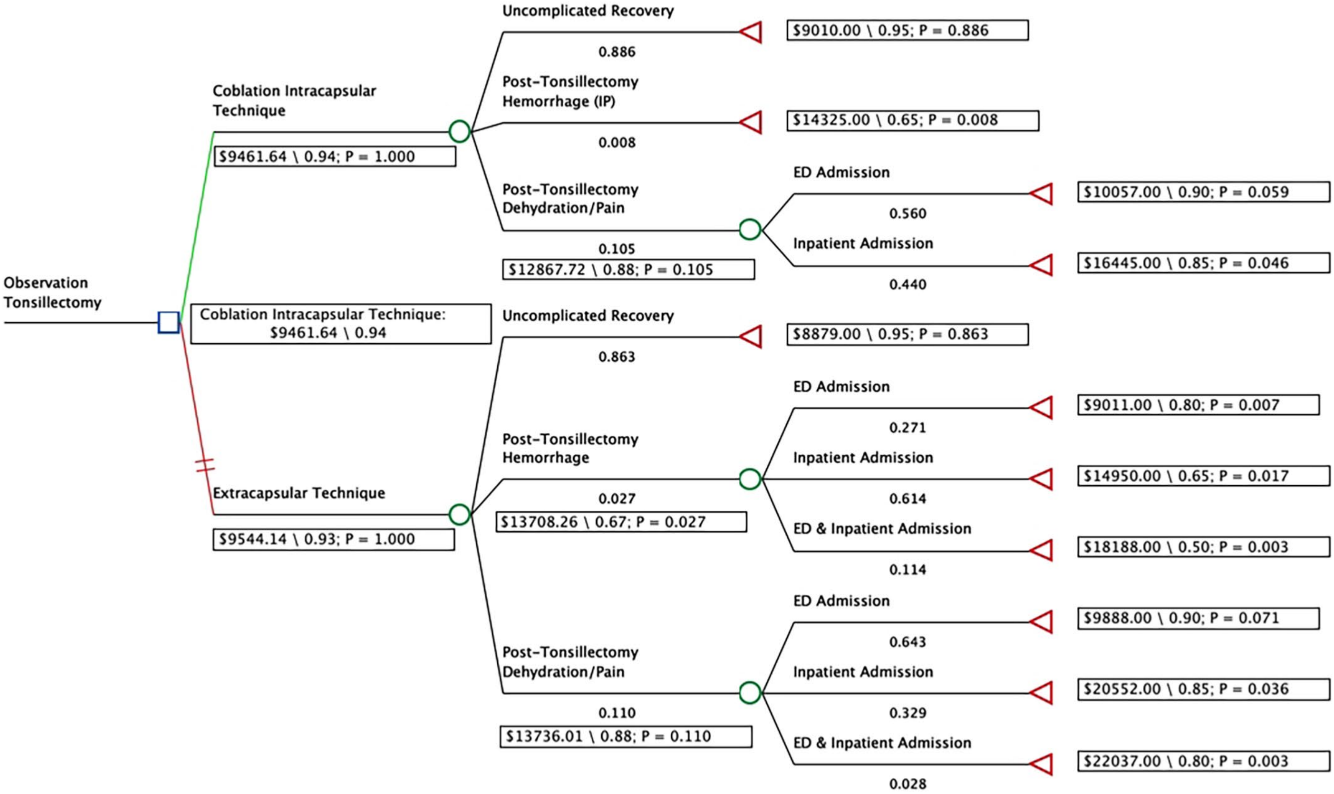

FIGURE 3 | Decision-tree model for observation tonsillectomies.

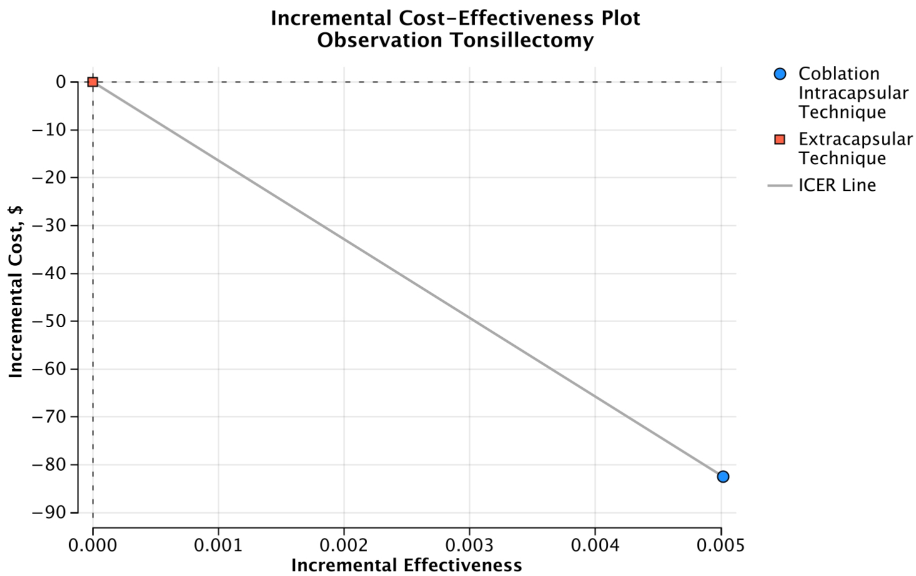

FIGURE 4 | Incremental cost-effectiveness plot for observation tonsillectomies.

concluded that total tonsillectomy was the more cost-effective approach, but partial tonsillectomy could be advantageous depending on model inputs [26]. The use of a prospective cohort to determine rates of events and actual costs to a hospital system strengthens the findings showing a clear advantage for ICT in this series. The model also provides a much more robust representation of recovery that reflects the nuances of postoperative complications necessitating ED or IP visits.

Given the costs associated with healthcare expenditure and the interest in novel management approaches, economic assessments have a key role in public health strategy. Cost-effectiveness analyses compare the relative value of interventions and provide decision makers with indispensable perspective when deciding between alternatives [24]. The calculation of an ICER, which is the additional consumption of medical resources divided by the benefits (QALYs) gained from healthcare interventions, is considered cost-effective if the ICER is less than a WTP threshold of $50,000–$100,000 in the United States [29]. In this study, both ICERs were negative due to lower cost and improved utility in which ICT is said to dominate ECT. A great deal of literature discusses how to interpret varying levels of an ICER. Ultimately,

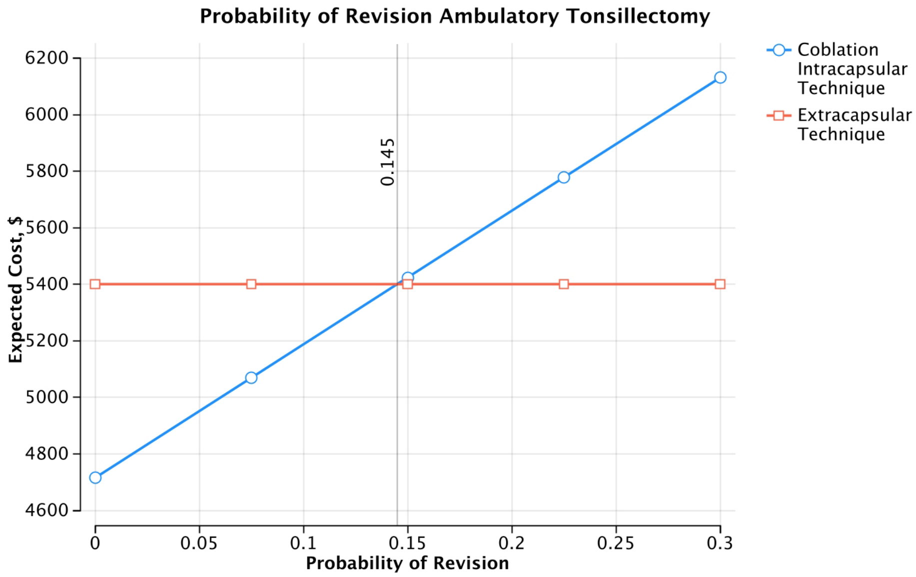

FIGURE 5 | One-way sensitivity analysis for the impact of revision ambulatory coblation tonsillectomies on expected costs.

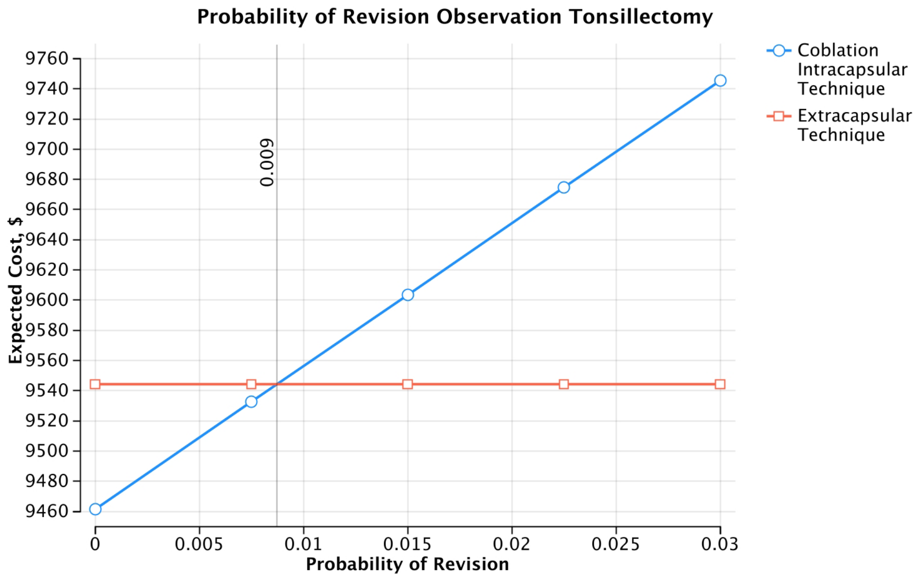

FIGURE 6 | One-way sensitivity analysis for the impact of revision observation coblation tonsillectomies on expected costs.

alternatives that dominate do not necessarily need to be compared to a WTP threshold since the intervention is always considered to be cost-effective with a negative incremental cost and positive incremental benefit [30–33]. In recent years, a growing number of publications in otolaryngology have highlighted cost-effectiveness analyses and suggest relevance with new and potentially expensive treatment modalities requiring health economic scrutiny [34, 35]. Interventions such as the addition of turbinoplasty to pediatric adenotonsillectomy [36], nasal surgery to increase continuous positive airway pressure adherence [37], and magnetic resonance imaging for asymmetric sensorineural hearing loss [38] have been among cost-effectiveness research in otolaryngology. It is important to recognize that these analyses are limited by model inputs and assumptions and are not designed to establish thresholds of healthcare expenditure. Rather, this information can provide comparison of interventions with varied outcomes to improve quality and to advocate for new approaches. With this perspective, otolaryngologists and key stakeholders can obtain a broader understanding of the advantages ICT may have over traditional ECT as they consider this approach in their individual practice.

There are several notable secondary findings explored in this cohort. First, among ICT cases undergoing ambulatory procedures, there were significantly fewer hospitalizations for pain (OR: 0.12), fewer ED readmissions (OR: 0.54), and fewer IP readmissions (OR: 0.42) in the first 30 days. Nursing calls (OR: 0.52) and nursing calls for complications (OR: 0.47) were also lower for ambulatory ICT. These findings are consistent with prior studies demonstrating lower pain and quicker recovery times after pediatric intracapsular tonsillectomy [6, 7, 11, 12]. While 30-day outcomes for pain, readmissions, and calls were not different in the observation group, it is important to note that ICT procedures were more often performed on children with Trisomy 21 (OR: 1.78), congenital defects (OR: 1.78), or with chronic comorbidities (OR: 1.65). The advantage of ICT among this medically complex group of children may be in its ability to keep complication rates low. Prior studies have suggested improved outcomes using intracapsular approaches among vulnerable pediatric populations such as those with Trisomy 21 or developmental delay [39, 40]. Further research will be needed to explore how intracapsular tonsillectomy might benefit children susceptible to poorer postoperative outcomes. Second, the operative posttonsillectomy bleeding rate was not statistically different between ICT and ECT cases after ambulatory or observation surgeries. There was one ICT bleed in the ambulatory group (0.27%) and one in the observation group (0.42%). Perhaps the lack of statistical significance was due to small case volume along with a low frequency of bleeding in the ECT group (1.5% and 2.1%, respectively). These rates place the entire cohort around the median for nationwide posttonsillectomy bleeding estimates [41]. While ICT has been associated with lower posttonsillectomy bleeding in meta-analyses [11, 12, 42], there has been some suggestion that small sample sizes and infrequent events explain a lack of statistical difference in operative bleeding control in some studies [12]. Third, no differences in postoperative caregiver-reported outcomes or PSG data were seen between ICT and ECT groups. This is consistent with several other studies in which patient-reported and objective measures of obstructive sleep apnea resolution were noninferior among intracapsular approaches [39, 43–45]. Ultimately, only a subset of this cohort had symptom resolution data with only 35% confirming a 6-week nursing call and 8.5% obtaining a PSG. This limits a strong conclusion. Continued investigation into the long-term outcomes after intracapsular tonsillectomy are required, but these secondary findings are consistent with established favorable outcomes following ICT.

The leading concern with intracapsular tonsillectomy has been the potential need for a revision procedure. Rates of revision surgery have been documented after 1.39%–2.6% of intracapsular tonsillectomies depending on technique and duration of follow-up [9, 20–22]. In this study, there were no cases of revision ICT; although anecdotally, some children were found to have asymptomatic tonsillar regrowth or continued growth. These did not necessitate a second surgery but may be affected by small sample size or short follow-up duration. Some patients may have undergone revision procedures at outside institutions, potentially leading to an underestimation of revision rates. For 7% of ambulatory ICT cases, the indication was an infectious etiology, and even in this group, no revisions for repeat infections were recorded. Despite most studies lacking adequate long-term follow-up, a recent 9-year series of over 4000 ICT cases found a revision rate of 3.3% with a decrease in revisions to 0.3% as surgeon experience and training increased [46]. The sensitivity analysis in our model determined that the theoretical revision rate of ICT would need to be more than 14.5% for ambulatory cases and 0.9% for observation cases to make ECT less costly. To put these rates in perspective, there would have needed to be 53 children in the ambulatory group and two children in the observation group requiring revision in this cohort to shift the estimated costs such that ECT would be advantageous. This suggests that for ambulatory cases, ICT is clearly the cost-effective approach since this theoretical rate of revision is extraordinarily high. In observation cases, a revision ICT rate close to the published estimates is necessary to maintain cost advantage. Therefore, concerns surrounding tonsillar regrowth should be tempered based on the findings of this analysis. Identifying the incidence of symptomatic tonsillar regrowth, the risk factors for development, and the techniques designed to minimize these events will be beneficial in future research.

Total costs after tonsillectomy were associated with a few key characteristics. On multivariable linear regression modeling, any nursing calls, complicated patients, a return to the OR for bleeding, and an IP readmission were associated with increased costs after ambulatory and observation surgeries. Only ambulatory cases had a reduction in cost when ICT was performed. Prior work has confirmed that partial tonsillectomy can decrease operative time, postanesthesia care unit time, IP admissions, ICU stays, ED visits, and readmission with the inference that decreased utilization reduced costs [47]. This also considers the varying expenses associated with disposable surgical equipment. For example, in 2009 the cost of a coblator wand was approximately $200 compared to $100 for a microdebrider blade, $5.34 for an electrocautery spatula, and $6.55 for suction electrocautery. Based on the operative time of total tonsillectomy and equipment used, the estimated average cost for the microdebrider technique was $2205.20, followed by a cost for electrocautery of $2825.10, and coblator tonsillectomy costs of $2837.1 [48]. Despite differences in the cost of surgical technologies, the major driver of healthcare costs is admissions and rehospitalizations. As shown in the findings presented here, an ED and IP readmission for pain/dehydration after observation ECT is greater than $22,000 and would triple total case costs. Individuals weighing the cost to purchase equipment needed for pediatric tonsillectomy should recognize these factors and consider how various approaches may impact postoperative readmissions.

Several notable limitations to this study should be discussed. First, the total cost of these procedures does not include any surgeon/anesthesiologist fees, which add to the total cost. Second, these procedures also included other surgical interventions such as ear tube placement, nasal cautery, or flexible laryngoscopy. As a result, there are some additional contributions to the cost of those procedures that may lead to variability. Third, among the ECT cases, there may be a few ($<0.5\%$) subtotal tonsillectomies, but these would not remove the same amount of tissue as the ICT cases. Fourth, analysis is limited to this institution, which may not be generalizable to all centers performing pediatric tonsillectomy. Variability in anesthetic approaches and practice patterns may alter results at other locations. This analysis used actual cost data, which incorporates variation in operative time, anesthesia duration, and recovery room stay. However, time-stamped variables were not collected for analysis but may provide additional insight into resource utilization. Fifth, patients were not randomized to receiving ICT, and all patients obtaining the ICT cases were performed by a single surgeon who does not offer an extracapsular approach. Finally, ECT techniques included a larger number of surgeons with a variety of equipment and approaches such as electrocautery, coblation, and bipolar diathermy. Ultimately, the removal of the entire tonsil is commonality for all ECT procedures. As such, there could be variability in recovery between approaches that was beyond the scope of this study.

From a generalizability perspective, the results of the study should be applicable to the broader population of pediatric tonsillectomy procedures. In this prospective cohort, all observation and ambulatory cases were included. There were no exclusions based on comorbidities or complexity. While IP cases were removed due to their extremely unique costs and outcomes, this represents a small subset of tonsillectomy surgeries performed annually. Therefore, providers could look at this information and recognize that most children offered tonsillectomy would be encompassed by the findings in this study. Additionally, while some cost data and practice patterns may be institution-specific, this modern measurement will be much more meaningful than estimated costs or charge to cost ratios used in other analyses. Institutions that do not offer a robust nursing after-hours service or 6-week outreach program may find that their outcomes vary based on the volume and approach algorithm. Nonetheless, all children with several comorbidities are included in this analysis and provide a broad applicability to other centers. This strategy to not select the healthiest patients helps evaluate the economic impact to a large, diverse hospital system.

Future studies should explore specific comorbidities and whether the cost savings for tonsillectomy could be realized even more when comparing high-risk patients. Studies could also try to define the utility values after tonsillectomy as well as the various complication scenarios. This analysis was conducted from a hospital system perspective and therefore included only direct medical costs. Important indirect costs—such as caregiver missed work, transportation, and childcare—were not included, although these factors may influence the broader economic burden of care and should be considered in future research using a societal perspective [24]. Other centers might look at this information and encourage strategic adoption of ICT. Concerns over the cost of equipment, training, or transitions of approaches might be tempered by considering the overall cost reduction due to uncomplicated recoveries beyond ECT cases.

5 | Conclusions

This economic analysis of ICT utilizing a large, prospective cohort determined that this tonsillectomy technique dominates traditional ECT with regard to cost-effectiveness. The economic advantages were more noticeable for ambulatory cases but were still present after complex observation cases. Even considering the potential for regrowth, which was encouragingly not identified during this 5-year period, ICT maintains its advantage over ECT when revision surgeries are less than 14.5% and 0.9% for ambulatory and observation cases, respectively. The primary driver of these findings is the frequency with which ECT cases utilize resources in the 30 days following surgery. Total costs are greatly impacted by readmissions and hospitalizations that were higher in the ECT group. Cost-utility analyses are valuable tools as newer approaches to healthcare management are incorporated. This model justifies the growing use of ICT in the management of pediatric tonsil disease. Otolaryngologists caring for children may reflect on these findings as they contemplate the role of ICT in their daily practice. For key stakeholders, the economic impact of adopting ICT can have substantial benefit to larger groups of patients as cost-effectiveness remains a priority.

Acknowledgments

The authors have nothing to report.

Conflicts of Interest

Stephen R. Chorney is an educational consultant for Smith & Nephew. The other authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.