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ORIGINAL RESEARCH

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A prospective, randomized, single-blind study comparing coblation and monopolar extracapsular tonsillectomy

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Abstract

Objective: The aim of this study was to compare intraoperative blood loss, postoperative pain, post-tonsillectomy hemorrhage (PTH), and medical costs associated with extracapsular tonsillectomy between coblation and monopolar electrocautery in children.

Materials and methods: This study included 293 patients aged 6–15 years planned to undergo extracapsular tonsillectomy. Data on estimated blood loss, postoperative pain score, operation time, PTH, and the cost of disposable equipment were collected.

Results: Coblation extracapsular tonsillectomy was associated with significantly lower mean pain scores than monopolar technique on postoperative days 1 (p <.001) and 2 ($p = 0.02$). However, the pain score was similar between the groups at all other time points. The monopolar group had a significantly shorter operation time compared to the coblation group (11.09 ± 7.53 vs. 17.12 ± 4.29 min, p <.001). Intraoperative estimated blood loss was not significantly different between the groups ($p = .43$).The cost of extracapsular tonsillectomy was significantly lower in the monopolar compared to the coblation group (US$ 28.18 vs. US$ 430.48, p <.001). PTH occurred in 17 patients (5.80%) and required a second surgery. Secondary PTH occurred in 6.16% (9/146) and 0.68% (1/147) of patients in the coblation and monopolar groups, respectively (p <.001). The PTH was significantly higher in the tonsillitis compared to in the tonsillar hypertrophy (12.37% vs. 2.55%, $p = .002$), However, the difference of PTH was not significant among mean pain scores subgroups. Of the 17 patients with PTH, the lower pole, middle portion, and upper pole were involved in 15 (88.24%), 2 (11.76%), and 0 cases, respectively.

Conclusions: Coblation and novel monopolar electrocautery extracapsular tonsillectomy are associated with similar postoperative pain scores except on postoperative days 1 and 2. However, monopolar technique offers significant advantages over coblation method with less operative time, decreased secondary PTH, and cost.

Level of Evidence: NA.

Zhengcai Lou and Zihan Lou have contributed equally to this work.

KEYWORDS
coblation, monopolar electrocautery, pain scores, post-hemorrhage tonsillectomy, tonsillectomy

1 | INTRODUCTION

Tonsillectomy is commonly performed in children with obstructive sleep apnoea and/or recurrent tonsillitis. Several techniques are used for tonsillectomy, including the traditional "cold steel" tonsillectomy, bipolar electrocautery, monopolar electrocautery, and coblation. Coblation (radiofrequency ablation) tonsillectomy is being increasingly used, which is used to generate current in a saline medium. The ionization of saline particles transfers energy to the molecular bonds of tissues, resulting in ablation. Coblation involves a significantly lower temperature for ablation compared to electrocautery (40–70°C and 400°C, respectively), which leads to less heat dissipation into the surrounding tissue and reduced postoperative pain compared with electrocautery technique.[1,2] Nevertheless, most of scholars found that Coblation tonsillectomy was associated with high post-tonsillectomy hemorrhage (PTH), especially for the secondary hemorrhage.[3–5] No consensus exists regarding the best surgical technique for tonsillectomy. It is unclear whether coblation is superior to electrocautery for tonsillectomy. In addition, some scholars suggested intracapsular tonsillectomy to reduce the PTH and pain.[6,7] However, others found that intracapsular tonsillectomy may result in regrowth of tonsillar tissue in patients with tonsillar hypertrophy and require revision surgery.[8–11] Thus, extracapsular tonsillectomy continues to be recommended in most of departments and our institution. The aim of this study was to compare the intraoperative blood loss, postoperative pain, PTH, and medical costs associated with extracapsular tonsillectomy between coblation and monopolar electrocautery in children.

2 | MATERIALS AND METHODS

2.1 | Ethical considerations

The study protocol was approved by the Institutional Ethical Review Board of Yiwu Central Hospital, China. Informed consent was written by their parents.

2.2 | Methods

This prospective, randomized clinical trial included patients aged 6–15 years who underwent extracapsular tonsillectomy due to chronic tonsillitis and/or tonsillar hypertrophy affecting feeding or sleep. Patients with acute tonsillitis within 2 weeks, bleeding disorder, or major diseases were excluded. In addition, patients undergoing combined adenoidectomy and tonsillectomy were excluded so that we could determine the most effective tonsillectomy technique. Preoperative blood routine examination and coagulation function were performed to exclude the bleeding risk.

Age, sex, disease duration, operation duration, estimated intraoperative blood loss, postoperative pain scores, PTH, cost of disposable equipment, and complications were recorded for each patient. No any steroids were used per or postoperatively.

Postoperative pain intensity was assessed using a visual analogue scale (range: 1–10; 1: no pain; 10: severe pain) on postoperative days 0 (i.e., the day of surgery), 1, 2, 3, and 7. The visual analogue scale was marked by the patients or their parents under the supervision of a senior surgeon. Pain score was assessed in the late afternoon on postoperative days 0 and in the early morning before breakfast on postoperative days 1, 2, 3, and 7. In addition, the mean pain scores of four assessment record each patient were divided into three subgroups: ≤3, 4–6, and ≥7. The surgical indication was divided into two subgroups: tonsillitis and tonsillar hypertrophy. Anesthesia, operation, hospitalization, nursing, and medical costs were similar for both techniques. Notably, we only included the cost of disposable equipment (coblation or monopolar coagulation) when calculating the medical costs. The operation time was calculated from successful exposure of the oropharynx using a mouth gag to complete removal of the bilateral palatine tonsils. Primary hemorrhage was defined as hemorrhage within 24 h postoperatively, while secondary hemorrhage was defined as hemorrhage after 24 h of surgery. Intraoperative blood loss was estimated.

2.3 | Technique selection

The patients were allocated to surgical techniques by the principal investigator and a registered operating room nurse using a simple randomization method. Consecutive patients who fulfilled the inclusion criteria and provided consent were assigned random numbers generated by the SPSS software (version 19.0; IBM Corp., Armonk, NY). The numbers were used to allocate patients to the coblation or monopolar electrocautery group. All operations were performed by the same surgeon. Patients were blinded to the group assignments.

2.4 | Surgical technique

The oropharynx was exposed using a mouth gag. The triangular area above the upper pole of the tonsil was identified by locating the point of convergence of the upper folds of the anterior and posterior pillars. Then, the upper pole of the tonsil was

located by digital palpation and separated from the tonsillar fossa using coblation or monopolar electrocautery.

A small portion of the upper pole of the tonsil was grasped using a small Allis clamp, and pulled medially and inferiorly to reveal the avascular space (i.e., peritonsillar space) above the tonsil. Then, a surgical instrument was used to push the tonsillar capsule and gradually separate the tonsil. The dissection was continued, with medial traction until the inferior tonsil pole was reached, after which the traction was in a superomedial direction to expose the inferior tonsil pole. At this stage, the tonsil was attached to the bed through a narrow inferior stalk, with pharyngeal and lingual extension of the lymphoid tissue. Dissection was not performed in this region and slow transverse electrocautery or coblation was used on the stalk to remove the tonsil. Electrocautery and coblation were performed in the peritonsillar space, which contains avascular fibroareolar tissue, to avoid muscle penetration. Bleeders were immediately coagulated under full view (Figure 1).

2.5 | Monopolar electrocautery

For electrocautery, coagulation was set to 25 W. We used a monopolar electrocautery device with suction hole, with the monopolar front-end modified to create a needle-like shape. The cautery was controlled by a switch on the handle (Video S1).

2.6 | Coblation

Coblation was performed with "ablate" set to 7 and "coagulate" to 3 (Video S2).

2.7 | Follow up

The patients received a liquid diet and intravenous antibiotics postoperatively. The patients were discharged at postoperative day 3 and presented for follow-up at postoperative day 7 in the outpatient clinic. The prescription of oral intake of liquid diet was proposed on postoperative 3 days and semi-liquid diet on postoperative 4–10 days.

2.8 | Outcome assessment

The primary outcomes were estimated blood loss and postoperative pain score on postoperative days 0, 1, 2, 3, and 7. The secondary outcomes were operation time, PTH, and the cost of disposable equipment.

2.9 | Statistical analysis

Statistical analyses were performed using the SPSS software (version 13.0; IBM Corp.). The Mann–Whitney *U* test was used to compare the groups. A p-value <.05 was considered significant.

3 | RESULTS

3.1 | Characteristics of the participants

This study enrolled 293 patients (coblation group, $n = 146$; monopolar group, $n = 147$), including 160 male and 133 female. The average age

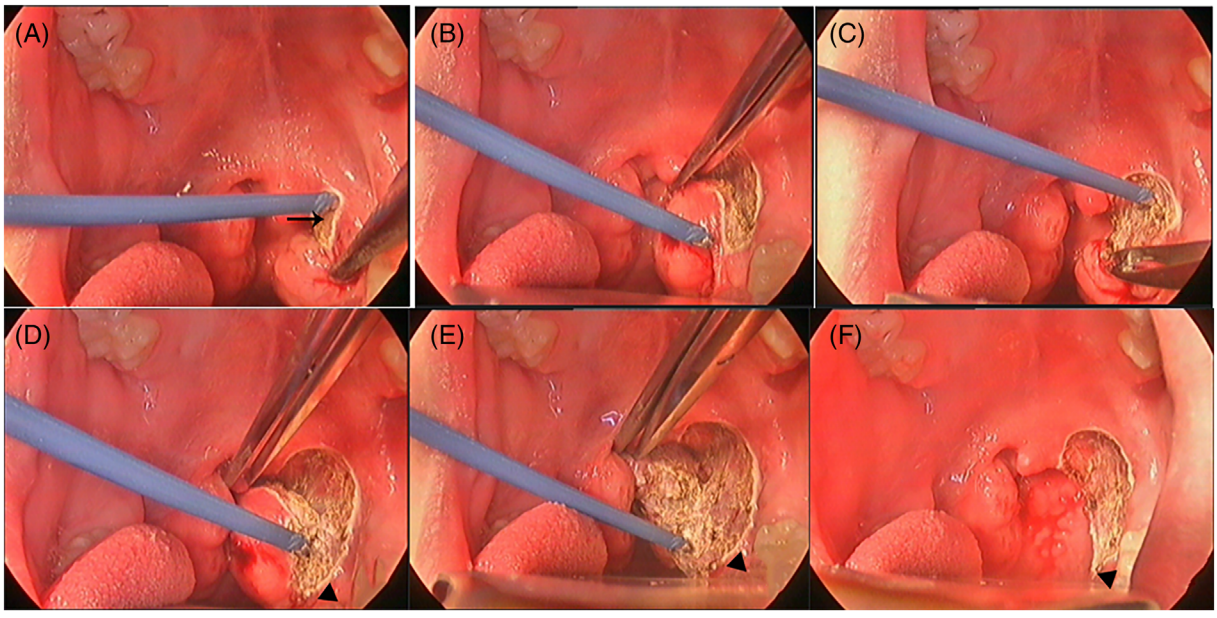

FIGURE 1 A: exposure of the upper pole; B–D: the tonsil was gradually separated from the upper to the inferior pole; E: removal of the inferior tonsil pole; F: tonsillar fossa. Black triangle indicates the pharyngeal and lingual extensions of the lymphoid tissue; black arrow indicates the upper pole

TABLE 1 Demographics, operation time, pain scores, blood loss, blood loss, and cost of two groups

	Coblation group	Monopolar group	*p* value
No.	146	147	
Age	11.92 ± 2.31	12.14 ± 1.89	.93
Sex (male:female)	81:65	79:68	.52
Duration, years	5.28 ± 2.37	6.01 ± 1.16	.48
Indication (chronic tonsillitis:tonsillar hypertrophy)	42:104	55:92	.15
Operation time, minutes	17.12 ± 4.29	11.09 ± 7.53	<.001
Intraoperative estimated blood loss, ml	6.39 ± 2.17	5.61 ± 1.63	.43
Postoperative pain scores			
Postoperative day 0	3.54 ± 1.47	3.81 ± 1.27	.92
Day 1	3.64 ± 2.01	5.28 ± 1.79	<.001
Day 2	4.15 ± 1.73	5.48 ± 1.69	.02
Day 3	3.91 ± 2.12	4.11 ± 1.24	.87
Day 7	3.09 ± 1.21	3.16 ± 1.08	.94
Primary hemorrhage, *n* (%)	5 (3.42)	2 (1.36)	.44
Secondary hemorrhage, n (%)	9 (6.16)	1(0.68)	<.001
Cost of disposable equipment, US$	430.48	28.18	<.001

TABLE 2 The percentage of operation time of two groups

	<5 ml	5–20 ml	21–50 ml
Coblation group ($n = 146$)	109 (74.66%)	31 (21.23%)	6 (4.11%)
Monopolar group ($n = 147$)	116 (78.91%)	25 (17.01%)	6 (4.08%)

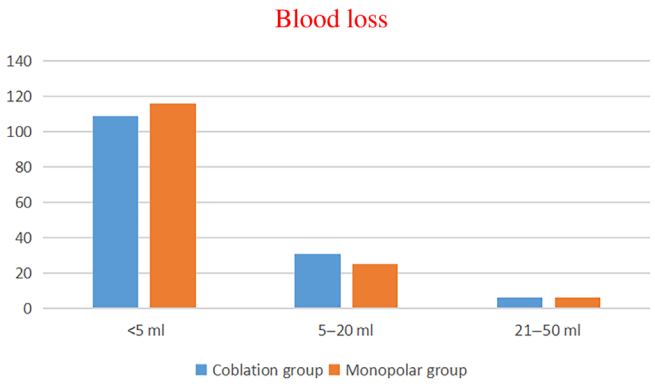

FIGURE 2 Distribution of blood loss

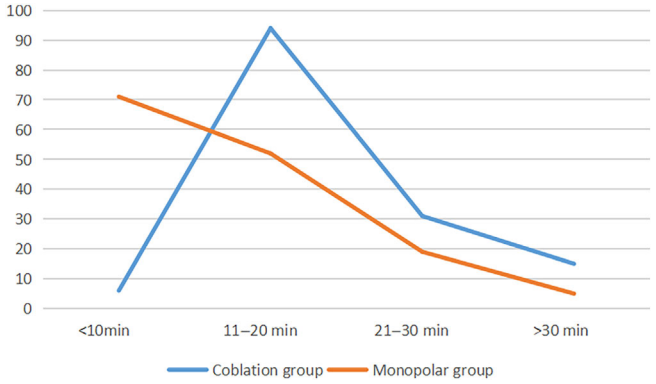

FIGURE 3 Distribution of operation time

of the patients was 11.84 ± 6.97 (range: 6–15) years. Of the 293 patients, tonsillitis was in 97 patients and tonsillar hypertrophy in 196. The mean age was 11.92 ± 2.31 years in the coblation group and 12.14 ± 1.89 years in the monopolar group. The disease duration was 5.28 ± 2.37 years and 6.01 ± 1.16 years in the monopolar group. Age, sex, disease duration, and surgical indication were similar in both groups (Table 1).

3.2 | Primary outcomes

Pain intensity in the coblation and monopolar groups was similar on postoperative days 0, 3, and 7 (Table 1). However, the mean maximum pain scores were significantly different between the two groups on postoperative days 1 (p <.001) and 2 ($p = .02$). Uvula edema was observed more frequently in the monopolar compared to coblation

TABLE 3 Incidence rate of post-tonsillectomy hemorrhage of between surgical indication and pain scores subgroups

	No	Incidence rate of PTH, *n* (%)	p^1 value	p^2 value
Surgical indication	No.	n (%)		.002
Tonsillitis	97	12 (12.37%)		
Coblation group	42	9 (21.43%)	.04	
Monopolar group	55	3 (5.45%)		
Tonsillar hypertrophy	196	5 (2.55%)		
Coblation group	104	5 (4.81%)	.09	
Monopolar group	92	0 (0.00%)		
Mean pain scores				.44
≤3	26	1(3.85%)		
4–6	204	14(6.86%)		
≥7	63	2(3.17%)		

Note: p^1 value: comparison of two techniques for the patients with tonsillitis or tonsillar hypertrophy. p^2 value: comparison of the patients with tonsillitis and tonsillar hypertrophy.

group. Intraoperative estimated blood loss was not significantly different between the groups ($p = .43$; Table 2 and Figure 2).

3.3 | Secondary outcomes

Table 1 and Figure.3 show that the mean operation time was significantly shorter in the monopolar compared to coblation group (11.09 ± 7.53 vs. 17.12 ± 4.29 min, $p < .01$).

3.4 | PTH

PTH occurred in 17 patients (5.80%) and required a second surgery. The PTH was primary in 41.18% (7/17) of cases and secondary in 58.82% (10/17). There were no serious abnormalities noted on blood tests in 17 patients. The subgroup analysis of PTH showed in the Table 3. The PTH was significantly higher in the patients with tonsillitis compared to in the patients with tonsillar hypertrophy (12.37% vs. 2.55%, $p = .002$), However, the difference of PTH was not significant among mean pain scores subgroups ($p = .44$). PTH occurred after 14 of the 146 coblation procedures (9.59%) and 3 of the 147 monopolar procedures (2.04%) ($p = .01$). Primary PTH occurred in 3.42% (5/146) of patients in the coblation group and 1.36% (2/147) of patients in the monopolar group ($p = .44$). Secondary PTH occurred in 6.16% (9/146) of patients in the coblation group and 0.68% (1/147) of patients in the monopolar group ($p < .001$). In addition, 42/146 (28.8%) patients with tonsillitis were included in the coblation group and 55/147(37.4%) in the monopolar group, the difference was not significant ($p = .15$). Of the 14 patients with PTH in the coblation group, 9 (21.43%) were referred for tonsillitis and 5 (4.81%) in the tonsillar hypertrophy, 11 (78.57%), 1 (7.14%), and 2 (14.29%) patients required second, third, and fourth surgeries, respectively. In the three patients requiring a third or fourth surgery, hemostasis was achieved using monopolar electrocautery. Of the three patients with PTH in the monopolar group, 3 (5.45%) were referred for tonsillitis and 0 (0.00%) in the tonsillar hypertrophy. All three patients with PTH in the monopolar group required a second surgery and achieved hemostasis with monopolar electrocautery. For the patients with tonsillitis, the difference of PTH was significant between coblation and monopolar groups ($p = .04$), while difference was not significant between coblation and monopolar groups for the patients with tonsillar hypertrophy ($p = 0.09$; Table.3). However, no muscular injuries were noted in 17 patients during revision surgery. The lower pole, middle portion, and upper pole were the site of bleeding in 15 (88.24%), 2 (11.76%), and 0 of the 17 patients with PTH, respectively.

3.5 | Cost and complications

The cost of disposable equipment was US$ 430.48 and US$ 28.18 in the coblation and monopolar groups, respectively ($p < .001$). No instrument-related complications were observed in either group.

4 | DISCUSSION

The main complications after extracapsular tonsillectomy are postoperative pain and intraoperative blood loss. Some previous studies reported that coblation extracapsular tonsillectomy was associated with less postoperative pain compared to the electrocautery technique.[12–14] Wiltshire et al.[12] reported that pain scores were significantly lower in the coblation group on postoperative days 1–3 compared to the bipolar group. Littlefield et al.[13] reported that coblation extracapsular tonsillectomy was associated with significantly less pain compared to the monopolar technique ($p = .04$). These studies included a small sample. In contrast, other studies have reported no advantage[15,16] or disadvantage of coblation.[17,18] Álvarez Palacios et al.[17] compared postoperative pain after cold, monopolar-bipolar, and coblation dissection techniques. They found no significant differences between the groups, except on postoperative day 1, when

coblation was associated with a higher pain score. Hasan et al.[18] reported higher pain scores in their coblator compared to bipolar group, at both 1 and 3 h postoperatively. It is unclear whether coblation is associated with reduced postoperative pain. Previous studies differed in observation time points and objectives. Electrocautery can produce temperatures above 400°C that may damage surrounding structures, leading to significant postoperative pain. In the present study, uvula edema was observed more frequently in the monopolar compared to coblation group. However, no significant difference was observed in the mean maximum pain scores, except for the higher mean maximum pain scores in the monopolar compared to coblation group on postoperative days 1 ($p = .001$) and 2 ($p = .02$).

Similar to a previous study,[14] the current study did not find a significant difference between the groups in terms of intraoperative estimated blood loss. Intraoperative blood loss and postoperative pain mainly depend on the skills of the surgeon. Blood loss and postoperative pain can be reduced by identifying and dissecting the upper pole of the tonsil and peritonsillar space. Minimal (or no) bleeding occurred when the operation was performed close to the tonsillar capsule in the peritonsillar space, regardless of the technique used (e.g., blunt dissection using a finger, cutting, electrocoagulation, or coblation), because the peritonsillar space is avascular.[19] If surgery is performed away from the tonsillar capsule, the pharyngeal muscles may be damaged, resulting in intraoperative bleeding and PTH.

Similar to previous studies,[2,14,16] in the present study the mean operation time was significantly shorter in the monopolar compared to coblation group. Noordzij et al.[14] reported that the mean times to remove a single tonsil with coblation and electrocautery were 8.22 and 6.33 min, respectively ($p = .01$). In the current study, we used the monopolar electrocautery device with a needle tip bovie, which can precisely identify the tonsils and tonsillar fossa, thereby reducing the operation time. In contrast, the coblation device has a large tip bovie, which prevents a full view of the surgical field and lead to damage to the surrounding structures. The speed of tissue separation and removal may also be faster in the monopolar device at 400°C compared to 60°C. Unfortunately, the monopolar device had the fire and burn risk associated with fiberoptic cables and electrosurgical devices,[20] although it was not encountered in present study. Nevertheless, the fire risk seems to be eliminated with coblation.

The most important complication after extracapsular tonsillectomy is PTH. In the present study, PTH occurred in 5.80% (17/293) of patients, similar to the rates of 1.4%–11.9% reported previously.[21–23] Most previous studies have reported an increased risk of PTH after coblation extracapsular tonsillectomy.[3–6,24] However, Glade et al.[25] reported similar rates of primary and secondary PTH between coblation and electrocautery groups. In the present study, no significant difference was observed between the groups in terms of primary PTH. However, coblation extracapsular tonsillectomy significantly increased the rate of secondary PTH compared to the electrocautery group (5.43% and 0.36%, respectively). This is similar to the results of previous studies.[4,5,24] The needle tip bovie of monopolar electrocautery could improve precision of cautery without damaging the surrounding structures. In contrast, the coblation device is larger than the monopolar device, which reduces the surgical field of vision and may lead to injury to the surrounding structures. The peritonsillar space contains thin fibroareolar tissue, which appears off-white after coblation, thus making further identification of the peritonsillar space difficult. Therefore, the risk of injury to the microvascular structure of the pharyngeal muscles is increased. In addition, these results showed that the PTH in the patients with tonsillitis was significantly higher compared to the patients with tonsillar hypertrophy.

For the patients with tonsillitis, the difference of PTH was significant between coblation and monopolar groups ($p = .04$), nevertheless, the difference of PTH was not significant among two groups for the patients with tonsillar hypertrophy ($p = .09$). Peritonsillar tissue might be more fibrotic in infective cases, which may affect the identification of peritonsillar space and the lower pole. However, we found that the difference of PTH was not significant among pain scores subgroups.

Coblation has weak coagulation ability for large blood vessels. In this study, although the blood vessels were briefly sealed, rebleeding occurred due to cough, infection, or frequent swallowing. Monopolar electrocautery has a wide area of effective coagulation, which prevents bleeding from large vessels.

Secondary PTH mainly occurs from the lower pole.[26,27] In the current study, 88.24% of the cases of PTH involved the lower pole. Bleeding from the inferior pole may result from damage to the pharyngeal and lingual extensions of the lymphoid tissue, which are closely related to the lingual artery and a branch of the tonsillar artery. PTH may occur if the inferior pole close to the root of the tongue is excessively excised. Bleeding from the inferior pole can be prevented by accurate identification of the inferior pole. PTH may occur after coblation, because the large coblation device may damage the pharyngeal and lingual extensions of the lymphoid tissue during removal of the inferior pole. Several methods have been recommended to reduce the incidence of PTH from the inferior pole. Li et al.[28] recommended the preservation of inferior pole capsule be preserved. Two Chinese studies recommended using sutures to secure the anterior and posterior pillars after coblation extracapsular tonsillectomy.[26,27] Burton et al.[19] suggested using sutures to secure the pharyngeal and lingual extensions of the lymphoid tissue in the inferior pole of the tonsil. In addition, the application of sutures prolonged the operation and increased scarring in the pharynx, resulting in postoperative pharyngeal discomfort. The needle tip bovie of monopolar electrocautery can easily identify the inferior pole and prevent injury to the pharyngeal and lingual extensions of the lymphoid tissue.

The cost of extracapsular tonsillectomy was significantly lower in our monopolar compared to coblation group, with the difference mainly due to the cost of disposable equipment (US$ 430.48 and US$ 28.18 in the coblation and monopolar groups, respectively). In addition, the short operation time in the monopolar group may reduce the anesthesia cost. Some researchers have found that monopolar electrocautery tonsillectomy is associated with a significantly reduced cost of disposable equipment compared to coblation extracapsular tonsillectomy.[17,29]

Extracapsular tonsillectomy requires good surgical skills and knowledge of the tonsil anatomy for accurate identification of the

upper and lower pole of the tonsil, and the peritonsillar space. The inferior pole should not be dissected beyond the level of the pharyngeal and lingual extensions of the lymphoid tissue. In addition, based on the findings of our study and previous studies, postoperative pain, PTH, operation time, and cost were not superior in the coblation extracapsular tonsillectomy compared to monopolar cautery group. Therefore, coblation extracapsular tonsillectomy may not be an ideal choice, especially in low-resource settings.

5 | CONCLUSIONS

Coblation and novel monopolar electrocautery extracapsular tonsillectomy are associated with similar postoperative pain scores except on postoperative days 1 and 2. However, monopolar technique offers significant advantages over Coblation method with less operative time, decreased secondary PTH, and cost.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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