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HEAD & NECK

Comparison of two modern and conventional tonsillectomy techniques in terms of postoperative pain and collateral tissue damage

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Abstract

Purpose To compare the tonsillectomy operations performed with bipolar radiofrequency clamp (BRC), plasma blade (PB), and cold dissection (CD) techniques in terms of postoperative pain and collateral tissue damage.

Methods This is a prospective randomized comparative cohort study conducted in a tertiary hospital. A total of 50 patients who underwent tonsillectomy in our institution met the inclusion criteria. Based on the tonsillectomy technique, patients were randomly divided into 3 groups as BRC (CURIS®) (n:20), PB (PEAK Surgical) (n:20), and CD (n:10). The patients were given a visual analog scale (VAS) for pain evaluation on the 1st postoperative day (3rd h) and on the 3rd and 6th days after discharge. The deepest and the most superficial necrosis depths were examined under the light microscope (Olympus BX53, Japan) by the same single blinded pathologist.

Results The age of the patients included in the study ranged from 5 to 45 years. The mean age was 14.5 years. Twenty-four of the patients were female, 26 were male. Mean 3rd h and 3rd day VAS scores for pain in the BRC group were significantly higher than the other two groups ($p < 0.001$). Although PB group had higher VAS scores compared with CD group, the difference was not significant ($p > 0.05$). The deepest necrosis depths (dND) in patients who were operated with BRC was significantly greater compared to patients operated with PB ($p < 0.01$), whereas no significant difference was observed between the techniques regarding the most superficial necrosis depth (msND) ($p > 0.05$). For patients operated with CD technique, only ischemic fields were observed.

Conclusion Both BRC and PB techniques seem to not provide significant advantage compared with conventional CD technique in terms of postoperative pain. Necrosis depths in tonsillectomy specimens due to thermal damage positively correlate with the postoperative pain level.

Keywords Plasma blade · Bipolar radiofrequency clamp · Cold dissection · Necrosis depth · Tonsillectomy · Postoperative pain

Introduction

Tonsillectomy is still one of the most commonly performed surgical procedures in otorhinolaryngology practice [1]. Tonsillectomies are usually performed for recurrent tonsillitis or adenotonsillar hypertrophy that results in sleep-disordered breathing [2].

Although considered as a simple procedure, tonsillectomy is associated with significant morbidity in both adults and children [3]. The most common risks specific to the procedure are pain and postoperative bleeding [4]. Postoperative pain lasts approximately 2 weeks and may delay resumption of normal activity and diet with the risk of dehydration. In severe cases, postoperative pain may result in delayed

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discharge, an emergency department visit or readmission for pain control and hydration [5]. By integrating new technological developments into classical tonsillectomy technique, it has been tried to improve efficiency and safety in tonsillectomy operations. These methods include cold dissection, monopolar and bipolar cauterization, bipolar radiofrequency dissection, laser tonsillectomy, cryosurgery, ultrasonic scalpel, microdebrider, coblation, thermal welding, and plasma blade tonsillectomy [3].

The ideal tonsillectomy procedure should achieve a safe, atraumatic, painless, and bloodless removal of the tonsils. This procedure should also be simple to perform with reliable results among surgeons [3]. The technique that will yield the best results to achieve ideal tonsillectomy will certainly be the most pleasing for both the surgeons and the patients. The choice of surgical technique can potentially influence postoperative morbidity, operative time, and intraoperative blood loss [1]. Perhaps more recent studies on this subject will take us closer to achieve the ideal tonsillectomy. As a result, in consideration of the frequency of tonsillectomy operations and the associated morbidity as well as the results of the previous related studies, it is understood that there is a lot of room for improvement in this field.

In this study, we aimed to compare tonsillectomy operations performed by bipolar radiofrequency clamp (BRC), plasma blade (PB) and cold dissection (CD) techniques in terms of postoperative pain and collateral tissue damage.

Materials and methods

The study included totally 50 patients who were operated in Samsun Training and Research Hospital Otorhinolaryngology department between 2014 and 2015 due to recurrent tonsillitis. After the approval of Scientific Research Evaluation Board (2015/9) all patients were informed about their disease and its treatment, and the surgical method to be applied was explained in detail. All patients provided informed consent.

The age of the patients included in the study ranged from 5 to 45 years. The mean age was 14.5 years. Twenty-four of the patients were female, 26 were male. All patients were examined with a complete physical examination. Patients with chronic diseases such as hypertension or diabetes mellitus, patients with suspicion of malignancy, or patients who underwent tonsillectomy due to uvulopalatopharyngoplasty (UPPP) were excluded. Based on the tonsillectomy technique, all the patients were randomly divided into 3 groups as BRC, PB, and CD.

Surgical techniques

Bipolar radiofrequency clamp (BRC)

BRC (CURIS® 4 MHz radiofrequency generator, To-BiTE™ non-stick bipolar clamp, Germany) is one of the more recent techniques for tonsillectomy and utilizes radiofrequency energy to produce a plasma field by passing it through a conducting medium (usually normal saline). It is also known as Coblation (cold-ablation), plasma-mediated ablation and bipolar radiofrequency ablation. The advantage of this technique is that the charge carrying ions have sufficient energy to cause molecular disintegration of tissues at low temperatures (typically 40–70 °C), thus avoiding thermal damage to surrounding tissues [5].

In the BRC group, all dissections including the anterior plica incision were made using BRC. The generator was adjusted to approximately 30—40 W, which equals an intensity of 6—7 ablation setting and a coagulation setting of 3–5. To-BiTE™ clamp offers grasping, dissection, coagulation, and suction in one instrument.

Plasma blade (PB)

The pulsed-electron avalanche knife (PEAK) PlasmaBlade device (PEAK Surgical-Pulsar Generator PS 100–100, PEAK PlasmaBlade TnA, Medtronic, USA) is a soft tissue dissection instrument that uses very brief, high-frequency pulses of radiofrequency (RF) energy to induce electrical plasma along the edge of a thin (12.5 µm), 99.5% insulated electrode. Due to the low-duty cycle from RF pulsing and proprietary Thermal Protection Shield (TPS) insulation technology, the device uses less total energy and, like bipolar radiofrequency ablation, operates at significantly lower temperatures (40–170 °C) than traditional electrocautery (200–350 °C), presumably allowing dissection of tonsil and hemostatic control with less collateral tissue damage than traditional electrocautery [6, 7].

In the PB group, the tonsil was clamped and medialized, and the PB probe on a coagulation setting of four was used to incise the anterior plica and remove the tonsils downward. The coagulation mode of PB was used for both dissection and hemostasis.

Cold dissection (CD)

In the CD group, the tonsil was clamped and medialized, and an incision was made in the anterior plica with a tonsil blade or no. 12 surgical blade. The tonsil was dissected from the pharyngeal muscles behind the capsule and from the posterior plica, and elevated until the root of the tongue,

and then removed with the help of the snare. Hemostasis was provided by pressure application, and suturing techniques. No other adjunctive device such as electrocautery was used for hemostasis.

Examination methods

Tonsil tissue was clamped in one area and was sent to the pathology laboratory separately by cutting with a scalpel under the clamped part to exclude the necrosis effect of the clamp. Right and left tonsils from each patient were prepared as separate specimens, by fixating in buffered 10% neutral formaldehyde. By the same pathologist, the tonsils were divided into sections that pass through the upper and lower poles. All the sections were passed through routine tissue processing and buried in paraffin blocks. Paraffin blocks were cut with 4–5 micron sections and stained with hematoxylin–eosin method. The deepest necrosis depths (dND) and the most superficial necrosis depths (msND) were examined for both right and left tonsil specimens under the Olympus BX53 light microscope by the pathologist. The images were photographed with the Olympus DP72 camera.

Evaluation methods

All operations in each group were performed by same otolaryngologists to provide standardization. The most experienced surgeon about the surgical technique performed the operation in each group. All patients were admitted overnight and discharged on the day following surgery and were prescribed with 40 mg/kg/day amoxicillin clavulanic acid and the same analgesic protocol (paracetamol suspension 500 mg for adults, 15 mg/kg for children per 4–6 h). Any patient was given neither stronger doses nor different analgesics. Each patient was given VAS form for pain to be filled on the first postoperative day at 3rd h, on the third and sixth days after discharge from the hospital. Patients were asked to mark their pain on the VAS with a score between 0 and 10 points. Postoperative evaluations of the patients were performed by another otolaryngologist who did not participate in the operations and was blinded to the technique used in the operation. When children could not cooperate, this information was provided from their parents. The third and sixth days' VAS form for pain were described to be completed in the morning before taking any analgesics.

Statistics

Analyses were performed after exporting the data from excel media to IBM SPSS Statistics 19 program. For evaluation of the data, frequency distributions were given for categorical variables, and descriptive statistics were given for continuous variables. Continuous variables were tested for normality before beginning the analysis. The results of the normality test showed that the age variable did not meet the normality assumption while pain scores and necrosis depths showed normal distribution. Accordingly, independent sample *t* test and one-way analysis of variance (ANOVA) were applied as parametric tests for comparison of continuous variables, and Chi-square test was applied for comparison of categorical variables with 95% confidence level.

Results

The mean patient age was 13.1 years in the BRC group, 14.9 years in the PB group, and 14.5 years in the CD group. There was no statistically significant difference between the groups regarding age or gender ($p > 0.05$) (Table 1).

Among patients operated with BRC, VAS for pain was 7.00 at the 3rd h, 3.70 on the 3rd day, and 2.15 on the 6th day. For patients operated with PB, VAS for pain was 5.55 at 3rd h, 2.55 on the 3rd day, and 1.75 on the 6th day. Among patients operated with CD, VAS for pain was 4.90 at the 3rd h, 2.40 on the 3rd day, and 1.60 on the 6th day (Table 2).

There was no mild pain in any group at postoperative 3rd h. Moderate pain was seen in 15 patients in the PB group, 5 patients in the BRC group, and 10 patients in the CD group. Severe pain was seen in 5 patients in the PB group, and 15 patients in the BRC group. On the postoperative 3rd day, all 20 patients in the PB group, and all 10 patients in the CD group had mild pain, while in the BRC group, 9 patients had mild pain and 11 patients had moderate pain. On the postoperative 6th day, all 20 patients in the PB group, and all 10 patients in the CD group had only mild pain, while in the BRC group, 19 patients had mild pain and 1 patient had moderate pain.

Table 1 Distribution of gender and age across groups based on techniques

	PB		BRC		CD		*P* value
	Min–max	Mean ± SD	Min–max	Mean ± SD	Min–max	Mean ± SD	
Age	6–45	14.9 ± 12.5	5–36	13.1 ± 11.6	7–45	14.5 ± 12.2	> 0.05
Male	10	50.0	12	60.0	4	40.0	> 0.05
Female	10	50.0	8	40.0	6	60.0	> 0.05

PB plasma blade, *BRC* bipolar radiofrequency clamp, *CD* cold dissection, SD standard deviation

Table 2 Comparison of the techniques according to VAS scores for pain

VAS score	Technique	*N*	Mean	SD	Multiple comparison	
					Groups	*P* values
3rd h	PB	20	5.55	±1.276	PB-BRC	0.001
	BRC	20	7.0	±0.795	PB-CD	>0.05
	CD	10	4.90	±0.738	BRC-CD	0.001
3rd day	PB	20	2.55	±0.686	PB-BRC	0.001
	BRC	20	3.70	±0.733	PB-CD	>0.05
	CD	10	2.40	±0.516	BRC-CD	0.001
6th day	PB	20	1.75	±0.639	PB-BRC	>0.05
	BRC	20	2.15	±0.813	PB-CD	>0.05
	CD	10	1.60	±0.699	BRC-CD	>0.05

PB plasma blade, *BRC* bipolar radiofrequency clamp, *CD* cold dissection, *SD* standard deviation

Table 3 Comparison of techniques according to dND and msND

Necrosis depth	Technique	*N*	Mean (µm)	SD (µm)	*P* values
	PB	40	771.95	278.492	
dND	BRC	40	1268.15	413.767	0.0002
	CD	20	0	0	
	PB	40	105.15	67.583	
msND	BRC	40	125.7	63.587	0.43
	CD	20	0	0	

dND the deepest tonsillar necrosis depth, *msND* the most superficial tonsillar necrosis depth, *PB* plasma blade, *BRC* bipolar radiofrequency clamp, *CD* cold dissection, *SD* standard deviation

The techniques were analyzed in terms of differences regarding VAS score for pain; accordingly, one-way ANOVA test results showed that there was statistically significant difference between the techniques regarding postoperative 3rd h and 3rd day VAS scores for pain ($p<0.001$), whereas there was no statistically significant difference regarding 6th day VAS score for pain ($p>0.05$). Mean 3rd h and 3rd day VAS scores in the BRC group were significantly higher compared to the mean 3rd h and 3rd day VAS scores of the other two groups ($p<0.001$) (Table 2). There was no statistically significant difference between the PB and CD groups regarding VAS scores on the postoperative 3rd h, 3rd day and 6th day ($p>0.05$).

As a result, reported pain levels were greater in patients operated with BRC, followed by the patients in the PB and CD groups. Although patients operated with PB had higher VAS scores compared to the patients operated with CD, the difference was not statistically significant.

For patients operated with PB technique, mean dND was 771.95 µm, and mean msND was 105.15 µm. For patients operated with BRC, mean dND was 1268.15 µm, and mean msND was 125.70 µm (Table 3, Figs. 1, 2).

In patients operated with CD technique, ischemic fields (Fig. 3) were observed.

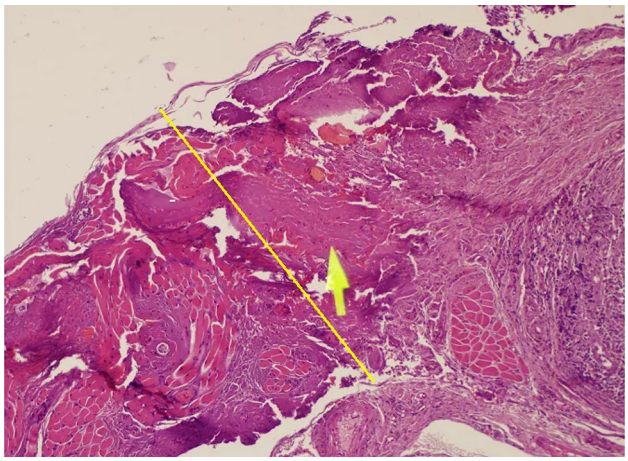

Fig. 1 Tonsillar necrotic field shown in ×200 magnification following operation with BRC

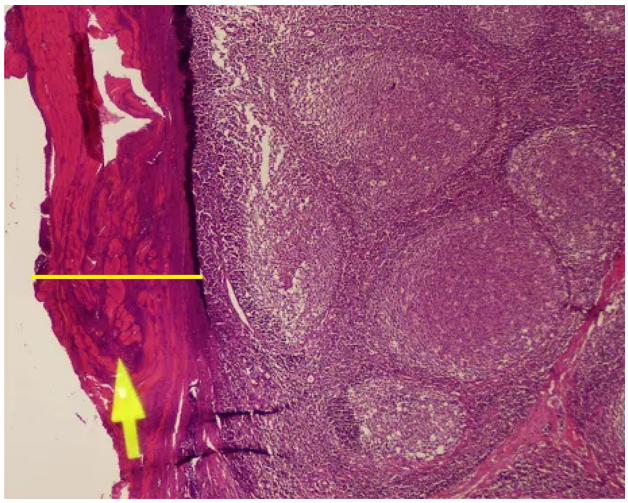

Fig. 2 Tonsillar necrotic area shown in ×200 magnification following operation with PB

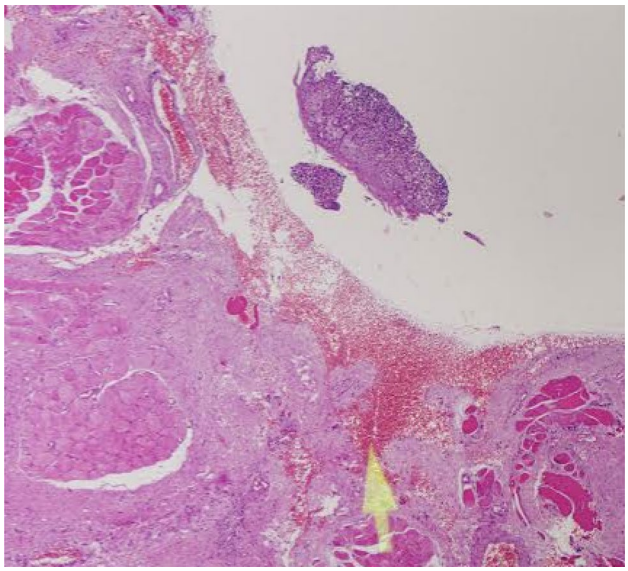

Fig. 3 Tonsillar ischemic areas shown in ×200 magnification following operation with CD

With regard to the difference between the techniques regarding dND and msND, independent samples *t* test results showed that there was statistically significant difference between the techniques regarding dND ($p < 0.01$), whereas no significant difference was observed between the techniques regarding the msND ($p > 0.05$). The dND in patients who were operated with BRC was significantly higher compared to the patients operated with PB (Table 3).

As a result, while there were significant differences between the techniques regarding the dND, no difference was observed between the techniques regarding the msND. dND was found to be greater in patients who were operated with BRC.

Discussion

Tonsillectomy is one of the most commonly performed surgical procedures in otolaryngology practice and the number is increasing per year over recent decades [8]. The indications for tonsillectomy have varied throughout history but still the most frequent indication is recurrent tonsillitis [9]. Although tonsillectomy itself can reduce the incidence of sore throat in patients who have frequent throat infections, postoperative pain remains the major drawback to tonsillectomy operations and is considered to be inherent in tonsillectomy procedure [9–11]. Pain is reported to be the main cause for seeking outpatient medical attention in the first 2 weeks after surgery [10].

Numerous factors such as parent/caregiver (socioeconomic status and cultural background), patient (age/maturity and indications), medication (palatability, effectiveness), surgical technique (hot vs. cold dissection), experience of the surgeon, and system (access to medications, adequacy of discharge instructions) contribute to the success of post-tonsillectomy pain control [11–13].

Tonsillectomy may damage tissue in a number of ways. After tonsillectomy, because the pharyngeal wound is left open, nerve pain fibers are exposed to hypotonic solutions and mechanical trauma from swallowed food. The retractor, which is used to expose the oropharynx, compresses the tongue, produces venous congestion, and may injure sensory nerves. The electrosurgical devices commonly used to excise the tonsils cause thermal damage to surrounding tissues, leading to acute inflammation and edema [11, 14].

As the choice of surgical technique seems to be the easiest factor which can potentially influence the post-tonsillectomy pain, multiple surgical techniques are used in practice, without a consensus on the optimal technique or instrumentation [1, 5, 15].

In the current study, we compared two modern electrosurgical techniques (bipolar radiofrequency ablation and plasma blade) and conventional cold dissection technique in terms of postoperative pain and collateral tissue damage. Mean 3rd h and 3rd day VAS scores in the BRC group were significantly higher compared to the other two groups ($p < 0.001$). There was no statistically significant difference between the PB and CD groups regarding VAS scores on the postoperative 3rd h, 3rd day and 6th day ($p > 0.05$). There was no significant difference between these techniques regarding pain levels on the postoperative 6th day ($p > 0.05$).

Chimona et al. compared BRC with thermal welding and CD techniques, and they found significantly less pain in the CD group on the 1st, 4th, 7th, and 10th days, whereas there was no significant difference between the thermal welding and BRC [10]. They experienced excessive uvula and soft-palate edema, probably due to thermal damage of the surrounding tissues and/or sealing of the lymphatic drainage producing voice changes, difficulty in food intake and a general discomfort in a number of patients from BRC and thermal welding group. Ozkul et al. reported impedance-controlled radiofrequency technique was superior to the CD technique regarding intra-operative bleeding and the CD technique was superior to the radiofrequency technique regarding returning to a painless dietary regimen [16]. Many other authors reported that the coblation (radiofrequency ablation) techniques do not provide any significant advantage compared with conventional techniques [13, 15, 17].

Polites et al. reported lower pain levels with coblation on the postoperative first 3 days compared to the CD technique; however, they did not find any significant differences after 3rd day [18]. Mitic et al. also concluded that patients undergoing coblation tonsillectomy reported less pain, less use of analgesics than patients undergoing CD

[19]. In their series hemostasis was provided by bipolar diathermy in CD group. As this technique was a "cold" dissection but "hot" hemostasis, impact of diathermy use for hemostasis should be clearly documented. In a current review comparing coblation versus other surgical techniques, Pynnonen et al. concluded that the use of any additional techniques, especially haemostasis methods, should be prespecified clearly in the trial protocol [5]. Metcalfe et al. also pointed that use of electrocautery haemostasis may have impacted pain outcomes and the reported pain outcomes should be viewed in this context [20].Timms and Temple, and Wiltshire et al. both suggested that coblation tonsillectomy is less painful because of lower operating temperatures compared with diathermy [21, 22]. Sure the diathermy was an adjunctive technique for hemostasis but the higher temperature and long time use can influence postoperative pain scores; because thermal damage to surrounding tissues, leading to acute inflammation and edema is an important state in post-tonsillectomy pain mechanism [11, 14]. Elinder et al., in their study of 18,712 patients in the National Tonsil Surgery Register in Sweden found that the use of cold steel instruments resulted in a decreased risk and the use of bipolar diathermy scissors for dissection or the use of bipolar diathermy for hemostasis increased the risk of contact with a health care provider due to pain [12]. In the series of Polites et al., patients were randomized to have one tonsil removed by CD and the other one by coblation.

With this method, we think that postoperative subjective pain perception cannot be clearly distinguished, which may give unreliable results. In our CD group hemostasis was provided by pressure application and suturing techniques. No other adjunctive device such as electrocautery was used for hemostasis. And same technique was used for same patient and for both tonsils.

In our study, although higher pain levels were observed with PB compared to the CD on postoperative 3rd h, 3rd day, and 6th day, the difference was not statistically significant ($p > 0.05$). Reviewing the literature there is a few trials comparing PB to BRC and CD in terms of postoperative pain. Spektor et al. compared PB to BRC in their current trial and concluded that there were no clinically relevant differences in postoperative pain scores between the groups on all postoperative days and total doses of analgesics were similar. But the surgery performed to enrolled patients was 'adenotonsillectomy' in this trial [7].

As a result, reported pain levels were greater among patients operated with BRC, followed by PB and CD groups. Greater necrosis depth suggests that it may contribute to the higher pain levels. Although there are many studies that examine healing in surgical cuts created with electrosurgical tools, studies on humans are scarce. Reviewing the literature, we did not encounter so many studies that investigated the necrosis depth formed in human subjects after tonsillectomy regarding the surgical technique.

In the present study we aimed to measure the necrosis depths in tonsillar specimens obtained from tonsillectomy operations. However, studying tissue effect on excised tonsils may not reflect the tissue injury seen on the patient side completely, we thought that this would provide an indirect clue about the necrosis depth in the tonsil location from which the specimens were excised, and this assumption was supported by the positive correlation between postoperative pain levels and necrosis depth at the tonsillar specimens. Shah et al. observed that tonsillar fossa appearance after coblation shows less charring subjectively, and a shorter average depth of thermal effect was seen in coblation tonsils compared to monopolar electrocautery tonsils (0.13 vs. 0.63 mm, respectively, $p = 0.03$). We agree with Shah et al., as this question may be better answered through the study of post-tonsillectomy pharyngeal injury in an animal model [23]. Magdy et al. evaluated the tonsillectomy specimens' excision margins and revealed marked vascular congestion in tonsils resected by the CD. Tissue charring was only observed with CO2 laser. On the other hand, necrosis, indicating tissue injury, was seen in all tonsil specimens resected by monopolar electrocautery, CO2 laser and coblation, with mean injury depths of $303.6 + 93.9$, $214.6 + 61.2$ and $89.2 + 23.2$ mm, respectively ($p = 0.001$, $p = 0.003$) [24].

In our study, the mean dND in BRC group (1268.15 µm) was significantly greater than those of PB (771.95 µm) ($p = 0.0002$). No difference was found between the methods with regard to the msDN ($p = 0.43$). On the other hand, there was no necrosis formation in tonsillectomies performed with cold dissection method, but only superficial ischemic areas. Both the dND and the pain scores on postoperative 3rd h and 3rd day were significantly higher in the BRC group compared to the other methods, and in parallel with this finding, patients in the PB group had less necrosis depth and less postoperative pain; therefore, it was thought that necrosis depth was positively correlated with the postoperative pain level.

Limitations of this study included the presence of three surgeons, and the reliance on visual analogue score for postoperative data collection.

Conclusion

Postoperative pain levels seem to be greater among patients operated with BRC, followed by PB and CD. According to our results necrosis depths in tonsillectomy specimens due to thermal damage positively correlate with the postoperative pain level. Both BRC and PB techniques seem to not provide significant advantage compared with conventional CD technique in terms of postoperative pain.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Informed consent All patients were informed about their disease and its treatment, and the surgical method to be applied was explained in detail. All patients provided informed consent.

Human and animal rights statement The study has been performed according to the ethical standards of the Helsinki Declaration. We declare that all authors have contributed to it, read and approved the final manuscript for submission.

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