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MAIN ARTICLE

Six years of evidence-based adult dissection tonsillectomy with ultrasonic scalpel, bipolar electrocautery, bipolar radiofrequency or 'cold steel' dissection

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Abstract

Objective: To conduct an adequately powered, prospective, randomised, controlled trial comparing adult dissection tonsillectomy using either ultrasonic scalpel, bipolar electrocautery, bipolar radiofrequency or 'cold steel' dissection.

Methods: Three hundred patients were randomised into four tonsillectomy technique groups. The operative time, intra-operative bleeding, post-operative pain, tonsillar fossa healing, return to full diet, return to work and post-operative complications were recorded.

Results: The bipolar radiofrequency group had a shorter mean operative time. The mean intra-operative blood loss during bipolar radiofrequency tonsillectomy was significantly less compared with cold dissection and ultrasonic scalpel tonsillectomy. Pain scores were significantly higher after bipolar electrocautery tonsillectomy. Patients undergoing bipolar electrocautery tonsillectomy required significantly more days to return to full diet and work. The bipolar electrocautery group showed significantly reduced tonsillar fossa healing during the first and second post-operative weeks.

Conclusion: In this adult series, bipolar radiofrequency tonsillectomy was superior to ultrasonic, bipolar electrocautery and cold dissection tonsillectomies. This method combines the advantages of 'hot' and 'cold' tonsillectomy.

Key words: Tonsillectomy; Adult; Electrocoagulation; Randomized Controlled Trial

Introduction

Adult tonsillectomy is a more stressful operation than paediatric tonsillectomy, mainly due to greater intra-operative bleeding. To date, there is no worldwide consensus on the standard technique for this procedure. 'Cold steel' dissection is considered the standard technique in Germany, while in the US electrocautery is favoured.[1–3] Newer methods such as radiofrequency dissection and the ultrasonic scalpel have been developed in the search for an efficient technique that reduces intra- and post-operative morbidity.[1–3]

Radiofrequency dissection involves the passage of an electric current through tissue to create a predictable histological effect.[4,5] In the field of tonsillar surgery, three main radiofrequency techniques have been described: tonsil ablation, tonsillotomy and tonsillectomy. These groups have been subdivided according to the radiofrequency probe and radiofrequency machine used. In 2005, the current author coined the term 'bipolar radiofrequency dissection tonsillectomy' to describe the use of bipolar radiofrequency forceps connected to an Ellman Surgitron 4 MHz radiofrequency machine to perform dissection tonsillectomy in children in the same manner as conventional cold dissection tonsillectomy.[6]

Tonsillectomy using the harmonic scalpel, also known as the ultrasonically activated scalpel, has also been described.[7,8] This scalpel is able to cut and coagulate at the same time due to its blade vibrations, which occur at a frequency of 55 000 per second over an excursion of 50–80 μm. These ultrasonic vibrations transfer frictional energy to tissues, which cause protein to denature by cleaving hydrogen bonds at a temperature of 60–80°C. No electric current passes through the tissues, and the thermal transduction from the blade to the tissues is less than with bipolar diathermy.[9]

In order to investigate the optimum method of adult dissection tonsillectomy, the current prospective, randomised, controlled study was conducted to evaluate

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and compare four different techniques of adult dissection tonsillectomy: ultrasonic scalpel, bipolar electrocautery, bipolar radiofrequency and 'cold steel' dissection.

Materials and methods

The study was conducted between January 2005 and March 2011, and included 300 adult patients with a history of recurrent tonsillitis (173 male and 127 female; age range 18–54 years; mean age ± standard deviation (SD), 29 ± 10 years) who were scheduled to undergo tonsillectomy. Patients were prospectively randomised into four equal groups: ultrasonic scalpel, bipolar electrocautery, bipolar radiofrequency and cold dissection tonsillectomy.

The study protocol and consent procedure were approved by the local postgraduate research ethics committee.

Exclusion criteria included: age less than 18 years; history of quinsy; bleeding disorders; any major illness or medical problems; contraindication to general anaesthesia; contraindication to paracetamol or diclofenac sodium intake; craniofacial anomalies; and the need to perform any other procedure together with the tonsillectomy.

Operative technique

All surgery was performed under general anaesthesia, and the anaesthesia protocols were standard for all patients.

Ultrasonic tonsillectomy was performed using a Sonosurg machine (Olympus, Tokyo, Japan). The machine power was adjusted to 50 per cent vibration amplitude. A short hook blade (5 mm diameter) was used to perform the dissection tonsillectomy. The capsule of the tonsil was entered and followed from the upper to the lower pole.

Bipolar electrocautery tonsillectomy was performed using bipolar forceps connected to an Erbe ICC 300 surgical unit (Erbe Electromedizin, Tübingen, Germany). The power was adjusted to 30 W.

Bipolar radiofrequency tonsillectomy was performed using bipolar radiofrequency forceps connected to a Surgitron 4 MHz radiofrequency machine (Ellman, Oceanside, New York, USA). The complete dissection tonsillectomy was performed using the same forceps, which were used for both dissection and haemostasis. A power grade of 40 was used, in a bipolar mode.

Cold steel dissection tonsillectomy was performed with a blunt dissector and snares, using ligatures for haemostasis.

The Boyle–Davis mouth gag was removed at the end of the operation and the patient returned to the care of the anaesthetist during recovery from anaesthesia.

The operative time was recorded by an independent nurse, and was defined as the time from the insertion to the removal of the Boyle–Davis mouth gag.

Intra-operative blood loss was calculated by measuring the blood volume in suction bottles (to the nearest 0.5 ml) and the weight of bloody swabs at the end of the procedure.

All patients were kept in hospital overnight and then reviewed on the 7th, 14th and 21st day after surgery.

Patients were interviewed by telephone and asked to report their post-operative pain using a standardised visual analogue scale (VAS) from 0 to 10, where 0 meant no pain and 10 the severest pain, on post-operative days 1, 4, 7, 10, 14 and 21. They were also asked to report the time needed to return to full dietary habits (i.e. without pain during solid food intake) and to work.

The proportion of observed tonsillar fossa healing was recorded using 5 categories (i.e. 0 per cent slough, 1–25 per cent slough, 26–50 per cent slough, 51–75 per cent slough and 76–100 per cent slough) on the 7th, 14th and 21st post-operative day.

All patients were prescribed a standard analgesia regimen of paracetamol (1 g every 6 hours) and diclofenac sodium (50 mg every 8 hours after food).

Post-operative complications were recorded and dealt with.

Statistical methods

Before starting the trial, a power calculation was performed to determine the sample size required for each group. A sample size of 64 patients in each group was calculated to give the study 80 per cent power in detecting a 25 per cent difference in post-operative pain at the 5 per cent level of significance. The primary end-point of the study was post-operative pain. Assuming a compliance rate of 85 per cent for completion of follow-up visits and questionnaires, the sample size was increased to 75 patients in each group in order to maintain the power of the study and to compensate for any cases lost to follow up.

In order to maintain exactly equal treatment numbers in all groups, randomisation was done using random blocks. Neither the patient nor the investigator was aware of the group assignment, either at the time of randomisation or during follow-up. The group assignment was placed in consecutively numbered envelopes, which were allocated to successive cases in chronological order. Each patient's envelope was opened in the operating theatre after induction of general anaesthesia.

During the follow-up period, the operative data were not disclosed to either the patient or the investigator.

Analysis was performed using the Statistical Package for the Social Sciences version 13 for Windows software program (SPSS Inc, Chicago, Illinois, USA). Data were expressed as mean ± SD. A p value of less than 0.05 was considered significant. Parametric tests such as the t-test and analysis of variance were applied for data that followed a normal distribution. Non-parametric tests such as the Mann–Whitney U test and Kruskal–Wallis test were applied for data that did not follow a normal distribution.

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Results

Study completion and baseline demographics

All patients completed the 21-day follow-up period. No statistically significant difference was found between the four groups as regards age or sex ($p > 0.05$).

Operative time

There was a shorter mean operative time (14.8 minutes) in the bipolar radiofrequency group compared with the other three groups ($p < 0.01$). The bipolar electrocautery group also had a significantly shorter operative time compared with the cold dissection and ultrasonic scalpel groups ($p < 0.01$). The operative times of the cold dissection and ultrasonic scalpel groups showed no statistically significant difference ($p = 0.052$) (Table I).

Intra-operative blood loss

The mean intra-operative blood loss during bipolar radiofrequency tonsillectomy was minimal (24.4 ml). This was significantly less than that during cold dissection and ultrasonic scalpel tonsillectomy ($p < 0.01$), but not during bipolar electrocautery tonsillectomy ($p > 0.05$). The mean intra-operative blood loss during bipolar electrocautery (28 ml) was also significantly less than that during cold dissection (78 ml) and ultrasonic scalpel tonsillectomy (60 ml) ($p < 0.01$). The mean intra-operative blood loss during ultrasonic scalpel tonsillectomy was significantly less than that during cold dissection tonsillectomy ($p < 0.01$) (Table I).

Pain score

There was no statistically significant difference in patients' pain scores, comparing the bipolar radiofrequency, cold dissection and ultrasonic scalpel groups ($p > 0.05$), except on the first post-operative day, when pain scores for the bipolar radiofrequency and ultrasonic scalpel groups were significantly lower than those for the cold dissection group ($p < 0.05$). Patients in the bipolar electrocautery group reported significantly higher pain scores than those in the bipolar radiofrequency and ultrasonic scalpel groups ($p < 0.01$), except on the 14th and 21st post-operative days. Bipolar electrocautery patients reported significantly higher pain scores than cold dissection patients ($p < 0.01$), except on the 1st, 14th and 21st post-operative days (Table II and Figure 1).

Return to full diet and work

Patients undergoing bipolar electrocautery tonsillectomy required significantly more days to return to full dietary habits and work than patients in the other three groups ($p < 0.01$). There were no statistically significant differences in return to full diet and work, comparing the bipolar radiofrequency, cold dissection and ultrasonic scalpel groups ($p > 0.05$) (Table III).

Tonsillar fossa healing

There was no significant difference in the proportion of tonsillar fossa slough observed on the 7th, 14th and 21st post-operative days, comparing the bipolar radiofrequency, cold dissection and ultrasonic scalpel groups ($p > 0.05$). The bipolar electrocautery group showed significantly more slough than the other three groups on the 7th and 14th post-operative days ($p < 0.01$) but not on the 21st post-operative day ($p > 0.05$) (Table IV).

Post-operative complications

The only post-operative complication encountered was bleeding. No cases of primary haemorrhage were seen in any group. Two cases of secondary haemorrhage (2.7 per cent) were reported in the bipolar electrocautery group and one case (1.3 per cent) in the ultrasonic scalpel group. There was no statistically significant difference in the rate of post-operative bleeding between the four groups ($p > 0.05$). All cases of bleeding responded to conservative management.

Discussion

Most randomised, controlled trials of adult tonsillectomy have suffered from three main defects.

First, when designing their study the majority of authors have over-estimated the 'assumed detected difference' they wish their study to detect; therefore, their calculated sample size has been smaller than would otherwise be the case.

Second, nearly all trials have used more than one surgeon. Their justification has been the similar qualifications and experience among surgeons; however, ideally only a single surgeon would be involved.

Third, the contralateral tonsil has been used as a control, based on the claim that this would abolish differences in pain perception as a confounding variable. In fact, this design in effect decreases the patient number by half: the assumption that patients can act as their own controls is acceptable for

TABLE I
OPERATIVE TIME AND INTRA-OPERATIVE BLOOD LOSS

Parameter	BR	CD	US	BE
Operative time (minutes)	14.8 ± 5.12	33.4 ± 8.16	30.93 ± 9.11	18.06 ± 6.47
Intra-operative blood loss (ml)	24.4 ± 25.1	78 ± 29.7	60 ± 21.7	28 ± 21.8

Data represent means ± standard deviations. BR = bipolar radiofrequency; CD = cold steel dissection; US = ultrasonic scalpel; BE = bipolar electrocautery

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TABLE II
PAIN SCORES

Post-op day	BR	CD	US	BE
1	8.26 ± 1.29	9.20 ± 0.91	8.20 ± 1.34	9 ± 1.16
4	7.6 ± 0.71	7.56 ± 0.77	7.47 ± 0.62	8.4 ± 1.09
7	4.4 ± 0.81	4.16 ± 0.84	4.27 ± 0.98	5.73 ± 0.78
10	2.0 ± 0.64	1.96 ± 0.67	1.97 ± 0.65	3.6 ± 0.89
14	0.8 ± 0.54	0.76 ± 0.56	0.86 ± 0.62	0.87 ± 0.72
21	0.2 ± 0.4	0.17 ± 0.37	0.19 ± 0.39	0.27 ± 0.45

Data represent pain score means ± standard deviations. BR = bipolar radiofrequency; CD = cold steel dissection; US = ultrasonic scalpel; BE = bipolar electrocautery

assessment of operative time and bleeding, but not for assessment of pain or return to normal diet and work. It is difficult to exclude the possibility of pain sensation across the midline, and also pain due to anaesthetic-related procedures. In addition, using patients as their own controls reduces the benefit of randomisation of treatment, regarding diluting the effect of confounding variables, and also reduces the advantage of increased patient numbers.

It is difficult to avoid these three defects when designing a study to compare adult tonsillectomy methods, especially given the low incidence of adult tonsillectomy; the extent of this difficulty may be appreciated from the fact that the present study, which sought to avoid such defects, took six years to complete. Notably, the most recent systematic review of 'hot' versus cold steel tonsillectomy concluded that large, well-designed, randomised, controlled trials investigating the optimum tonsillectomy method were still lacking in the literature.[10]

Generally speaking, the 'gold standard' method of hot tonsillectomy, electrodissection, enables a shorter operative time and reduced intra-operative blood loss, compared with the gold standard cold tonsillectomy method, conventional cold steel dissection. However, the former produces more post-operative pain and a delayed return to normal diet and work, compared with the latter. Furthermore, controversy persists regarding the existence of any significant difference in post-operative haemorrhage rates.[2] Clearly, a safe surgical technique that combined the advantages of the hot and the cold gold standard methods would be the procedure of choice for adult dissection tonsillectomy.

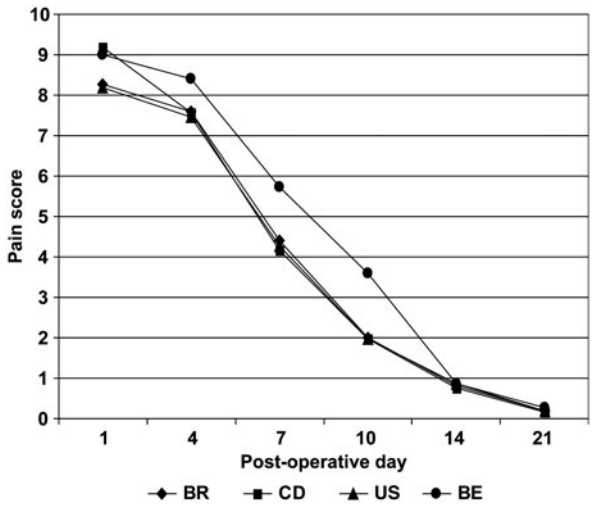

FIG. 1
Pain score versus post-operative day after bipolar radiofrequency (BR), cold dissection (CD), ultrasonic scalpel (US) and bipolar electrocautery (BE) tonsillectomy.

The current study found a significantly shorter operative time for bipolar radiofrequency compared with cold dissection, ultrasonic scalpel and bipolar electrocautery, while the intra-operative blood loss during bipolar radiofrequency tonsillectomy was significantly less than that during cold dissection and ultrasonic scalpel tonsillectomy but not bipolar electrocautery tonsillectomy. Previous adult studies have similarly found a shorter operative time and reduced intra-operative bleeding for hot versus cold tonsillectomy methods.[10] The significantly increased operative time for cold dissection and ultrasonic scalpel methods seen in the present study could be explained by the extra time needed to control increased intra-operative blood loss. Although ultrasonic scalpel is considered a hot tonsillectomy method, and consequently was expected to produce better haemostasis, 61 per cent of the ultrasonic scalpel group required ligatures to control the more vigorous bleeding points. Sheahan *et al.* reported that an alternative haemostasis technique was required in 70 per cent of ultrasonic scalpel dissected tonsillectomy cases.[11] The slightly reduced operative time for bipolar radiofrequency cases compared with bipolar electrocautery cases could be explained by the former requiring somewhat more time for dissection, compared with the coagulation of the tonsil pedicles performed in some bipolar electrocautery cases. The high radiofrequency waves used in bipolar radiofrequency cases coagulates and disrupts the tonsil pedicles at the same time, through a process of cell volatilisation and explosion.[4,12]

Adult tonsillectomy is often associated with a considerable amount of post-operative pain. In the present study, the bipolar electrocautery group experienced the worst post-operative pain profile of the four study groups. The bipolar radiofrequency, cold

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TABLE III
RETURN TO FULL DIET AND WORK

Time delay	BR	CD	US	BE
Full diet (days)	8.77 ± 1.09	8.6 ± 1.59	8.53 ± 1.14	11.8 ± 2.11
Work (days)	9.05 ± 1.24	8.93 ± 1.78	8.96 ± 1.53	11.92 ± 2.20

Data represent means ± standard deviations. BR = bipolar radiofrequency; CD = cold steel dissection; US = ultrasonic scalpel; BE = bipolar electrocautery

dissection and ultrasonic scalpel groups demonstrated nearly the same pain profile across the three weeks of pain score recording, except on the first post-operative day, on which bipolar radiofrequency and ultrasonic scalpel patients reported significantly lower pain scores than cold dissection patients. However, this seemed to benefit patients only as regards early alleviation of the fear of post-operative pain and the early start of a soft diet (seen from the first post-operative day in the bipolar radiofrequency and ultrasonic scalpel groups). Patients' post-operative pain profiles depended on pain scores measured on post-operative days 1, 4, 7, 10, 14 and 21. Although pain scores could have differed on post-operative days 5 and 6, it was felt that measuring the pain score every 3 days in the first 2 weeks would give enough information about patients' general post-operative pain profiles. It has been reported that early post-operative pain may be more intense after the mechanical trauma of cold tonsillectomy, whereas hot methods may have a higher incidence of late post-operative pain. Akural *et al.* observed that ultrasonic activated scalpel tonsillectomy was associated with decreased severity of pharyngeal pain immediately after the operation but increased pharyngeal pain and otalgia during the second post-operative week, compared with blunt dissection tonsillectomy.[13] The current data support previous evidence that electrodissection tonsillectomy increases post-operative pain after hospital discharge.[2]

TABLE IV
TONSILLAR HEALING

Slough proportion	BR	CD	US	BE
At 1 wk post-op				
0%	13.3	20	13.3	0
1–25%	20	20	13.3	13.3
26–50%	40	33.3	46.7	20
51–75%	20	20	20	26.7
76–100%	6.7	6.7	6.7	40
At 2 wk post-op				
0%	66.7	73.3	60	48
1–25%	33.3	26.7	40	38.7
26–50%	0	0	0	13.3
At 3 wk post-op				
0%	100	100	100	97.3
1–25%	0	0	0	2.7

Data represent patient percentages. BR = bipolar radiofrequency; CD = cold steel dissection; US = ultrasonic scalpel; BE = bipolar electrocautery; wk = weeks; post-op = post-operative

Cardozo *et al.* found a significant relationship between bipolar diathermy energy and post-operative pain in adult tonsillectomy.[14] Sheahan *et al.* reported no significant difference in pain, comparing ultrasonic scalpel and bipolar diathermy; however, their results may have been distorted by the use of bipolar diathermy to control bleeding in 70 per cent of ultrasonic cases.[11] In the current study, the other two hot methods assessed, bipolar radiofrequency and ultrasonic scalpel, did not show the marked increase in post-operative pain seen in the electrodissection group (compared with cold dissection).[2] The use of radiofrequency waves in bipolar mode and ultrasonic energy are known to cause minimal coagulation and lateral heat release, thus reducing the depth of lateral thermal injury and decreasing scarring and pain.[6,9,11]

Adults usually require up to 14 days of convalescence after tonsillectomy before they are able to return to full dietary habits and work. Thus, reducing patients' post-tonsillectomy recovery time by even 10 or 20 per cent could represent a substantial annual saving in lost productivity.[3] Furthermore, one could consider patients' return to work as the parameter that inherently encapsulates all recovery data. In the current study, patients who underwent bipolar electrocautery required approximately 26 and 25 per cent more days to return to full diet and work, respectively. This difference could have a significant impact on work productivity. Although delayed return to work is a very important consideration when choosing a tonsillectomy technique, with a substantial financial impact on the patient's community, unfortunately few trials have addressed it, because of the paired study design adopted by most adult tonsillectomy trials. One exception, a longitudinal study of electrodissection tonsillectomy conducted by Salonen *et al.*, reported a mean of 12 days required for return to normal daily activities.[15]

Whether trauma is mechanical (due to cold tonsillectomy methods) or thermal (due to hot methods), its extent has been shown to affect the rate of healing.[12] In the current study, the bipolar electrocautery group had a slower rate of tonsil healing than the other three groups. It could be supposed that gentle cold steel tonsillectomy dissection would produce the least histopathological damage of all the methods studied. However, in this study the post-operative pain and tonsillar fossa healing rate of the cold dissection group did not differ significantly from those of the

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bipolar radiofrequency and ultrasonic scalpel groups. This suggests a comparable histopathological effect of the mechanical trauma induced by cold dissection versus the minimal thermal trauma induced by bipolar radiofrequency and ultrasonic scalpel tonsillectomy. Silverman *et al.* showed that radiofrequency induced significantly less lateral thermal injury and charring penetration than CO_2 laser or electrocautery, using a canine skin model.[12]

- **High-level evidence on the optimum adult tonsillectomy method is still lacking**
- **This prospective, randomised, controlled trial compared ultrasonic scalpel, bipolar electrocautery, bipolar radiofrequency and cold dissection methods**
- **Bipolar radiofrequency was quicker, with less intra- and post-operative bleeding, and favourable results for post-operative pain, healing, and return to full diet and work**
- **It was thus superior to the other three methods**

The post-operative secondary haemorrhage rates in this study were 2.7 per cent for bipolar electrocautery, 1.3 per cent for ultrasonic scalpel, and 0 per cent for bipolar radiofrequency and cold dissection. These rates are comparable to the general reported incidence of post-tonsillectomy bleeding, which ranges from 0 to 7 per cent.[2,10,16,17] Controversy still persists in the world literature regarding the occurrence of significantly increased post-operative bleeding rates after hot tonsillectomy methods. Gilbey *et al.* compared the post-operative bleeding rate amongst harmonic scalpel tonsillectomy patients versus cold dissection patients, and found a significant increase only in those above 12 years of age.[8] The National Prospective Tonsillectomy Audit in England and Northern Ireland found a significantly higher post-operative bleeding rate (i.e. a 3.1-fold increase) for electrodissection tonsillectomy.[16] The rates reported in that audit were quite close to those observed in the current study. Leinbach *et al.* reported no significant difference in post-operative bleeding rates between electrodissection and cold tonsillectomy.[2] The most recent systematic review of cold dissection versus diathermy tonsillectomy found non-significant differences between the two methods; however, concern was expressed that the number of well designed, large, randomised, controlled trials was insufficient to detect a small difference in secondary haemorrhage rates.[10] Higher power bipolar diathermy may induce greater morbidity. In the current study, bipolar electrocautery used a power setting of only 30 W, but the bipolar electrocautery group still had a post-operative bleeding rate approximately three times that of the bipolar radiofrequency and cold dissection groups, and twice that of the ultrasonic scalpel group. Whether the increased post-operative bleeding rate following bipolar diathermy is related to the nature of diathermy energy and its histopathological effect is not yet clear. Studies of the relationship between the level of bipolar diathermy energy and the incidence of post-operative bleeding have not produced clear answers. Cardozo *et al.* reported that the dose–response relationship between the two parameters was unclear.[14] Lowe and colleagues' study findings further added to the confusion.[18] They found that when bipolar diathermy was used for both dissection and haemostasis, the overall post-operative haemorrhage rate was 4.6 per cent and the risk of haemorrhage was unrelated to the diathermy power setting. However, when cold steel methods were used for dissection and bipolar diathermy for haemostasis, the haemorrhage rate increased significantly from 1.8 to 3.7 per cent, and was related to increased power settings.

Conclusion

Bipolar radiofrequency dissection tonsillectomy is superior to ultrasonic, bipolar electrocautery and cold steel dissection adult tonsillectomy methods. Bipolar radiofrequency dissection tonsillectomy combines the advantages of hot tonsillectomy (in terms of shorter operative time and minimal intra-operative bleeding) and cold tonsillectomy (in terms of less post-operative pain, faster tissue healing, quicker return to full diet and work, and less post-operative bleeding). Thus, we recommend bipolar radiofrequency as the technique of choice for adult dissection tonsillectomy.

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