Article published online: 2025-10-14

Original Article

Outcomes of Craniotomy Scalp Incision Using Cutting Micro-Needle Diathermy versus Traditional Stainless-Steel Scalpel

Olakunle Michael Adegboye[1] Olugbenga Timothy Odebode[1] Salamat Ahuoiza Aliu-Ibrahim[1]
Nurudeen Abiola Adeleke[1] Oghenevwoke Enaworu[1] Olukorede Olabanji Adekunle[1]
Hakeem Ayinde Yeqeen[1] Akingbade Adebayo Akin-Dosumu[1]

[1] Department of Surgery, University of Ilorin Teaching Hospital, Ilorin, Kwara State, Nigeria

Asian J Neurosurg

Address for correspondence Olakunle Michael Adegboye, MBChB, FWACS, FMCS, Department of Surgery, PMB1459, University of Ilorin Teaching Hospital, Ilorin 241102, Kwara State, Nigeria (e-mail: omadegboye@gmail.com).

Abstract

Background Scalp incision bleeds profusely due to its high vascularity. In other regions of the body, studies have debunked the initial concern of poor wound outcomes thought to be associated with thermal skin injury if diathermy is used to make skin incision and found that skin incision with diathermy led to reduced incisional blood loss. Studies on cranial operations involving scalp incisions in which incisional blood loss is more likely are scarce.

Objective The objective of this study was to compare the outcomes of scalp incisions using either cutting micro-needle diathermy (MND) or the traditional stainless-steel scalpel (TSSS) during craniotomy.

Materials and Methods The study was a hospital-based, prospective, randomized comparative study. Consented adult patients who had craniotomy were randomized into either cutting MND or TSSS group. Outcome measures were volume of blood loss per wound length and incision duration per wound length during scalp incision, 30-day surgical site infection (SSI), and scar appearance at 3 months postoperatively.

Statistical Analysis The data were analyzed using SPSS version 23, and statistical significance was set at p-value <0.05.

Results A total of 56 patients were recruited for the study, with 28 patients in each group. The mean age of the patients was 36.21 ± 13.90 years. The mean volume of incisional blood loss per wound length was 3.21 ± 2.06 and 4.65 ± 3.25 mL/cm in MND and TSSS groups, respectively ($p = 0.053$). In the MND group, the mean incision duration per wound length was 0.39 ± 0.18 minutes/cm, while it was 0.35 ± 0.10 minutes/cm in the TSSS group ($p = 0.364$). Five patients (22.7%) and four patients (16.7%) developed SSI in the MND and TSSS groups, respectively ($p = 0.885$). At 3 months postoperatively, the mean scar score was 9.06 ± 0.94 in the MND group and 8.63 ± 1.26 in the TSSS group ($p = 0.255$).

Keywords
- blood loss
- micro-needle diathermy
- scalp incision
- stainless-steel scalpel
- surgical site infection

DOI https://doi.org/10.1055/s-0045-1812304.
ISSN 2248-9614.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

Conclusion The study revealed no significant difference in the outcomes of craniotomy scalp incision between the two methods of making scalp incision. The study concludes that the use of diathermy in making scalp incision is not inferior to the use of the traditional scalpel, and the method of scalp incision may be left to the discretion of the surgeon.

Introduction

Craniotomy is a surgical procedure that provides access to the cranial cavity for different surgical interventions; it is one of the most frequently performed operations in neurosurgical practice, and scalp incision is the first step in these procedures.[1–3] Traditionally, incisions were made with a stainless-steel scalpel.[4] This has been the instrument of choice for making skin incision because of its ease of use, accuracy, and predictable tissue damage.[5] However, its use has been associated with significant blood loss.[6] Moreover, operation time could be prolonged as a result of time spent securing hemostasis during skin incision.

Concerns about blood loss during skin incision with a scalpel have led surgeons in search of more effective ways of making skin incision with minimal blood loss. Different options such as laser and plasma scalpels have been tried, but these are unsustainable due to high cost and relative unavailability, especially in resource-poor centers, thus sustaining the widespread use of the scalpel for skin incision.[7] Although diathermy has been in use in surgical practice for a long time, its use is usually limited to deep tissue dissection and coagulation to secure hemostasis. Diathermy is not used routinely in making skin incision due to concerns about thermal skin injuries, which could lead to increased risk of surgical site infection (SSI), wound dehiscence, increased postoperative pain, and excessive scarring.[7–10] However, studies involving skin incision on other parts of the body apart from the scalp have compared stainless-steel scalpel and diathermy in making skin incision and found that incisional blood loss was less and duration of skin incision was shorter without increased risk of wound complication in favor of diathermy.[4,8,11–15] Despite these findings, even to date, opinion differs among surgeons whether to use diathermy or the scalpel; while some now use cutting diathermy directly to make skin incisions, others continue to use the scalpel for skin incision and reserve diathermy for deeper tissue dissection.

The significant reduction in blood loss may be particularly beneficial in neurosurgical operations, where one of the potential areas of blood loss is scalp incision due to the high vascularity of the scalp. Sakhai revealed that bleeding from scalp incisions during cranial operations can be quite marked and troublesome.[16] Most cranial neurosurgical operations consisting of scalp incision, raising of scalp and bone flaps, and intracranial procedure proper are known to be of long duration. The scalp incision time can be prolonged due to hemostatic challenge, hence prolonging the total operation time. Thus, reducing the duration of scalp incision may lead to shorter overall duration of operation and better outcomes, especially for patients under general anesthesia.

There is a paucity of studies on scalp incision outcomes comparing the two methods of incision to the best of our knowledge. Among the few studies in neurosurgical practice are those of Sheikh in Saudi Arabia and Nitta et al in Japan.[17,18] Sheikh found that skin incision in neurosurgical operations with cutting micro-needle diathermy (MND) was faster, with three to five times less incisional blood loss, no significant difference in wound complication rates and scar outcome when compared with traditional scalpel incision.[17] However, the study was not limited to scalp incisions but included neck, back, abdomen, and upper extremities incisions for neurosurgical procedures. The study by Nitta et al showed that scalp incision with MND was associated with minimal blood loss without increased wound complication.[18] However, they used only diathermy in their study without comparing with a scalpel and only reported that there was minimal blood loss without quantifying the loss.

Therefore, the aim of this study was to compare the outcomes of craniotomy scalp wounds between incisions made with MND and the traditional scalpel by measuring the volume of incisional blood loss per unit length, duration of incision per unit length, rate of SSI, and postoperative scar appearance.

Materials and Methods

Study Design and Study Population

The study was a hospital-based, prospective, randomized comparative study, performed in the Division of Neurosurgery of the Department of Surgery at the University of Ilorin Teaching Hospital, over a period of 21 months. Ethical approval was obtained from the Health Research Ethical Committee of the hospital. All consented adult patients, aged 18 years and older who were scheduled to have elective or emergency craniotomies were recruited into the study. Patients who had increased risk factors for excessive bleeding such as bleeding disorders, vascular scalp disease, and previous scalp surgery were excluded from the study. Likewise, patients with risk factors for developing SSI such as patients with immunosuppression (patients on prolonged use of steroids, diabetic and HIV patients), malnourished patients (with hypoproteinemia and hypoalbuminemia), and patients with open skull fracture and scalp infection were excluded. These patients were excluded because these risk factors may serve as cofounders.

Sample Size Determination and Sampling Method

The sample size for the study was calculated using the formula for a comparative study (Lehr's rule).[19] With an attrition rate of 10%, a total of 28 patients were calculated for each group, making a total sample size of 56 patients in both groups.

The patients who fit into the inclusion criteria were randomized into either group A (MND) or group B (traditional stainless-steel scalpel [TSSS]). Simple randomization was performed using balloting to assign patients to either of the two groups.

The Procedure

All operations were performed under general anesthesia with endotracheal intubation and relaxation technique. One gram of intravenous ceftriaxone (Rocephin) was administered at the induction of anesthesia as antibiotic prophylaxis, which was repeated for operations that lasted longer than 4 hours.

Patients in group A had their scalp incision made with micro-needle cutting diathermy made by Hangzhou Valued Medtech Co., Ltd, China using electrosurgical unit obs (Baisheng Medical Co., Ltd), waveform of 330 to 460 kHz set at pure cutting power of 30W. Micro-needle (needle point) cutting diathermy was used to minimize contact with the skin and hence reduce thermal injury. Patients in group B had their scalp incisions made with a surgical blade size 20 mounted on number 4 Bard Parker knife handle. Hemostasis during scalp incision was achieved with dandy forceps applied to the edges of the scalp flap, and hemostasis was considered achieved when the operative field was dry and the surgery could proceed.

The volume of blood loss during scalp incision was estimated using the gravimetric method by weighing the surgical sponges (gauze) before use (dry weight) and after use (wet weight) with a digital electronic weighing scale (SF-400, made by Hebei Renquin Co., Ltd, China). The estimated blood volume loss was taken as the difference between the wet and dry weights of the pieces of gauze used (1 g = 1 mL), which is the gravimetric method of intraoperative blood loss measurement. Mopping of blood during scalp incision was restricted to the use of gauze and suctioning was not done so as to have an accurate measurement of blood loss. The duration of incision was taken as the time the epidermis was incised to the time the incision was carried through all the layers of the scalp down to the cranium along the whole length of the incision with all hemostasis secured. This was measured by the unit registrar using a stopwatch and recorded in minutes.

All the scalp incisions for craniotomy designated for this study were performed by the researcher and other neurosurgeons of the same level of experience in the unit, so as to avoid the confounding effect of different levels of experience. The length of incision was measured using a silk suture immediately after closure of the wound, which was then extrapolated onto a tape measure to get the actual length of the incision in centimeter (cm). The volume of incisional blood loss and duration of scalp incision were divided by the length of incision. This was done to take into consideration the length of incision based on the craniotomies performed, as the length of incision may determine the volume of incisional blood loss and duration of scalp incision.

Postoperative Care and Assessment

Patients in both groups had routine postoperative care for the craniotomy procedure. Subgaleal drains were removed at 48 hours postoperation, which is the usual time subgaleal drain is removed in our neurosurgery unit except if it is still functioning beyond this period (i.e., effluent more than 50 mL in 24 hours). Patients who required subgaleal draining beyond 48 hours were noted and documented appropriately. One gram of intravenous ceftriaxone (Rocephin) was administered daily for 48 hours during which the patient was on a subgaleal drain to eliminate the risk factor of foreign body for SSI. Patients who required antibiotics for a longer period than 48 hours were noted and documented, and the individual reasons were also documented.

The surgical wounds were inspected for SSI on the 3rd, 7th, 14th, and 30th postoperative days using the Southampton wound scoring system, and the patients who developed SSI were managed thereafter according to the regular protocol of SSI management. Surgical wound scar assessment was performed at 3 months postoperatively in the surgical outpatient clinic, by scoring the scars using the Manchester scar scale. SSI and scar assessments were done by a resident in the neurosurgery team, who was excused at the time of making the scalp incision and hence not aware of the method of the scalp incision.

Assessment of Outcome Measures

The primary outcome of the study was the mean volume of blood loss per unit length of the wound during scalp incision in both groups. This was defined as the volume of blood loss divided by the length of incision and recorded in milliliter per centimeter (mL/cm). Volume per length was used since the length of incision varied depending on the indication for craniotomy and thus could affect the volume of blood loss during the process of making the scalp incision. The secondary outcomes were mean incision duration per unit wound length, recorded in centimeter per minute (-cm/min), the rate of SSI, and surgical scar appearance scores at 3 months postoperatively. Likewise, mean incision duration per length was used in this study since the length of incision could affect the time spent on making the incision.

Statistical Analysis

The data were collected using a predesigned proforma and analyzed using Statistical Package for Social Sciences (IBM SPSS, version 23.0) software (SPSS Inc., Chicago, Illinois, United States). Descriptive statistics were presented with tables and figures. Analyses were performed using Student's *t*-test for continuous variables and chi-square test for categorical variables. Differences were considered statistically significant if the p-value is less than 0.05 ($p < 0.05$).

Results

A total of 56 patients were recruited for the study, with 28 patients in each group of cutting MND and TSSS. The mean age of the patients was 36.21 ± 13.90 years. Other sociodemographics are shown in ►**Table 1**. ►**Fig. 1** shows the

Table 1 Demographic characteristics of 56 patients who had craniotomy

Variable	Frequency	Percentage (%)
Age group (y)		
18–20	6	10.7
21–30	19	33.9
31–40	12	21.4
41–50	9	16.1
51–60	8	14.3
> 60	2	3.6
Mean ± SD	36.21	± 13.90
Sex		
Male	48	85.7
Female	8	14.3

Abbreviation: SD, standard deviation.

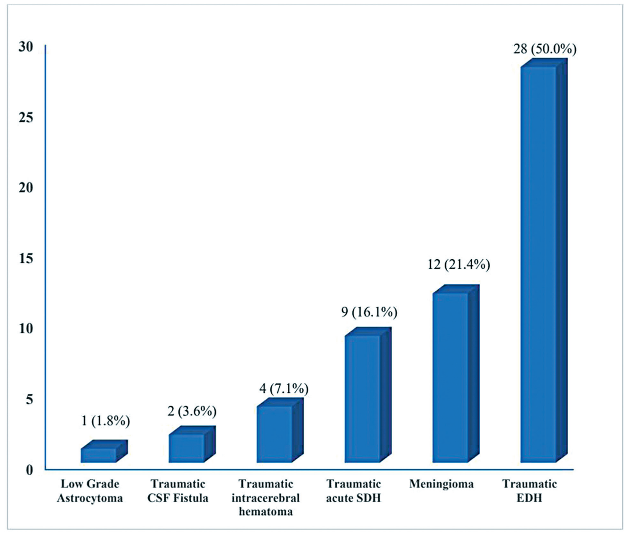

Fig. 1 Spectrum of diagnosis of patients who had craniotomy in the study. CSF, cerebrospinal fluid; EDH, extradural hematoma; SDH, subdural hematoma.

spectrum of diagnoses for which craniotomies were done. Traumatic events accounted for 43 (76.8%) of the cases operated, while the remaining 13 (23.2%) cases were brain tumors.

The patients in both groups of MND and TSSS were compared in terms of sociodemographics and baseline parameters, as shown in ►**Table 2**. Eighteen patients in both groups were given antibiotics beyond 48 hours, out of whom 8 (44.4%) were in the MND group and 10 (55.6%) were in the TSSS group. Chest infection, prolonged use of a drain, SSI, and urosepsis were the reasons for the prolonged use of postoperative antibiotics. ►**Table 3** shows the mean volume of incisional blood loss, incisional blood loss volume per unit length, and the mean incision duration per unit wound length between the two groups. The mean volume of incisional blood loss was significantly higher in the TSSS group than in the MND group (144.54 ± 114.19 and 95.50 ± 58.02 mL, respectively, $p = 0.048$). However, when the incisional blood

Table 2 Comparison of baseline between the two methods of scalp incision for craniotomy procedure

Variable	Micro-needle diathermy	Traditional stainless-steel scalpel	χ^2	*p*-Value
Age group (y)				
< 40	17 (48.6)	18 (51.4)	0.076	0.783
≥40	11 (52.4)	10 (47.6)		
Sex				
Male	24 (85.7)	24 (85.7)	0.416[a]	0.702
Female	4 (14.3)	4 (14.3)		
Diagnosis				
Brain tumor	7 (25.0)	6 (21.4)	0.100	0.752
Traumatic head injuries	21 (75.0)	22 (78.6)		
Nature of operation				
Elective	8 (28.6)	7 (25.0)	0.091	0.763
Emergency	20 (71.4)	21 (75.0)		
Repeated intraoperative antibiotics				
Yes	5 (17.9)	8 (28.6)	0.902	0.342
No	23 (82.1)	20 (71.4)		
Prolonged postoperative antibiotics				
Yes	8 (44.4)	10 (55.6)	0.327	0.567
No	20 (52.6)	18 (47.4)		

[a]Yate corrected chi-square test.

Table 3 Comparison of operative findings between MND and TSSS groups

Variable	MND	TSSS	t	p-Value
	Mean ± SD	Mean ± SD		
Incisional blood loss (mL)	95.50 ± 58.02	144.54 ± 114.19	−2.026	**0.048**
Incision duration (min)	11.72 ± 4.83	10.48 ± 2.78	1.182	0.242
Incision length (cm)	31.41 ± 8.10	30.12 ± 5.26	0.712	0.480
Blood loss per wound length (mL/cm)	3.21 ± 2.06	4.65 ± 3.25	−1.978	0.053
Incision duration per wound length (min/cm)	0.39 ± 0.18	0.35 ± 0.10	0.915	0.364

Abbreviations: MND, micro-needle diathermy; SD, standard deviation; TSSS, traditional stainless-steel scalpel.

Table 4 Surgical wound outcomes between MND and TSSS methods of craniotomy scalp incision

Variable	MND	TSSS	χ^2	p-Value
Surgical site infection				
Yes	5 (22.7)	4 (16.7)	0.021[a]	0.885
No	17 (77.3)	20 (83.3)		
	Mean ± SD (n = 18)	**Mean ± SD (n = 19)**	t	p-Value
Manchester scar score (n = 37)	9.06 ± 0.94	8.63 ± 1.26	1.158	0.255

Abbreviations: MND, micro-needle diathermy; SD, standard deviation; TSSS, traditional stainless-steel scalpel.
[a]Yate corrected chi-square test.

loss was divided by the length of incision, the difference was not statistically significant (3.21 ± 2.06 and 4.65 ± 3.25 mL/cm in the MND and TSSS groups, respectively, $p = 0.053$). In the MND group, the mean incision duration per unit wound length was 0.39 ± 0.18 minutes/cm, while it was 0.35 ± 0.10 minutes/cm in the TSSS group ($p = 0.364$).

Ten patients in the study (6 and 4 patients in the MND and TSSS groups, respectively) died before 30 days postoperatively, leaving 46 patients (22 in the MND group and 24 in the TSSS group) for assessment for SSI at 30 days postoperatively. Also, 9 patients (4 patients in the MND group and 5 patients in the TSSS group) were lost to follow-up, leaving 37 patients (18 in the MND group and 19 in the TSSS group for scar assessment at 3 months postoperatively. In the study, 9 out of 46 patients (19.6%) developed SSI, out of whom 5 (22.7%) patients were in the MND group and 4 (16.7%) patients were in the TSSS group. The mean Manchester scar scores in the MND and TSSS groups were 9.06 ± 0.94 and 8.63 ± 1.26, respectively. There was no statistically significant difference in the wound outcomes (occurrence of SSI and scar appearance) between the two groups ($p > 0.05$) (►**Table 4**).

Discussion

Many surgeons continue to use a scalpel to make surgical incision due to anecdotal concerns that direct use of diathermy on the skin could lead to poor wound outcomes such as SSI and abnormal scars. Previous studies have however debunked this fear. While most of these studies were on other regions of the body, studies involving scalp incision where blood loss and the need to reduce this may be more warranted are few. This study set out to compare the outcomes of craniotomy scalp incisions using MND versus TSSS. The mean age of patients in the study was 36.21 ± 13.90 years. This is similar to the work of Adeleye in Ibadan, South-Western Nigeria, who reported a mean age of 32.2 ± 17.2 years among patients who had craniotomy.[20] Patients who had craniotomy in the current study were younger than the patients who had craniotomy in the developed countries, as reported by Jiménez-Martínez et al in a study in Spain (52.8 ± 14.4 years) and Golas et al in the United States (56 years).[21,22] The contrast in mean ages seen in this study and in Ibadan, both centers in a developing country, compared with the developed countries is probably due to differences in indications for the craniotomies.

In this study, majority (76.8%) of the craniotomies were done for head injuries. Similarly, Adeleye reported that traumatic events accounted for the highest (46.7%) indication among their patients who had craniotomies.[20] In contrast, the study by Jiménez-Martínez et al showed that only 2.7% of the craniotomies were done for trauma, while the rest were done on account of brain tumors, epilepsy, and vascular pathologies, while Golas et al reported that brain tumors were the indication for 75% of craniotomies in their study.[21,22] The high proportion of head injuries requiring craniotomy in the developing country centers (Ilorin and Ibadan in Nigeria) might be due to the high rate of road traffic crashes stemming from bad roads, bad vehicles, poor vehicle maintenance attitude, less adherence to traffic regulations, careless and unlicensed driving in developing countries compared with developed countries.

The absolute mean volume of incisional blood loss in the MND group was significantly less when compared with the TSSS group. When the length of incision was taken into consideration, the incisional blood loss was still less in the MND group and nearly reached a significant level (3.21 ± 2.06 and 4.65 ± 3.25 mL/cm in the MND and TSSS groups, respectively, $p = 0.053$). If a larger sample size had been studied, this difference would have probably been significant. The small sample size in this study may be a limitation of the study.

Studies, both in neurosurgical and general surgical procedures, reported significantly less incisional blood loss in the diathermy group than the scalpel group. Sheikh in Saudi Arabia found that blood loss was four times less when incisions were made with micro-needle tip monopolar diathermy compared with the scalpel for neurosurgical procedures (although the incisions in his study were not limited to the scalp alone but involved other regions of the body).[17] Likewise, Ayandipo et al in Ibadan, South-Western Nigeria and Chauhan and Charpot in India reported that diathermy skin incision was associated with significantly less incisional blood loss when compared with the scalpel for general surgical procedures.[8,23] The difference in the findings of the index and previous studies might be due to differences in sample size.

In the current study, the mean incision duration per wound length was slightly longer in the MND than in the TSSS group, the difference was not however significant ($p = 0.364$). In contrast to the findings of this study, studies by Ayandipo et al, Damani et al, and Kearns et al found that it took less time to make an incision with cutting diathermy than with the scalpel.[8,9,24] Their studies were on general surgical procedures, which dealt with other regions of the body and not the scalp. The difference between their studies and the current study might be due to differences in the vasculature of the parts of the body incised.

The fear of wound complications thought to be associated with direct skin diathermy incision as a result of thermal injury, which has prevented some surgeons from using this method of skin incision, was debunked by the findings of the current study, as well as by several other studies. This study reported no significant difference in the rate of SSI between the two methods of making scalp incision (22.7 and 16.7% in the MND and TSSS groups, respectively, $p = 0.885$). Similarly, Ayandipo et al in Ibadan found that wound infection was similar in both methods ($p = 0.206$), while Okereke et al in Ile-Ife reported that no patient in the diathermy arm developed wound infection, while 1 out of 32 patients in the scalpel arm developed wound infection.[8,11] Similar findings were reported by many other authors including Kadyan et al in India, Kalawar et al in Asia, and Kearns et al in Ireland.[4,9,25]

The scar appearance at 3 months of the wounds made by MND and TSSS in this study was similar, without a statistically significant difference between the two methods (the mean Manchester wound scar scores were 9.06 ± 0.94 and 8.63 ± 1.26 in the MND and TSSS groups, respectively, $p = 0255$). It was thought that scar outcome may be worse when incision is made with diathermy due to increased incidence of SSI, wound breakdown, secondary wound healing, and subsequent scarring consequent upon thermal injury. However, the current study found no difference in the cosmetic appearance of wounds created either by MND or TSSS. Similarly, Okereke et al reported a total Patient and Observer Scar Assessment Scale (POSAS) scar score of 22.44 in the diathermy group versus 22.21 in the scalpel group ($p = 0.95$) and concluded that there was no difference in patients' satisfaction with their wound appearance at 3 months' follow-up postoperatively.[11] Kumar et al in India also reported no significant difference in the cosmetic outcome of wounds made with diathermy and traditional scalpel.[13] Also, Sheikh in Saudi Arabia found that patients who had scalp incisions with either diathermy or scalpel reported no incisional alopecia at 3 months postoperatively.[17]

This study and previous studies found that there is no difference in the postoperative scar outcome and patients' satisfaction with surgical wounds created with diathermy or scalpel as against the initial concern of poor scar outcome associated with diathermy skin incision.

Conclusion

The study revealed no significant difference in the volume of incisional blood loss per unit wound length, duration of scalp incision per unit wound length, rate of SSI, and postoperative scar appearance between the two methods of scalp incision. The poor wound outcomes earlier attributed to thermal injury when diathermy is used to make skin incision was not found in this study. The study concludes that the use of diathermy in making scalp incision is not inferior to the use of the traditional scalpel, and the method of scalp incision may be left to the discretion of the surgeon.

Ethical Approval
Approval for this study was obtained from the Human Research Ethical Committee of the hospital.

Authors' Contribution
O.M.A. was responsible for the conceptualization, methodology, study protocol, data collation, and drafting of the original manuscript. O.T.O., S.A.A.-I., and N.A.A. contributed to the methodology, reviewed and edited the manuscript, and provided supervision for the study. O.E., O.O.A., and H.A.Y. contributed to the study protocol, data collation, and manuscript review and editing. A.-D.A.A. also contributed to the study protocol and data collation.

Conflict of Interest
None declared.

References

1 de Gray LC, Matta BF. Acute and chronic pain following craniotomy: a review. Anaesthesia 2005;60(07):693–704
2 Champagne P, Brunette-Clement T, Bojanowski MW, Moumdjian R, Bouthillier A, Shedid D. Safety of performing craniotomy in the elderly: the utility of co-morbidity indices. Interdiscip Neurosurg 2018;14:97–101

3 Upadhyayula PS, Yue JK, Yang J, Birk HS, Ciacci JD. The current state of rural neurosurgical practice: an international perspective. J Neurosci Rural Pract 2018;9(01):123–131
4 Kalawar RS, Khanal GP, Chaudhary P, et al. Comparative study of safety and efficacy of electrocautery blade with cold scalpel for skin opening. Health Renaiss 2015;13(02):43–49
5 Lee BJ, Marks M, Smith DP, Hodges-Savola CA, Mischke JM, Lewis RD. Advanced cutting effect system versus cold steel scalpel: comparative wound healing and scar formation in targeted surgical applications. Plast Reconstr Surg Glob Open 2014;2 (10):e234
6 Shivagouda P, Gogeri BV, Godhi AS, Metgud SC. Comparing the efficacy of diathermy incision versus scalpel incision over skin in patients undergoing hernia repair: prospective randomized control trial. Recent Res Sci Technol. 2010;2(08):44–47
7 Chhabda TS, Mohit A. Prospective randomized control trial comparing diathermy versus scalpel for skin incisions in patients undergoing elective surgeries. Int J Sci Res 2015;4(12):1414–1419
8 Ayandipo OO, Afuwape OO, Irabor D, Oluwatosin OM, Odigie V. Diathermy versus scalpel incision in a heterogeneous cohort of general surgery patients in a Nigerian Teaching Hospital. Niger J Surg 2015;21(01):43–47
9 Kearns SR, Connolly EM, McNally S, McNamara DA, Deasy J. Randomized clinical trial of diathermy versus scalpel incision in elective midline laparotomy. Br J Surg 2001;88(01):41–44
10 Shamim M. Diathermy vs. scalpel skin incisions in general surgery: double-blind, randomized, clinical trial. World J Surg 2009; 33(08):1594–1599
11 Okereke CE, Katung AI, Adesunkanmi AK, Alatise OI. Surgical outcome of cutting diathermy versus scalpel skin incisions in uncomplicated appendectomy: a comparative study. Niger Postgrad Med J 2019;26(02):100–105
12 Chau JKM, Dzigielewski P, Mlynarek A, et al. Steel scalpel versus electrocautery blade: comparison of cosmetic and patient satisfaction outcomes of different incision methods. J Otolaryngol Head Neck Surg 2009;38(04):427–433
13 Kumar V, Tewari M, Shukla HS. A comparative study of scalpel and surgical diathermy incision in elective operations of head and neck cancer. Indian J Cancer 2011;48(02):216–219
14 Gupta S, Mehta A, Gupta V. A comparative study between electrocautery and steel scalpel in making abdominal wall incision in caesarean section. Int J Reprod Contracept Obstet Gynecol 2017;6 (06):2328–2330
15 Chandra RV, Savitharani B, Reddy AA. Comparing the outcomes of incisions made by Colorado microdissection needle, electrosurgery tip, and surgical blade during periodontal surgery: a randomized controlled trial. J Indian Soc Periodontol 2016;20(06): 616–622
16 Sakhai H. Hemostatic control of scalp incisions. Technical note. J Neurosurg 1989;70(01):142
17 Sheikh B. Safety and efficacy of electrocautery scalpel utilization for skin opening in neurosurgery. Br J Neurosurg 2004;18(03): 268–272
18 Nitta N, Fukami T, Nozaki K. Electrocautery skin incision for neurosurgery procedures–technical note. Neurol Med Chir (Tokyo) 2011;51(01):88–91
19 Lehr R. Sixteen S-squared over D-squared: a relation for crude sample size estimates. Stat Med 1992;11(08):1099–1102
20 Adeleye AO. Low rates of post-craniotomy surgical site infections in a developing country: surgical technique and results. Br J Neurosurg 2018;32(02):136–140
21 Golas AR, Boyko T, Schwartz TH, Stieg PE, Boockvar JA, Spector JA. Prophylactic plastic surgery closure of neurosurgical scalp incisions reduces the incidence of wound complications in previously-operated patients treated with bevacizumab (Avastin®) and radiation. J Neurooncol 2014;119(02):327–331
22 Jiménez-Martínez E, Cuervo G, Hornero A, et al. Risk factors for surgical site infection after craniotomy: a prospective cohort study. Antimicrob Resist Infect Control 2019;8(01):69
23 Chauhan HR, Charpot RV. A comparative study to evaluate the outcome between electrocautery versus scalpel skin incision in tension-free inguinal hernioplasty: a tertiary care teaching centre experience. Int Surg J 2016;3(02):516–520
24 Damani SR, Haider S, Sagheer S, Shah H. Scalpel versus diathermy for midline abdominal incisions. J Surg Pak 2014;19(01):18–21
25 Kadyan B, Chavan S, Mann M, Punia P, Tekade S. A prospective study comparing diathermy and steel scalpel in abdominal incisions. Med J Dr. DY Patil Univ 2014;7(05):558–563

