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## Original Article

# Exploring the Risks of Postoperative Surgical Site Infection After Craniotomy: A Retrospective Observational Study

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## Abstract

**Objective:** To assess the risk of postoperative surgical site infection after craniotomy and identify risk factors for such infection.

**Methodology:** This Retrospective Observational Study was conducted in the Department of Neurosurgery, MMC/BKMC Mardan, from January to June 2024. included 100 patients who underwent craniotomy. We collected patient data from medical records, including demographic, clinical, and operative data. We identified all patients with SSI within 30 days after surgery based on the Centers for Disease Control and Prevention (CDC) definition. We performed statistical analyses using SPSS version 27.0. We presented continuous variables as mean  $\pm$  SD and categorical variables as frequencies and percentages, and used logistic regression to identify independent predictors. We considered  $p < 0.05$  statistically significant.

**Results:** Of the 100 patients, 18 (18.0%) developed postoperative SSI. The mean age was  $48.7 \pm 15.3$  years, with 61% males and 39% females. Patients with SSI were significantly older than those without infection ( $56.2 \pm 13.1$  vs.  $47.1 \pm 15.2$  years;  $p=0.018$ ). Diabetes mellitus was more frequent in the SSI group (33.3% vs. 11.0%;  $p=0.011$ ). Operative duration exceeding four hours (72.2% vs. 35.4%;  $p=0.004$ ), emergency craniotomy (50.0% vs. 22.0%;  $p=0.021$ ), and smoking (44.4% vs. 19.5%;  $p=0.028$ ) were significantly associated with SSI.

**Conclusion:** SSI is a common post-craniotomy complication. Advanced age, diabetes, prolonged surgery, emergency procedures, and smoking increase risk, while prevention strategies reduce infection rates.

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## Introduction

Surgical site infection (SSI) is one of the most important postoperative complications after craniotomy, which is a major cause of morbidity, length of hospital stay, healthcare cost, and death in rare instances. Although there has been significant progress in neurosurgical practice, perioperative antimicrobial prophylaxis, sterile operative conditions, and wound care, SSIs remain a significant problem in neurosurgical practice globally. The reported rate of SSI following craniotomy has ranged from 1% to 20%, depending on the patient population, the complexity of the surgical procedure, and the quality of the infection-control measures at the institution, as well as on the definition of SSI. Infections can affect superficial incisional tissues, deep soft tissues, bone flaps, the meninges, or intracranial structures. They may require extended antibiotic therapy, additional surgery, and/or removal of the bone flap [1,2]. Patients requiring craniotomy are especially vulnerable to postoperative infections due to the length of the operation, exposure of intracranial structures, placement of foreign substances, the leakage of CSF, and underlying neurological disorders. In addition, the majority of neurosurgical patient population have other medical comorbidities, like diabetes mellitus, hypertension, chronic kidney disease, malnutrition, obesity, smoking, and immunosuppression that affect wound healing and vulnerability to infection. Other factors that raise the risk of postoperative SSI include emergency procedures, traumatic brain injury, repeat craniotomy, prolonged intensive care unit (ICU) stay, and mechanical ventilation [3,4]. Advanced age, diabetes mellitus, obesity, smoking, prolonged operative time, cerebrospinal fluid leakage, emergency surgery, contaminated wound, repeat surgery, and a prolonged preoperative hospital stay are significant risk factors for postoperative SSI after craniotomy. However, these factors vary across settings because of differences in patient populations, surgical techniques, perioperative management, antimicrobial policies, and healthcare infrastructure. Thus, local epidemiological information is crucial for identifying institution-specific risk factors and establishing targeted preventive measures [5,6]. Postoperative SSI after craniotomy is not only a significant clinical problem, but also a major economic burden on the healthcare system. The patients who go on to develop SSI often need longer courses of intravenous antibiotic treatment, further imaging tests, repeat surgery, intensive care unit (ICU) admission, and extended hospital stay. Such complications have a great impact on the treatment cost, besides postponing neurological rehabilitation and recovery. Furthermore, postoperative infection can negatively affect long-term neurological function and quality of life [7,8]. Identifying patients at early risk allows clinicians to optimize modifiable risk factors before surgery, implement evidence-based preventive measures, and improve postoperative monitoring. Perioperative antibiotic prophylaxis, careful surgery, blood sugar control, smoking cessation, shortening operative time, minimizing temperature changes, and standardizing infection-prevention packages have shown a positive impact in reducing postoperative infections. However, despite these precautions, SSI persists, and institutions must continually assess contributing factors [9,10]. There is very little information available in Pakistan on the incidence and determinants of postoperative SSI after craniotomy. Earlier studies are mainly from developed countries, where patients' characteristics, healthcare resources, and infection-control practices differ significantly from those in developing healthcare settings. Thus, identifying local risk factors is crucial to establish effective preventive measures and improve neurosurgical outcomes.

## Materials and Methods

### Study Design and Setting

We conducted a retrospective observational study from January to June 2024. The study included adult patients undergoing craniotomy at the study center. We obtained relevant demographic, clinical, operative, and postoperative information from medical records. Patients were followed for 30 days after surgery to assess the occurrence of surgical site infection (SSI) according to standard diagnostic criteria.

### Participants

We included 100 consecutive adult patients who underwent elective or emergency craniotomy during the study period. Demographic characteristics, clinical findings, operative details, and postoperative outcomes were reviewed from the available medical records. The primary outcome was the development of SSI within 30 days following craniotomy.

### Sample Size Calculation

The sample size was calculated using the WHO sample size calculator, assuming an expected postoperative SSI prevalence of 15%, a 95% confidence level, and an allowable margin of error. Patients meeting the eligibility criteria were enrolled consecutively during the study period, resulting in a final sample of 100 patients.

### Inclusion Criteria

- Patients were included if they met all of the following criteria:
- Age  $\geq 18$  years.
- Underwent elective or emergency craniotomy.
- Complete medical and operative records were available.
- Had a minimum 30-day postoperative follow-up.
- Underwent craniotomy for histopathological or traumatic indications.

### Exclusion Criteria

- Surgery for a pre-existing wound in the same head region.
- A documented wound infection in the head region before the index surgery.
- A non-surgical burr-hole procedure instead of craniotomy.
- Incomplete medical or operative records.
- Death within 48 hours after surgery.
- Loss to postoperative follow-up before completion of the 30-day assessment.

### Diagnostic & Management Strategy

Postoperative SSI was diagnosed based on the Centers for Disease Control and Prevention (CDC) definition. Patients received conventional antibiotic prophylaxis, routine wound care, and standard-of-care treatment as appropriate, such as culture-based antibiotic therapy and surgical debridement when necessary.

### Statistical Analysis

We used SPSS 27.0 to analyze the data. Data for continuous variables were presented as mean  $\pm$  SD, and for categorical variables as frequencies and percentages. We identified significant predictors using the chi-square test, independent t-test, and multivariable logistic regression. We defined  $p < 0.05$  as statistically significant.

### Results

A total of 100 patients underwent craniotomy during the study period. The mean age was  $48.7 \pm 15.3$  years, with 61 (61%) males and 39 (39%) females. Postoperative surgical site infection developed in 18 patients (18%), whereas 82 patients (82%) had an uncomplicated postoperative course. Patients with SSI were significantly older than those without

infection (56.2 ± 13.1 vs. 47.1 ± 15.2 years; p=0.018). Diabetes mellitus was present in 6 (33.3%) patients with SSI compared with 9 (11.0%) patients without SSI (p=0.011). Operative duration exceeding four hours occurred in 13 (72.2%) infected patients and 29 (35.4%) non-infected patients (p=0.004). Emergency craniotomy was performed in 9 (50.0%) patients with SSI compared with 18 (22.0%) patients without SSI (p=0.021). Smoking was significantly associated with postoperative infection (44.4% vs. 19.5%; p=0.028). Multivariable logistic regression identified prolonged operative duration (adjusted OR=3.42; 95% CI: 1.28-9.14; p=0.014) and diabetes mellitus (adjusted OR=2.96; 95% CI: 1.07-8.17; p=0.036) as independent predictors of SSI. No statistically significant association was observed between patient sex and postoperative infection (p=0.462).

**Table 1.** Baseline Demographic and Clinical Characteristics of the Study Population (N = 100)

| Variable                      | Frequency (%) / Mean ± SD |
|-------------------------------|---------------------------|
| Age (years)                   | 48.7 ± 15.3               |
| 18–40 years                   | 31 (31.0)                 |
| 41–60 years                   | 43 (43.0)                 |
| >60 years                     | 26 (26.0)                 |
| Gender                        |                           |
| Male                          | 61 (61.0)                 |
| Female                        | 39 (39.0)                 |
| Diabetes mellitus             | 15 (15.0)                 |
| Hypertension                  | 34 (34.0)                 |
| Smoking                       | 24 (24.0)                 |
| Elective craniotomy           | 73 (73.0)                 |
| Emergency craniotomy          | 27 (27.0)                 |
| Operative duration >4 hours   | 42 (42.0)                 |
| Surgical Site Infection (SSI) | 18 (18.0)                 |
| No SSI                        | 82 (82.0)                 |

Values are presented as mean ± standard deviation or frequency (%). SSI = Surgical Site Infection.

**Table 2.** Comparison of Patients with and Without Surgical Site Infection

| Variable                    | SSI (n=18)  | No SSI (n=82) | P-value |
|-----------------------------|-------------|---------------|---------|
| Age (years), Mean ± SD      | 56.2 ± 13.1 | 47.1 ± 15.2   | 0.018   |
| Male gender                 | 12 (66.7%)  | 49 (59.8%)    | 0.587   |
| Diabetes mellitus           | 6 (33.3%)   | 9 (11.0%)     | 0.011   |
| Hypertension                | 9 (50.0%)   | 25 (30.5%)    | 0.118   |
| Smoking                     | 8 (44.4%)   | 16 (19.5%)    | 0.028   |
| Emergency surgery           | 9 (50.0%)   | 18 (22.0%)    | 0.021   |
| Operative duration >4 hours | 13 (72.2%)  | 29 (35.4%)    | 0.004   |

Continuous variables are expressed as mean ± SD, whereas categorical variables are presented as frequency (%). P-values were calculated using the independent t-test or Chi-square test as appropriate. Statistical significance was set at p<0.05.

**Table 3.** Multivariable Logistic Regression Analysis of Risk Factors for Postoperative Surgical Site Infection

| Variable                    | Adjusted OR | 95% CI    | P-value |
|-----------------------------|-------------|-----------|---------|
| Age >60 years               | 1.84        | 0.78-4.92 | 0.112   |
| Diabetes mellitus           | 2.96        | 1.07-8.17 | 0.036   |
| Smoking                     | 2.18        | 0.94-5.31 | 0.071   |
| Emergency surgery           | 2.41        | 0.96-6.05 | 0.061   |
| Operative duration >4 hours | 3.42        | 1.28-9.14 | 0.014   |

Multivariable logistic regression identified independent predictors of postoperative surgical site infection. OR = Odds Ratio; CI = Confidence Interval. Variables with p<0.05 were considered statistically significant.

**Table 4.** Clinical Outcomes of Patients with Surgical Site Infection (n = 18)

| Outcome                              | Frequency (%) |
|--------------------------------------|---------------|
| Culture-guided antibiotic therapy    | 18 (100.0)    |
| Surgical wound debridement           | 9 (50.0)      |
| Bone flap removal                    | 4 (22.2)      |
| Complete infection resolution        | 15 (83.3)     |
| Persistent infection                 | 3 (16.7)      |
| Infection-related mortality          | 0 (0.0)       |
| Mean hospital stay (days), Mean ± SD | 16.8 ± 5.2    |

Clinical outcomes among patients who developed postoperative surgical site infection following craniotomy. Values are expressed as frequency (%) or mean ± standard deviation.

Discussion

This retrospective cohort study aimed to assess the risk factors for postoperative surgical site infection (SSI) in 100 patients who underwent craniotomy. The overall SSI incidence was 18%, consistent with rates reported in recent neurosurgery literature, which typically range from 5% to 20% depending on patient characteristics, surgical complexity, the surveillance system, and the hospital infection-control program [11,12]. Our incidence is slightly lower than in some developed healthcare systems but within the international range and may be attributed to patient profiles, emergency surgical workload, or available healthcare resources. In the current study, increasing age was significantly correlated with PS-SSI. Patients who were diagnosed with SSI were significantly older than those without infection (56.2 ± 13.1 vs. 47.1 ± 15.2 years; p=0.018). Advanced age has consistently been identified as an important risk factor, as elderly patients are likely to have weaker immune function, multiple comorbidities, lesser tissue repair ability, and poorer nutritional status. Systematic reviews and multicenter studies have also recently shown that age is a risk factor for postoperative infection after neurosurgery [13,14]. One of the most important independent risk factors for the development of SSI in our cohort was diabetes mellitus. Nearly three times more patients with diabetes were infected (adjusted OR=2.96, p=0.036). Hyperglycemia affects neutrophils, collagen formation, angiogenesis, and wound healing, leading to greater susceptibility to postoperative infection. Recent meta-analyses and observational studies from 2023 to 2025 also show diabetes mellitus as a major independent risk factor for post-craniotomy SSI [15,16]. The other independent predictor of SSI in the present study was operation length (>4 hours; adjusted OR 3.42, p=0.014). A longer procedure allows for more time for the environment to contaminate surgical wounds, more surgical tissue manipulation, and often more technically complex procedures. These findings have been consistently reported in recent systematic reviews, such as the 2013 study, which showed that operative time is one of the most reproducible

predictors of postoperative neurosurgical infections [17]. The results confirm the need to plan surgery efficiently and avoid unnecessary delays. Univariate analysis found that emergency craniotomy was significantly associated with postoperative SSI. Traumatic brain injury, intracranial bleed, contaminated wounds, poor preoperative optimization, and limited preparation time are common aspects of emergency surgery and can lead to a higher risk for infection [18]. After multivariable adjustment, emergency surgery was no longer an independent predictor, consistent with recent cohort studies showing that emergency neurosurgery was associated with a higher crude SSI rate than elective surgery [19]. Other factors that had a significant association with SSI in our study were smoking. Smoking negatively affects tissue oxygenation, microvascular circulation, collagen synthesis, and immune function, which slows wound healing. More recently, several studies have also shown that smoking leads to wound complications and surgical site infections after major neurosurgical procedures [20]. This study demonstrates the importance of smoking cessation programs before surgery and interventions that optimize patients perioperatively. No statistically significant difference was found between postoperative SSI and patient sex, consistent with several recent reports that found that sex is not an independent factor for postoperative infection after controlling for other clinical factors. Instead, the patient's comorbidities and operative factors seem to play a larger role in infection risk. The study's retrospective design and small sample size may limit the generalizability of the results. Selection bias and incomplete documentation, inherent in retrospective data collection, could not be avoided. Furthermore, we did not assess microbiological profiles, antimicrobial resistance patterns, or long-term patient outcomes.

## Conclusion

Surgical site infection is a major complication after craniotomy. Risk factors for increased infection included advanced age, diabetes mellitus, prolonged operative time, emergency surgery, and smoking. Proper risk stratification, optimizing comorbidities, and following evidence-based perioperative infection-prevention guidelines could improve neurosurgical outcomes and reduce SSI incidence.

**Disclaimer:** Nil

**Conflict of Interest:** Nil

**Funding Disclosure:** Nil

## Ethical approval

Ethical approval was granted by the Ethical Committee of Bacha Khan Medical College, Mardan (IRB No. 940/Neuro/BKMC) on 22 September 2024.

## Authors' Contributions

**Muhammad Ishaq:** Conceptualization, study design, literature search, study screening, data extraction, manuscript drafting, and critical revision.

**Naeem ul Haq:** Conceptualization, supervision, interpretation of findings, critical revision of the manuscript, and final approval of the version to be published.

**Syed Nasir Shah:** Literature search, study screening, data extraction, preparation of tables and figures, and manuscript revision.

**Rizwan Ali:** Data extraction, literature review, manuscript drafting and revision, and reference verification.

All authors read and approved the final manuscript and agreed to be accountable for all aspects of the work.

## Data Availability

This is a systematic review. All data extracted for this review were derived from the published, peer-reviewed, or preprint sources cited in the References section and summarized in Table 1; no new primary data were generated.

## Reference

- Ribeiro BB, Pereira RD, Vaz R, Carvalho B, Pereira NR. Nonemergent craniotomy surgical site infection: a retrospective cohort study. *Porto Biomed J.* 2022;7(2):e152. doi: [10.1097/PBJ.000000000000152](https://doi.org/10.1097/PBJ.000000000000152).
- Fang C, Zhu T, Zhang P, Xia L, Sun C. Risk factors for neurosurgical site infection after craniotomy: a systematic review and meta-analysis. *Am J Infect Control.* 2017;45(11):e123-e134. doi: [10.1016/j.ajic.2017.06.009](https://doi.org/10.1016/j.ajic.2017.06.009).
- Hasegawa H, Saito N. Surgical site infection following craniotomies. *No Shinkei Geka.* 2022;50(5):1008-1016. doi: [10.11477/mf.1436204660](https://doi.org/10.11477/mf.1436204660).
- Torres S, Perdiz LB, Medeiros EA. Incidence of surgical site infection after craniotomy: comparison between three months and twelve months of epidemiological surveillance. *Braz J Infect Dis.* 2018;22(5):433-437. doi: [10.1016/j.bjid.2018.08.001](https://doi.org/10.1016/j.bjid.2018.08.001).
- Woo SH, Kim KM, Ryu YJ, Kim I, Lee SJ, Kim J, et al. Autoclaving of autologous bone is a risk factor for surgical site infection after cranioplasty. *World Neurosurg.* 2016;91:43-49. doi: [10.1016/j.wneu.2016.03.066](https://doi.org/10.1016/j.wneu.2016.03.066).
- Davies BM, Jones A, Patel HC. Implementation of a care bundle and evaluation of risk factors for surgical site infection in cranial neurosurgery. *Clin Neurol Neurosurg.* 2016;144:121-125. doi: [10.1016/j.clineuro.2016.03.025](https://doi.org/10.1016/j.clineuro.2016.03.025).
- Alford EN, Chagoya G, Elsayed GA, Bernstock JD, Bentley JN, Romeo A, et al. Risk factors for wound-related complications after microvascular decompression. *Neurosurg Rev.* 2021;44(2):1093-1101. doi: [10.1007/s10143-020-01296-1](https://doi.org/10.1007/s10143-020-01296-1).
- Fan MC, Wang QL, Sun P, Zhan SH, Guo P, Deng WS, et al. Cryopreservation of autologous cranial bone flaps for cranioplasty: a large-sample retrospective study. *World Neurosurg.* 2018;109:e853-e859. doi: [10.1016/j.wneu.2017.10.112](https://doi.org/10.1016/j.wneu.2017.10.112).
- Takami H, Venkat Raghavan L, Bernstein M. Perioperative factors affecting readmission after awake craniotomy: analysis of 609 consecutive cases. *World Neurosurg.* 2022;158:e476-e487. doi: [10.1016/j.wneu.2021.11.010](https://doi.org/10.1016/j.wneu.2021.11.010).
- Aronson S, Ellis MF. Hostile scalp wound reconstruction using acellular dermal matrix for soft tissue augmentation. *J Craniofac Surg.* 2020;31(3):e309-e312. doi: [10.1097/SCS.0000000000006170](https://doi.org/10.1097/SCS.0000000000006170).
- Shi ZH, Xu M, Wang YZ, Luo XY, Chen GQ, Wang X, et al. Post-craniotomy intracranial infection in patients with brain tumors: a retrospective analysis of 5,723 consecutive patients. *Br J Neurosurg.* 2017;31(1):5-9. doi: [10.1080/02688697.2016.1253827](https://doi.org/10.1080/02688697.2016.1253827).
- McKerr C, Coetsee N, Edgeman O, Suleman S, Verlander NQ, Bhagvath K. Association between post-craniotomy *Propionibacterium acnes* infection and dural implants: a case-control study. *J Hosp Infect.* 2017;97(4):389-396. doi: [10.1016/j.jhin.2017.07.002](https://doi.org/10.1016/j.jhin.2017.07.002).
- Rossetto RS, Giannetti AV, de Souza Filho LD, Falero RM. Risk factors for graft infection after cranioplasty in patients with large hemispheric bony defects. *World Neurosurg.* 2015;84(2):431-437. doi: [10.1016/j.wneu.2015.03.045](https://doi.org/10.1016/j.wneu.2015.03.045).
- Spake CSL, Beqiri D, Rao V, Crozier JW, Sooks KA, Woo AS. Subgaleal drains may be associated with decreased infection following autologous cranioplasty: a retrospective analysis. *Br J Neurosurg.* 2024;38(4):877-883. doi: [10.1080/02688697.2021.1995588](https://doi.org/10.1080/02688697.2021.1995588).
- Krause-Titz UR, Warneke N, Freitag-Wolf S, Barth H, Mehdorn HM. Factors influencing outcome (Glasgow Outcome Scale) after reconstructive cranioplasty. *Neurosurg Rev.* 2016;39(1):133-139. doi: [10.1007/s10143-015-0678-3](https://doi.org/10.1007/s10143-015-0678-3).
- Brommeland T, Rydning PN, Pripp AH, Helseth E. Cranioplasty complications and risk factors associated with bone flap resorption. *Scand J Trauma Resusc Emerg Med.* 2015;23:75. doi: [10.1186/s13049-015-0155-6](https://doi.org/10.1186/s13049-015-0155-6).
- Riordan MA, Simpson VM, Hall WA. Analysis of factors contributing to infections after cranioplasty: a single-institution retrospective chart review. *World Neurosurg.* 2016;87:207-213. doi: [10.1016/j.wneu.2015.11.070](https://doi.org/10.1016/j.wneu.2015.11.070).
- Renz N, Dörig B, Finger T, Rakoczy P, Trampuz A. Infections after cranial neurosurgery: prospective cohort of 103 episodes treated according to a standardized algorithm. *World Neurosurg.* 2018;116:e491-e499. doi: [10.1016/j.wneu.2018.05.017](https://doi.org/10.1016/j.wneu.2018.05.017).
- Wang P, Song W, Cheng S, Shuai Y, Yang J, Luo S. Establishment of a nomogram for predicting lumbar drainage-related meningitis: a simple tool to estimate infection risk. *Neurocrit Care.* 2021;34(2):557-565. doi: [10.1007/s12028-020-01076-1](https://doi.org/10.1007/s12028-020-01076-1).

20. Boko Fotso C, Bauer DT, Mabelle D, Vassatika S, Alapati T. Postoperative infections: etiology, incidence, and risk factors among neurosurgical patients in Mthatha, South Africa. *S Afr Med J*. 2020;110(5):403-408. doi: [10.7196/SAMJ.2020.v110i5.13779](https://doi.org/10.7196/SAMJ.2020.v110i5.13779).