Neurosurgical post-operative wound infections: A retrospective study of incidence and risk factors in surgical site infection

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INTRODUCTION

Surgical site infections (SSIs) are a significant and costly complication following neurosurgical procedures. They carry a high morbidity rate, leading to prolonged hospitalization, the emergence of antibiotic-resistant bacteria, and potentially life-threatening consequences. SSIs account for a notable cause of postoperative morbidity in neurosurgery, with approximately 5% of craniotomies and 3% of spinal procedures resulting in infections. Regardless of the specific surgery, SSIs increase patient morbidity, length of hospital stay, and healthcare costs. In some cases, SSI-related adverse events such as sepsis, reoperation, readmission, and even death can be more harmful and contribute more to patient morbidity than the SSI itself.

Efforts are made to maintain a sterile environment during surgery, but wound infections are still common and can be related to factors like wound dehiscence, hemorrhage, infection, or poor surgical technique.[3] The choice of closure method plays a crucial role in reducing the risk of SSI. Surgical site infections may be classified as superficial or deep, typically occurring within 30 days after the operation.[8] The primary pathogens involved in acute infections are gram-positive cocci, including Staphylococcus aureus, B-hemolytic Streptococci, and Staphylococcus epidermidis.[1]

Certain risk factors increase the likelihood of developing SSIs, such as poor glycemic control in diabetics, advanced age, smoking, obesity, malignancy, and immunosuppression.[4-7]In 2% to 5% of patients these infections are associated with prolonged hospital stays of 9.7 days and increased mortality rates by 2 to 11-fold.[2,9,11,12]

The financial burden of SSIs is substantial, with estimated costs ranging from 3.5 billion to 10 billion dollars in the United States alone.[6] To tackle the issue of SSIs, research has explored alternative suture materials, including antimicrobial sutures and bioactive sutures with drug-eluting stents or stem cell-seeded sutures.[10] Studies have shown a reduction in post-operative wound infections with the use of antimicrobial sutures compared to traditional sutures.[3,15]

Given the availability of new suture materials, the authors of this study conducted a retrospective analysis of their institution's neurosurgical cases to evaluate the incidence of SSIs and assess the need to adopt novel suture materials or closure techniques. Their study focuses on primary closure neurosurgical cases, such as craniotomies and spinal surgeries, and the type of closure material used. The aim is to identify trends in the data and determine if antibiotic sutures should be considered as an alternative based on a comparison with other studies using these sutures.

Previous studies have examined risk factors for SSIs following neurosurgery, including prior neurosurgical procedures, concomitant infections, cerebrospinal fluid (CSF) leaks, and venous sinus entry. The use of external CSF devices has also been associated with a higher risk of SSI and 90-day mortality.[13,14] However, these studies have focused less on the mechanism of wound closure.[19]

In conclusion, SSIs are a significant concern in neurosurgery, and the choice of closure material can impact the incidence of these infections. Research on novel suture materials, such as antimicrobial sutures, has shown promising results in reducing post-operative wound infections. The authors' retrospective analysis aims to shed light on their institution's experience with contemporary wound closure techniques and determine if adopting antibiotic sutures could be beneficial for their neurosurgical patients.

METHODS

This study conducted a retrospective analysis at a single institution to investigate patients who underwent cranial or spine surgery performed by neurosurgeons over the past 1 year. The inclusion criteria for the study were patients aged 18 and over who had undergone a neurosurgical procedure and received primary wound closure at the institution using suture or staple techniques. Conversely, patients under 18 were excluded from the analysis, those who did not undergo a neurosurgical procedure, and those whose wound closure was performed outside the institution.

Data were collected from electronic medical records and organized in a Microsoft Excel spreadsheet. The collected information included medical record numbers, gender, age, smoking status, diabetes, IV drug usage, date of surgery, type of surgery, type of closure, time of infection after surgery, type of infection, co-existing infection, and treatment (surgery versus antibiotics).

The study was designed as a retrospective analysis of prospectively collected data on all neurosurgical site infections that occurred from November 2021 to November 2022. Patient medical record numbers were obtained through the medical record department with approval from the local Institutional Review Board. Patient consent was not required for this study design.

The patient cohort included individuals admitted to the post-operative ward between November 2021 and November 2022 following surgeries for intracranial tumors, chronic subdural hematomas, shunts, reconstructive cranioplasty, or spinal procedures. Surgical procedures for tumors involved removal or resection through craniotomies and craniectomies, as well as biopsies performed through burr holes.

RESULTS

A data retrieval software program collected data from 125 patients who had undergone cranial and spinal surgeries. Among these cases, only 1 patient developed a post-operative wound infection. To assess the significance of our results, we compared them with data from published studies in the medical literature. Previous research has indicated that up to 33% of surgical cases experience post-operative infections.[18] When we compared this value with our data (1 infective case), there was a statistically significant difference (Table 1). However, when we specifically looked at a certain type of surgical site infection (SSI) with a reported incidence of 1.5%, our data (0.08% incidence) did not show statistical significance in comparison. When analyzing infection rates in spinal surgeries and comparing them to two different publications reporting rates of 3% and 4.15%, our data (0.08% infection incidence) demonstrated statistical significance. Similarly, for cranial surgeries, our data with an infection rate of 0.0097% showed statistical significance when compared to the quoted data of 1.4%.

Out of the patients who experienced post-operative infections, the demographics revealed that the patient was male (100%) (Figure 1), aged 19 to 35 years (100%) (Figure 2), and had a BMI <18.5 (100%) (Figure 3). None of the patients with infections were active or former smokers (0%) (Figure 4), admitted to intravenous drug abuse (IVDA) (0%) (Figure 5), or had diabetes mellitus (DM) (0%) (Figure 6). When considering surgical specifics, there seemed to be no significant difference in infection rates when comparing the type of surgical closure or procedure. Only one patient who had cranial surgery suffered from SSI only one patient who had closure with sutures experienced SSI (Figure). The patient who did experience SSI had infections occur within 11 to 30 days after surgery. In some cases, there were instances of purulent debris in the wound during washout surgery, but cultures were not taken (labeled as "N/A") (Figure 9). All patients with infections required repeated surgical interventions alongside antibiotic treatment (Figure 10).

TABLE 1: ANALYSIS OF SURGICAL SITE INFECTION AT OUR INSTITUTION VERSUS REPORTED LITERATURE VALUES

	Our Institution	**Fiani B et al [26]**	**Kolpa et al[20]**	**Chaudhary et al[17]**	**Ueno et al[18]**
SSI	0.08%	1%	1.5%		
Spinal SSI	nil	0.05%	(2.2%—did not use for statistical analysis)	3%	
Spinal SSI	nil	0.05%			4.15%
Cranial SSI	0.097%	0.05%	1.4%		

FIGURE 1 GENDER RATIO OF PATIENTS WITH POST–OPERATIVE WOUND INFECTION

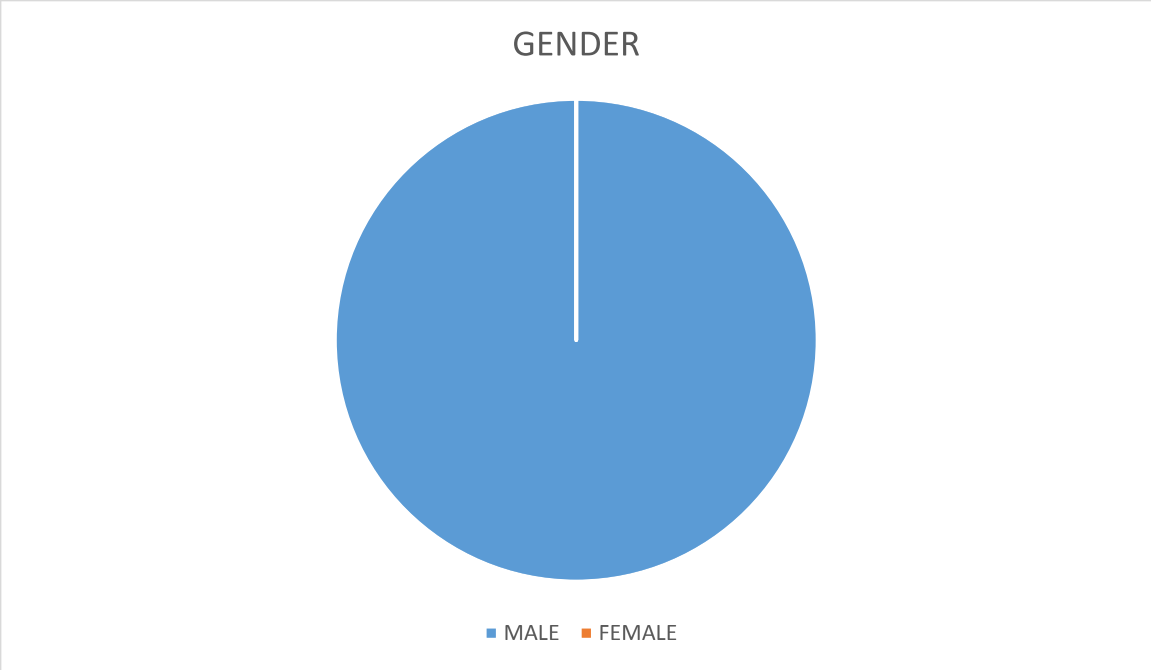


FIGURE 2 AGE OF PATIENTS WITH WOUND INFECTION OF PATIENTS WITH POST-OPERATIVE WOUND INFECTION

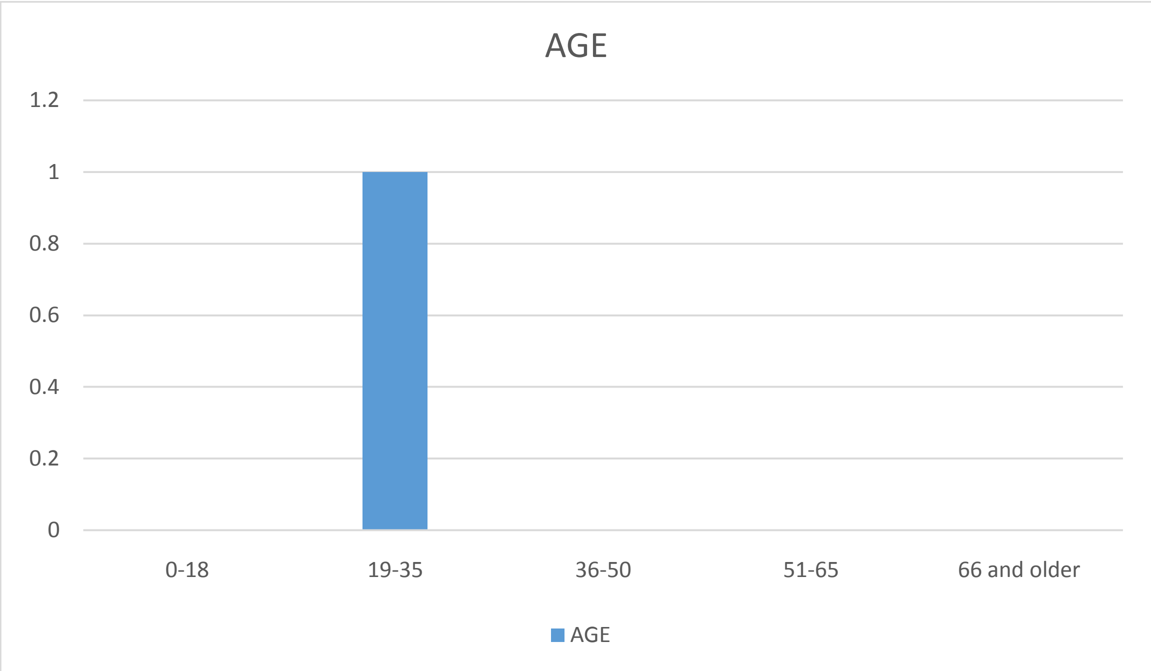


FIGURE 3 BODY MASS INDEX OF PATIENTS WITH POST – OPERATIVE WOUND INFECTION

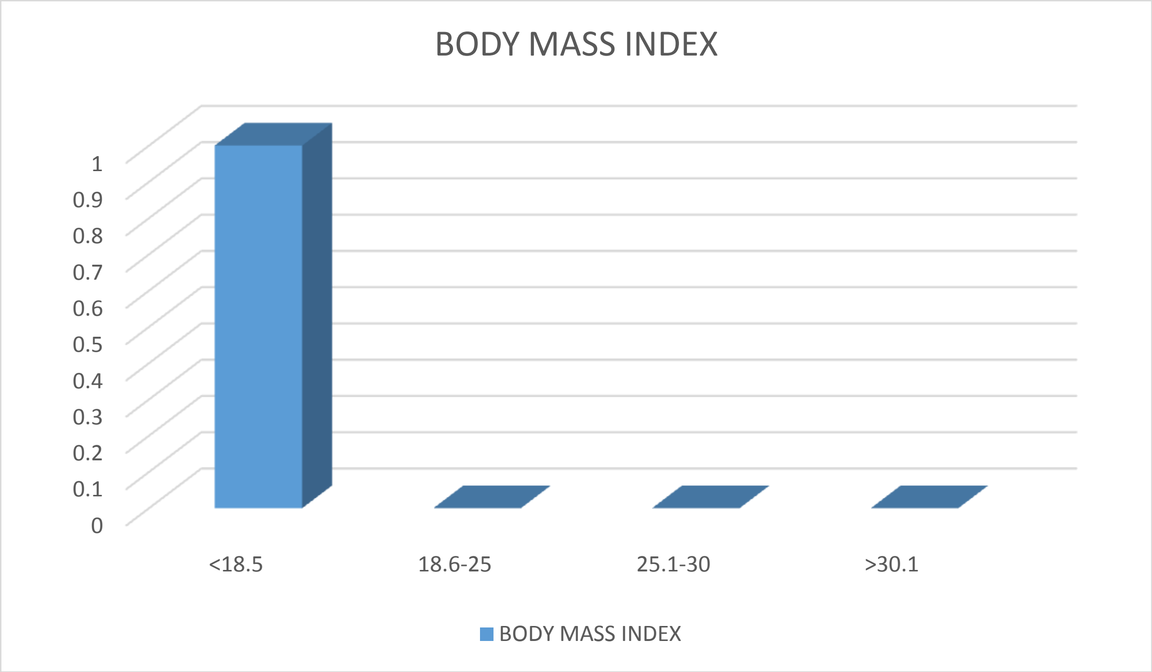


FIGURE 4 SMOKING STATUS OF PATIENTS WITH POST – OPERATIVE WOUND INFECTION

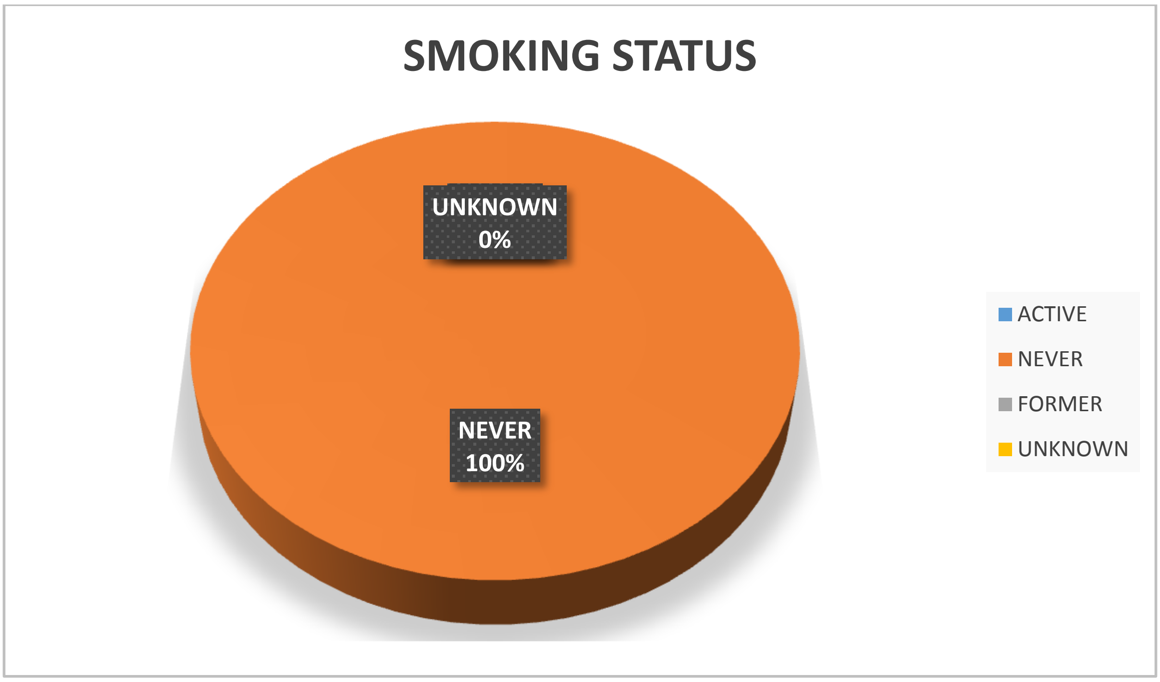


FIGURE 5 INTRAVENOUS DRUG ABUSE IN PATIENTS WITH POST – OPERATIVE WOUND INFECTION

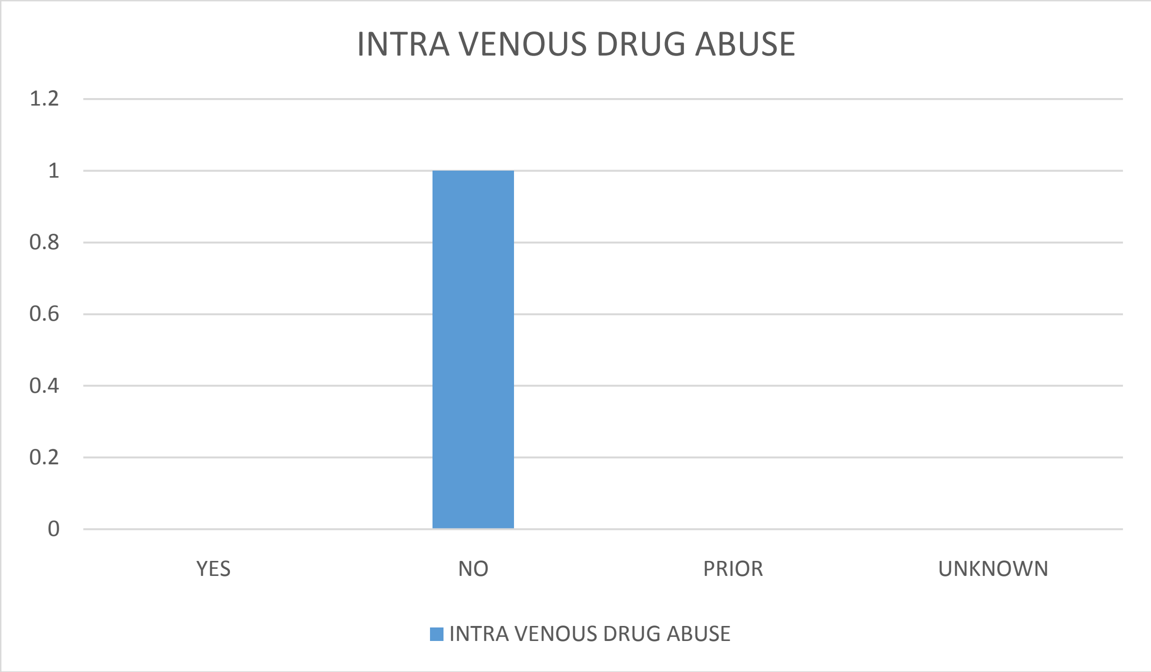


FIGURE 6 DIABETES MELLITUS IN PATIENTS WITH POST – OPERATIVE WOUND INFECTION

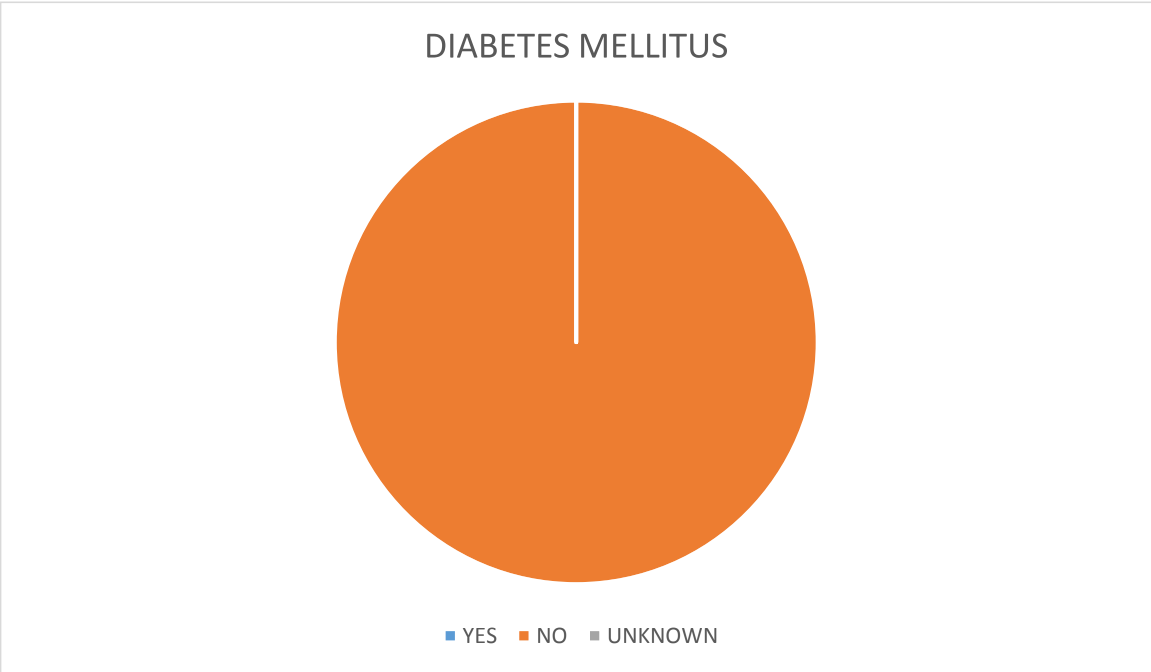


FIGURE 7 TYPE OF SURGERY IN PATIENTS WITH POST-OPERATIVE WOUND INFECTION

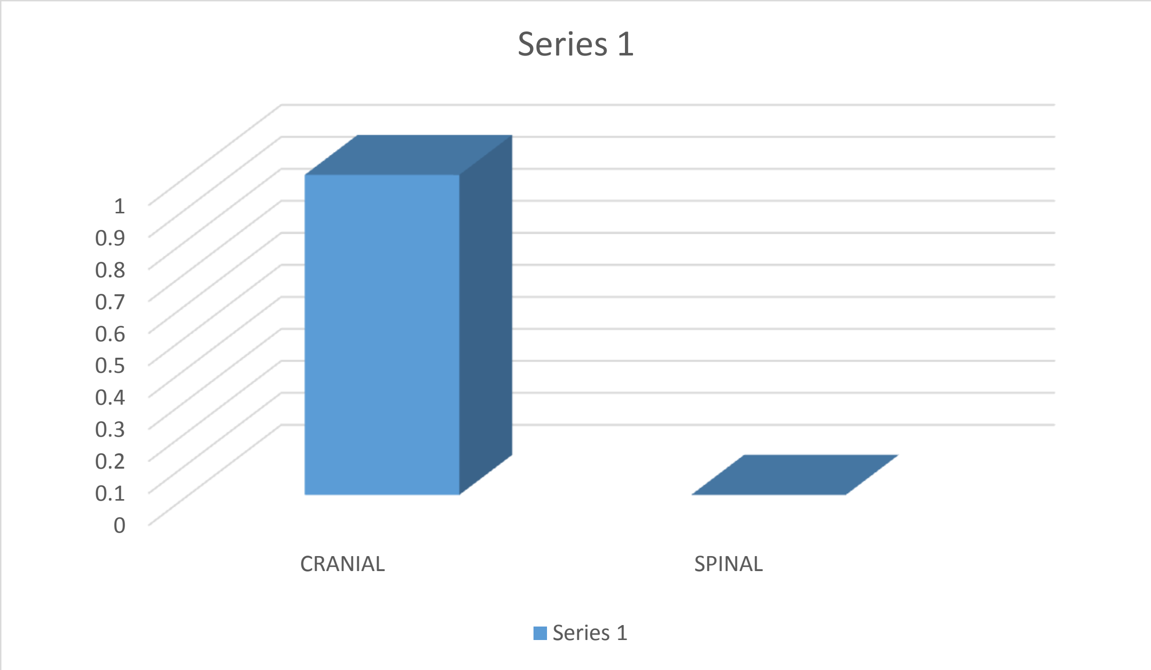


FIGURE 8 CLOSURE MATERIAL IN PATIENTS WITH POST – OPERATIVE WOUND INFECTION

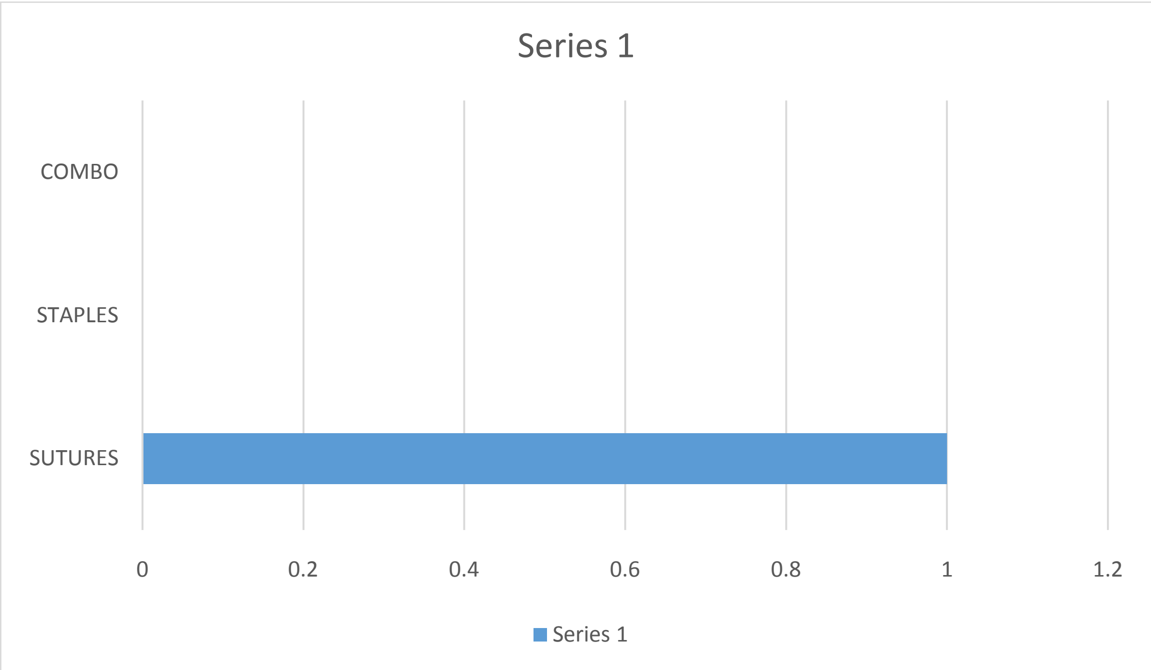


FIGURE 9 DAYS AFTER SURGERY OF INFECTION

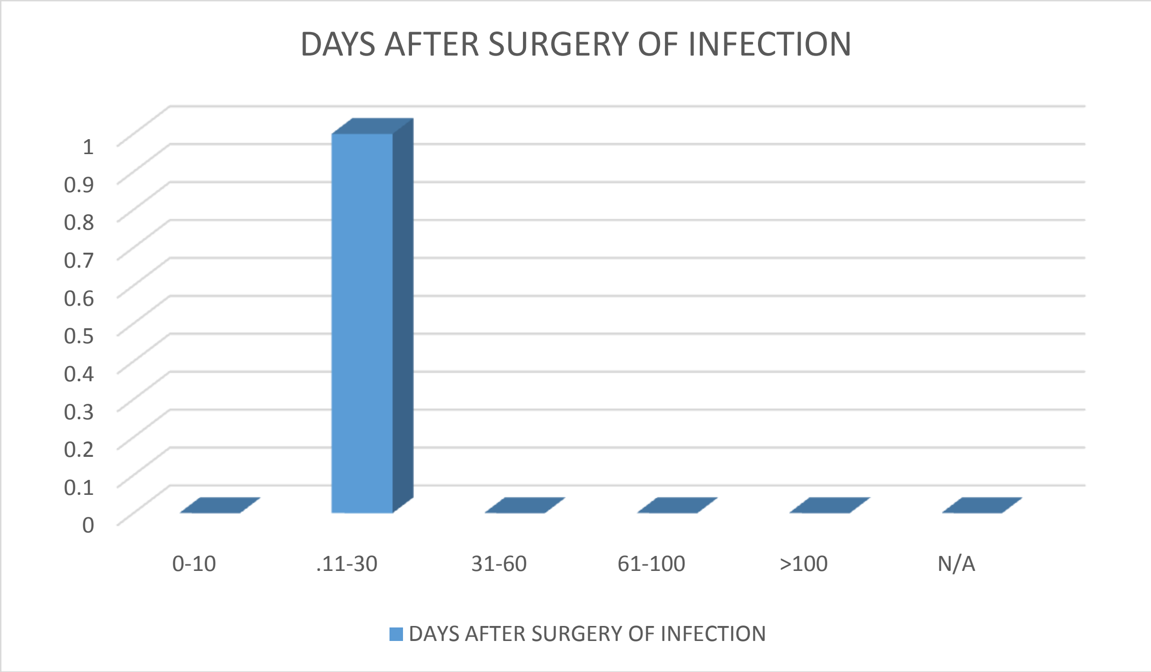
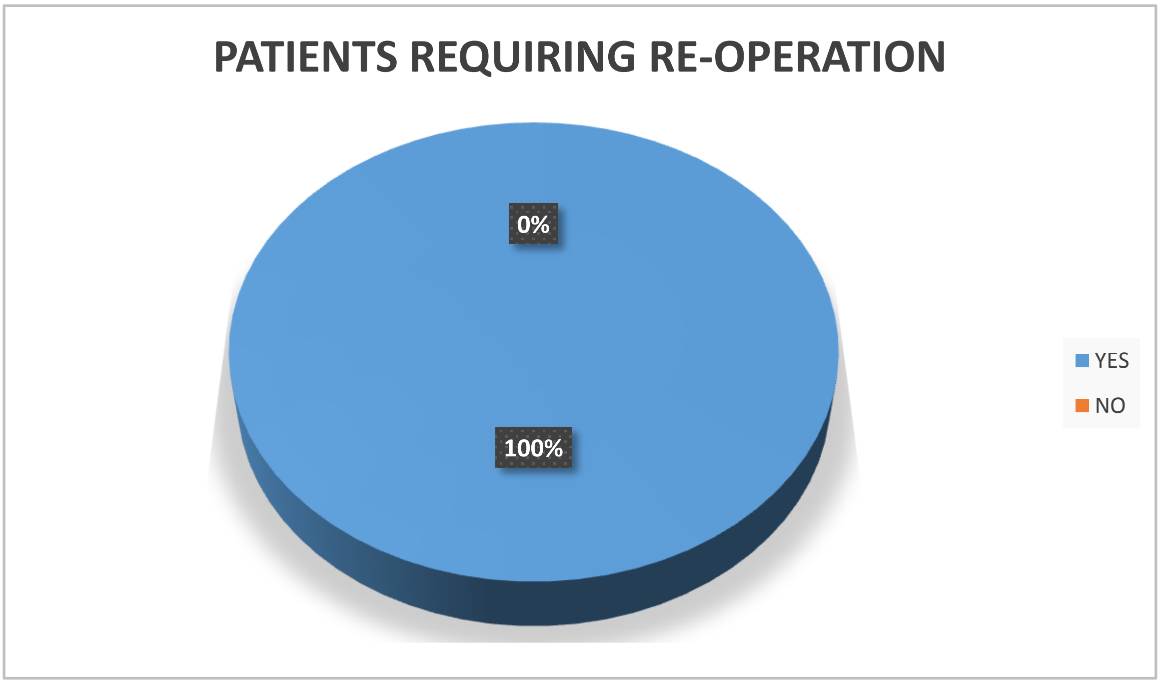


FIGURE 10 PATIENT REQUIRING RE-OPERATION WITH POST – OPERATIVE WOUND INFECTION



DISCUSSION

The retrospective analysis of patients who underwent cranial or spine surgery at a single institution over the past 1 year showed that the rate of neurosurgical post-operative SSI fell within the range consistent with existing literature, which reported infection rates from <1% to 15%, depending on various factors such as surgery type, technique, and patient characteristics.[13,24]

The study evaluated both intrinsic and extrinsic variables that may impact the incidence of SSI. Intrinsic

VARIABLE	INCREASE VS. DECREASE IN SSI	REPORTED p-VALUE	REFERENCES

variables included surgery type (spinal versus cranial), type of closure material (staples, sutures, or a combination), and the number of days post-operation. No statistically significant difference was found in SSI incidence based on these intrinsic variables, aligning with previous meta-analyses in the literature.[13,21,22,24,27]

Extrinsic factors unrelated to the surgical technique but associated with the patient's profile and overall health were also considered. These factors included gender, age, BMI, smoking status, intravenous drug use (IVDU), and history of diabetes. The study did not reveal any specific extrinsic risk factors that correlated well with SSI incidence. However, the small group size of patients with SSI may have limited the ability to identify significant correlations.

Despite not identifying clear risk factors, the study's low-average SSI incidence is noteworthy. The institution's practice emphasizes maintaining sterility throughout the surgical process, which likely contributes to the low infection rate. The study highlights that conventional surgical closure methods at the institution are safe and effective, potentially eliminating the need for major changes in standard practices.

Variable	**Increase versus decreased in SSI**	**Reported P-value**	**References**
Male gender	Increase	P = .091	Fang et al[13]
Number of previous neurosurgeries	Increase	P = .02; P = .000; P < .001	Fang et al[13]; Schipmann et al[21]; Meng et al[24]
Tobacco smoking	Increase	P < .10; P = .015	Kong et al[25]; Meng et al[24]
Diabetes	Increase	P < .001; P = .001	Meng et al[24]; Fei et al[22]
BMI >35	Increase	P < .001; P = .015	Meng et al[24]; Fei et al [22]
Urinary tract infection	Increase	P < .001	Meng et al[24]
Hypertension	Increase	P < .001	Meng et al[24]

TABLE 2: EXTRINSIC RISK FACTORS INCLUDE THOSE UNRELATED TO THE TECHNIQUE OR SPECIFIC DETAILS OF THE PROCEDURE

The study offers valuable insights for other hospitals and academic institutions to conduct similar retrospective analyses to assess their success in preventing SSIs and explore potential areas for improvement. The reproducibility of the methodology allows for future studies to examine the benefits and cost-effectiveness of alternative closure methods or materials.

The study does have limitations, such as potential changes in surgical skill or technique over the one-year data collection period. Additionally, the retrospective nature of the study comes with inherent limitations related to documentation and data gathering. Despite these limitations, the large sample size and even distribution of data make the study reliable.

Overall, the retrospective analysis provides valuable data on neurosurgical rates of SSI and offers insights into strategies for reducing infection rates in similar institutions. Further research and studies may build on these findings to improve patient outcomes and reduce healthcare costs.

TABLE 3: INTRINSIC RISK FACTORS IMPACTING THE INCIDENCE OF SSI

CSF Leak	Increase; increase	P = .001; P = .009	Fang et al[13]; Meng et al[24]
CSF Drainage	Increase; increase	P = .001; P = .009	Fang et al[13]; Schipmann et al[21]
Prolonged duration of operation (>4 h)	Increase; increase	P = .001; P = .009	Fang et al[13]; Fei et al[22]
Venous sinus entry	Increase	P = .007	Fang et al[13]
Implantation of foreign material	Increase	P < .001	Schipmann et al[21]
Posterior approach to spinal surgery	Increase	P = .009	Fei et al[22]
Spinal surgeries involving seven or more intervertebral levels	Increase	P = .023	Fei et al[22]
Surgical scrub with antiseptic foam	Increase	P = .01	Sarmey et al[27]
Omission of 5% chlorhexidine hair wash	Increase	P = .051	Sarmey et al[27]
Antibiotic-impregnated sutures	Decrease	P = .038	Sarmey et al[27]
Lack of hair shaving in ventriculoperitoneal shunt (VPS) placement	Decrease	P > .05	Sarmey et al[27]
Double gloving with changes of gloves before shunt handling	Decreases	P= .046	Sarmey et al[27]

CONCLUSIONS

Surgical site infections (SSIs) can be a significant and costly complication after surgery. While risk factors for SSIs have been extensively studied in the past, each institution needs to engage in introspection to ensure accountability and optimize patient care in comparison with established data and guidelines. This study demonstrates that at our institution, the incidence of neurosurgical wound infections is comparable to reported literature and data on the same topic. Our rates were found to be statistically significantly lower than the reported averages.

Given our institution's excellent outcomes and adherence to standard practices, there is no immediate need for major deviations from current techniques, such as the implementation of antibiotic sutures, as our standard practice already exceeds the standard of care. This is particularly important as the use of antibiotic sutures can incur elevated costs compared to non-antibiotic sutures. However, a future study could potentially explore the direct comparison of SSIs between cohorts using non-antibiotic sutures and those using antibiotic sutures to investigate if there are institutional benefits associated with the latter.

The study's methodology was deemed reliable and sound, providing a framework for other institutions to replicate and analyze their own SSI data for quality improvement purposes. This allows healthcare facilities to continuously assess and enhance their infection control measures, thereby improving patient outcomes and reducing healthcare costs.

In conclusion, this study emphasizes the importance of analyzing SSI rates within individual institutions to gauge their performance against established benchmarks. At our institution, neurosurgical wound infection rates were found to be impressively low compared to reported averages, indicating a high standard of care. Continuous evaluation and exploration of potential improvements in infection prevention measures remain essential for providing optimal patient care and ensuring patient safety.

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