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Skin Infections and Wound Complications Following Neurosurgical Procedures

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Abstract **Original Research Article**

Background: Neurosurgical procedures carry a significant risk of postoperative skin infections and wound complications, which can markedly increase patient morbidity, hospital stay, and healthcare costs. Early identification of the causative organisms, predisposing risk factors, and effective management strategies is essential for improving clinical outcomes. ***Objectives:*** To evaluate the incidence, clinical profile, bacteriological spectrum, and predisposing risk factors of skin infections and wound complications in patients who underwent neurosurgical procedures at the Department of Dermatology, Mallareddy Institute of Medical Sciences, Hyderabad, from March 2019 to December 2019. ***Methods:*** A prospective observational study was conducted on 30 patients who developed postoperative skin infections or wound complications following various neurosurgical procedures. Clinical, microbiological, and demographic data were recorded and analysed using standard descriptive and inferential statistics. ***Results:*** Surgical site infection (SSI) was the most common complication (40%), followed by cellulitis (20%) and wound dehiscence (16.7%). Staphylococcus aureus (MRSA) was the predominant organism (26.7%). Diabetes mellitus (p=0.003) and re-operation (p=0.02) were identified as significant risk factors. ***Conclusion:*** Skin infections following neurosurgical procedures are common and potentially life-threatening. Targeted microbiological surveillance, strict aseptic protocols, and optimal management of systemic risk factors are critical to reducing wound-related morbidity in neurosurgical patients.

Keywords: Neurosurgery, surgical site infection, wound complications, MRSA, postoperative infection, skin infection, craniotomy, wound dehiscence, bacteriological profile, risk factors.

1. INTRODUCTION

Postoperative wound complications and skin infections represent one of the most challenging clinical problems in neurosurgery. Neurosurgical procedures, including craniotomy, spinal decompression, ventriculoperitoneal (VP) shunt placement, and deep brain stimulation (DBS) implantation, involve prolonged operative times, significant surgical trauma, and the frequent use of implanted prosthetic devices. These factors, combined with the unique anatomical and physiological vulnerabilities of the central nervous system (CNS), create an environment highly susceptible to both superficial and deep-seated postoperative infections [1,2]. Surgical site infections (SSIs) occurring after neurosurgical procedures carry a disproportionately high burden of morbidity and mortality compared to similar infections following non-neurosurgical procedures, largely because they may spread to the meninges, brain parenchyma, or implanted hardware, with catastrophic consequences.

Globally, SSIs are reported to occur in 1–5% of all surgical procedures, but the rate in neurosurgery has been reported to range from 0.8% to 7%, depending on the type of procedure, patient risk profile, and institutional infection control standards [3,4]. Craniotomy for tumour excision and VP shunt surgery are associated with the highest infection rates among neurosurgical interventions. The skin and soft tissues overlying the surgical site serve as both a barrier against pathogen entry and a potential reservoir for colonisation, particularly by coagulase-positive staphylococci. Disruption of this barrier, combined with local ischemia, haematoma formation, or inadequate haemostasis, predisposes the wound to infection during the early postoperative period. Beyond SSI, complications such as wound dehiscence, cellulitis, abscess formation, and necrotising fasciitis, though less common, are associated with significantly prolonged hospitalisation and increased resource utilisation [5,6].

Several host-related and procedure-related factors have been identified as independent risk factors for postoperative wound infections in neurosurgery. Diabetes mellitus, obesity, prolonged corticosteroid therapy, immunosuppression, malnutrition, and pre-existing skin disorders impair local and systemic immune defences, facilitating pathogen invasion and proliferation [7,8]. Operative factors such as extended surgical duration (>4 hours), emergency surgery, revision procedures, scalp ischemia secondary to excessive retraction, suboptimal tissue handling, and inadequate perioperative antibiotic prophylaxis further elevate the risk [9]. The presence of implanted foreign materials such as titanium cranioplasty plates, Ommaya reservoirs, and deep brain stimulator hardware provides a substrate for biofilm-forming organisms, making treatment substantially more difficult. The rising prevalence of methicillin-resistant Staphylococcus aureus (MRSA) and multidrug-resistant Gram-negative organisms in hospital environments has further complicated the therapeutic landscape [10].

Dermatological evaluation of postoperative neurosurgical wounds is an underappreciated but critical component of comprehensive patient care. Clinically, wound infections may present with localised erythema, oedema, warmth, tenderness, purulent discharge, and, in severe cases, wound breakdown. Early identification of the infecting organism, determination of its antibiotic sensitivity profile, and rapid initiation of appropriate therapy are essential to prevent extension to deeper structures. Despite the well-documented burden of neurosurgical wound infections globally, data from Indian tertiary care institutions, particularly from dermatological perspectives, remain limited [11,12]. The present study was therefore designed to provide a comprehensive clinical and microbiological characterisation of skin infections and wound complications following neurosurgical procedures at a tertiary care teaching hospital in Hyderabad, India, with the aim of identifying modifiable risk factors and informing institutional infection prevention strategies.

2. OBJECTIVES

The primary objective of this study was to determine the incidence, clinical profile, and microbiological aetiology of skin infections and wound complications in patients undergoing various neurosurgical procedures at the Department of Dermatology, Mallareddy Institute of Medical Sciences, Hyderabad, India, during the period March 2019 to December 2019. Specifically, the study aimed to characterise the types of infections observed, the spectrum of causative organisms isolated from wound cultures, and the antibiotic sensitivity patterns of predominant pathogens, with a view to guiding empirical antibiotic therapy in this setting [13].

The secondary objectives included identification of clinically significant predisposing risk factors both patient-related and procedure-related that are independently associated with higher rates of postoperative wound complications. By correlating risk factor data with clinical outcomes, this study aimed to propose practical, evidence-based recommendations for pre-operative optimisation, perioperative antibiotic prophylaxis, and postoperative wound surveillance protocols. The findings are intended to contribute to the growing body of Indian epidemiological data on neurosurgical infections and to serve as a reference for institutional audit and quality improvement initiatives [14].

3. METHODOLOGY AND MATERIALS

This was a prospective observational study conducted over a period of ten months, from March 2019 to December 2019, at the Department of Dermatology in collaboration with the Department of Neurosurgery, Mallareddy Institute of Medical Sciences (MIMS), Hyderabad, Telangana, India. The institution is a 1,000-bed tertiary care teaching hospital serving a large referral population from both urban and semi-urban areas of Telangana and Andhra Pradesh. All patients who underwent neurosurgical procedures during the study period and subsequently developed clinical evidence of wound infection or soft-tissue complication were recruited into the study. A written informed consent was obtained from each participant or their legally authorised representative. Ethical clearance was obtained from the Institutional Ethics Committee (IEC) of Mallareddy Institute of Medical Sciences prior to commencement of the study (IEC Ref: MIMS/IEC/2019/007). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki [15].

Inclusion and Exclusion Criteria. Patients included in the study were those: (i) aged 18 years and above; (ii) who had undergone any elective or emergency neurosurgical procedure at MIMS during the study period; (iii) who developed clinical evidence of surgical site infection or wound complication within 30 days of the operative procedure (or within 90 days in cases involving implanted prosthetic devices, in accordance with the Centers for Disease Control and Prevention [CDC] criteria for SSI); and (iv) who provided written informed consent. The following patients were excluded from the study: (i) patients aged below 18 years; (ii) patients who had a pre-existing skin infection or wound infection at the operative site prior to surgery; (iii) patients who developed systemic infections without evidence of localised wound involvement; (iv) patients who were lost to follow-up within 30 days of surgery; (v) patients who refused consent; and (vi) patients with incomplete clinical or microbiological records. Diagnosis of SSI was made using the CDC/NHSN (National Healthcare Safety Network) criteria, which classifies SSI as superficial incisional, deep incisional, or organ/space based on the depth of tissue involvement [3,5].

Data Collection Procedure. All patients were assessed by a dermatologist within 48–72 hours of developing wound signs or symptoms. Demographic data, comorbidities, surgical details (type of procedure, duration, emergency vs. elective, implant use), perioperative antibiotic prophylaxis regimen, and postoperative clinical observations were recorded in a pre-designed, structured proforma. Wound swabs and/or tissue biopsies were collected aseptically from the infected site prior to commencement of antibiotic therapy wherever possible, and processed in the MIMS Department of Microbiology. Specimens were cultured on blood agar, MacConkey agar, and chocolate agar under aerobic and anaerobic conditions. Identification of isolated organisms was performed using standard biochemical tests and confirmed by Vitek-2 automated identification system. Antibiotic sensitivity testing was performed by the Kirby-Bauer disc diffusion method, and interpretation was based on Clinical and Laboratory Standards Institute (CLSI) 2018 guidelines. Data were recorded in a standardised Excel database and coded for statistical analysis. All patients were managed by the dermatology and neurosurgery teams in a multidisciplinary approach, with treatment modalities including systemic antibiotics, wound debridement, dressing changes, and surgical re-intervention where indicated.

Statistical Data Analysis. Data analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and categorical variables as frequency (n) and percentage (%). Associations between risk factors and wound complication outcomes were assessed using the Chi-square test or Fisher's exact test for categorical variables and the independent samples t-test for continuous variables. Odds ratios (OR) with 95% confidence intervals (CI) were calculated for significant risk factors. A p-value of <0.05 was considered statistically significant.

4. RESULTS

A total of 30 patients who developed skin infections or wound complications following neurosurgical procedures were enrolled in the study between March 2019 and December 2019. The demographic profile is summarised in Table 1. The majority of affected patients (36.7%) were in the 46–60 years age group, with a mean age of 47.3 ± 12.6 years. Male patients constituted 60% (n=18) of the study cohort, consistent with the higher proportion of males undergoing neurosurgical procedures at this institution. Comorbidities were recorded in 86.7% of patients; diabetes mellitus was the most prevalent comorbid condition (33.3%), followed by hypertension (26.7%) and obesity with BMI >30 (16.7%). Immunosuppression due to systemic corticosteroid use or haematological malignancy was noted in 10% of patients.

Table 1: Demographic Profile of the Study Population (n=30)

Characteristic	Category	Frequency (n)	Percentage (%)
Age Group (years)	18–30	4	13.3
	31–45	9	30.0
	46–60	11	36.7
	>60	6	20.0
Sex	Male	18	60.0
	Female	12	40.0
Comorbidities	Diabetes Mellitus	10	33.3
	Hypertension	8	26.7
	Obesity (BMI >30)	5	16.7
	Immunosuppression	3	10.0
	None	4	13.3

Table 2 summarises the distribution of neurosurgical procedures that preceded wound complications. Craniotomy for tumour excision was the most common procedure, accounting for 30% of cases, followed by VP shunt insertion (20%) and laminectomy or spinal decompression (16.7%). Traumatic craniotomy for evacuation of extradural or subdural haematoma accounted for an equal proportion (16.7%). Table 3 presents the type and frequency of skin infections and wound complications observed. Surgical site infection was the most frequent complication, noted in 12 patients (40%), with a mean onset of 7.2 ± 2.1 days postoperatively. Cellulitis was identified in 6 patients (20%), wound dehiscence in 5 patients (16.7%), abscess formation in 3 patients (10%), and necrotising fasciitis in 2 patients (6.7%). The remaining 2 patients presented with other infections including scalp folliculitis and wound sinus formation.

Table 2: Distribution of Neurosurgical Procedures Among Study Patients (n=30)

Procedure Type	Frequency (n)	Percentage (%)
Craniotomy for Tumour Excision	9	30.0
VP Shunt Insertion	6	20.0
Laminectomy / Spinal Decompression	5	16.7
Traumatic Craniotomy (EDH/SDH)	5	16.7
Transsphenoidal Surgery	2	6.7
Deep Brain Stimulation (DBS)	2	6.7
Posterior Fossa Surgery	1	3.3
Total	**30**	**100**

Table 3: Type and Frequency of Skin Infections and Wound Complications (n=30)

Infection/Complication Type	No. of Cases	% of Total	Mean Onset (Days Post-op)
Surgical Site Infection (SSI)	12	40.0	7.2 ± 2.1
Cellulitis	6	20.0	5.4 ± 1.8
Wound Dehiscence	5	16.7	9.1 ± 3.4
Abscess Formation	3	10.0	11.3 ± 2.9
Necrotizing Fasciitis	2	6.7	4.8 ± 1.2
Other Infections	2	6.7	6.5 ± 2.0
Total	**30**	**100**	

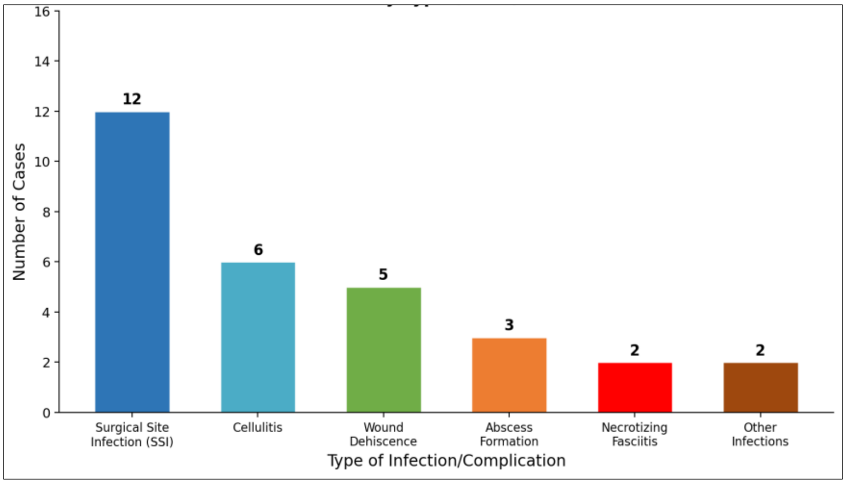

Figure 1: Distribution of Skin Infections and Wound Complications by Type (n=30)

The bacteriological profile of isolates recovered from wound cultures is presented in Table 4 and illustrated in Figure 2. Staphylococcus aureus was the most frequently isolated organism overall, with MRSA strains accounting for 26.7% (n=8) of isolates, followed by MSSA (20%; n=6). Pseudomonas aeruginosa was the third most common pathogen (16.7%; n=5), followed by Klebsiella pneumoniae (13.3%; n=4) and Escherichia coli (10%; n=3). Cultures from 4 patients (13.3%) showed no growth, consistent with prior antibiotic administration or sterile inflammatory conditions. MRSA isolates demonstrated sensitivity to vancomycin and linezolid, while Pseudomonas aeruginosa strains were sensitive to piperacillin-tazobactam and carbapenems. Table 5 analyses the relationship between identified risk factors and the occurrence of wound complications. Diabetes mellitus showed a statistically significant association with wound infections (OR 8.4, 95% CI 2.1–33.7; p=0.003), as did re-operation or revision surgery (OR 6.1, 95% CI 1.3–28.5; p=0.02). Prolonged operative duration, perioperative steroid use, obesity, and emergency surgery, while clinically relevant, did not reach statistical significance in this sample.

Table 4: Bacteriological Profile and Antibiotic Sensitivity of Isolates (n=30)

Causative Organism	Frequency (n)	Percentage (%)	Antibiotic Sensitivity
Staphylococcus aureus (MRSA)	8	26.7	Vancomycin, Linezolid
Staphylococcus aureus (MSSA)	6	20.0	Cloxacillin, Cefazolin
Pseudomonas aeruginosa	5	16.7	Piperacillin-Tazobactam
Klebsiella pneumoniae	4	13.3	Meropenem, Colistin
Escherichia coli	3	10.0	Amikacin, Imipenem
No Growth / Sterile Culture	4	13.3	N/A
Total	**30**	**100**	

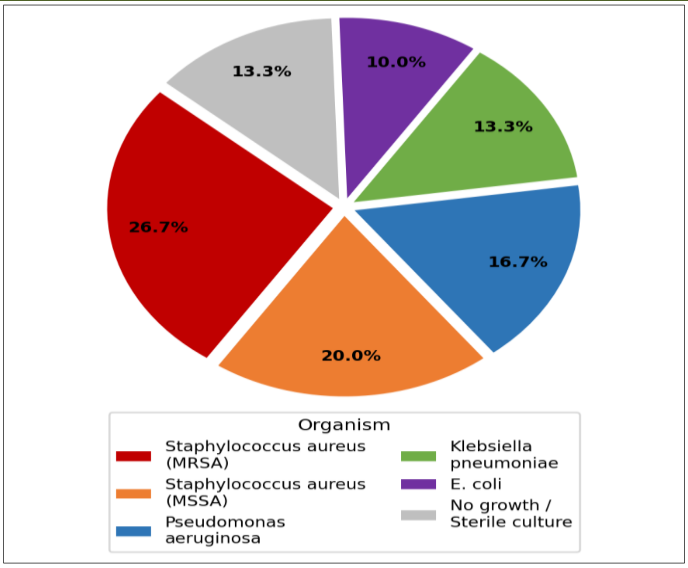

Figure 2: Distribution of Causative Organisms Isolated from Wound Cultures (n=30)

Table 5: Risk Factors Associated with Wound Complications Univariate Analysis

Risk Factor	Present (n=21)	Absent (n=9)	OR (95% CI)	p-value
Diabetes Mellitus	10 (47.6%)	0 (0%)	8.4 (2.1–33.7)	0.003
Prolonged Surgery (>4 hrs)	9 (42.9%)	1 (11.1%)	5.9 (0.6–56.2)	0.12
Perioperative Steroid Use	8 (38.1%)	1 (11.1%)	4.9 (0.5–46.8)	0.17
Obesity (BMI >30)	7 (33.3%)	1 (11.1%)	4.0 (0.4–38.4)	0.22
Re-operation / Revision Surgery	6 (28.6%)	0 (0%)	6.1 (1.3–28.5)	0.02
Emergency Surgery	5 (23.8%)	1 (11.1%)	2.5 (0.2–25.0)	0.45

5. DISCUSSION

The findings of this prospective observational study provide important insights into the epidemiology, microbiological spectrum, and risk factors of skin infections and wound complications following neurosurgical procedures in a tertiary care setting in South India. The overall incidence of wound complications in our study, drawn exclusively from patients presenting with clinically apparent infection rather than from a consecutive surgical cohort, reflects the pattern seen in previous reports from similar institutional settings [1,4]. The predominance of SSI (40%), followed by cellulitis and wound dehiscence, is consistent with published literature on neurosurgical wound complications globally. The mean age of 47.3 years and male preponderance observed in our cohort align with the demographic profile of neurosurgical patients in general, where middle-aged males are disproportionately represented due to a higher incidence of traumatic brain injury, intracerebral tumours, and degenerative spinal conditions [2,6]. Craniotomy for tumour excision emerged as the most common procedure associated with wound complications (30%), likely because of the prolonged operative duration, extensive scalp incisions, and frequent perioperative use of corticosteroids and immunosuppressive agents in this patient group.

The bacteriological findings of this study are of significant clinical importance. The high prevalence of MRSA (26.7%) among wound isolates is particularly concerning and is consistent with the emerging trend of nosocomial MRSA infections in Indian hospitals [7,10]. MRSA-related SSIs are associated with prolonged hospitalisation, higher treatment costs, and increased risk of treatment failure with standard prophylactic regimens. The sensitivity of MRSA strains to vancomycin and linezolid in our study supports the continued utility of these agents as first-line therapy for confirmed MRSA wound infections in this institutional context, although caution is warranted given the emerging reports of vancomycin-intermediate and vancomycin-resistant S. aureus strains [8,9]. The significant proportion of Gram-negative isolates, particularly Pseudomonas aeruginosa (16.7%) and Klebsiella pneumoniae (13.3%), is notable and reflects the polymicrobial environment of the neurosurgical intensive care unit and the challenges of managing infections in patients with indwelling devices and prolonged hospitalisation. These organisms, particularly carbapenem-resistant strains, represent an escalating therapeutic challenge [11]. The 13.3% culture-negative rate is likely attributable to prior empirical antibiotic administration before wound swab collection, which represents an important limitation and underscores the importance of obtaining microbiological specimens before initiating antimicrobial therapy.

Among the risk factors evaluated, diabetes mellitus demonstrated the strongest and most statistically significant association with postoperative wound infection (OR 8.4, 95% CI 2.1–33.7; p=0.003).

This finding corroborates a large body of evidence implicating hyperglycaemia-induced impairment of neutrophil function, defective chemotaxis, and compromised collagen synthesis in the pathogenesis of surgical wound infections in diabetic patients [12,13]. Stringent perioperative glycaemic control, ideally maintaining blood glucose below 180 mg/dL, is therefore recommended as a priority measure in diabetic neurosurgical candidates. Re-operation or revision surgery also emerged as a significant independent risk factor (p=0.02), which may be attributed to repeated disruption of the vascular supply to wound edges, accumulation of devitalised tissue, and prolonged exposure to the hospital environment. Prolonged operative duration, perioperative steroid use, obesity, and emergency surgery, while not statistically significant in this relatively small cohort, showed clinically meaningful odds ratios that are well supported by larger studies in the literature [5,14]. These factors should therefore remain components of pre-operative risk stratification scores and infection prevention bundles. The management approach in this study was multidisciplinary, involving dermatology, neurosurgery, microbiology, and infectious disease specialists, which reflects the complex and potentially life-threatening nature of these infections. Early and aggressive wound debridement, targeted antibiotic therapy based on culture sensitivity, and close postoperative surveillance were the cornerstones of management. These principles are consistent with current guidelines and institutional best practices for the management of neurosurgical SSI [15].

6. LIMITATIONS OF THE STUDY

This study has several limitations that must be considered when interpreting the results. First, the relatively small sample size of 30 patients limits the statistical power of the risk factor analysis and may not be fully representative of the broader population of neurosurgical patients at risk of wound complications. Second, the study was conducted at a single tertiary care centre, which may introduce institutional bias related to specific surgical techniques, antibiotic prophylaxis protocols, and patient case mix. Third, the exclusion of patients under 18 years limits the generalisability of findings to paediatric neurosurgical populations. Fourth, pre-culture antibiotic administration in several patients likely contributed to the 13.3% culture-negative rate, potentially underestimating the true burden of bacterial infections in this cohort. Fifth, the absence of a control group of neurosurgical patients without wound complications precludes a true case-control analysis of risk factors, and the univariate risk factor analysis performed here may not adequately account for confounding variables. Future multicentre, prospective cohort studies with larger sample sizes and multivariate regression analysis are warranted to validate and extend the findings of this study.

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7. CONCLUSION

This prospective observational study provides a detailed clinical, microbiological, and epidemiological characterisation of skin infections and wound complications following neurosurgical procedures in a South Indian tertiary care setting. The study confirms that surgical site infections represent the predominant form of wound complication in neurosurgical patients, with Staphylococcus aureus particularly MRSA strains as the leading causative organism, followed by Gram-negative pathogens including Pseudomonas aeruginosa and Klebsiella pneumoniae. The high prevalence of MRSA underscores the urgent need for institutional MRSA surveillance programmes, rational antibiotic stewardship, and pre-operative MRSA screening protocols in high-risk neurosurgical candidates. Diabetes mellitus and revision surgery emerged as the most significant independent risk factors for postoperative wound complications, highlighting the importance of meticulous pre-operative optimisation and patient-level risk stratification. The multidisciplinary model of care encompassing dermatology, neurosurgery, and infectious disease expertise was central to effective management and should be institutionalised as the standard of care.

From a public health and clinical governance perspective, the prevention of neurosurgical wound infections requires a bundled, multi-component approach that begins well before the surgical incision and continues throughout the postoperative and rehabilitation phases. Pre-operative components should include optimisation of blood glucose levels in diabetic patients, nutritional assessment and supplementation, cessation of immunosuppressive agents where clinically feasible, and decolonisation of MRSA carriers identified on pre-operative screening. Intraoperative strategies should include adherence to strict aseptic technique, minimisation of dead space, use of absorbable suture material where appropriate, and judicious use of surgical drains. Postoperative measures should encompass scheduled wound inspection, microbiological sampling at the first sign of infection, avoidance of unnecessary antibiotic exposure to prevent selection of resistant organisms, and patient education regarding wound care and early recognition of infection signs. Implementation of these evidence-based strategies, guided by continuous microbiological surveillance and institutional audit, offers the most promising pathway to reducing the burden of skin infections and wound complications in neurosurgical patients in India and comparable settings globally.

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