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Research Article

Determinants Influencing Surgical Outcomes in Chronic Osteomyelitis: A Clinical Evaluation

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Abstract
Background: Chronic osteomyelitis is a persistent infection of bone and bone marrow which results from trauma, surgery, or hematogenous spread. The condition is complicated by microbial biofilm formation, host immune evasion, and the presence of implants. It poses a significant clinical challenge due to high recurrence rates and difficulties in eradication.
Objective: To evaluate the risk factors associated with chronic osteomyelitis, assess surgical outcomes, and determine the influence of these risk factors on patient recovery.
Methodology: This prospective observational study was conducted at PES Institute of Medical Sciences and Research, Kuppam, from June 2023 to June 2024. Thirty-four patients diagnosed with chronic osteomyelitis of long bones were included. Data were collected on demographic characteristics, comorbidities, injury and implant history, microbiological findings, and laboratory parameters. Functional outcomes were assessed using LEFS and DASH scores at 1-, 2-, and 3-month follow-ups. Statistical analysis was performed using SPSS v26 with ANOVA and chi-square tests.
Results: The majority of participants were males (85.3%) aged 40–60 years. Most cases were associated with the presence of implants (94.1%), particularly nails and plates. Common risk factors included diabetes mellitus and smoking. Among microbiological isolates, *Staphylococcus aureus*, *E. coli*, and coagulase-negative staphylococci were predominant. Significant associations were found between functional outcomes and factors such as age, duration of symptoms, implant status, hemoglobin levels, and Cierny-Mader classification.
Conclusion: Implant-related infections and host factors such as anemia, diabetes, and smoking significantly influence the development and outcome of chronic osteomyelitis. Early identification and aggressive surgical management combined with targeted antibiotic therapy are essential for favorable recovery.

Keywords: Chronic osteomyelitis, surgical outcome, Tertiary care centre.

INTRODUCTION

Osteomyelitis defined as infection of bone marrow. It can develop when bacterial or fungal pathogens enter the bone tissue through the bloodstream, often following surgery or trauma.[1] It is a chronic inflammatory process induced by infectious agents, leading to bone degradation and the formation of sequestra.The infection may remain confined to the bone, or it can spread to the periosteum, and adjacent soft tissues.[2]

Post-traumatic osteomyelitis frequently develops following open fractures, commonly resulting from traffic accidents or machinery-related injuries. It serves as a significant marker of postoperative infections in such cases. Bacteria enter the bone after injury, multiply rapidly, and increase the risk of infection.[3]

Several factors can increase the risk of developing osteomyelitis, including open fractures, poor nutrition, cancer, chronic alcohol consumption, smoking, diabetes, substance abuse, and prolonged steroid use. Preoperative lymphocyte counts below 1500/mm³ and albumin levels under 3.5 g/L are linked to a higher likelihood of wound healing issues and deep infections. Infection rates in internal fixation of closed fractures are low (1–2%), but in open fractures has significantly higher risk, sometimes exceeds 30%.[4]

The diagnosis of chronic osteomyelitis depends on medical history, laboratory tests results, and different imaging techniques. Laboratory tests may show a normal leukocyte count but increased levels of erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP).[5]

Accurate identification of the infecting organisms is essential for effective treatment and improved patient outcomes. Two commonly used microbiological techniques for diagnosing

infections are swab culture and tissue culture. While swab cultures are noninvasive and easy to perform, they may be prone to contamination and fail to reflect deepseated infections. In contrast, tissue cultures, obtained through biopsy, provide a more reliable representation of the true infecting pathogens but require specialized techniques.

Chronic osteomyelitis can occur as a persistent or episodic condition, with symptoms varying in severity and duration. Periods of inactivity may also differ from case to case. Even after treatment appears successful, the risk of recurrence remains high, making management difficult for healthcare providers. A diagnosis of 'remission' should only be considered after a minimum of 12 months of follow-up, while confirming a complete 'cure' remains uncertain.[6]

Early diagnosis and proactive management for chronic osteomyelitis are pivot for a favorable prognosis and outcome. The primary goal of treatment is eliminate the infection and restore it function. Traditionally, management has involved prolonged antibiotic therapy alongside extensive surgical debridement. Although there is ongoing debate regarding the optimal antibiotic selection, delivery method, and duration, adequate debridement with wide excision is widely recognized as the key factor in achieving successful treatment outcomes.[7]

MATERIAL AND METHODS

A Prospective observational study was conducted at Department Of Orthopedics, PES Hospital, Kuppam from June 2023- June 2024

Study Population: include All patients presenting to ortho OPD and ER with chronic osteomyelitis of long bones. 32 patients were selected by purposive sampling and included.

All patients admitted in orthopaedic ward with chronic osteomyelitis were included in the study and patients previously diagnosed and operated for chronic osteomyelitis were excluded.

Tools To Be Used in the Study: Proforma**,** History and clinical examination• Past history (previous surgeries,DM,HTN), Blood investigations(CBC,ESR,CRP,)**,** Preop and intraop sample collection (pus specimen):

Outcome scoring methods (lower extremity functional scoring for lowerlimb and disability of arm, shoulder, hand scoring for upperlimb). Patient-related factors like age, sex, aetiology, duration, comorbidities like diabetes, Hypertension,

Cierny-Mader Classification

Anatomical Type: 1.medullary osteomyelitis, 2.superficial osteomyelitis, 3.localised osteomyelitis, 4.diffuse osteomyelitis

Physiologic Host Type: Type A host –normal patient,normal immune system, Type B host – systemic compromised ,local compromised,both, Type C host-treatment morbidity worse than present condition ,poor prognosis for cure.

Treatment offered (post-debridement fixation and staged bone graft)

Procedure for Data Collection

After ethical committee approval, patients who are presenting to OPD and emergency department and satisfying inclusion criteria and exclusion criteria will be included in the study, after obtaining an informed written consent.

Blood investigations: Hb%, coagulation profile, Blood grouping and Rh typing, blood sugar, blood urea, and serum creatinine, serum lactate,lft, ESR, CRP and CBC. Urine: albumin, sugar & microscopy. ECG, chest X-ray. Preoperative and postoperative X-rays were done

A Detailed history will be taken pertaining pre osteomyelitis health status, onset of osteomyelitis, treatment taken, presence of co morbidities, details pertaining to etiology also will be collected. Antibiotics given, duration type also will be noted. Risk factors like DM, HTN, trauma, and previous orthopedic surgeries should be noted.

Infective material will be collected twice; once on presentation second time during surgery. Microbiological growth, culture and sensitivity pattern will also will be noted. Lefs- lower extremity functional score for lower limb and DASH-disability of arm, shoulder,hand For upper limb will be used for outcome measurement.

Patients will be started on broad spectrum antibiotics initially and later specific antibiotics as per sensitivity patterns. Patients will be followed on regular basis after discharge at 1m, 2m and 3 m ; more frequently if case demands.

The data was entered into MS Excel 2019 version and further analyzed using SPSS(version 26.0;SPSS Inc.,Chicago IL,USA) For descriptive analysis, Categorical variables will be summarized using frequencies and percentages, and appropriate visualizations will include bar

charts, pie charts, and stacked bar charts. Continuous variables will be summarized using mean ± standard deviation (SD), For inferential analysis, the numerical data were analyzed using the "ANOVA"-test. The categorical data

analyzed using Chi square test will be applied and a "p" <0.05 will be considered as statistically significant.

RESULTS

Table 1. Distribution According To Sociodemographic Factors, Implant, Habits and Fracture Type

Variable		Frequency	Percentage
Age group	<30 years	8	23.5
	31-60 years	14	41.2
	>60 years	12	35.3
Gender	Female	5	14.7
	Male	29	85.3
Implant status	Absent	1	2.9
	Present	33	97.1
Implant type	Nail	17	50.1
	Plate	13	38.2
	Others	3	8.8
	No implant	1	2.9
Pre op discharge	Absent	1	2.9
	Present	33	97.1
Smoking	Absent	21	61.8
	Present	13	38.2
Alcohol	Absent	24	70.6
	Present	10	29.4
Initial injury	Closed	18	52.9
	Open	15	44.1
	De novo osteomyelitis	1	2.9
Gustilo-Anderson Classification	3A	6	40
	3B	9	60
Comorbidities	Absent	19	55.9
	Present	14	44.1
CIERNEY MADER Classification	2A	5	14.7
	2B	8	23.5
	3A	7	20.6
	3B	12	35.3
	4A	2	5.9

Most participants (41.2%) were between 31 and 60 years, while 23.5% were under 30, and 35.3% were over 60. The majority of the participants were male (85.3%), with females comprising 14.7% of the total. Nearly all participants (97.1%) had implants placed during treatment, with only one case lacking implant placement. Among those with implants, 50% had nails, 38.2% had plates, and 8.8% had other types. One participant had no implant. A significant portion of patients (97.1%) presented with discharge prior to surgery. 38.2% of participants had a smoking history, while 61.8% did not. 29.4% reported alcohol use, while the majority (70.6%) did not. Participants were almost equally split between open (44.1%) and closed (52.9%) injuries, with one case of denovo osteomyelitis. Fractures were classified as type 3A (40%), 3B (60%). About 44.1% had one or more comorbid conditions. Osteomyelitis cases were graded from type 2A to 4A, with 3B being the most common (35.3%).

Table 2. Distribution According To Lab Values and Diabetes and Hypertension

Variable		Frequency	Percentage
Anaemia	Present	26	76.5
	Absent	8	23.5
ESR	Raised	26	76.5
	Normal	8	23.5
CRP	Raised	23	67.6

	Normal	11	32.4
TLC	Raised Normal	13 21	38.2 61.8
Albumin	Reduced Normal	7 27	20.6 79.4
Diabetes	Absent Present	22 12	64.7 35.3
Hypertension	Absent Present	30 4	88.2 11.8

Majority (76.5%) were anemic preoperatively, with only 23.5% showing normal hemoglobin levels. 76.5% had elevated ESR levels at presentation, indicating inflammation. CRP was elevated in 67.6% of participants, with 32.4% showing normal values. 38.2% had elevated TLC, while 61.8% were within normal limits. A majority had normal albumin levels, while some had hypoalbuminemia. About 35.3% of the participants had diabetes, while the rest were non-diabetic. Only 11.8% of the subjects had a history of hypertension.

Table 3. Distribution of Intraop Swab and Intraop Tissue

Organism	**Intra OP Swab**	**Intra OP Tissue**
CITROBACTOR	3 (8.8)	3 (8.8)
CONS	3 (8.8)	5 (14.7)
E.Coli	4 (11.8)	5 (14.7)
ENTEROCOCCUS	3 (8.8)	3 (8.8)
Klebsiella pneumoniae	1 (2.9)	1 (2.9)
No growth	11 (32.4)	6 (17.7)
Proteus	1 (2.9)	1 (2.9)
Pseudomonas aeruginosa	1 (2.9)	1 (2.9)
S. aureus	7 (20.6)	8 (23.5)

The most common intraoperative swab results were no growth (32.35%), followed by Staphylococcus aureus (20.59%), E. coli (11.76%), and Citrobactor, CONS, and Enterococcus (8.82% each). Other bacteria detected included Klebsiella pneumoniae, Proteus, and Pseudomonas aeruginosa (2.94% each).

Intraoperative tissue cultures most commonly showed Staphylococcus aureus (23.53%) and CONS, E. coli (14.71% each). Other bacteria included Citrobactor, Enterococcus (8.82% each), and several others at lower frequencies, with 17.65% showing no growth.

Table 4. Association between Functional Outcome 1, 2, 3 Month Follow Up and Sociodemographic Factors, Implant, Habits and Fracture Type in Patients

Variable		**LEF-1M Excellent N (%)**	**LEF_1M Good to Fair N (%)**	**LEF-2M Excellent N (%)**	**LEF_2M Good to Fair N (%)**	**LEF-3M Excellent N (%)**	**LEF_3M Good to Fair N (%)**
Age group	<30 years 31-60 years >60 years	2 (5.9) 0 (0) 0 (0)	6 (17.6) 14 (41.2 12 (35.3)	8 (23.5) 8 (23.5) 0 (0)	0 (0) 6 (17.6) 0(35.3)	8 (23.5) 13 (38.2) 2 (5.9)	0 (0) 1 (2.9) 10 (29.4)
P value		0.032		<0.001		<0.001	
Gender	Female Male	2 (5.9) 0 (0)	3 (8.8) 29 (85.3)	2 (5.9) 14 (41.2)	3 (8.8) 15 (44.1)	3 (8.8) 20 (58.8)	2 (5.9) 9 (26.5)
P value		<0.001		0.732		0.692	
Implant status	Absent Present	0 (0) 2 (5.9)	1 (2.9) 31 (91.2)	0 (0) 16 (47.1)	1 (2.9) 17 (50)	1 (2.9) 22 (64.7)	0 (0)

							11 (32.4)
P value		0.800		0.339		0.483	
Implant type	Nail Plate Others No implant	0 (0) 2 (5.9) 0 (0) 0 (0)	17 (50) 11 (32.4) 3 (8.8) 1 (2.9)	9 (26.5) 6 (17.6) 1 (2.9) 0 (0)	8 (23.5) 7 (20.6) 2 (5.9) 1 (2.9)	12 (35.3) 8 (23.5) 2 (5.9) 1 (2.9)	5 (14.7) 5 (14.7) 1 (2.9) 0 (0)
P value		0.634		0.545		0.576	
Pre op discharge	Absent Present	0 (0) 2 (5.9)	1 (2.9) 31 (91.2)	0 (0) 16 (47.1)	1 (2.9) 17 (50)	1 (2.9) 22 (64.7)	0 (0) 11 (32.4)
P value		0.800		0.339		0.483	
Smoking	Absent Present	2 (5.9) 0 (0)	19 (55.9) 13 (38.2)	16 (47.1) 0 (0)	5 (14.7) 13 (38.2)	19 (559) 4 (11.8)	2 (5.9) 9 (26.5)
P value		0.251		<0.001		<0.001	
Alcohol	Absent Present	2 (5.9) 0 (0)	22 (64.7) 10 (29.4)	16 (47.1) 0 (0)	8 (23.5) 10 (29.4)	22 (64.7) 1 (2.9)	2 (5.9) 9 (26.5)
P value		0.347		<0.001		<0.001	
Initial injury	Closed De novo osteomyelitis Open	2 (5.9) 0 (0) 0 (0)	16 (47.1) 1 (2.9) 15 (44.1)	16 (47.1) 0 (0) 0 (0)	2 (5.9) 1 (2.9) 15 (44.1)	18 (52.9) 1 (2.9) 4 (11.8)	0 (0) 0 (0) 11 (32.4)
P value		0.389		<0.001		<0.001	
Gustilo-Anderson Classification	3A 3B De novo osteomyelitis Closed fracture	0 (0) 0 (0) 0 (0) 2 (5.9)	6 (17.6) 9 (26.5) 1 (2.9) 16 (47.1)	0 (0) 0 (0) 0 (0) 16 (47.1)	6 (17.6) 9 (26.5) 1 (2.9) 2 (5.9)	2 (5.9) 2 (5.9) 1 (2.9) 18 (52.9)	4 (11.8) 7 (20.6) 0 (0) 0 (0)
P value		0.596		<0.001		<0.001	
Comorbidities	Absent Present	2 (5.9) 0 (0)	17 (50) 15 (44.1)	14 (41.2) 2 (5.9)	5 (14.7) 13 (38.2)	17 (50) 6 (17.6)	2 (5.9) 9 (26.5)
P value		0.195		<0.001		0.002	
CIERNEY MADER Classification	2A 2B 3A 3B 4A	2 (5.9) 0 (0) 0 (0) 0 (0) 0 (0)	3 (8.8) 8 (23.5) 7 (20.6) 12 (35.3) 2 (5.9)	5 (14.7) 6 (17.6) 4 (11.8) 1 (2.9) 0 (0)	0 (0) 2 (5.9) 3 (8.8) 11 (32.4) 2 (5.9)	5 (14.7) 7 (20.6) 6 (17.6) 5 (14.7) 0 (0)	0 (0) 1 (2.9) 1 (2.9) 7 (20.6) 2 (5.9)
P value		0.015		0.001		0.012	

Patients aged <30 years showed rapid and sustained improvement, with all reaching excellent outcomes by the second month. Those aged 31–60 years improved steadily, achieving favorable scores by the third month. In contrast, individuals over 60 exhibited slower and less complete recovery, with many remaining in the good-to-fair category at 3 months, indicating age-related limitations in healing and infection control. At 1 month, females showed significantly better outcomes ($p = 0.000$), despite being fewer in number. By

2 and 3 months, males showed gradual improvement, and gender differences were no longer significant (p = 0.732, 0.692). Early recovery favored females, while males improved. At all follow-up intervals, no significant association was found between implant status and functional recovery (p > 0.05). Most patients had implants, and their outcomes showed a steady improvement over time. The single patient without an implant showed minimal recovery. Overall, implant presence did not significantly influence functional outcomes in this cohort. steadily over time.

Functional outcomes across different implant types showed no significant variation over 1, 2, or 3 months (p > 0.05). Patients with intramedullary nails demonstrated the most consistent improvement by 3 months. Those with plates also progressed, though slightly more gradually. Results were limited in the other and no implant groups. Overall, implant type did not have a notable impact on recovery in this cohort. There was no statistically significant association between pre-operative discharge and functional outcomes at 1, 2, or 3 months (p = 0.800, 0.339, and 0.483, respectively). Although patients with pre-operative discharge showed a trend toward better LEF scores over time, the differences were not significant.

It indicates a growing impact of comorbidities on functional recovery over time. Although the 1- month difference was not significant (p = 0.195), outcomes at 2 months (p = 0.000) and 3 months (p = 0.002) showed significantly better LEF scores in patients without comorbidities. It shows that smoking significantly affects functional outcomes, with smokers having poorer results at 2 months (p = 0.000) and 3 months (p = 0.000) compared to non-smokers, though no significant difference was found at 1 month (p = 0.251).

It shows that alcohol use significantly impacts functional outcomes, with alcohol users having worse results at 2 months (p = 0.000) and 3 months (p = 0.000), but no significant difference at 1 month (p = 0.347). There is no significant difference was observed at 1 month (p = 0.389), patients with closed injuries had significantly better outcomes at 2 months (p = 0.000) and 3 months (p = 0.000), compared to those with open injuries or de novo osteomyelitis.

This shows no significant difference at 1 month (p = 0.596), but at 2 months (p = 0.000) and 3 months (p = 0.000), patients with closed fractures had significantly better outcomes compared to those with Gustilo-Anderson 3A, 3B, or de novo osteomyelitis.

Table 5. Association between Functional Outcome 1, 2, 3 Month Follow Up and Lab Values and Diabetes and Hypertensionin Patients

Variable		**LEF-1M Excellent N (%)**	**LEF_1M Good to Fair N (%)**	**LEF-2M Excellent N (%)**	**LEF_2M Good to Fair N (%)**	**LEF-3M Excellent N (%)**	**LEF_3M Good to Fair N (%)**
Anaemia	Absent Present	2 (5.9) 0 (0)	6 (17.6) 26 (76.5)	7 (20.6) 9 (26.5)	1 (2.9) 17 (50)	7 (20.6) 16 (47.1)	1 (2.9) 10 (29.4)
P value		0.009		0.009		0.170	
ESR	Normal Raised	0 (0) 2 (5.9)	8 (23.5) 24 (70.6)	3 (8.8) 13 (38.2)	5 (14.7) 13 (38.2)	3 (8.8) 20 (58.8)	5 (14.7) 6 (17.6)
P value		0.419		0.536		0.037	
CRP	Normal Raised	0 (0) 2 (5.9)	11 (32.4) 21 (61.8)	5 (14.7) 11 (32.4)	6 (17.6) 12 (35.3)	7 (20.6) 16 (47.1)	4 (11.8) 7 (20.6)
P value		0.313		0.897		0.730	
TLC	Normal Raised	2 (5.9) 0 (0)	19 (55.9) 13 (38.2)	10 (29.4) 6 (17.6)	11 (32.4) 7 (20.6)	14 (41.2) 9 (26.5)	7 (20.6) 4 (11.8)
P value		0.251		0.934		0.877	

Albumin	Normal Reduced	1 (2.9) 1 (2.9)	26 (76.5) 6 (17.6)	12 (35.3) 4 (11.8)	15 (44.1) 3 (8.8)	19 (55.9) 4 (11.8)	8 (23.5) 3 (8.8)
P value		0.289		0.549		0.505	
Diabetes	Absent Present	2 (5.9) 0 (0)	20 (58.8) 12 (35.3)	15 (44.1) 1 (2.9)	7 (20.6) 11 (32.4)	20 (58.8) 3 (8.8)	2 (5.9) 9 (26.5)
P value		0.282		0.001		<0.001	
Hypertension	Absent Present	2 (5.9) 0 (0)	28 (82.4) 4 (1.8)	16 (47.1) 0 (0)	14 (41.2) 4 (11.8)	20 (58.8) 3 (8.8)	10 (29.4) 1 (2.9)
P value		0.595		0.055		0.738	

This table shows that anemia significantly impacts functional outcomes at 1 month (p = 0.009) and 2 months (p = 0.009), with worse recovery compared to normal hemoglobin levels. However, no significant difference was found at 3 months (p = 0.170).

It shows no significant differences at 1 month (p = 0.419) and 2 months (p = 0.536), but at 3 months, raised ESR was significantly associated with poorer outcomes (p = 0.037). This study shows no significant differences in functional outcomes at 1 month (p = 0.313), 2 months (p = 0.897), and 3 months (p = 0.730) between patients with normal and raised CRP levels. This suggests that CRP levels may not significantly affect long-term recovery in this cohort. This study shows no significant differences in functional outcomes at 1 month 14 (p = 0.251), 2 months (p = 0.934), and 3 months (p = 0.877) between patients with normal and raised TLC levels.

This study shows no significant differences in functional outcomes between patients with normal albumin levels and hypoalbuminemia at 1, 2, and 3 months, indicating that albumin levels may not significantly affect recovery.

It shows a significant association between the Cierney-Mader classification and functional outcomes at 1, 2, and 3 months. At 1 month, patients in more severe classifications (3B and 4A) had worse outcomes (p = 0.015). This trend continued at both 2 months (p = 0.0016) and 3 months (p = 0.0125), with more severe classifications correlating with poorer functional recovery.

A significant association was observed between diabetes and functional outcomes at 2 and 3 months postoperatively (p = 0.001 and p = 0.000, respectively). Patients without diabetes showed markedly better LEF scores over time. At 2 months, 44.1% of non-diabetic patients had excellent outcomes compared to 2.9% of diabetics. By 3 months, this increased to 58.8% versus 8.8%. No significant difference was noted at 1 month (p = 0.282).

Across all follow-up intervals, no statistically significant relationship was found between hypertension and postoperative LEF scores (1M: p = 0.595; 2M: p = 0.055; 3M: p = 0.738). Although not significant, the 2-month data suggested a potential trend, with nearly half of the non-hypertensive group achieving excellent outcomes.

DISCUSSION

This study investigated how demographic, clinical, laboratory, and injury-related factors impact surgical outcomes in individuals with chronic osteomyelitis. The results emphasize the complex interplay of these variables in influencing recovery and identify specific elements that may facilitate or hinder functional improvement at 1,2 and 3 month follow up.

Implant presence showed no significant impact on functional outcomes in chronic osteomyelitis patients at 1, 2, or 3 months (p = 0.800, 0.339, 0.483). Although better scores were observed among those with implants, the differences were not statistically meaningful, indicating implant status alone may not influence recovery (Kumar A et al., 2020)[8], Mader JT et al 2007.[9]

Implant type did not significantly influence functional outcomes in chronic osteomyelitis over 3 months (p > 0.05). Intramedullary nails showed slightly better recovery by the third month, though outcomes were comparable with plates due to minimal invasisve technique with nails. Prior studies support that both methods can be effective when combined with thorough debridement and local antibiotics (1–3)· (Metsemakers WJ, et al. Injury. 2018).[10]

Preoperative discharge was not significantly linked to functional recovery at 1, 2, or 3 months. However, better outcomes in these patients may reflect effective early intervention. Timely debridement and antibiotic therapy can

mitigate infection impact and aid recovery in chronic osteomyelitis (Lazzarini et al., 2004).[11]
Diabetes negatively impacted functional recovery in chronic osteomyelitis patients, particularly at 2 and 3 months ($p = 0.001$ and $p = 0.000$). Diabetic patients showed poorer outcomes, likely due to impaired healing and immune response, consistent with previous studies on diabetes as a prognostic factor in osteomyelitis (McNally et al., 2018).[12]
Hypertension and Recovery: Hypertension appears to impair functional recovery in chronic osteomyelitis patients. At 1 month, 5.9% of non-hypertensive patients had "Excellent" outcomes, compared to none in the hypertensive group. At 2 months, 47.1% of non-hypertensive patients achieved "Excellent" outcomes ($p = 0.055$), with 58.8% at 3 months.Embil, J. M., et al. (2016).[13]
Initial injury type significantly influences recovery in chronic osteomyelitis. At 2 and 3 months, patients with closed injuries had markedly better functional outcomes compared to those with open fractures or de novo osteomyelitis ($p = 0.000$). Open injuries were associated with delayed healing and poorer outcomes, likely due to greater tissue damage and higher infection risk. According to Lew and Waldvogel (2004) in *The Lancet*, open fractures and direct inoculation increase susceptibility to chronic infection and complicate treatment, highlighting the need for early, aggressive management in such cases.[14]
The Cierney-Mader classification significantly impacts recovery in chronic osteomyelitis with higher grades (3B and 4A) linked to poorer outcomes ($p = 0.0016$ and $p = 0.0125$). Severe disease in higher classifications leads to delayed healing. Cierney and Mader (1985)[15] emphasize the role of disease severity in recovery outcomes. In chronic osteomyelitis, intraoperative cultures reveal a broad range of microbial growth, with Staphylococcus aureus being the most common pathogen in both swabs (20.59%) and tissue (23.53%). Other significant bacteria included E. coli and CONS. A substantial proportion (32.35% swabs, 17.65% tissue) showed no growth, suggesting possible anaerobic or difficult-to-culture pathogens. These findings are consistent with studies by Mader et al. (1999), which highlight that Staphylococcus aureus is a predominant pathogen in chronic osteomyelitis, complicating treatment and requiring targeted antimicrobial therapy. (Butrico CE et al 2020) [16], (Mthethwa PG et al 2015).[17]

The functional recovery in chronic osteomyelitis is multifactorial, with significant associations found between clinical outcomes and patient age, systemic comorbidities, injury classification, and selected biochemical markers. Younger, healthier individuals with closed injuries, normal hemoglobin and albumin levels, and no history of smoking or alcohol consumption demonstrated superior functional recovery over time. These findings highlight the importance of comprehensive preoperative assessment and targeted postoperative management strategies, particularly in high-risk groups, to optimize patient outcomes.

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