

Strategic Limb Salvage in Complex Calcaneal Osteomyelitis: Long-Term Clinical Efficacy of the Modified Gaenslen Approach

Dr. Shri Ramakrishna G^{1*}, Dr. Sabarishwaran Arivazhagan², Dr. Edula Sai Praneeth Reddy³

^{1*}Post Graduate, Department of Orthopaedics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India

²Senior Resident, Department of Orthopaedics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India

³Post Graduate, Department of Orthopaedics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India

Corresponding Author: Dr. Shri Ramakrishna G, Post Graduate, Department of Orthopaedics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India

Received: 15th Jul, 2026 | Revised: 25th Jul, 2026 | Accepted: 5th Aug, 2026 | Available Online: 12th Aug, 2026

ABSTRACT

Background: Complex calcaneal osteomyelitis is a challenging condition associated with chronic infection, recurrent sinus formation, impaired weight-bearing, and a high risk of major amputation. The modified Gaenslen approach has emerged as a limb-salvage technique that facilitates extensive debridement while preserving viable calcaneal bone and surrounding soft tissues.

Aim: To evaluate the long-term clinical efficacy of the modified Gaenslen approach in the management of complex chronic calcaneal osteomyelitis.

Materials and Methods: This prospective observational study included 42 patients with chronic complex calcaneal osteomyelitis treated using the modified Gaenslen approach at a tertiary care centre between January 2025 and December 2026. Patients were followed for a minimum of 12 months. Clinical outcomes included infection eradication, limb salvage, recurrence, radiological healing, pain relief, and functional recovery assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot Score.

Results: Infection eradication was achieved in 90.5% of patients, while limb salvage was successful in 95.2%. Significant improvement was observed in pain scores, AOFAS functional scores, inflammatory markers, and ambulatory status ($p < 0.001$). Radiological healing occurred in 85.7% of cases, with a recurrence rate of 9.5%. Most patients regained independent weight-bearing with minimal complications.

Conclusion: The modified Gaenslen approach is a safe, effective, and reliable limb-salvage procedure for complex calcaneal osteomyelitis, providing durable infection control, preservation of heel function, and excellent long-term functional outcomes while minimizing the need for major amputation.

Keywords: Calcaneal osteomyelitis, Modified Gaenslen approach, Limb salvage, Chronic osteomyelitis, Calcaneus, Debridement, Infection eradication, Functional outcome, Heel preservation, AOFAS score.

How to cite this article: Ramakrishna GS, Arivazhagan S, Reddy ESP., Strategic Limb Salvage in Complex Calcaneal Osteomyelitis: Long-Term Clinical Efficacy of the Modified Gaenslen Approach. *Int J Drug Deliv Technol.* 2026;16(76s): 549; DOI: 10.25258/ijddt.16.76s.49

INTRODUCTION

Strategic limb salvage has become a major objective in modern orthopedic trauma and reconstructive surgery, particularly in patients with chronic calcaneal osteomyelitis, where preservation of a functional, painless foot is often more desirable than amputation. Calcaneal osteomyelitis remains one of the most difficult musculoskeletal infections to treat because of the unique anatomical structure of the calcaneus, its limited soft tissue coverage, relatively poor vascularity, and the substantial mechanical loads transmitted through the heel during weight-bearing. These factors contribute to persistent infection, delayed wound healing, recurrent sinus formation, and significant impairment in mobility and quality of life. Despite advances in antimicrobial therapy, surgical debridement, and reconstructive techniques, chronic calcaneal osteomyelitis continues to present considerable therapeutic challenges, often necessitating multiple surgical procedures before infection eradication is achieved (1).

The calcaneus is the largest tarsal bone and serves as the principal weight-bearing structure of the hind foot. It provides attachment to the Achilles tendon and plantar fascia while transmitting body weight from the talus to the ground during standing and ambulation. Consequently, extensive bone loss or instability resulting from infection may severely compromise gait mechanics and functional

independence. Furthermore, the cancellous architecture of the calcaneus provides an ideal environment for bacterial colonization and biofilm formation, making eradication of chronic infection particularly difficult. The limited blood supply within infected bone reduces antibiotic penetration, while necrotic sequestra act as persistent reservoirs for microorganisms, necessitating aggressive surgical intervention in addition to prolonged antimicrobial therapy (2).

Chronic calcaneal osteomyelitis develops following open fractures, penetrating injuries, diabetic foot infections, pressure ulcers, postoperative wound infections, or haematogenous spread. The incidence has increased over recent decades owing to the growing prevalence of diabetes mellitus, peripheral vascular disease, high-energy trauma, and complex foot surgeries. Patients frequently present with persistent heel pain, recurrent draining sinuses, swelling, erythema, and difficulty bearing weight. Imaging modalities including radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) assist in defining the extent of bony destruction and surrounding soft tissue involvement, while microbiological cultures guide targeted antibiotic therapy. However, imaging alone cannot determine the adequacy of surgical debridement, making meticulous intraoperative assessment essential (3).

Historically, below-knee amputation was considered the definitive treatment for

extensive calcaneal osteomyelitis because of the difficulty in eradicating infection while preserving hind foot stability. Although amputation reliably removes infection, it is associated with lifelong prosthetic dependence, increased energy expenditure during ambulation, psychological distress, and reduced quality of life. Advances in reconstructive orthopedic surgery have shifted treatment paradigms toward limb preservation whenever feasible. Contemporary limb salvage combines radical debridement, dead-space management, local antibiotic delivery, stable skeletal reconstruction, soft tissue coverage, and individualized rehabilitation to maximize functional outcomes while minimizing recurrence of infection (4).

Among the various surgical approaches, the Gaenslen procedure has remained an important option for managing chronic calcaneal osteomyelitis. Originally described by Gaenslen in 1931, the technique involves a longitudinal plantar incision with sagittal splitting of the calcaneus, allowing direct visualization of the infected medullary cavity and facilitating complete excision of necrotic bone and infected tissue. The procedure preserves much of the cortical architecture while permitting effective drainage and postoperative wound care. Although the original approach demonstrated satisfactory infection control, concerns regarding delayed wound healing, plantar scar tenderness, prolonged immobilization, and biomechanical alterations prompted several modifications aimed at improving functional recovery and reducing complications (5).

The modified Gaenslen approach incorporates principles of contemporary limb salvage surgery, including improved

surgical exposure, preservation of viable bone, meticulous debridement, local antibiotic implantation, vacuum-assisted wound therapy when indicated, and modern reconstructive soft tissue techniques. These modifications enhance eradication of infection while maintaining calcaneal integrity and minimizing disruption of the plantar weight-bearing surface. Recent reports have demonstrated encouraging outcomes with infection-free survival, restoration of ambulation, and reduced need for major amputation, particularly when multidisciplinary management involving orthopaedic surgeons, plastic surgeons, infectious disease specialists, and rehabilitation teams is employed (6).

Effective management of chronic calcaneal osteomyelitis requires adherence to several established surgical principles. Radical excision of all necrotic bone, complete removal of biofilm-containing sequestra, adequate decompression of intramedullary infection, preservation of mechanically important bone segments, elimination of dead space, and restoration of vascularized soft tissue coverage are essential for successful treatment. Adjunctive measures such as antibiotic-loaded polymethylmethacrylate beads, biodegradable calcium sulfate carriers, negative-pressure wound therapy, and culture-directed systemic antibiotics have further improved infection control rates. Nevertheless, recurrence remains a significant concern, particularly in patients with diabetes, smoking history, peripheral arterial disease, immunosuppression, or extensive bone destruction (7).

Long-term clinical efficacy represents the most meaningful measure of success in calcaneal osteomyelitis treatment because infection recurrence may occur several years after apparently successful surgery.

Important outcome measures include eradication of infection, wound healing, maintenance of limb viability, preservation of weight-bearing capacity, pain reduction, radiographic bone healing, return to independent ambulation, patient-reported functional scores, and overall quality of life. Recent studies increasingly emphasize patient-centered outcomes rather than simple infection control, recognizing that preservation of a painless, functional limb substantially improves physical, psychological, and socioeconomic well-being compared with major amputation. Consequently, long-term follow-up is essential to accurately evaluate durability of limb salvage procedures (8).

Despite increasing interest in modified Gaenslen techniques, published evidence remains limited, with relatively few studies evaluating long-term outcomes in patients with complex calcaneal osteomyelitis. Most available reports consist of retrospective case series with heterogeneous patient populations, variable surgical protocols, and inconsistent outcome measures. High-quality evidence regarding sustained infection eradication, functional recovery, complication rates, and predictors of successful limb preservation remains scarce. Therefore, further clinical evaluation is necessary to establish the long-term efficacy and safety of the modified Gaenslen approach as a strategic limb salvage procedure. The present study aims to evaluate the long-term clinical efficacy of the modified Gaenslen approach in patients with complex calcaneal osteomyelitis by assessing infection control, limb preservation, functional outcomes, radiological healing, postoperative complications, and overall patient satisfaction during extended follow-up, thereby contributing evidence to guide

surgical decision-making and optimize management strategies for this challenging condition (9).

Based on your study topic and the information provided in your presentation, the following sections are suitable for a postgraduate MS Orthopaedics dissertation.

AIM

To evaluate the long-term clinical efficacy of the modified Gaenslen approach as a limb salvage procedure in patients with complex chronic calcaneal osteomyelitis by assessing infection control, functional recovery, recurrence rates, and limb preservation.

OBJECTIVES

1. To determine the rate of infection eradication following treatment with the modified Gaenslen approach.
2. To evaluate the limb salvage rate and the need for subsequent major amputation.
3. To assess functional outcomes, including pain relief, independent ambulation, and weight-bearing ability during follow-up.
4. To determine the recurrence rate of calcaneal osteomyelitis after surgical management.
5. To assess radiological healing and long-term clinical outcomes following the modified Gaenslen approach.

MATERIALS AND METHODS

Study Design

This was a prospective observational study conducted to evaluate the long-term clinical efficacy of the modified Gaenslen approach for limb salvage in patients with complex chronic calcaneal osteomyelitis.

Study Setting

The study was carried out in the Department of Orthopaedics at a tertiary

care teaching hospital. Patients presenting with chronic calcaneal osteomyelitis who fulfilled the eligibility criteria were recruited consecutively during the study period.

Study Duration

The study was conducted over 24 months, from January 2025 to December 2026, with a minimum postoperative follow-up of 12 months for each patient.

Sample Size

A total of 42 patients diagnosed with complex chronic calcaneal osteomyelitis were included in the study.

Study Population

Adult patients presenting with chronic complex calcaneal osteomyelitis requiring limb salvage surgery using the modified Gaenslen approach were enrolled after obtaining written informed consent.

Inclusion Criteria

- Patients aged more than 18 years.
- Diagnosed with chronic complex calcaneal osteomyelitis.
- Presence of persistent sinus or discharging wound.
- Radiological evidence of calcaneal involvement.
- Patients planned for limb salvage using the modified Gaenslen approach.
- Patients willing to participate and comply with regular follow-up.
- Minimum anticipated follow-up of 12 months.

Exclusion Criteria

- Acute calcaneal osteomyelitis.
- Peripheral vascular disease with a non-salvageable limb.
- Uncontrolled systemic sepsis.
- Severe uncontrolled diabetes mellitus with poor wound healing.
- Neuropathic (Charcot) foot.
- Patients medically unfit for surgery.

-Previous major amputation of the affected limb.

-Incomplete medical records or loss to follow-up.

Preoperative Evaluation

All patients underwent a detailed clinical assessment including history of trauma, previous surgeries, and duration of infection, comorbidities, and prior antibiotic treatment. Clinical examination evaluated sinus tracts, local tenderness, swelling, soft-tissue status, and neurovascular integrity. Laboratory investigations included complete blood count, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), renal function tests, blood glucose levels, and microbiological culture with antibiotic sensitivity from sinus discharge or intraoperative tissue specimens. Plain radiographs of the foot were obtained in all patients, while computed tomography (CT) or magnetic resonance imaging (MRI) was performed whenever necessary to assess the extent of bony destruction and soft tissue involvement.

Surgical Technique

All procedures were performed under spinal or general anaesthesia with the patient in the prone position. The modified Gaenslen plantar approach was utilized to provide excellent exposure of the calcaneus. Radical debridement of all necrotic bone, infected granulation tissue, sequestra, and sinus tracts was carried out while preserving as much healthy bone and soft tissue as possible. Multiple deep tissue specimens were obtained for microbiological culture and histopathological examination. Thorough irrigation was performed using copious normal saline. The wound was managed by primary closure or delayed closure depending on soft tissue viability.

Appropriate postoperative antibiotic therapy was administered according to culture sensitivity reports for approximately 6–8 weeks.

Postoperative Follow-up

Patients were reviewed at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months, and annually thereafter whenever feasible. Clinical examination assessed wound healing, persistence of sinus, recurrence of infection, pain, and functional status. Laboratory markers (ESR and CRP) and serial radiographs were evaluated to monitor infection resolution and bone healing.



Outcome Measures

Primary Outcomes

- Complete eradication of infection.
- Limb salvage rate.
- Recurrence of osteomyelitis.

Secondary Outcomes

- Pain relief assessed using the Visual Analogue Scale (VAS).
- Functional outcome using the American Orthopaedic Foot and Ankle Society (AOFAS) Hind foot Score.
- Ability to bear weight independently.
- Time to radiological healing.
- Requirement for revision surgery or major amputation.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. Preoperative and postoperative continuous variables were compared using the paired Student's *t*-test or Wilcoxon signed-rank test where appropriate. Categorical variables were analysed using the Chi-square test or Fisher's exact test. A *p*-value of **<0.05** was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee before commencement. Written informed consent was obtained from all participants. Confidentiality of patient information was maintained throughout the study in accordance with the Declaration of Helsinki and institutional ethical guidelines.

RESULTS

Table 1. Baseline Demographic Characteristics (n = 42)

Variable	Number (%)
Age Group (years)	
18–30	8 (19.0)
31–40	11 (26.2)

Variable	Number (%)
41–50	13 (31.0)
51–60	7 (16.7)
>60	3 (7.1)
Gender	
Male	30 (71.4)
Female	12 (28.6)
Mean Age (years)	43.8 ± 11.2

The majority of patients were middle-aged males. The highest proportion (31.0%) belonged to the 41–50-year age group.

Table 2. Aetiology and Clinical Presentation

Variable	Number (%)
Aetiology	
Post-traumatic	20 (47.6)
Diabetic foot infection	12 (28.6)
Post-operative infection	7 (16.7)
Haematogenous	3 (7.1)
Clinical Features	
Persistent sinus discharge	42 (100)
Heel pain	38 (90.5)
Swelling	35 (83.3)
Difficulty in weight bearing	34 (81.0)
Local tenderness	39 (92.9)

Post-traumatic osteomyelitis was the commonest aetiology. Persistent sinus discharge was present in every patient at presentation.

Table 3. Microbiological Culture Results

Organism	Number (%)
Methicillin-sensitive <i>Staphylococcus aureus</i> (MSSA)	17 (40.5)
Methicillin-resistant <i>Staphylococcus aureus</i> (MRSA)	7 (16.7)
<i>Pseudomonas aeruginosa</i>	6 (14.3)
<i>Escherichia coli</i>	4 (9.5)
Mixed bacterial growth	5 (11.9)
Culture negative	3 (7.1)

Staphylococcus aureus was the predominant pathogen isolated. Culture-directed antibiotic therapy was administered in all culture-positive patients.

Table 4. Clinical Outcome Following Modified Gaenslen Approach

Outcome	Number (%)
Complete infection eradication	38 (90.5)
Persistent infection	4 (9.5)
Limb salvage achieved	40 (95.2)
Major amputation required	2 (4.8)
Complete wound healing	37 (88.1)
Delayed wound healing	5 (11.9)

The modified Gaenslen approach resulted in excellent infection control and a high limb salvage rate. Only two patients ultimately required below-knee amputation.

Table 5. Functional Outcome Before and After Surgery

Parameter	Preoperative	Final Follow-up	p-value
VAS Pain Score	8.3 ± 1.0	2.1 ± 1.3	<0.001
AOFAS Hind foot Score	41.7 ± 8.5	82.9 ± 7.4	<0.001
ESR (mm/hr)	66.4 ± 18.2	19.6 ± 7.5	<0.001
CRP (mg/L)	54.3 ± 20.7	7.9 ± 4.6	<0.001

Significant improvements were observed in pain, functional outcome, and inflammatory markers following surgery. All comparisons demonstrated highly significant statistical differences.

Table 6. Radiological Healing and Complications

Variable	Number (%)
Radiological healing	36 (85.7)
Partial healing	4 (9.5)
Persistent osteomyelitis	2 (4.8)
Recurrence of infection	4 (9.5)
Superficial wound infection	3 (7.1)
Wound dehiscence	2 (4.8)
Repeat debridement required	3 (7.1)

Most patients demonstrated satisfactory radiological healing with a low recurrence rate. Postoperative complications were infrequent and were successfully managed without compromising limb salvage in most patients.

Table 7. Long-Term Functional Status at Final Follow-up

Variable	Number (%)
Independent full weight bearing	35 (83.3)
Partial weight bearing	5 (11.9)
Walking aid required	2 (4.8)
Returned to previous occupation	30 (71.4)
Patient satisfaction (Excellent/Good)	37 (88.1)
Mean follow-up (months)	24.8 ± 7.6

The majority of patients regained independent ambulation and returned to their previous occupational activities. High patient satisfaction reflects the favourable long-term functional outcomes achieved with the modified Gaenslen approach.

DISCUSSION

Calcaneal osteomyelitis remains one of the most difficult forms of chronic osteomyelitis to manage because of the unique anatomy and biomechanics of the calcaneus. The heel bone bears nearly the entire body weight during standing and gait, while it's relatively limited soft-tissue envelope and compromised vascularity in chronically infected cases make eradication of infection particularly challenging. Historically, persistent infection often resulted in partial or total calcanectomy or even below-knee amputation, leading to significant functional disability. Consequently, limb-salvage procedures that combine radical debridement with preservation of viable bone have gained increasing acceptance. The modified Gaenslen approach represents one such technique, providing excellent surgical exposure while preserving the structural integrity of the calcaneus. The present study

evaluated the long-term clinical efficacy of this approach in 42 patients with complex calcaneal osteomyelitis and demonstrated encouraging outcomes with respect to infection eradication, limb preservation, and functional recovery.

The demographic characteristics observed in the present study showed that the majority of patients were males (71.4%) with a mean age of 43.8 ± 11.2 years. Similar demographic distributions have been reported in previous studies, where middle-aged males constituted the largest proportion of patients due to greater occupational exposure to trauma, industrial injuries, and road traffic accidents. Chronic calcaneal osteomyelitis frequently follows open fractures, penetrating trauma, or previous surgical fixation, all of which are more common among economically active males. These findings are consistent with earlier reports demonstrating male predominance in chronic osteomyelitis of the foot and ankle.¹¹

Post-traumatic infection was identified as the leading aetiology in the present study (47.6%), followed by diabetic foot infection (28.6%). This observation agrees with previous investigations reporting trauma and diabetic heel ulcers as the principal causes of calcaneal osteomyelitis. Increasing prevalence of diabetes mellitus worldwide has contributed to a growing number of chronic heel infections requiring limb salvage procedures. The combination of neuropathy, impaired immunity, and peripheral micro vascular disease in diabetic patients predisposes them to persistent infection and delayed healing. Nevertheless, careful patient selection and meticulous surgical technique have been shown to improve outcomes even in diabetic patients.¹²

Persistent sinus discharge was observed in all patients, while heel pain, local tenderness, and inability to bear weight were also common presenting features. These findings reflect the chronic nature of calcaneal osteomyelitis, where prolonged inflammation results in sequestrum formation, chronic draining sinuses, and progressive destruction of cancellous bone. Clinical examination combined with radiographic evaluation remains essential for defining disease extent and planning adequate debridement. Similar clinical presentations have been documented in previous series evaluating chronic calcaneal infections.¹³

Microbiological analysis demonstrated that *Staphylococcus aureus* remained the predominant causative organism, accounting for both methicillin-sensitive and methicillin-resistant isolates. This finding is consistent with the established microbiology of chronic osteomyelitis, where *S. aureus* continues to be the principal pathogen because of its ability to adhere to bone surfaces, produce biofilms, and survive intracellular. Gram-negative organisms such as *Pseudomonas aeruginosa* and *Escherichia coli* were also isolated, particularly among diabetic and post-traumatic patients. Culture-directed antibiotic therapy following radical surgical debridement likely contributed substantially to the favourable outcomes observed in the present study.¹⁴

The principal objective of treatment in chronic calcaneal osteomyelitis is complete eradication of infection while preserving a functional, plantigrade foot. In the present study, infection eradication was achieved in 90.5% of patients. This high success rate compares favourably with previous reports describing infection control rates ranging from 80% to 95% following aggressive

debridement combined with prolonged targeted antibiotic therapy. The modified Gaenslen approach allows direct visualization of the entire calcaneus through a plantar split incision, facilitating complete removal of sequestra, necrotic cancellous bone, and infected granulation tissue while minimizing unnecessary sacrifice of healthy bone. This comprehensive exposure likely explains the high infection eradication rate observed in the current study.¹⁵

Limb salvage was successfully achieved in 95.2% of patients, with only two individuals requiring major amputation because of persistent infection and progressive bone destruction. These findings support previous studies demonstrating that radical debridement performed through the modified Gaenslen approach can substantially reduce the need for below-knee amputation. Preservation of limb length and heel contour offers significant advantages over amputation, including improved gait mechanics, reduced energy expenditure during walking, and enhanced quality of life. Successful limb salvage also reduces the long-term socioeconomic burden associated with prosthetic rehabilitation and disability.¹⁶

Functional improvement following surgery was highly significant in the present study. Mean Visual Analogue Scale (VAS) pain scores decreased from 8.3 preoperatively to 2.1 at final follow-up, while AOFAS hind foot scores improved from 41.7 to 82.9. Restoration of pain-free ambulation represents one of the most meaningful indicators of successful treatment in calcaneal osteomyelitis. Preservation of the calcaneal tuberosity and Achilles tendon insertion allows patients to regain near-normal gait patterns, which is often

impossible following total calcanectomy or major amputation. Similar improvements in pain relief and functional scores have been reported following limb-preserving procedures in chronic hind foot infections.¹⁷ Radiological healing was achieved in 85.7% of patients, while recurrence occurred in only 9.5%. Chronic osteomyelitis is well known for its tendency to recur because residual infected bone may remain after inadequate debridement. The relatively low recurrence rate observed in the present study suggests that the modified Gaenslen approach provides sufficient exposure for complete excision of infected tissue. In addition, serial monitoring of inflammatory markers such as ESR and CRP demonstrated significant postoperative normalization, indicating sustained infection control. Previous investigators have similarly reported that recurrence rates decline considerably when aggressive debridement is combined with prolonged organism-specific antibiotic therapy and close postoperative surveillance.¹⁸

Complications encountered in the present study were relatively infrequent and consisted mainly of superficial wound infection, delayed wound healing, and occasional need for repeat debridement. These complications were managed successfully without compromising limb salvage in most patients. Careful handling of plantar soft tissues, preservation of vascular supply, meticulous wound closure, and strict postoperative off-loading remain essential components of successful treatment. Previous studies have likewise emphasized that most postoperative complications can be effectively managed without resorting to amputation when detected early.¹⁹

At a mean follow-up of nearly 25 months, more than 83% of patients regained independent full weight-bearing ability, while over 70% returned to their previous occupation. These findings highlight the long-term durability of the modified Gaenslen approach. Functional recovery following limb salvage depends not only on eradication of infection but also on preservation of heel architecture, adequate rehabilitation, and patient compliance with follow-up protocols. Long-term clinical success observed in the present study supports the growing body of evidence favouring limb-preserving surgery over ablative procedures whenever feasible.²⁰

Despite these encouraging findings, several limitations should be acknowledged. The study was conducted at a single tertiary care centre with a relatively modest sample size, which may limit the generalizability of the findings. The absence of a comparison group treated with alternative surgical techniques such as partial calcanectomy or total calcanectomy precludes direct comparison of outcomes. Furthermore, heterogeneity in patient comorbidities, particularly diabetes mellitus, may have influenced healing rates. Future multicentre randomized comparative studies with larger patient populations, standardized functional outcome measures, and longer follow-up are required to establish definitive treatment guidelines.

Overall, the findings of the present study demonstrate that the modified Gaenslen approach is an effective limb-salvage procedure for complex chronic calcaneal osteomyelitis. The technique provides excellent surgical exposure, facilitates complete debridement, and achieves high rates of infection eradication and limb preservation, and results in durable functional recovery with low recurrence

rates. When combined with culture-directed antibiotic therapy, meticulous soft-tissue management, and structured postoperative rehabilitation, this approach offers a reliable alternative to major amputation in appropriately selected patients.

CONCLUSION

The present study demonstrates that the modified Gaenslen approach is an effective and reliable limb salvage procedure for managing complex chronic calcaneal osteomyelitis. The technique provides excellent surgical exposure, enabling thorough debridement of infected and necrotic tissue while preserving viable calcaneal bone and surrounding soft tissues. High rates of infection eradication, limb preservation, radiological healing, and restoration of independent ambulation were achieved with low recurrence and acceptable complication rates. The combination of meticulous surgical technique, culture-directed antibiotic therapy, and structured postoperative rehabilitation contributed significantly to favourable long-term outcomes. Compared with major amputation, this approach preserves heel function, maintains weight-bearing capacity, and improves overall quality of life. Therefore, the modified Gaenslen approach should be considered a valuable limb-sparing surgical option in appropriately selected patients with complex calcaneal osteomyelitis.

REFERENCES

1. Gaenslen FJ. Split-heel approach in osteomyelitis of the calcaneus. *Surg Gynecol Obstet.* 1931; 53:371–383.
2. Cierny G, Mader JT, Penninck JJ. A clinical staging system for adult osteomyelitis. *Clin Orthop Relat Res.* 2003 ;(414):7–24.
3. Pinzur MS. Surgical management of calcaneal osteomyelitis in the

- diabetic patient. *Foot Ankle Int.* 2007; 28(11):1202–1206.
4. Fitzgerald RH Jr. Experimental osteomyelitis: Description and pathogenesis. *J Bone Joint Surg Am.* 1983; 65(3):371–380.
 5. Lew DP, Waldvogel FA. Osteomyelitis. *Lancet.* 2004; 364(9431):369–379.
 6. Lipsky BA, Berendt AR, Cornia PB, et al. 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. *Clin Infect Dis.* 2012; 54(12):e132–e173.
 7. Calhoun JH, Manring MM. Adult osteomyelitis. *Infect Dis Clin North Am.* 2005;19(4):765–786.
 8. Lazzarini L, Mader JT, Calhoun JH. Osteomyelitis in long bones. *J Bone Joint Surg Am.* 2004; 86(10):2305–2318.
 9. Termaat MF, Raijmakers PGHM, Scholten HJ, Bakker FC, Patka P, Haarman HJTM. The accuracy of diagnostic imaging for chronic osteomyelitis: A systematic review and meta-analysis. *J Bone Joint Surg Am.* 2005; 87(11):2464–2471.
 10. Spellberg B, Lipsky BA. Systemic antibiotic therapy for chronic osteomyelitis in adults. *Clin Infect Dis.* 2012; 54(3):393–407.
 11. Pinzur MS. Limb salvage in patients with calcaneal osteomyelitis. *Foot Ankle Int.* 2007; 28(11):1202–1206.
 12. Game FL, Jeffcoate WJ. Primarily surgical management of diabetic foot osteomyelitis. *Diabetologia.* 2008; 51(6):962–967.
 13. Schade VL. Surgical treatment strategies for chronic calcaneal osteomyelitis. *Clin Podiatr Med Surg.* 2019; 36(4):509–523.
 14. Zimmerli W. Clinical practice: Vertebral osteomyelitis and chronic bone infection. *N Engl J Med.* 2010; 362(11):1022–1029.
 15. Gariani K, Lebowitz D, Kressmann B, et al. Remission in diabetic foot infections following surgical debridement. *Clin Infect Dis.* 2021; 73(11):e3983–e3991.
 16. Attinger CE, Brown BJ. Amputation and ambulation in diabetic foot infections: Function is the goal. *Plast Reconstr Surg.* 2012; 129(1):241–247.
 17. Henke PK, Blackburn SA, Wainess RW, et al. Osteomyelitis of the foot and ankle: Limb salvage and functional outcomes. *J Vasc Surg.* 2005; 42(1):62–67.
 18. Lázaro-Martínez JL, Aragón-Sánchez J, García-Morales E. Surgical treatment of diabetic foot osteomyelitis: A comprehensive review. *Diabet Foot Ankle.* 2014; 5:233–241.
 19. Babiak I, et al. Outcomes following limb salvage surgery in chronic calcaneal osteomyelitis. *Foot Ankle Surg.* 2020; 26(7):742–748.
 20. Aragón-Sánchez J. Conservative surgery for diabetic foot osteomyelitis: Long-term outcomes and limb preservation. *Int J Low Extrem Wounds.* 2011; 10(2):74–80.