International Journal of Research in Orthopaedics
Mehta NR et al. Int J Res Orthop. 2026 May;12(3):646-652
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20261210

Functional outcome of surgical management of ankle fractures classified as per Lauge-Hansen classification

Nisarg R. Mehta*, Prabhav P. Tijoriwala, Pratik V. Sidhdhapuria

Department of Orthopedic, SMIMER Medical College, Surat, Gujarat, India

Received: 14 July 2025
Revised: 04 September 2025
Accepted: 13 February 2026

***Correspondence:**
Dr. Nisarg R. Mehta,
E-mail: nisarg.mehta30@gmail.com

ABSTRACT

Background: Ankle fractures are one of the common types of fractures treated by orthopaedic surgeons. There has been an increase in the prevalence of such fractures over the last two decades both in the young and active patients and in the elderly. The Lauge-Hansen classification system, based on the mechanism of injury, remains one of the most widely used methods for categorizing ankle fractures. It divides fractures into four main types-supination-adduction (SA), supination-external rotation (SER), pronation-abduction (PA), and pronation-external rotation (PER)-based on the position of the foot at time of injury and the direction of the applied force. Ankle injuries gain importance because the whole-body weight is transmitted through the ankle and locomotion depends upon the stability of the ankle joint
Methods: The inclusion criterion included all those ankle fracture more than 18 years and who consent to participate. The operative procedure was performed within 4 to 5 days of the injury. A preoperative clinical examination of the affected ankle was carried in all aspects like- abrasions, swelling, contusion, puckering and neurovascular deficit. Antero posterior (AP) and lateral (Lat) and mortise radiographs of the patient were evaluated.
Results: Out of the thirty patients followed up to a minimum of 18 months in the study twenty-one were males and nine were females. The mean age was 41.3 years (range 18 to>50 years). Eighteen out of thirty patients (60%) had the right side fractured and remaining twelve out of thirty had a left sided fracture (40%). In terms of anatomical classification trimalleollar fractures constituted the majority of cases (n=17,56.7%), followed by brimalleolar fractures (n=13, 43.3%). Five patients (16.7%) had open fractures classified as Gustilo-Anderson grade I or II, while the remaining 25 (83.3% presented with closed injuries.
Conclusions: Surgical treatment of ankle fractures, guided by accurate classification and operative principles, leads to favorable outcomes. The Lauge-Hansen system remains useful for diagnosis, prognosis, and surgical planning. Further multicenter studies with extended follow-up are needed to optimize care for complex fracture types.

Keywords: Ankle fracture, Lauge-Hansen classification, Supination-external rotation, ORIF, Pronation-abduction, Supination-adduction syndesmotic injury

INTRODUCTION

Ankle fractures are common orthopaedic injuries that significantly impact mobility and function. They range from stable fractures managed conservatively to unstable fractures requiring surgery. Proper classification and treatment are crucial to prevent complications such as chronic pain, post-traumatic arthritis, and long-term disability.

The Lauge-Hansen classification, widely used for ankle fractures, categorizes injuries based on foot position and applied force, helping predict soft tissue damage and ligamentous involvement. It divides fractures into SER, PER, SA, and PA types, guiding treatment decisions and improving outcomes.[1]

Surgical management is preferred for unstable or displaced fractures, aiming to restore alignment, stability, and

function while reducing arthritis risk. Open reduction and internal fixation (ORIF), using screws and plates, is the standard approach. Surgery selection depends on fracture pattern, patient age, activity level, and comorbidities. Studies show that surgical intervention leads to better pain relief, mobility, and the recovery than conservative treatment.

Complications include malunion, nonunion, infection, instability, and post-traumatic arthritis, particularly in patients with poor bone quality, diabetes, or inadequate rehabilitation. Even minor misalignment can alter biomechanics and accelerate joint degeneration. Weight-bearing post-surgery is carefully planned to prevent fixation failure, with early mobilization encouraged to reduce stiffness and muscle loss. Rehabilitation focuses on restoring range of motion, strength, and balance for optimal recovery.[2]

The Lauge-Hansen system helps predict high-risk fractures, such as SER injuries, which have a greater risk of syndesmotic damage and complications. Newer imaging techniques like weight-bearing CT and MRI improve assessment and surgical planning. Advancements in minimally invasive surgery and bio absorbable implants may further enhance outcomes.[3]

Pain relief is a key success measure, with ORIF proving more effective than conservative treatment, particularly for displaced fractures. However, residual pain can arise from soft tissue injury, implant irritation, or arthritis, sometimes requiring implant removal or joint injections. Return to normal activities is another success indicator, with most patients regaining pre-injury function within 3-12 months, though recovery time varies based on fracture severity and rehabilitation compliance.[4]

Patient-reported outcomes provide insight into satisfaction and quality of life improvements. Ankle fractures can be emotionally distressing, especially for those dependent on mobility for work or sports.

Psychological support in rehabilitation programs may improve overall well-being and recovery.[5]

Surgical management of ankle fractures, particularly using the Lauge-Hansen classification, is crucial for restoring joint function and minimizing complications.

Future research on optimized surgical techniques, rehabilitation strategies, and innovative treatments will continue to improve outcomes, offering better patient care and long-term success.[6]

Objective of the study design were to assess the functional outcomes of surgically managed ankle fractures classified according to the Lauge-Hansen system, and to determine the utility of this classification in guiding treatment planning and predicting post-operative results.

METHODS

Study design

It was a prospective observational study.

Patients with fractures of ankle were treated as per Lauge-Hansen classification in a case series of study between February 2023 to October 2024 at SMIMER medical collage Surat. The cases were followed for a minimum period of 18 months. All patients who had fracture at ankle level were selected institutional ethical committee approved the study.

The inclusion criterion included all those ankle fracture more than 18 years of age, ankle malleolar fracture, open type 1 and 2 fractures according to Gustillo-Anderson classification and who consented to participate. The operative procedure was performed within 4 to 5 days of the injury.

Inclusion criteria

Patients with age group: more than 18 years, ankle malleolar fracture and open type 1 and 2 fractures according to Gustillo-Andersen classification were included.

Exclusion criteria

Patients with age less than 18 year, pilon fractures, any other fracture in ipsilateral limb, open type 3 fracture according to Gustillo-Andersen classification and medically and anesthetic unfit patient were excluded from the study.

Patient were shifted to operation theatre and anesthesia was given. Supine/prone position was given. Tourniquet was applied and painting and drapping was done. Appropriate surgical approach was taken. Open reduction was done and after achieving desired reduction, fracture was fixed with appropriate implants. Final images were taken with the help of image intensifier thorough wash was taken. Closure was done layer wise.

Analysis-patients will be assessed by AOFAS scoring system

As soon as the patients were brought to the casualty a complete survey was carried out to rule out significant injuries. Then the patients' radiographs were taken, anteroposterior, lateral and mortise views of the ankle joints. CT scan was taken in indicated cases. On admission to the ward detailed history was taken relating to the age, sex, occupation, address, mode of injury past and associated medical illness. Patients general condition was assessed and then they were put through a thorough clinical examination. In all these patients the following clinical signs were looked for.

Primary outcome measure

Assesses functional recovery after surgical fixation, quantifies pain, mobility, and ankle stability.

Dependent variable for statistical analysis

You can use AOFAS scores to: Compare preoperative vs postoperative outcomes, → Paired t-test/Wilcoxon signed-rank test. Compare outcomes between different Lauge-Hansen fracture patterns→ANOVA/Kruskal-Wallis test.

Correlate AOFAS with: Age, time to surgery, type of fixation and → Pearson/Spearman correlation.

Case 1

A 36/female with history of road traffic accident presented with ankle injury with diagnosis of trimalleolar fracture left side.

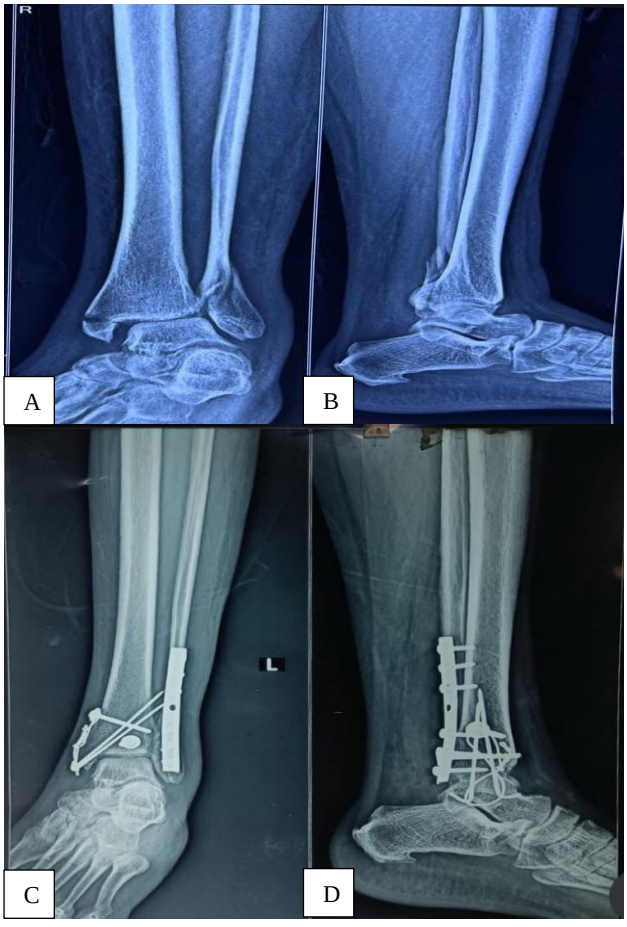

Figure 1 (A-D): A-Pre op and B-post op Lauge-Hansen type-supination external rotation (case 1).

Case 2

A 28/female with history of fall from stairs presented with ankle injury with diagnosis of trimalleolar fracture left side.

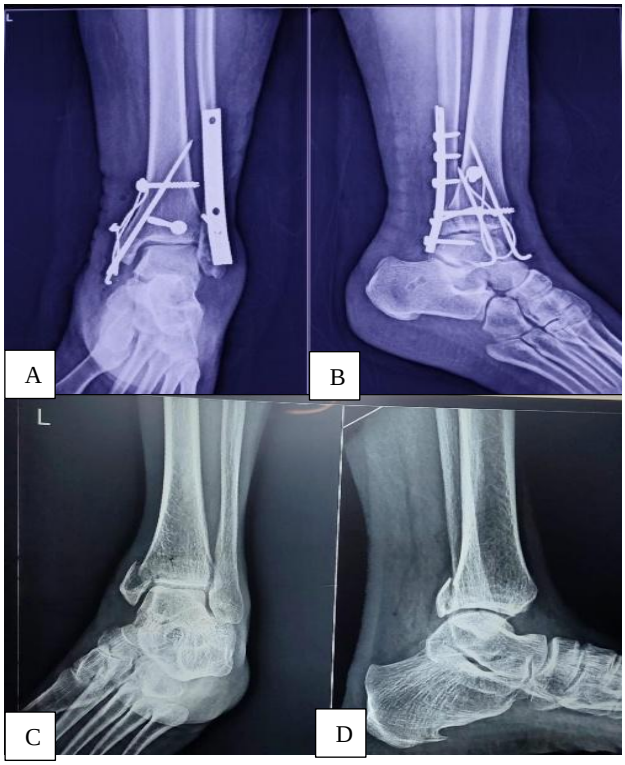

Figure 2 (A-D): A-Pre and B-post op Lauge-Hansen type-supination external rotation (case 2).

Case 3

A 44/male with H/O RTA presented with ankle injury with diagnosis of bimalleolar fracture right side.

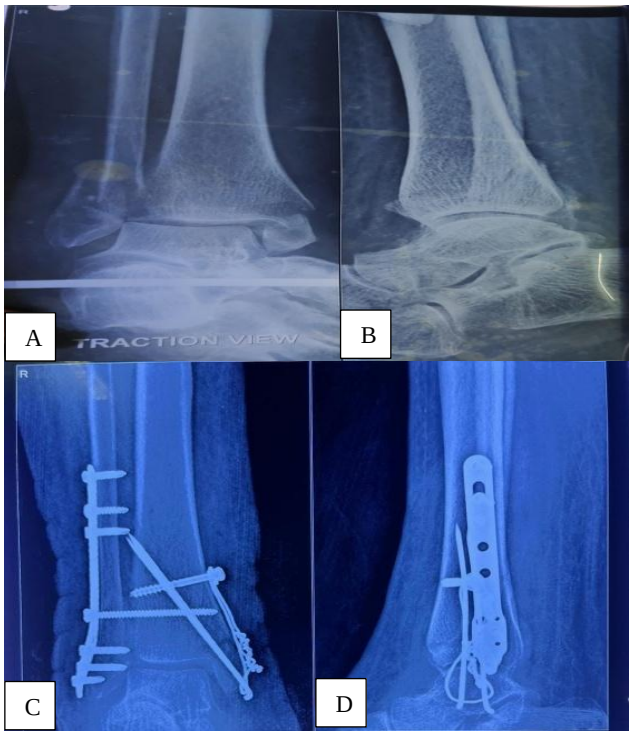

Figure 3 (A-D): A-Pre and B-post op Lauge-Hansen type-supination external rotation (Case 3).

Case 4

A 58/female with history of road traffic accident presented with ankle injury with diagnosis of bimalleolar fracture right side

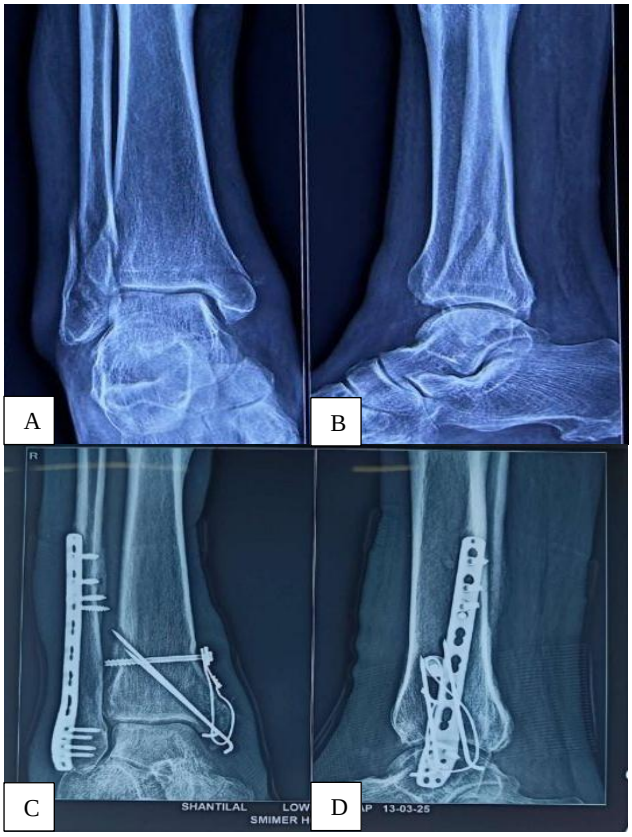

Figure 4 (A-D): A-Pre and B-post op Lauge-Hansen type-supination external rotation (Case 4).

Surgical technique

The Lauge-Hansen classification system is used to categorize ankle fractures based on the mechanism of injury, particularly the position of the foot (supination or pronation) and the direction of the deforming force (external rotation, abduction, or adduction). Understanding this helps guide surgical treatment strategies.[1,10-18]

SER-most common type

Stages (I to IV):

I: Anterior inferior tibio-fibular ligament injury, II: Oblique fibular fracture at syndesmosis level, III: Posterior malleolus fracture or posterior ligament rupture and IV: Medial malleolus fracture or deltoid ligament rupture

Surgical technique

ORIF of the fibula using a plate and screws, assessment and fixation of the posterior malleolus if fragment >25% or unstable medial malleolus ORIF/deltoid ligament repair if needed and syndesmotic screw if instability present.

SA

Stages (I to II): I: Transverse fracture of the lateral malleolus (below syndesmosis) and II: Vertical medial malleolus fracture.

Surgical technique

Lateral malleolus ORIF with plate and screw (lag screw or tension band if small) and medial malleolus ORIF with plate and screw or tension band wiring.

PER

Stages (I to IV): I: Deltoid ligament rupture or medial malleolus fracture, II: Anterior syndesmosis disruption, III: High fibular fracture (Maisonneuve) and IV: Posterior malleolus fracture or posterior ligament injury

Surgical technique

ORIF with plate and screw for fibular fracture (proximal if Maisonneuve) or consideration of conservative if above syndesmosis, medial malleolus fixation with tension band wiring or deltoid repair, posterior malleolus ORIF with plate and screw or screw and syndesmotic fixation when required

PA

Stages (I to III): I: Medial malleolus fracture or deltoid ligament injury, II: Syndesmotic disruption and III: Transverse or comminuted fibular fracture above ankle joint.

Surgical technique

Medial malleolus with tension band wiring, lateral malleolus ORIF with plate and screw and syndesmotic screw placement if needed.

General principles of surgery

Anatomical reduction of the mortise is critical. Fixation generally begins with the fibula, followed by medial malleolus or posterior fragments.

Use syndesmotic screws if instability persists after fixation Intraoperative stress tests (Cotton or external rotation test) guide syndesmotic fixation.

Study design

Prospective or retrospective cohort study. Patients selected were individuals with the ankle fractures managed surgically.

Assessment tools

AOFAS ankle-hind foot score (American orthpaedic foot and ankle score).

Follow-up period

Follow up period was for every 6 weeks for 6 months.

RESULTS

This prospective observational study evaluated the functional outcomes of 30 patients with ankle fractures classified using the Lauge-Hansen system and managed surgically. The cohort included 21 males and 9 females, with a mean age of 41.3 years. Right-sided fractures were more common (60%). Bimalleolar (56.7%) and trimalleolar (43.3%) fractures were the predominant types. Most injuries were closed (83.3%), and internal fixation techniques varied by fracture configuration, with plate and screw fixation most frequently used for lateral malleolus fractures (86.7%) and tension band wiring for medial malleolus (80%). Surgical intervention was performed within 3 days in 60% of cases. Functional outcomes were assessed using the AOFAS Ankle-Hindfoot Score at 6 weeks, 3 months, and 6 months, with scores significantly improving from 64.2-88.3 ($p<0.001$). SER-type fractures had the highest functional scores at 6 months (mean=91.2). Radiological evaluation showed anatomical reduction in 90% of patients. Study supports the effectiveness of timely surgical management in achieving favorable functional and radiological outcomes in ankle fractures.

Overview of study population

Age distribution

Among the 30 patients included in this study, the majority were between 31 and 50 years of age (n=16, 53.3%), followed by those older than 50 years (n=8, 26.7%) and the 18-30 years age group (n=6, 20%). The mean age was 41.3 years, indicating a relatively younger, active cohort susceptible to high-impact injuries.

Table 1: Age-wise distribution of study subjects.

Age (in years)	N	Percentage (%)
18-30	6	20.0
31-50	16	53.3
>50	8	26.7
Total	30	100

Sex distribution

There was a clear male predominance in study population. Out of 30 cases, 21 were male (70%), while only 9 (30%) females. This finding supports prior epidemiological observations that males, especially those in occupational/vehicular risk groups, are more frequently affected by ankle fractures.

Table 2: Gender-wise distribution of cases.

Sex	N	Percentage (%)
Male	21	70.0
Female	9	30.0
Total	30	100.0

Laterality of injury

In terms of side distribution, right ankle fractures were more frequent than left, with 18 patients (60%) sustaining right-sided injuries. Left-sided fractures were noted in 12 individuals (40%). Though the cause of this asymmetry is unclear, some literature suggests a link to dominant leg use and reflexive injury avoidance behaviours.

Table 3: Distribution according to side of involvement.

Side involved	N	Percentage (%)
Right	18	60.0
Left	12	40.0
Total	30	100.0

Mode of injury

Road traffic accidents (RTAs) were the most common mechanism of injury, accounting for 17 cases (56.7%). Twisting injuries were second most frequent, responsible for 10 cases (33.3%), while 3 fractures (10%) occurred as a result of falls. Predominance of RTAs may be reflective of urban setting and increased vehicular exposure.

Table 4: Mode of injury among study participants.

Mode of injury	N	Percentage (%)
RTA	17	56.7
Twisting Injury	10	33.3
Fall	3	10.0
Total	30	100.0

Lauge-Hansen classification

Fractures were classified based on Lauge-Hansen mechanisms. SER injuries were most prevalent (n=18, 60%), followed by PER I n=6 patients (20%), SA in 4 (13.3%), and PA in 2 (6.7%). These results align with existing literature citing SER as the most common mechanism of ankle injury.

Table 5: Fracture types based on Lauge-Hansen system.

Type of fracture	N	Percentage (%)
SER	18	60.0
PER	6	20.0
SAD	4	13.3
PAB	2	6.7
Total	30	100.0

DISCUSSION

The present prospective observational study evaluated the functional outcomes of surgically managed ankle fractures classified according to the Lauge-Hansen system with outcome assessment using the American orthopaedic foot and ankle society (AOFAS) ankle-Hindfoot score.[7-9] The findings demonstrate favorable radiological and functional outcomes, consistent with previously published literature.

The mean age of patients in our study was 41.3 years, with the majority falling within the 31-50-year age group. This distribution reflects the higher incidence of ankle fractures among economically active individuals exposed to high-energy trauma. Epidemiological studies by Daly et al and Court-Brown et al similarly reported a predominance of ankle fractures in active adult populations, although increasing incidence in older age groups has also been noted.[10,11]

Road traffic accidents constituted the most common mechanism of injury (56.7%) in our cohort, followed by twisting injuries and falls. High-energy trauma has been consistently identified as a major contributor to ankle fractures in urban populations.[11]

In accordance with existing literature, SER fractures were the most prevalent pattern (60%) in our study. Warner et al reported SER-IV fractures in 77% of their cohort, while Delaney et al also identified SER as the dominant injury mechanism.[12,13] The predictable biomechanical progression described in the Lauge-Hansen classification may explain the frequency and comparatively favorable outcomes associated with SER injuries.[1,2]

Surgical fixation strategies were individualized according to fracture morphology and soft tissue status. Plate and screw fixation was most commonly employed (66.7%), consistent with biomechanical principles of stable anatomical reduction. Verhage et al emphasized the importance of rigid fixation in achieving improved long-term functional outcomes.[15] Early surgical intervention-performed within three days in the majority of cases-was associated with improved AOFAS scores, supporting the observations of Baird and Jackson that early reduction minimizes soft tissue compromise and enhances recovery.[14]

Functional outcomes demonstrated progressive improvement, with mean AOFAS scores increasing from 64.2 at 6 weeks to 88.3 at 6 months. The AOFAS scoring system, originally described by Kitaoka et al remains widely utilized for evaluating postoperative ankle function.[9] Comparable studies have reported similar outcome ranges, with fracture complexity influencing final scores.[12,15] In our study, SER fractures achieved superior functional outcomes, consistent with prior prognostic analyses.[13]

Complication rates were low and predominantly minor, including superficial wound infections and transient stiffness. No cases of deep infection or hardware failure were observed. These findings align with reported complication rates in contemporary series.[15,16] Radiological union was achieved in all cases at a mean of 11.2 weeks, consistent with expected healing timelines following stable internal fixation.[17]

Statistical analysis demonstrated a significant association between fixation type and complication rate ($p=0.042$), underscoring the importance of appropriate implant selection based on fracture configuration. Weak negative correlations between age, hospital stay, and AOFAS score suggest that while these variables may influence recovery, fracture morphology and mechanical stability remain the principal determinants of outcome.

Collectively, our findings support the continued clinical relevance of the Lauge-Hansen classification in guiding surgical planning and prognostication.[7,8] Early anatomical reduction and stable fixation provide favorable functional outcomes with minimal complications. Although limited by sample size and follow-up duration, the consistency of our findings with established literature strengthens their validity. Larger randomized controlled trials and meta-analyses are warranted to further refine treatment strategies and long-term outcome prediction in ankle fracture management.

CONCLUSION

In conclusion, surgical management of ankle fractures, when guided by precise fracture classification and executed with sound operative principles, yields excellent functional and radiological outcomes. The Lauge-Hansen classification remains a valuable clinical tool not only for fracture description but also for outcome prediction and surgical planning. While this study reinforces the role of operative intervention in ankle fracture care, it also calls for larger, multi centeric studies with longer follow-up to further refine treatment strategies, particularly for complex and less common fracture subtypes.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Goost H, Wimmer MD, Barg A, Kabir K, Valderrabano V, Burger C. Fractures of the ankle joint: investigation and treatment options. Dtsch Arztebl Int. 2014;111(21):377-88.
2. Krumbach B, Meretsky CR, Polychronis A, Schiuma AT. A Systematic Review of the Optimal Management of Pediatric Distal Radius Displacement Fractures: Open Reduction and Internal Fixation Versus Cast Placement. Cureus. 2024;16(8):e66696.
3. Wylie JD, Beckmann JT, Granger E, Tashjian RZ.

Functional outcomes assessment in shoulder surgery. World J Orthop. 2014;5(5):623-33.
4. Chirayath A, Dhaniwala N, Kawde K. A Comprehensive Review on Managing Fracture Calcaneum by Surgical and Non-surgical Modalities. Cureus. 2024;16(2):e54786.
5. Shahid J, Kashif A, Shahid MK. A Comprehensive Review of Physical Therapy Interventions for Stroke Rehabilitation: Impairment-Based Approaches and Functional Goals. Brain Sci. 2023;13:5.
6. Özkan Y, Öztürk A, Özdemir R, Atıcı T, Özbölük S. The results of surgical management of ankle fractures. Ulus Travma Acil Cerrahi Derg. 2005;11(4):329-35.
7. Lauge-Hansen N. Fractures of the ankle. II. Combined experimental-surgical and experimental-roentgenologic investigations. Arch Surg. 1950;60(5):957-85.
8. Lauge-Hansen N. Fractures of the ankle. III. Genetic roentgenologic diagnosis of fractures of the ankle. Am J Roentgenol Radium Ther Nucl Med. 1954;71(3):456-71.
9. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int. 1994;15(7):349-53.
10. Daly PJ, Fitzgerald RH Jr, Melton LJ, Ilstrup DM. Epidemiology of ankle fractures in Rochester, Minnesota. Acta Orthop Scand. 1987;58(5):539-44.
11. Court-Brown CM, McBirnie J, Wilson G. Adult ankle fractures-an increasing problem? Acta Orthop Scand. 1998;69(1):43-7.
12. Warner SJ, Garner MR, Schottel PC, Fabricant PD, Helfet DL, Lorich DG. Analysis of ankle fracture mechanisms using the Lauge-Hansen classification. J Orthop Trauma. 2015;29(12):e481-7.
13. Delaney RA, Hess EP, Vopat BG. Predictive value of Lauge-Hansen classification in ankle fractures. Foot Ankle Int. 2019;40(6):694-701.
14. Baird RA, Jackson ST. Fractures of the distal part of the fibula with associated disruption of the deltoid ligament. J Bone Joint Surg Am. 1987;69(9):1346-52.
15. Verhage SM, Schipper IB, Hoogendoorn JM. Long-term functional and radiographic outcomes in ankle fractures. Foot Ankle Surg. 2015;21(3):201-5.
16. Ovaska MT, Mäkinen TJ, Madanat R. Predictors of poor outcomes following deep infection after ankle fracture fixation. Injury. 2013;44(7):1002-6.
17. Schepers T. To retain or remove the syndesmotic screw: a review of literature. Arch Orthop Trauma Surg. 2011;131(7):879-83.

Cite this article as: Mehta NR, Tijoriwala PP, Sidhdhapuria PV. Functional outcome of surgical management of ankle fractures classified as per Lauge-Hansen classification. Int J Res Orthop 2026;12:646-52.