

Original Research Article

A functional outcome of lateral end clavicle fractures treated surgically with open reduction and internal fixation

Prabhav P. Tijoriwala*, Kashish Shah, Raj Gadhavi, Prakash Chaudhary

Department of Orthopedics, SMIMER Hospital, Surat, Gujarat, India

Received: 10 October 2025

Revised: 08 April 2026

Accepted: 13 August 2026

*Correspondence:

Dr. Prabhav P. Tijoriwala,

E-mail: tijoriwala_prabhav@yahoo.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: Lateral end clavicle fractures represent a clinically significant subset of clavicular injuries due to their inherent instability and higher risk of non-union, particularly in Neer type II fractures. Surgical management using open reduction and internal fixation (ORIF) has gained increasing acceptance to restore anatomical alignment and optimize functional recovery.

Methods: This prospective observational study was conducted in the department of orthopedics at SMIMER, Surat, from February 2023 to October 2024. Thirty patients aged 18-70 years with lateral end clavicle fractures (Neer type II and III) were included. Patients underwent ORIF using locking plates, hook plates, or locking plate with coracoclavicular augmentation based on fracture configuration. Postoperative follow-up was conducted at 6 weeks, 3 months, and 6 months. Functional outcomes were assessed using the QuickDASH score and visual analogue scale (VAS), along with radiographic evaluation of fracture union.

Results: The majority of patients achieved radiological union within 12 weeks. Significant improvement in pain scores and shoulder function was observed across follow-up intervals. Most patients demonstrated good to excellent functional outcomes at six months, with minimal complications. Early surgical fixation provided stable fixation, facilitated early mobilization, and improved overall shoulder performance.

Conclusions: ORIF for lateral end clavicle fractures provides reliable fracture union and favorable functional outcomes. Surgical stabilization is particularly beneficial in displaced and unstable fractures, enabling early return to daily activities with satisfactory shoulder function.

Keywords: Coracoclavicular augmentation, Distal clavicle fracture, Functional outcome, Lateral end clavicle fracture, Locking plate fixation, Neer classification, Open reduction and internal fixation, QuickDASH score, Radiological union, Shoulder function, Surgical management

INTRODUCTION

The clavicle, commonly known as the collarbone, is an S-shaped long bone that serves as a vital structural connection between the axial skeleton and the upper limb. Acting as a strut, it maintains the lateral position of the shoulder and allows a wide range of upper limb motion while facilitating transmission of forces from the arm to the trunk.¹

The medial end articulates with the sternum at the sternoclavicular joint, and the lateral end articulates with the acromion at the acromioclavicular (AC) joint. This anatomical configuration plays a crucial role in shoulder biomechanics and stability.¹

Clavicle fractures are among the most common injuries encountered in orthopedic practice, accounting for approximately 5% of all adult fractures and up to 15% in children.²

Although midshaft fractures are most frequent, lateral end clavicle fractures represent about 15-20% of all clavicle fractures and present unique management challenges.³ These fractures typically result from a direct blow to the shoulder or a fall onto the lateral aspect of the arm.

Due to the anatomical relationship of the distal clavicle with the coracoclavicular (CC) ligaments and the AC joint, fractures at this site are more prone to displacement and instability.³

Accurate classification is essential for guiding treatment decisions and predicting outcomes.⁴ The Neer classification system categorizes distal clavicle fractures based on their location relative to the coracoclavicular ligaments and the AC joint.^{4,6} Type I fractures occur lateral to the CC ligaments and are usually stable.

Type II fractures are unstable injuries occurring medial to or between the CC ligaments, leading to loss of ligamentous support and higher displacement rates. Type III fractures extend into the AC joint and may predispose to post-traumatic arthritis.⁴

Rockwood further sub classified type II fractures into type IIA and IIB based on the integrity of the conoid and trapezoid ligaments.⁵ This distinction is clinically significant, as type II fractures are associated with higher rates of nonunion.

Nonunion rates for Neer type II fractures range from 21% to 33%, which frequently influences the decision toward operative management.⁸ However, radiographic nonunion does not always correlate with symptoms, and some patients may retain good shoulder function despite lack of complete union.⁹ Therefore, treatment decisions should consider both radiological and clinical findings.

Management options include nonoperative treatment with sling immobilization and rehabilitation, or operative intervention for displaced and unstable fractures.^{7,12}

Surgical techniques include open reduction and internal fixation (ORIF) using locking plates, hook plates, coracoclavicular screw fixation, or suture-button devices.⁷ While operative management generally results in higher union rates and improved anatomical restoration, it carries risks such as infection, hardware irritation, and the need for secondary implant removal.^{9,12}

Recent advances, including minimally invasive and arthroscopic techniques, aim to reduce soft tissue damage and improve recovery.¹³

Advanced imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) provide better visualization of fracture patterns and associated soft tissue injuries, aiding in preoperative planning.^{10,11}

In conclusion, lateral end clavicle fractures represent a clinically significant subgroup due to their instability and higher risk of nonunion.¹⁴ The Neer classification remains fundamental in guiding management decisions.^{4,6} A patient-centered approach that considers fracture type, displacement, functional demands, and risk of complications is essential to achieve optimal shoulder function and overall patient satisfaction.

METHODS

Study type

This was a prospective observational study designed to evaluate the functional outcomes of surgically treated lateral end clavicle fractures.

Study place and period

The study was conducted in the department of orthopedics at Surat Municipal Institute of Medical Education and Research (SMIMER), Surat, Gujarat, from February 2023 to October 2024.

Inclusion criteria

Patients with lateral end clavicle fracture. Age between 18-70 years. Open fracture type I and type II according to Gustilo-Anderson classification. Displaced fractures classified as Neer type II and III

Exclusion criteria

Age <18 years or >70 years. Associated acromioclavicular joint disruption. Open fracture type III (Gustilo-Anderson classification). Neurovascular injury. Ipsilateral limb trauma. Patients medically unfit for surgery or anesthesia.

Sample size and sampling technique

A total of 30 patients meeting the inclusion criteria were enrolled using purposive sampling.

Procedure (surgical technique)

All patients with displaced lateral end clavicle fractures (Neer type II and III) underwent open reduction and internal fixation (ORIF) under general anesthesia or regional block.

Patients were positioned in the beach chair or supine position with an interscapular support. A superior approach to the clavicle was used with an incision centered over the fracture site. Care was taken to protect surrounding neurovascular structures.

Fracture fragments were exposed, reduced under direct visualization, and temporarily stabilized. Definitive fixation was performed using precontoured lateral end clavicle locking plates, hook plates, or locking plates with

coracoclavicular augmentation depending on fracture configuration. Typically, 2.7 mm locking screws and 3.5 mm cortical/locking screws were used. Stability was confirmed intraoperatively before layered wound closure.

Postoperatively, the limb was immobilized in a sling for 3-4 weeks. Rehabilitation included pendulum exercises followed by progressive range-of-motion and strengthening exercises as per protocol.

Follow-up and outcome measures

Patients were followed at 6 weeks, 3 months, and 6 months. Functional outcome was assessed using the QuickDASH score and visual analogue scale (VAS). Radiological union was evaluated with serial anteroposterior radiographs. Range of motion, complications, and return to daily activities were recorded.

Representative radiographic and clinical findings from four cases are presented in Figures 1-4.

Ethical approval

Ethical clearance was obtained from the institutional ethics committee of SMIMER prior to commencement of the study. Written informed consent was obtained from all patients before inclusion.

Statistical analysis

Data were analyzed using appropriate statistical methods. Descriptive statistics were expressed as mean±standard deviation. Pearson correlation was used to assess the relationship between VAS and QuickDASH scores. Chi-square tests were applied to evaluate categorical variables. A p value <0.05 was considered statistically significant.

Case 1

Closed fracture of lateral end of clavical right side without distal neuro vascular deficit.

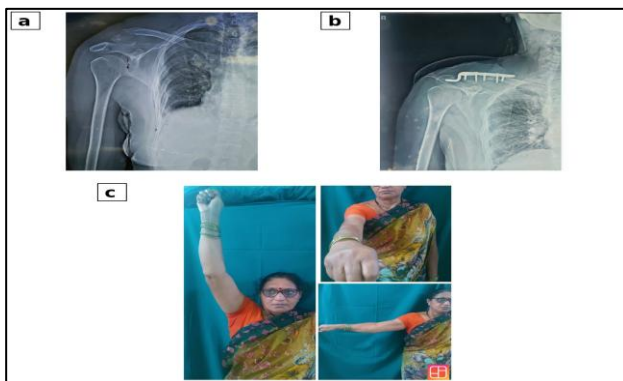


Figure 1: Case 1 (a) preoperative radiograph, (b) postoperative radiograph, and (c) postoperative clinical assessment.

Case 2

Closed fracture of shaft of calvical right side without distal neuro vascular deficit.

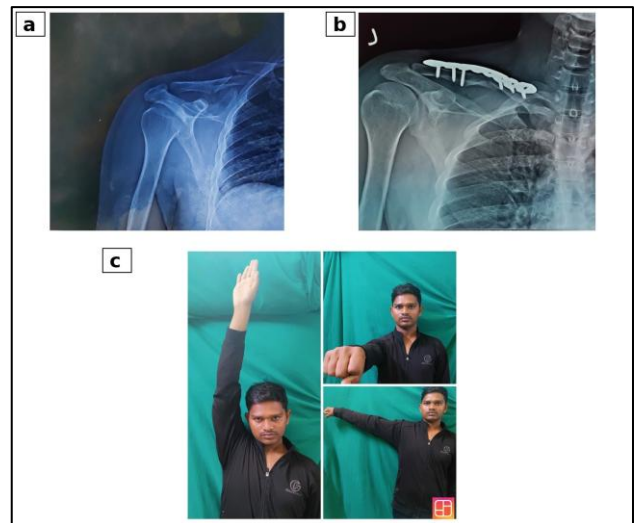


Figure 2: Case 2 (a) preoperative radiograph, (b) postoperative radiograph, and (c) postoperative clinical assessment.

Case 3

Closed fracture of lateral end of calvical right side without distal neuro vascular deficit.

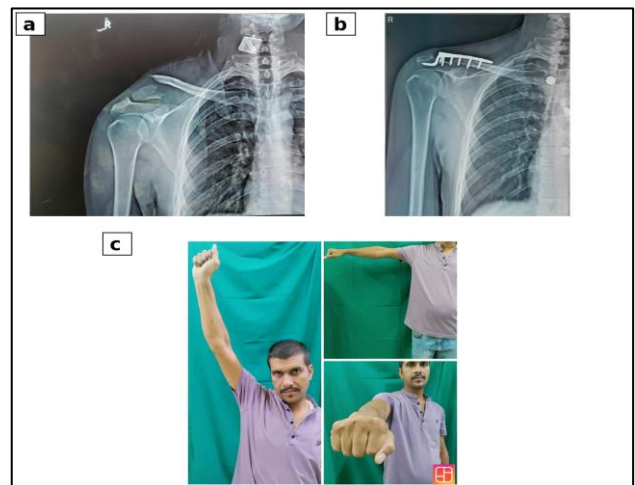


Figure 3: Case 3 (a) preoperative radiograph, (b) postoperative radiograph, and (c) postoperative clinical assessment.

Case 4

Closed fracture of lateral end of calvical left side without distal neuro vascular deficit.

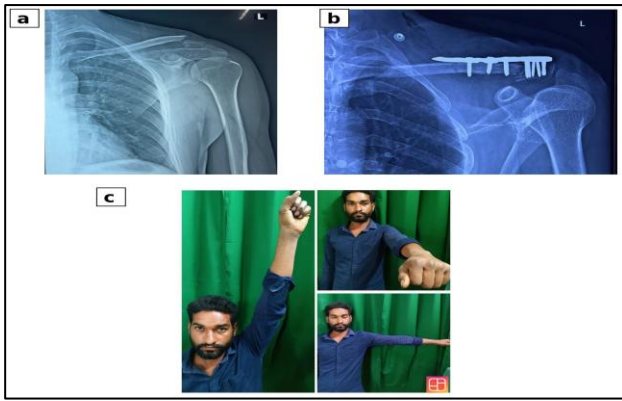


Figure 4: Case 4 (a) preoperative radiograph, (b) postoperative radiograph, and (c) postoperative clinical assessment.

Surgical technique

Patient preparation

The patient was placed in a beach-chair or supine position under general anesthesia, with the head and upper chest supported and the operative shoulder and arm fully exposed. A sterile field was prepared, and the arm was draped free to allow manipulation during the procedure.

Approach

A transverse or slightly oblique skin incision was made over the lateral third of the clavicle, centered over the fracture site. Dissection was carried down through the subcutaneous tissue, and care was taken to preserve the supra clavicular nerves. The delt trapezial fascia was incised in line with the clavicle and elevated to expose the fracture ends.

Fracture reduction

Once the fracture site was visualized, hematoma and interposed soft tissue were cleared. Fracture fragments were anatomically reduced using small pointed reduction forceps. In cases with comminution or multiple fragments, temporary Kirschner wires (K-wires) might be used for provisional fixation and alignment.

Fixation

Internal fixation was performed using a pre-contoured locking clavicle plate specifically designed for lateral clavicle fractures. The plate was positioned superiorly or anterosuperiorly on the clavicle, and fixation was achieved with a combination of locking and cortical screws. Care was taken to ensure that the lateral fragment has adequate fixation- often requiring smaller screws or hook plates if bone stock was insufficient. In select cases, coracoclavicular (CC) ligament reconstruction might be

performed concurrently using suture anchors or synthetic loops if the ligaments are compromised.

Intraoperative assessment

Fluoroscopy was used to confirm fracture reduction, plate positioning, and screw placement. The stability of the fixation was assessed by gentle range of motion of the shoulder.

Closure

The deltotrachezial fascia was closed meticulously over the plate to restore soft tissue coverage and reduce hardware prominence. Subcutaneous and skin layers were closed in standard fashion, and a sterile dressing was applied.

Postoperative management

The arm was immobilized in a sling for 2-3 weeks, with early pendulum and passive range-of-motion exercises initiated as tolerated. Active shoulder mobilization begins at 3-4 weeks postoperatively, progressing to strengthening exercises by 6-8 weeks. Return to full activity was generally allowed by 12-16 weeks, depending on clinical and radiological evidence of healing.

Follow up

Follow-up schedule

Patients were followed at regular intervals postoperatively to monitor healing, assess function, and evaluate for complications. Follow-up visits are scheduled as follows:

2 weeks post-op: wound inspection, suture removal, initial clinical assessment.

6 weeks post-op: radiographic evaluation for early signs of union, initiation of active range-of-motion exercises.

3 months post-op: assessment of union, shoulder strength, and functional recovery.

6 months post-op: evaluation of complete fracture healing, return to activities, and functional outcome

12 months post-op (final): long-term functional assessment and documentation of any complications (non-union, malunion, implant irritation, etc.).

Clinical evaluation

Each follow-up includes a clinical examination focusing on: pain level (visual analog scale- VAS); range of motion (ROM) of the shoulder in all planes; strength testing of the deltoid and rotator cuff muscles; signs of hardware irritation or wound-related issues

Radiological assessment

At each visit (except 2 weeks), standard anteroposterior (AP) and 15° cephalic tilt views of the clavicle were obtained. CT scans may be used selectively in cases of delayed union or suspected non-union. Union is defined as the presence of bridging callus across the fracture site on at least three cortices.

Functional outcome measures

The following standardized scoring systems were used to assess shoulder function: Constant-Murley Score- for assessing pain, daily activity, strength, and ROM. Disabilities of the arm, shoulder and hand (DASH) score- for evaluating disability and symptoms from the patient's perspective. University of California, Los Angeles (UCLA) shoulder rating scale- for pain, function, and patient satisfaction.

Scores were recorded at 3, 6, and 12 months to evaluate progression and long-term outcomes.

Complications monitoring

Any intraoperative or postoperative complications such as: infection, non-union or malunion, hardware failure or migration, reoperation (e.g., implant removal).

RESULTS

Baseline demographic and clinical profile

The age distribution of the cohort showed a higher concentration in the 31-50-year age group, reflecting the common demographic for road traffic accidents (RTAs), the predominant injury mechanism. The mean age was approximately 44 years, with a standard deviation indicating moderate dispersion.

Table 1: Baseline demographic and clinical characteristics.

Characteristics	Category	Number of patients	Percentage
Age group (years)	18-30	9	30.0
	31-50	14	46.7
	51-70	7	23.3
	Total	30	100.0
Gender	Male	24	80.0
	Female	6	20.0
	Total	30	100.0
Side of injury	Right	18	60.0
	Left	12	40.0
	Total	30	100.0
Mechanism of injury	Road traffic accident (RTA)	22	73.3
	FOOSH	6	20.0
	Direct trauma	2	6.7
	Total	30	100.0

Table 2: Type of fixation used in surgery.

Fixation Technique	Number of patients	Percentage
Locking plate only	20	66.7
Locking plate + CC augmentation in Neer type IIB	10	33.3
Total	30	100.0

Male patients predominated in the cohort, comprising 80% of the total. This male preponderance is consistent with global epidemiological trends in orthopedic trauma, particularly in active, outdoor-occupying populations.

Laterality analysis revealed that 60% of fractures occurred on the right side, potentially reflecting hand dominance and its impact on injury susceptibility during defensive maneuvers or falls.

The leading cause of injury was road traffic accidents, accounting for nearly three-quarters of cases. Falls

contributed to 20%, and a minor proportion was linked to sports-related trauma. These findings highlight the need for targeted preventive measures, particularly in traffic safety.

Intraoperative and surgical profile

Surgical management was conducted using two primary modalities: locking plate which includes anatomical lateral end clavicle plate and hook plate fixation alone, and locking plate with coracoclavicular (CC) augmentation. The selection was determined based on intraoperative

findings and fracture morphology. Most patients (66.7%) received locking plate fixation without additional augmentation.

Radiological union outcomes

The assessment of bony union was based on anteroposterior radiographs obtained during each follow-up visit. Radiological union was defined as the visible presence of healing the fracture site on at least three of four cortices. The time to union was categorized into three intervals. A majority of patients (93.3%) showed radiological healing within 12 weeks, while 40% achieved union by 9-12 weeks. Only 6.7% had union after the 12-week mark.

Table 3: Time to radiological union.

Time to union	Number of patients	Percentage
<12 weeks	28	93.3
>12 weeks	2	6.7
Total	30	100.0

DISCUSSION

Lateral end clavicle fractures are inherently unstable injuries due to disruption of the coracoclavicular ligaments and are associated with a higher risk of non-union when managed conservatively, particularly in unstable Neer type II fractures. The present prospective observational study evaluated the functional outcomes of surgically treated lateral end clavicle fractures using open reduction and internal fixation (ORIF).

In this study, 93.3% of patients achieved radiological union within 12 weeks, and all fractures united by six months. These findings are consistent with previously published data supporting operative stabilization. Madsen et al reported a 100% union rate following locking plate fixation with coracoclavicular augmentation, while Salazar et al and Gangadhar et al also documented excellent union rates within similar timeframes.¹⁴⁻¹⁶ The high union rate observed in our series reinforces the reliability of ORIF in preventing non-union and avoiding secondary procedures.

The demographic profile of the present cohort aligns with global epidemiological trends. The mean age was approximately 44 years, with the majority of patients between 31-50 years. Similar age distribution and male predominance have been reported by Gangadhar et al and Lingaraju et al.^{14,16}

Road traffic accidents were the leading cause of injury (73.3%), consistent with findings from Gangadhar et al, highlighting the burden of high-energy trauma in economically active individuals.¹⁴

Locking plate fixation was the primary surgical method (66.7%), with 33.3% requiring additional coracoclavicular augmentation based on fracture instability. Comparable approaches have been recommended by Salazar et al and Madsen et al, emphasizing the biomechanical stability offered by anatomical precontoured plates with selective augmentation.^{15,16} The mean operative time (68 minutes) was similar to that reported in comparable studies, and no intraoperative complications were noted.¹⁵

Functional outcomes improved significantly over time. The mean QuickDASH score improved from 38.5 at six weeks to 9.2 at six months, indicating substantial reduction in disability. Pain scores (VAS) decreased from 3.8 to 0.6 over the same period, with a positive correlation ($r=0.67$) between pain and functional limitation. Similar improvements have been reported by Gangadhar et al and Salazar et al.^{14,16}

Shoulder mobility was effectively restored, and most patients resumed daily activities by eight weeks and occupational duties by twelve weeks, consistent with prior literature.¹⁶ Complications were minimal and manageable.

Despite limitations such as small sample size and absence of a conservative control group, this study supports ORIF as a safe and effective treatment for unstable lateral end clavicle fractures, providing reliable union and excellent functional recovery.

CONCLUSION

Lateral end clavicle fractures, though less common, are prone to non-union and functional impairment- especially Neer type II fractures- when treated conservatively. This prospective study of 30 patients treated with open reduction and internal fixation (ORIF) demonstrates that surgical management ensures high union rates (93.3% within 12 weeks), minimal complications, and excellent functional recovery, with significant improvements in QuickDASH and VAS scores.

Use of precontoured locking plates, with or without coracoclavicular augmentation, provided stable fixation and allowed early mobilization. Most patients resumed daily activities and work within three months. Complications were minor and resolved without long-term issues.

The study confirms ORIF as a safe, effective, and reproducible treatment for unstable lateral clavicle fractures, supporting its role as the standard of care in active individuals. Further large-scale research is encouraged to refine treatment protocols and rehabilitation strategies.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Epperson TN, Black AC, Varacallo MA. Anatomy, shoulder and upper limb, sternoclavicular joint. In: StatPearls. StatPearls Publishing; 2023.
2. Twomey-Kozak J, Whitlock KG, O'Donnell JA, Klifto CS, Anakwenze O. Epidemiology of Sports-Related Clavicle Fractures in the United States: Injuries From 2015 to 2019. *Orthop J Sports Med.* 2022;10(10):23259671221126553.
3. Quillen DM, Wuchner M, Hatch RL. Acute shoulder injuries. *Am Fam Phys.* 2004;70(10):1947-54.
4. O'Neill BJ, Hirpara KM, O'Briain D, McGarr C, Kaar TK. Clavicle fractures: a comparison of five classification systems and their relationship to treatment outcomes. *Int Orthopaed.* 2011;35(6):909-14.
5. Sambandam B, Gupta R, Kumar S, Maini L. Fracture of distal end clavicle: a review. *J Clin Orthop Trauma.* 2014;5(2):65-73.
6. Stenson J, Baker W. Classifications in brief: the modified Neer classification for distal-third clavicle fractures. *Clin Orthopaed Rel Res.* 2020;479(1):205.
7. Ahmed AF, Salameh M, AlKhatib N, Elmhiregh A, Ahmed GO. Open reduction and internal fixation versus nonsurgical treatment in displaced midshaft clavicle fractures: a meta-analysis. *J Orthopaed Trauma.* 2018;32(7):e276-83.
8. Paladini P, Pellegrini A, Merolla G, Campi F, Porcellini G. Treatment of clavicle fractures. *Transl Med UniSa.* 2012;2:47-58.
9. Stenson J, Baker W. Classifications in brief: the modified Neer classification for distal-third clavicle fractures. *Clin Orthopaed Rel Res.* 2020;479(1):205.
10. Omid R, Kidd C, Yi A, Villacis D, White E. Measurement of clavicle fracture shortening using computed tomography and chest radiography. *Clin Orthop Surg.* 2016;8(4):367-72.
11. Sirin E, Aydin N, Mert Topkar O. Acromioclavicular joint injuries: diagnosis, classification and xligamentoplasty procedures. *EFORT Open Rev.* 2018;3(7):426-33.
12. Thurston D, Jordan RW, Thangarajah T, Haque A, Woodmass J, D'Alessandro P, et al. Are displaced distal clavicle fractures associated with inferior clinical outcomes following nonoperative management? A systematic review. *J Shoulder Elbow Surg.* 2024;33(8):1847-57.
13. Treuting R. Minimally invasive orthopedic surgery: arthroscopy. *Ochsner J.* 2000;2(3):158-63.
14. Gangadhar S. Surgical management of lateral third of clavicle fracture: a prospective study. *Int J Life Sci Biotech Pharma Res.* 2024;13(9):494-501.
15. Madsen W et al., *Am J Sports Med.* 2006 Title: "Suture anchor fixation of distal clavicle fractures: a biomechanical study"
16. Neer CS. Fractures of the distal clavicle. *Clin Orthop RelatRes* 1968;58:43-50.
17. Salazar BP, Chen MJ, Bishop JA, Gardner MJ. Outcomes after locking plate fixation of distal clavicle fractures with and without coracoclavicular ligament augmentation. *Eur J Orthopaed Surg Traumatol.* 2021;31:473-9.

Cite this article as: Tijoriwala PP, Shah K, Gadhavi R, Chaudhary P. A functional outcome of lateral end clavicle fractures treated surgically with open reduction and internal fixation. *Int J Res Orthop* 2026;12:xxx-xx.