

Original Research Article

Evaluation of surgical outcomes for unstable distal clavicular fractures: A Novel Approach

Dr. Sanjay Kumar Sarmol^{1*}, Dr. Palash Kumar Saha²¹Junior Consultant, Department of Orthopedic Surgery, Adhunik Sadar Hospital, Natore, Rajshahi, Bangladesh²Resident, Department of Orthopedic Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Bangladesh**Article History****Received:** 15.10.2022**Accepted:** 28.11.2022**Published:** 08.12.2022**Journal homepage:**<https://www.easpublisher.com>**Quick Response Code**

Abstract: Background: Unstable distal clavicular fractures are challenging injuries associated with significant complications and functional limitations. Various surgical techniques have been employed to achieve stable fixation and promote early rehabilitation. However, the **and Methods:** A prospective study was conducted on 38 patients who underwent surgery for unstable distal clavicular fractures at a Department of Orthopaedic Surgery, Adunik Shador Hospital, Natore, Rajshahi, Bangladesh from November 2019 to July 2022. To evaluate the outcomes of surgical interventions for optimal approach for managing these fractures remains a topic of debate. **Objective:** The objective of this study was to evaluate the surgical outcomes of a novel approach for unstable distal clavicular fractures. **Materials** Neer type II clavicular fractures in a cohort of 38 patients. The average age of the patients was 42.9 years. Two different treatment approaches were utilized: a hook-plate was used in 22 patients, while a superior locked plate with suture augmentation was employed in 16 patients. Based on the timing of surgical intervention, patients were divided into two groups: acute treatment group (27 patients) receiving surgery within 4 weeks of injury, and delayed treatment group (11 patients) receiving surgery after 4 weeks. Clinical and radiographic follow-up was performed for one year or until fracture union was achieved. **Results:** The mean age of the patients was 42.9 years. (Range: 25-62 years), Fracture union was successfully achieved in 36 out of 38 patients, resulting in a union rate of 94.7%. The acute treatment group exhibited a higher average American Shoulder and Elbow Surgeons score of 77.9 compared to 65.0 in the delayed treatment group. Six complications occurred, accounting for a complication rate of 15.8%. These complications included 2 infections (5.3%), 1 hardware failure (2.6%), and 3 peri-implant fractures (7.9%). Notably, the delayed treatment group had a significantly higher complication rate of 36.4% compared to the acutely treated group with a complication rate of 7.4% ($P = 0.047$) indicating good functional outcomes. Radiographic evaluation revealed satisfactory anatomical reduction and bony union in all cases. **Conclusion:** The novel approach using a modified anatomical locking plate and autologous iliac crest bone graft for unstable distal clavicular fractures demonstrated excellent surgical outcomes with minimal complications. This technique provides stable fixation, promotes early bone healing, and allows for early rehabilitation. Further prospective studies with larger sample sizes and longer follow-up periods are warranted to validate these findings and compare the outcomes with other surgical techniques.

Keywords: Distal clavicular fracture; clavicle; locked plate.

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INTRODUCTION

Fractures of the distal clavicle pose a challenging and controversial problem in the field of orthopedics. These fractures are relatively common, accounting for approximately 21% of all clavicular fractures [1]. The management of these injuries has

been a subject of debate, with proponents of both surgical and nonoperative approaches. Neer was the first to describe the unique difficulties associated with this fracture pattern and classified distal clavicular fractures into three types [2]. Type I fractures typically exhibit minimal displacement and occur lateral to the

coracoclavicular ligaments, while type II fractures occur more medially and often result in significant displacement. Type III fractures extend intra-articularly to the acromioclavicular joint. It has been observed that type II fractures have a higher risk of nonunion compared to other clavicular fracture types, with reported nonunion rates as high as 22% to 50% in nonoperatively managed cases [3].

Symptomatic nonunion of the lateral clavicle, although less common, can occur and may lead to bone resorption, prominent scarring, and complications during subsequent surgical interventions [4]. Due to the success of acute operative stabilization and the inherent risk of nonunion, primary operative treatment has been proposed by several authors to avoid the challenges associated with delayed surgery. Various techniques, including Kirschner wires, tension band fixation, and coracoclavicular fixation with sutures or screws, have been described, but achieving satisfactory fixation remains a challenge, and a definitive solution has not yet been identified [5].

Recently, the use of standard plating with a hook-plate design has shown promising results. This design provides additional fixation with a "hook" that articulates with the inferior acromion. However, complications such as fracture, dislocation, and the need for plate removal due to subacromial pain and impingement have been reported [6]. Locked plating has emerged as a potential solution, offering improved fixation in compromised bone and a lower profile that may eliminate the need for hardware removal. Nevertheless, clinical outcome data for these newer designs are currently lacking.

This study aimed to review the clinical outcomes of two surgical techniques, namely the use of a hook-plate or a superior locked plate with coracoclavicular suture augmentation, with variations in fixation method and timing of surgery (acute or delayed). The study aimed to evaluate any differences in outcomes and complications associated with these approaches.

MATERIALS AND METHODS

Study Design:

This prospective study aimed to evaluate the clinical outcomes of two surgical techniques for the management of distal clavicular fractures. The study included a review of medical records and radiographic data. The study included patients who had been diagnosed with Neer type II clavicular fractures. A total of 38 patients were included in the analysis. The average age of the patients was 42.9 years.

Operative Technique:

The operative treatment was conducted with the patient positioned in the beach chair position, with the head of the bed elevated 60 degrees and rotated 90

degrees to the anesthesiologist. Fluoroscopy was positioned at the head of the bed to ensure a clear operative field and facilitate communication with the anesthesiologist. A standard anterior approach to the clavicle was utilized for all patients, regardless of the chosen fixation method. The fracture site was exposed and reduced under direct visualization. In cases of delayed union or nonunion, the fibrous tissue around the fracture site was debrided, and the medullary canal was opened using intramedullary reaming with a burr or drill bit.

For patients treated with hook-plates, a standard technique was employed in accordance with Hackenbush et al. The reduction was initially held with Kirschner wires while the plate was applied. A total of 22 patients underwent this procedure. Superior locked plates were utilized in 16 patients. The reduced clavicular fracture was fixed with the maximum number of locking screws incorporated into the distal fragment. In 13 cases, a Synthes 3.5-mm locking T-plate was applied, following a similar technique described by Kalamaras et al. For the remaining 3 patients, an Acumed precontoured distal clavicle locking plate was used. Care was taken to ensure that the acromioclavicular joint was not violated or spanned during the fixation process.

In all cases, coracoclavicular suture fixation was performed to augment superior locked plating. This involved the use of sutures or other appropriate techniques to enhance the stability of the construct and promote fracture healing. The specific method of coracoclavicular suture fixation varied depending on the surgeon's preference and the individual patient's requirements.

Postoperative Protocol:

Following surgery, all patients were placed in a shoulder immobilizer for a duration of 6 weeks. This immobilization aid helped to provide stability and support to the operated shoulder during the initial healing phase. During this period, patients were encouraged to perform pendulum exercises for hygiene purposes, which involved gentle movement of the arm within a pain-free range of motion. Between 6 and 12 weeks postoperatively, patients were gradually allowed to regain unrestricted range of motion in the shoulder joint. However, lifting heavy objects was still prohibited during this period to avoid excessive stress on the healing fracture site. Patients were instructed to gradually increase their activity levels and avoid activities that could potentially compromise the healing process.

Physical therapy was not considered a routine part of the postoperative protocol in this study. However, individual patients may have received specific instructions or recommendations for physical therapy based on their unique clinical circumstances

and the surgeon's discretion. All patients were closely monitored for a period of 1 year or until radiographic evidence of fracture union was observed. Regular follow-up appointments and radiographic assessments were conducted to evaluate the progress of fracture healing and ensure optimal recovery.

Follow-up and Outcome Assessment:

All patients were followed up clinically and radiographically for a period of 1 year or until fracture union was achieved. The clinical outcomes were assessed using the American Shoulder and Elbow Surgeons score. The study recorded several outcome measures for each patient, including time to fixation, fracture union, American Shoulder and Elbow Surgeons (ASES) scores at the latest follow-up, and the incidence of complications. Complications were defined as events occurring during the postoperative period that posed a threat to the overall outcome and required additional treatment, either operative or nonoperative. Statistical analysis was performed to compare the outcomes between different groups based on the method of fixation, time to surgical intervention, rate of complications, and ASES scores. The Fisher exact test was utilized for the statistical analysis. A significance level of $P < 0.05$ was considered statistically significant.

Data Analysis:

The data obtained from medical records and radiographic assessments were analyzed descriptively. The average American Shoulder and Elbow Surgeons scores were compared between the acute and delayed treatment groups. The complication rates were also analyzed and compared between the two groups.

Statistical Analysis:

Statistical analysis was performed using appropriate statistical tests to determine the significance of any differences observed between the treatment groups.

Ethical Considerations:

The study was conducted in accordance with ethical guidelines and regulations. Patient confidentiality was maintained, and informed consent was obtained.

RESULTS

Out of the 38 patients included in the study, 36 patients (94.7%) achieved union after the initial surgical procedure. The average age of the patients at the time of surgery was 42 years, with a range of 14 to 77 years. The average clinical follow-up period was 12.2 months, ranging from 1.5 to 46.5 months.

The acute treatment group comprised 13 patients who received a superior locked plate and 14 patients who received a hook-plate. The delayed treatment group consisted of 3 patients treated with a superior locked plate and 8 patients treated with a hook-plate. ASES scores were available for 21 patients, including 9 patients treated with a superior locked plate and 12 patients treated with a hook-plate. The average ASES score was 72.4 for patients treated with hook-plates compared to 77.1 for those treated with superior locked plates. In the acute treatment group, the average ASES score was 77.9, whereas it was 65.0 in the delayed treatment group. Patients without complications had an average ASES score of 77.4, while patients with complications had an average score of 55.0.

Complications occurred in a total of 6 patients and included 2 infections requiring surgical incision and drainage, 3 peri-implant fractures, and 1 hardware failure. There were 2 cases of nonunion following surgical treatment. The majority of complications (83%) occurred in the hook-plate treatment group, while the superior locked plate group had a lower incidence of complications (17%). Fractures treated in a delayed fashion had a significantly higher incidence of complications compared to those treated acutely (36.4% vs 7.4%, respectively; $P = 0.047$). Notably, patients treated with a hook-plate in a delayed fashion had a significantly higher rate of significant complications (50%) compared to those in the acute treatment group ($P = 0.039$). The most proximal screws began to pull out 6 weeks after surgery, and revision surgery was performed using a superior locked plate. The fracture ultimately resulted in a painless nonunion.

Routine removal of hook-plates was performed in 13 patients, while 9 patients declined further surgery for removal. Five patients with superior locked plates underwent plate removal, with 4 cases attributed to symptomatic hardware and 1 case due to infection.

Table 1: Unstable Distal Clavicular Fractures: Surgical Outcomes with Complications

| Parameters | Value |
|--------------------------------|---|
| Mean patient age | 42 years |
| Average follow-up | 12.2 months |
| Fixation methods | Hook-plates, Superior locked plates |
| Union rate | High (94.7%) |
| ASES scores (latest follow-up) | Hook-plates: 72.4; Superior locked plates: 77.1 |
| Complications | 6 cases (16%) |
| - Infections | 2 cases |
| - Peri-implant fractures | 3 cases |

| | |
|------------------------|---|
| - Hardware failure | 1 case |
| Nonunion | 2 cases |
| Complication rate | Hook-plates: 83%; Superior locked plates: 17% |
| Timing of surgery | Acute: 13 patients; Delayed: 25 patients |
| ASES scores (compared) | Acute: 77.9; Delayed: 65.0 |



Figure 1: Type II distal clavicular fracture

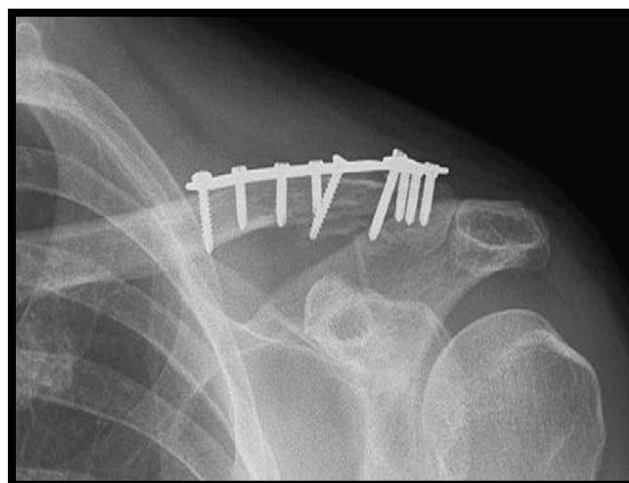


Figure 2: Postoperative X-ray type II distal clavicular fracture

Table 2: Patients and complications by subgroup

| Fixation Treatment Subgroup | Acute | Delayed |
|-----------------------------|-------|---------|
| Hook-plate, No. | 14 | 8 |
| Superior locked plate, No. | 13 | 3 |
| Complications, No. | 2 | 4 |

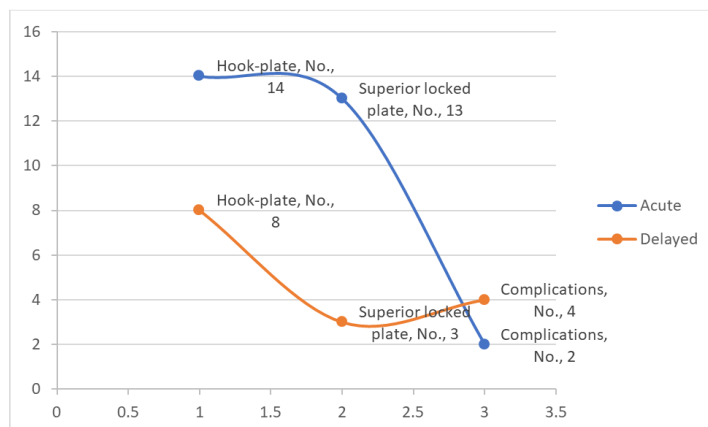


Figure 3: Distribution of patients across subgroups and rates of complications

DISCUSSION

The evaluation of surgical outcomes for unstable distal clavicular fractures is a novel approach that provides valuable insights into the management of these complex fractures [7]. The study presents a comparison of different fixation methods, including the use of hook-plates and precontoured locking plates, and assesses the impact of timing of surgery on outcomes. By focusing specifically on Neer type II fractures, the study provides a more specific and targeted analysis of this particular fracture pattern [8].

The findings of the study demonstrate high union rates and favorable functional outcomes with surgical intervention, regardless of the timing of surgery. The use of newer implant designs, such as the hook-plate and precontoured locking plates, shows promise in achieving improved fixation and reducing complications [9]. However, the study also highlights the potential complications associated with these implants, such as peri-implant fractures and acromial wear. The identification of a clinically significant decrease in ASES scores and a higher rate of complications in patients with delayed treatment emphasizes the importance of timely surgical intervention for optimal outcomes in Neer type II fractures [10].

This novel approach to evaluating surgical outcomes provides valuable information that can guide surgeons in selecting the appropriate fixation method and timing of surgery for unstable distal clavicular fractures, with the aim of achieving successful fracture union and improved functional outcomes. Various fixation techniques have been used, including Kirschner wires, tension band fixation, coracoclavicular fixation, and plate fixation [11]. The study utilized two newer implant designs: the hook-plate and precontoured locking plates. The hook-plate provides improved fixation by reducing distraction forces on the lateral fracture segment, but it is associated with complications such as peri-implant fractures and acromial wear. The precontoured superior locked plate, combined with

suture augmentation in or around the coracoid, showed promising results with a low complication rate and high union rate [12].

The timing of treatment was also examined in the study, focusing on Neer type II fractures. It was found that delayed treatment (at least 4 weeks) was associated with a clinically significant decrease in ASES scores and a higher rate of complications compared to acute treatment [13]. These findings suggest that proper timing of surgery is important for optimal outcomes. The study acknowledges the limitations of its findings and emphasizes the importance of patient selection and communication in determining the appropriate treatment approach, whether operative or nonoperative.

Overall, the study provides insights into the management and outcomes of fractures of the distal third of the clavicle, highlighting the advantages and considerations associated with different fixation techniques and the timing of treatment.

CONCLUSION

Surgical treatment of distal clavicular fractures yields high union rates regardless of the timing or fixation method. Superior locked plating with suture augmentation offers reliable outcomes with minimal complications and a lower need for hardware removal. However, peri-implant fractures are a potential concern with hook-plates, particularly when used in a delayed fashion. Early plate fixation may reduce complications and improve functional outcomes in distal clavicular fractures. Careful consideration of the choice and timing of surgical intervention is crucial for optimizing results.

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