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Original Article

Endobutton plates demonstrate superior efficacy in treating unstable distal clavicle fractures

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Abstract: Objective: To compare the effectiveness of clavicular hook plates and Endobutton plates in treating unstable distal clavicle fractures (UDCFs). Methods: Data from 95 patients with UDCFs (Neer II and V types) were retrospectively analyzed. Among them, 55 cases were treated with clavicular hook plates (control group), and 40 cases with Endobutton plates (research group). Comparative analyses included intraoperative indicators (incision length, intraoperative blood loss, operation time), postoperative recovery metrics (fracture healing time, fracture displacement distance, hospitalization time), pain assessment (Visual Analogue Scale [VAS]), shoulder joint function (American Shoulder and Elbow Surgeons [ASES] questionnaire), postoperative complications (plate loosening, recurrent fractures, incision infection, and fracture end redisplacement), and overall clinical efficacy. Results: The research group demonstrated significantly shorter incision lengths, comparable intraoperative blood loss, longer operation times, and shorter fracture healing times compared to the control group (all $P < 0.05$). No significant differences were observed in fracture displacement distance or hospitalization time (both $P > 0.05$). However, VAS scores were significantly lower, while ASES scores (pain, function, and total) were notably higher in the research group (all $P < 0.05$). The incidence of postoperative complications was similar between the groups ($P > 0.05$), but the excellent and good treatment rate was significantly higher in the research group ($P < 0.05$). Conclusions: Endobutton plates offer significantly better clinical outcomes compared to clavicular hook plates for treating UDCFs, demonstrating advantages in postoperative recovery, pain management, and functional improvement.

Keywords: Clavicular hook plates, endobutton plates, unstable distal clavicle fractures, controlled study, clinical effect

Introduction

A clavicle fracture is a common injury caused by high-energy trauma, frequently involving the lateral third of the clavicle, which accounts for approximately 40% of shoulder injuries and 5% of all fractures in adults [1]. Distal clavicle fractures comprise 10-30% of all clavicle fractures and have a 50% risk of displacement, with symptomatic malunion or nonunion observed in up to 44% of cases [2, 3]. Unstable distal clavicle fractures (UDCFs), predominantly classified as Neer type II and V, are characterized by severe displacement and a high likelihood of nonunion with conservative treatment. These outcomes are attributed to factors such as the small size of the distal fracture fragment, making it difficult to secure fixation, and the loss of coracoclavicular ligament integrity in the proximal fragment [4, 5]. As a result, managing UDCFs poses significant treatment challenges.

Surgical intervention is currently considered an effective approach for UDCFs, aiming to minimize complications such as nonunion, malunion, and shoulder asymmetry [5, 6]. However, there is ongoing debate regarding the most effective fixation method for optimizing clinical outcomes in these patients [7]. Further clinical exploration is necessary to identify the optimal treatment strategy, which holds great promise for improving patient outcomes.

Clavicular hook plates are a widely used surgical option for treating UDCFs. Their design is based on the anatomical biomechanics of the acromioclavicular joint, stabilizing the proximal clavicle and securing the distal fragment with a hook beneath the acromion to maintain align-

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ment and joint stability [8, 9]. Although this method achieves favorable outcomes, complications such as subacromial bone abrasion, direct impact between the acromion, distal clavicle, and the plate, and resultant shoulder pain or restricted movement are common. These adverse effects can significantly impair postoperative recovery and daily activities [10, 11]. For example, Elrih et al. [12] reported favorable radiological outcomes with clavicular hook plates but noted a relatively high incidence of postoperative complications.

The Endobutton plate offers an alternative approach for UDCF treatment, using coracoclavicular elastic fixation. This technique is associated with smaller incisions, minimal soft-tissue irritation, lower rates of postoperative complications, and no requirement for device removal after surgery [13]. Its mechanism involves reducing displacement between fracture fragments by narrowing the coracoclavicular space, while its biomechanical design ensures appropriate strength and stiffness to maintain acromioclavicular joint balance [14]. In a study by Erden et al. [15], Endobutton plates yielded superior functional and radiological outcomes with minimal complication risks in UDCF patients.

Despite these advances, controlled studies directly comparing clavicular hook plates and Endobutton plates for UDCF treatment are limited. This study aims to address this gap, providing evidence-based insights to inform superior treatment strategies for patients with UDCFs.

Materials and methods

Case selection

This retrospective study was approved by the Ethics Committee of Shanghai East Hospital, 95 patients with unstable distal clavicle fractures (UDCFs) treated at Shanghai East Hospital between May 2022 and May 2024 were included. The control group comprised 55 patients treated with clavicular hook plates, while 40 patients in the research group received treatment with Endobutton plates.

Inclusion criteria: (1) Confirmed diagnosis of UDCFs (Neer type II or V) [16]; (2) Clear history of direct or indirect trauma; (3) Fresh fractures; (4) Lateral clavicle pain, local swelling, tenderness, and shoulder dysfunction; (5) Closed distal clavicle fractures caused by various traumas; (6) No skin inflammation or wounds in the surgical area; (7) First-time treatment with no contraindications; (8) Complete clinical data required for the study.

Exclusion criteria: (1) Old or open fractures; (2) Acromioclavicular joint dislocation or injury; (3) Vascular or nerve injuries, or severe systemic diseases contraindicating surgery; (4) Severe osteoporosis; (5) Cognitive dysfunction or psychiatric disorders.

Intervening methods

Patients in the control group were treated with clavicular hook plates. Patients were positioned supine, with nerve block anesthesia administered and a pad placed under the operative shoulder. Routine skin preparation and draping followed. An approximately 10 cm incision was made from the acromioclavicular joint to the proximal clavicle, with layer-by-layer dissection to expose the middle and distal clavicle segments and the acromion. After clearing and irrigating the fracture site, a Kirschner wire was used for temporary fixation. A suitable hook plate was then selected, with the hook end inserted beneath the acromion from the posterior acromioclavicular ligament margin. The proximal fracture end was secured with screws. After fluoroscopic confirmation of satisfactory alignment and fixation, Kirschner wires were removed, a drainage strip was placed, and the wound was sutured layer by layer.

Patients in the research group underwent treatment with Endobutton plates. Brachial plexus block anesthesia was performed, and patients were placed supine with a soft pillow under the shoulder. The surgical area was disinfected and draped. A curved approximately 5 cm incision was made from the clavicle fracture line to the coracoid process. Layer-by-layer dissection exposed the clavicle fracture end, coracoid process, and coracoclavicular ligament. A cruciate ligament guide was positioned on the clavicle and coracoid base, and a 2.0 mm Kirschner wire was inserted as a guide wire. After fluoroscopic confirmation, a 4.5 mm Endobutton drill created a bone tunnel in the clavicle and coracoid process. The Endobutton plate was implanted via the guide wire, and the clavicle was reduced and secured under direct visualization. After confirming alignment and secure fixation with C-arm fluoroscopy, the wound was

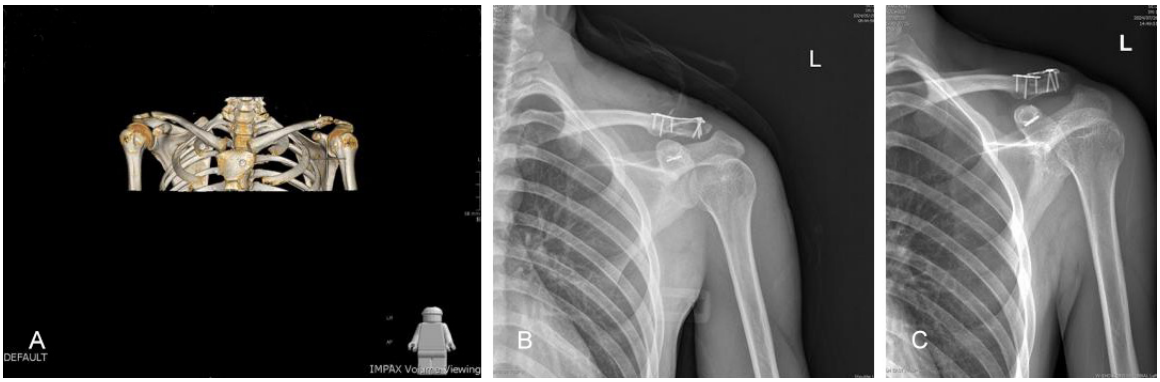

Figure 1. Images from the research group before and after surgery. A. Images from the research group before surgery. B. Images from the research group after 1 month of surgery. C. Images from the research group after 3 months of surgery.

irrigated, ensuring no foreign bodies remained. A drainage strip was placed, and the wound was sutured layer by layer.

In both groups, the affected limb was immobilized with a triangular bandage for six weeks. Patients were instructed to perform joint function exercises, such as pendulum movements and small circular motions, at least five times daily. After six weeks, the triangular bandage was removed, and active full-range shoulder movements were gradually initiated. Pre- and postoperative imaging of the research group is shown in **Figure 1**.

Data collection

(1) Intraoperative parameters. The incision length, intraoperative blood loss, and operation time (OT) of both groups were recorded. (2) Postoperative recovery indices. Fracture healing time, fracture displacement distance, and hospitalization time were measured and analyzed. (3) Pain intensity. Pain was assessed preoperatively and postoperatively using the Visual Analog Scale (VAS). The scale ranges from 0 (no pain) to 10 (unbearable severe pain), with patients self-evaluating their pain level by marking the scale. Higher scores indicate greater pain intensity. (4) Shoulder joint function. Shoulder joint function was evaluated using the American Shoulder and Elbow Surgeons (ASES) questionnaire. The total score is 100 points, comprising 36 points for pain, 36 for stability, and 28 for function. Higher scores indicate better shoulder function. (5) Postoperative complications. Adverse events, including internal fixation plate loosening, recurrent clavicle fractures, incision infection, and fracture end redisplacement, were recorded for both groups. The incidence rates were calculated. (6) Clinical efficacy. Clinical efficacy was evaluated six months post-surgery using the Karlsson Scoring Scale: Excellent: No pain on the affected side, normal upper limb muscle strength, unrestricted shoulder joint movement, and good fracture reduction on X-rays. Good: Mild pain on the affected side, moderate upper limb muscle strength, slight shoulder movement limitation, and X-rays showing slightly poor fracture reduction. Poor: Nighttime pain on the affected side, weak upper limb muscle strength, significant shoulder movement restriction, and poor fracture reduction on X-rays. Shoulder joint function, postoperative complications, and clinical efficacy were primary outcomes, while intraoperative parameters, postoperative recovery indices, and pain intensity were considered secondary outcomes.

Statistical analysis

Measurement data (Mean ± SEM) and categorical data (rates or percentages) were analyzed using SPSS 19.0. T-test and one-way ANOVA, followed by the Tukey test, were used for comparing measurement data. Chi-square test was employed for comparing categorical data. A P-value < 0.05 was considered statistically significant.

Results

Comparison of general data between the two groups

No statistically significant differences were observed in baseline characteristics, including

Table 1. Comparison of general data between the two groups

Data	Control group (n=55)	Research group (n=40)	χ^2/t	P
Gender			0.657	0.418
Male	27 (49.09)	23 (57.50)		
Female	28 (50.91)	17 (42.50)		
Age (years)	39.27±6.00	40.42±5.65	0.945	0.347
Time from injury to surgery (days)	3.64±1.06	3.72±1.04	0.715	0.366
Injured side			0.553	0.457
Left	29 (52.73)	18 (45.00)		
Right	26 (47.27)	22 (55.00)		
Cause of injury			0.219	0.896
Traffic accident	17 (30.91)	12 (30.00)		
Falls	28 (50.91)	22 (55.00)		
Others	10 (18.18)	6 (15.00)		

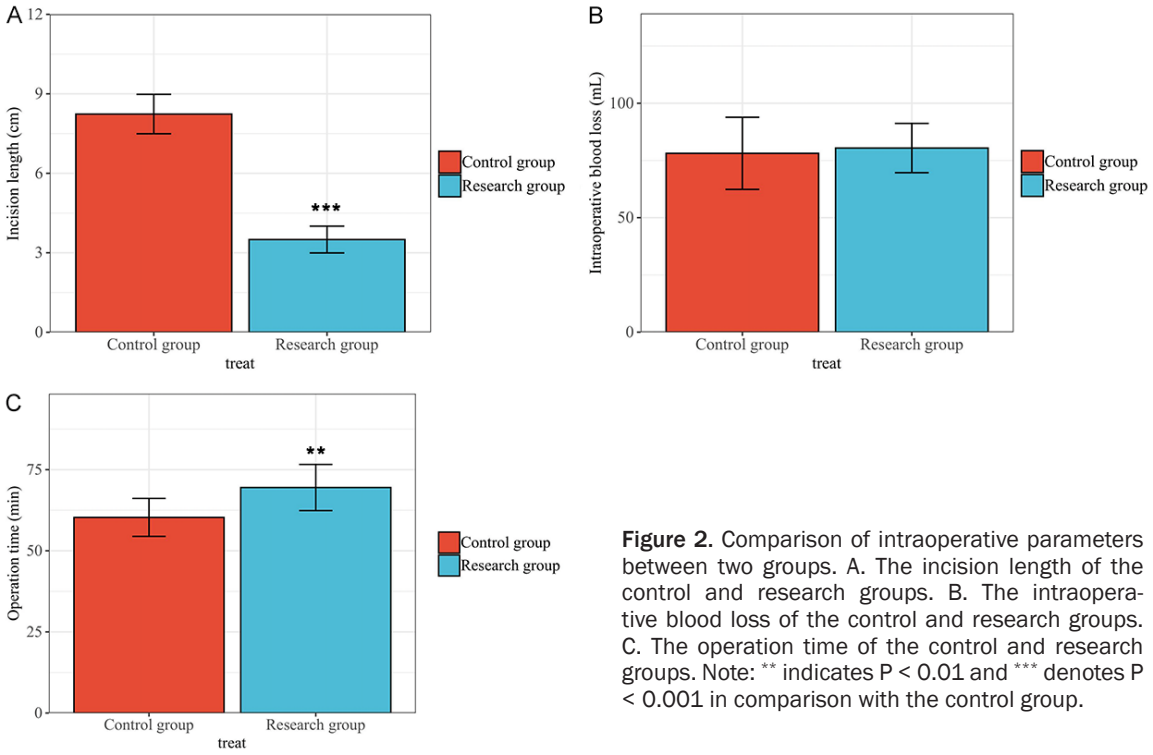

Figure 2. Comparison of intraoperative parameters between two groups. A. The incision length of the control and research groups. B. The intraoperative blood loss of the control and research groups. C. The operation time of the control and research groups. Note: ** indicates P < 0.01 and *** denotes P < 0.001 in comparison with the control group.

gender, age, time from injury to surgery, injured side, and cause of injury, between the control and research groups (all P > 0.05) (**Table 1**).

Comparison of intraoperative parameters between the two groups

The research group had a significantly shorter incision length compared to the control group (P < 0.001), while intraoperative blood loss was similar between the two groups (P > 0.05). However, the operation time (OT) in the research group was significantly longer (P < 0.01) (**Figure 2**).

Comparison of postoperative recovery indicators between the two groups

The research group demonstrated a significantly shorter fracture healing time (P < 0.001). However, no statistically significant differences were noted in fracture displacement distance or hospitalization time between the groups (both P > 0.05) (**Figure 3**).

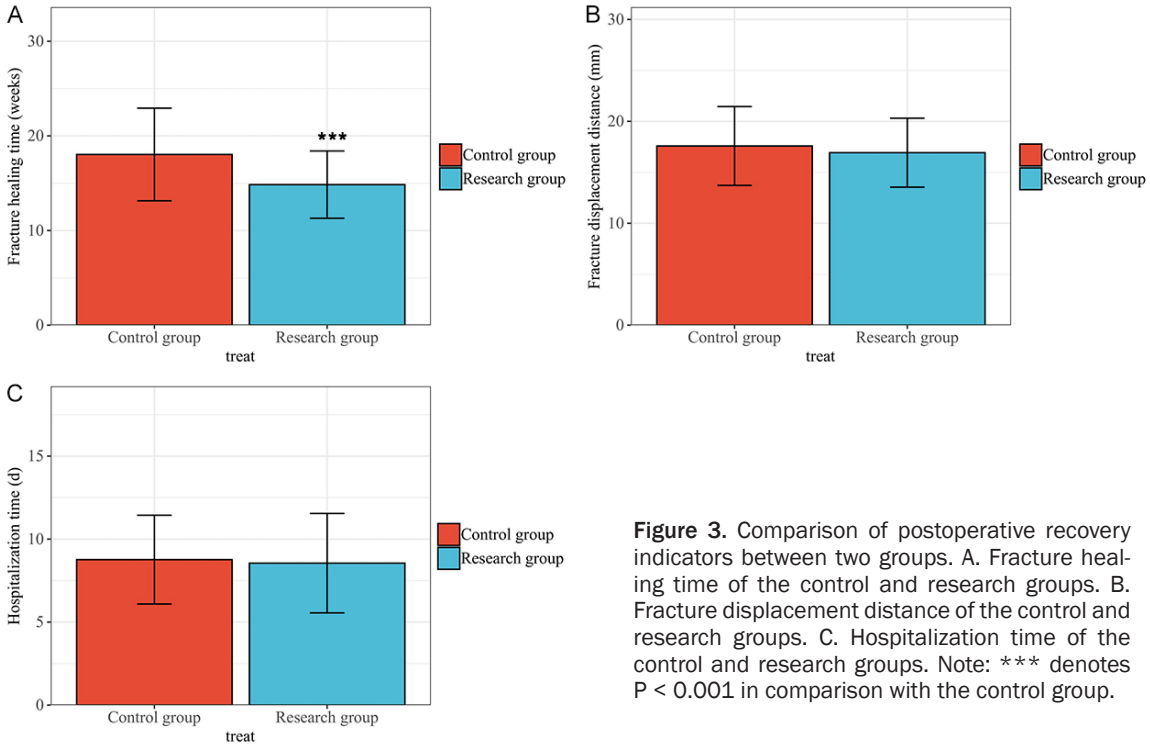

Figure 3. Comparison of postoperative recovery indicators between two groups. A. Fracture healing time of the control and research groups. B. Fracture displacement distance of the control and research groups. C. Hospitalization time of the control and research groups. Note: *** denotes P < 0.001 in comparison with the control group.

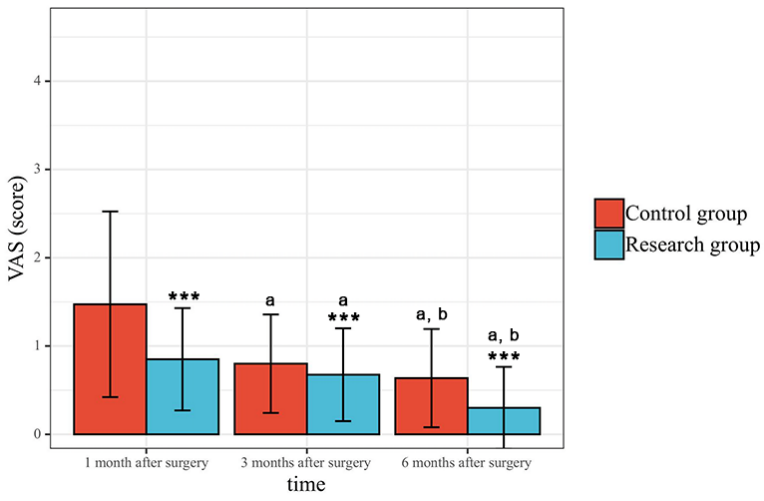

Figure 4. Comparison of pain intensity between two groups. ***P < 0.001 vs. control group; [a]P < 0.05 vs. one month after surgery; [b]P < 0.05 vs. 3 months after surgery. VAS, Visual Analogue Scale.

Comparison of pain intensity between the two groups

Postoperative pain assessment using the VAS scale showed significantly lower scores in the research group compared to the control group at 1, 3, and 6 months post-surgery (all P < 0.05). Both groups exhibited a significant decreasing trend in VAS scores over time (P < 0.05) (**Figure 4**).

Comparison of shoulder joint function between the two groups

Shoulder joint function, assessed using the ASES scale, revealed significantly higher scores for pain, function, and total scores in the research group compared to the control group at 1, 3, and 6 months post-surgery (P < 0.001). Both groups showed a significant increasing trend in pain scores and total scores over time (P < 0.05). No significant intergroup differences in stability scores were observed at any time point (P > 0.05). Function scores in both groups significantly improved at 3 and 6 months compared to 1 month postoperatively (P < 0.05), but there was no statistical difference between 3 and 6 months (P > 0.05) (**Table 2**).

Comparison of postoperative complications between the two groups

The total incidence of complications, including internal fixation plate loosening, recurrent cla-

Table 2. Comparison of shoulder joint function between the two groups

ASES		Control group (n=55)	Research group (n=40)	χ^2/t	P
Pain	1 month after surgery	22.31±2.18	29.62±3.04	13.657	< 0.001
	3 months after surgery	24.38±2.79[a]	29.20±3.23	7.777	< 0.001
	6 months after surgery	29.67±3.88[a,b]	33.15±1.86[a,b]	5.246	< 0.001
Stability	1 month after surgery	31.80±2.63	32.33±2.38	1.009	0.316
	3 months after surgery	33.09±2.32	33.30±2.00	0.461	0.646
	6 months after surgery	32.93±1.97	33.42±1.97	1.197	0.234
Function	1 month after surgery	17.93±3.15	21.32±2.88	5.367	< 0.001
	3 months after surgery	21.00±2.76[a]	23.65±2.72[a]	4.649	< 0.001
	6 months after surgery	21.95±2.87[a]	24.62±2.14[a]	4.963	< 0.001
Total score	1 month after surgery	72.04±4.66	83.28±4.01	12.296	< 0.001
	3 months after surgery	78.47±4.81[a]	86.15±4.54[a]	7.866	< 0.001
	6 months after surgery	84.55±4.91[a,b]	91.20±3.56[a,b]	7.282	< 0.001

Note: ASES, American Shoulder and Elbow Surgeons. [a]P < 0.05, compared with 1 month after surgery; [b]P < 0.05, compared with 3 months after surgery.

Table 3. Comparison of postoperative complications between the two groups

Complications	Control group (n=55)	Research group (n=40)	χ^2	P
Internal fixation plate loosening	1 (1.82)	0 (0.00)		
Recurrent clavicle fracture	2 (3.64)	0 (0.00)		
Incision infection	1 (1.82)	0 (0.00)		
Fracture end redisplacement	0 (0.00)	1 (2.50)		
Total	4 (7.27)	1 (2.50)	1.058	0.304

Table 4. Comparison of clinical efficacy between the two groups

Curative effect	Control group (n=55)	Research group (n=40)	χ^2	P
Excellent	12 (21.82)	15 (37.50)		
Good	30 (54.55)	22 (55.00)		
Poor	13 (23.64)	3 (7.50)		
Excellent and good	42 (76.36)	37 (92.50)	4.305	0.038

vicle fracture, incision infection, and fracture end redisplacement, showed no statistically significant difference between the research and control groups (P > 0.05) (**Table 3**).

Comparison of clinical efficacy between the two groups

The excellent and good rates of the control and research groups were 76.36% and 92.50%, respectively, indicating significantly higher clinical efficacy in the research group (P < 0.05) (**Table 4**).

Discussion

This study included 95 patients with Neer type II or V UDCFs to compare the clinical efficacy of clavicular hook plates and Endobutton plates. The research group demonstrated significantly shorter incision lengths, comparable blood loss, and longer OT than the control group. The reduced incision length reflects the minimally invasive nature of the Endobutton plate technique, while the extended OT likely results from its more complex surgical process [17]. Despite the longer OT, postoperative rehabilitation was not adversely affected. Consistent with our findings, Xiong et al. [18] reported that Endobutton plates offer advantages such as reduced blood loss, shorter incisions, and minimal shoulder irritation compared to anatomical and clavicular hook plates.

Patients treated with Endobutton plates exhibited significantly shorter fracture healing times compared to the control group. However, no significant differences were observed in fracture displacement distance or hospitalization time, suggesting that both surgical approaches effectively maintain fracture reduction. The longer

OT for Endobutton plate placement, attributed to the complexity of the procedure, which may explain the lack of significant differences in some recovery metrics. Nevertheless, Endobutton plates promote faster fracture healing, likely due to their biomechanical design.

Postoperative VAS scores at 1, 3, and 6 months were significantly lower in the research group compared to the control group, with a consistent downward trend over time. This suggests that Endobutton plates effectively alleviate pain, outperforming clavicular hook plates. The improved pain outcomes may result from the smaller size and superior biocompatibility of Endobutton plates, which reduce trauma from a second surgery. Additionally, the loop's alignment with ligament forces minimizes interference with surrounding soft tissues, aiding early rehabilitation and improving shoulder function [19, 20]. Similar findings were reported by Qiu et al. [21], who observed fewer cases of residual pain with Endobutton plates compared to clavicular hook plates in patients with acute acromioclavicular dislocation.

Shoulder function assessed via the ASES scale revealed significantly higher pain, function, and total scores in the research group at 1, 3, and 6 months post-surgery. These scores increased over time, reflecting progressive functional recovery. Stability scores, however, were comparable between groups and showed no significant changes over time. These results align with the findings of Kanchanatawan et al., who reported that Endobutton plates enhance healing rates and shoulder function while minimizing complications [22].

The overall incidence of complications was low in both groups, with no significant differences between them (2.50% in the research group vs. 7.27% in the control group). The main complications in the research group were fracture end redisplacement, while the control group experienced internal fixation plate loosening, recurrent clavicle fractures, and incision infections. These findings indicate that Endobutton plates provide a favorable safety profile without increasing the risk of complications. Hsu et al. also reported superior clinical outcomes and lower complication rates with Endobutton plates compared to clavicular hook plates [23].

The excellent and good rate of the research group (92.50%) was significantly higher than that of the control group (76.36%), demonstrating superior therapeutic effects of Endobutton plates for UDCFs. This can be attributed to their elastic fixation, which reconstructs coracoclavicular ligament stability and ensures secure fracture healing. Additionally, Endobutton plates minimize subacromial and acromioclavicular joint interference, reducing foreign body irritation [24, 25]. Similar results were reported by Panagopoulos et al. [26], who found that Endobutton plates provided superior outcomes for Neer type IIB distal clavicle fractures, despite comparable complication rates.

This study has several limitations. First, the sample size of 95 cases may limit the generalizability and precision of the findings. Second, the absence of long-term follow-up prevents assessment of the prognostic implications of the two surgical approaches. Incorporating long-term outcomes would enhance the understanding of their durability and effectiveness. Finally, the study lacks quantitative or qualitative evaluations of patients' quality of life and treatment satisfaction. Adding these analyses would provide a more comprehensive comparison of the specific advantages of the two surgical methods. Future research will aim to address these limitations by expanding the sample size, extending follow-up periods, and including assessments of quality of life and patient satisfaction. In conclusion, for patients with UDCFs, Endobutton plates demonstrate a significantly higher excellent and good rate compared to clavicular hook plates. This approach effectively shortens fracture healing time, alleviates postoperative pain, reduces specific complications, and improves shoulder joint function.

Disclosure of conflict of interest

None.

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