OPERATIVE TECHNIQUE

A Modified Endoscopic Technique with Three Incisions for Rockwood Types III and V Acromioclavicular Joint Dislocation

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Objective: Acromioclavicular joint dislocation is one of the most common shoulder injuries in young men. With the advancement of minimally invasive technology, arthroscopy of acromioclavicular joint dislocation has been recognized for its good curative effect. This study aimed to explore the technical details and clinical efficacy of a modified minimally invasive endoscopic treatment for acromioclavicular joint dislocation.

Methods: Clinical data of patients receiving the three-incision endoscopic treatment were retrospectively reviewed between July 2013 and July 2019. A total of 72 patients with acromioclavicular joint dislocation of Rockwood type III ($n = 42$) and type V ($n = 30$) were included in this study. Postoperative routine radiography was performed to evaluate acromioclavicular joint reduction and fixation. In addition, functional recovery of the shoulder joint was assessed using the American Shoulder and Elbow Surgeons (ASES) and Constant–Murley scores. Differences between the preoperative and postoperative data were compared using paired *t*-tests.

Results: All patients underwent loop plate elastic fixation under endoscopy during 24 to 48 months of follow-up. Postoperative radiography showed that the acromioclavicular joint achieved anatomical reduction. The ASES score (91.1 ± 4.2) was significantly improved compared to the preoperative ASES score (62.4 ± 3.1) ($t = 46.65$, $P < 0.0001$). The Constant–Murley score (93.1 ± 4.6) was also significantly higher than that before the operation (40.7 ± 6.4) ($t = 56.41$, $P < 0.0001$). No postoperative complications occurred. During follow-up, four patients had mild acromioclavicular joint degeneration but no obvious pain symptoms.

Conclusion: The modified three-incision endoscopic technique optimizes the surgical incision, reduces trauma, is minimally invasive, and provides rapid rehabilitation with satisfactory clinical outcomes.

Key words: Acromioclavicular joint dislocation; Arthroscopic treatment; Minimally invasive treatment; Three-incision

Introduction

The acromioclavicular joint's stability depends on the surround joint capsule, ligaments, attached muscle, and fascia tissue. This joint plays a critical role in limiting the upward movement of the clavicle.[1] The acromioclavicular joint easily dislocates when exposed to high-energy direct or indirect forces. Acromioclavicular joint dislocation is a common injury, which mostly occurs in young adults, accounting for about 12% of shoulder trauma dislocations.[2] Most acromioclavicular dislocations result from direct trauma. Acromioclavicular joint dislocation can cause acute pain around the joint, chronic pain, and changes in shoulder biomechanics, leading to long-term disability.[3]

According to the Rockwood classification, acromioclavicular joint dislocation can be classified into types I–VI according to the degree of dislocation.[4] Various therapeutic strategies have been developed to manage acromioclavicular joint dislocation, including surgical and non-

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surgical approaches. Generally, conservative treatment is recommended to treat Rockwood type I and type II acromioclavicular joint dislocations. In contrast, because of the severity of Rockwood type IV–VI injuries and the large displacement of the acromioclavicular joint, surgery is recommended for these types of acromioclavicular joint dislocation.[5] At present, the surgical methods for the treatment of acromioclavicular joint dislocation mainly include hook plate fixation, coracoclavicular screw fixation, coracoclavicular tendon reconstruction, coracoclavicular ligament reconstruction, and minimally invasive arthroscopic techniques.[6] Although all methods have a high response rate, complications of shoulder pain, acromial impact, weakening of upper limb strength, recurrence of dislocation, distal clavicle, and coracoid process fracture still exist.[7,8] Among these surgical methods, the size and number of surgical incisions may affect the postoperative recovery speed and the esthetic outcome.[9] With the extensive development of arthroscopic minimally invasive technology, further reduction in the number of surgical incisions to enhance esthetic outcome is one of the goals pursued by researchers.[10] Studies have shown that arthroscopic minimally invasive technology can reduce morbidity and complications during convalescence and improve surgical outcomes.[11,12]

Arthroscopy for acromioclavicular joint dislocation treatment has been recognized by doctors and patients for its favorable efficacy.[13] Therefore, it is informative to retrospectively analyze the curative effect of minimally invasive endoscopic treatment of dislocation of the lock joint. In this study, we aimed to: (i) evaluate the clinical efficacy of minimally invasive endoscopic treatment of Rockwood type III or V acromioclavicular dislocation; (ii) explore the simple operation by perfecting the establishment of the clavicle tunnel and the reduction of the acromioclavicular joint to make the operation convenient and fast; and (iii) prompt physicians to explore more beneficial treatments for patients.

Materials and Methods

Patients

This study was approved by the Ethics Committee of Chenggong Hospital of Xiamen University (approval number: 73JYY202276176). Clinical data of patients with type III–V dislocations of the acromioclavicular joint treated by the endoscopic three-incision technique between July 2013 and July 2019 were retrospectively reviewed. The inclusion criteria for this study were: (i) a diagnosis of III–V acromioclavicular dislocation (Fig. 1); (ii) a diagnosis of acromioclavicular dislocation confirmed by routine preoperative shoulder radiography; and (iii) follow-up for more than 1 year. Patients with clavicle fractures, acromion fractures, or rotator cuff injuries were excluded from this study.

Operation Method

Anesthesia and Position

Patients were treated with general anesthesia in the beach chair position (Fig. 2).

Approach and Exposure

The D approach (D approach: 1 cm outside front and outer corner of shoulder peak, Fig. 3) uses the area under the outer corner of the anterior lateral angle of the acromion as the

Fig. 1 Rockwood III acromioclavicular joint dislocation

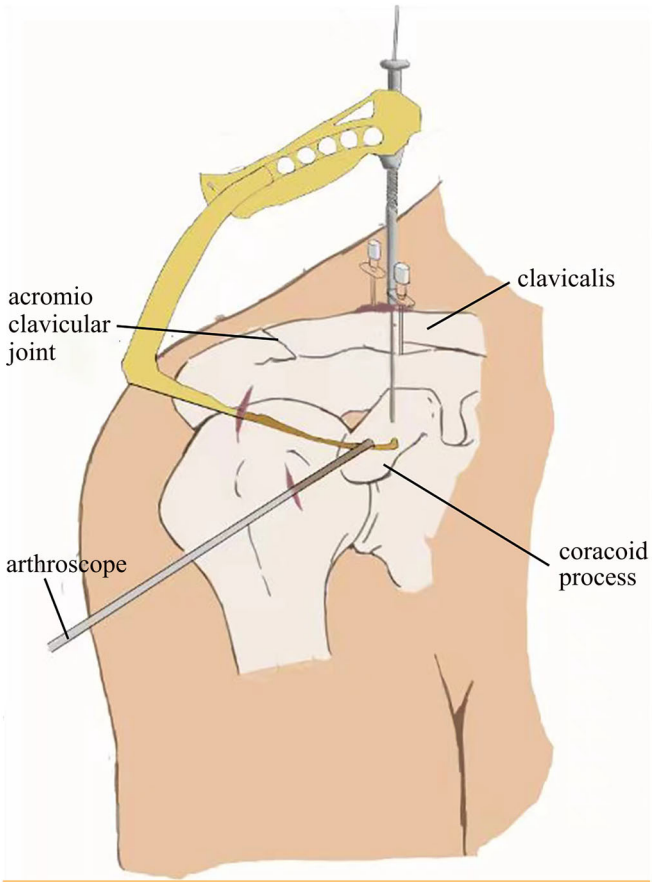

Fig. 2 Surgical diagram of the modified three-incision endoscopic technique for the treatment of Rockwood-type acromioclavicular dislocation

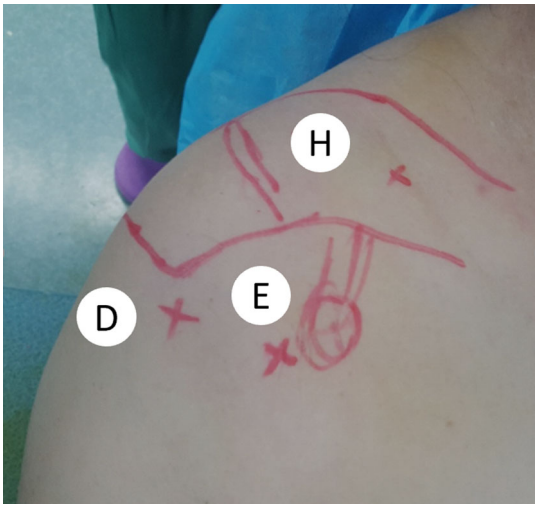

Fig. 3 Preoperative marker D approach (1 cm of anterior and inferior acromion), E approach (1 cm of the inferior coracoid tip), and H approach (approximately 3 cm from distal clavicle)

Fig. 4 The E approach was used as the observation channel. The cruciate ligament locator is inserted using the D approach. The epidural puncture needle marks the anterior and posterior edges of the clavicle, and the Kirschner wire is inserted from the clavicle to the subcoracoid process through the clavicle guide

observation approach. After the approach is established, the upper surface of the coracoid can be easily accessed with an arthroscopic sheath, and the dissection of the soft tissue space can be performed. After finding the coracoid process, arthroscopic transfer to the E approach (1 cm inferior to the apex of the coracoid, Fig. 4) was used as an observation channel. Subsequently, the superior surface of the coracoid process was exposed, and the space between the joint tendon and the coracoacromial ligament was cleared. The subcoracoid space was easily accessed through the soft tissue space between the conjoint tendon and the subscapularis muscle to expose the subcoracoid surface.

Tunnel Establishment

The tibial locator of the cruciate ligament was inserted through the D approach to adjust the maximum angle caused by the guide. The anterior and posterior edges of the clavicle were located percutaneously with an epidural needle approximately 3 cm from the distal end of the clavicle. The 2.0 mm wire was inserted along with the guide and observed using arthroscopy. After confirming that the position of the Kirschner wire on the inferior surface of the coracoid process was satisfactory (Fig. 5), a small skin incision was made at the Kirschner wire above the clavicle to establish a bone tunnel with the H approach (approximately 3 cm from the distal clavicle). Under the guidance of the Kirschner wire, a bone tunnel between the clavicle and the root of the coracoid process was established by expanding the hole through the clavicle to the root of the coracoid process with a 4.5 mm hollow bit. A traction wire was then placed in the tunnel.

Fixation of the Acromioclavicular Joint

The acromioclavicular joint was fixed with the TightRope loop titanium plate kit (Titanium plate, 10 mm, Model: AR-2257, Arthrex Inc, Naples, CA, USA). After a No.2 fiberwire line was inserted into the equipment, the loop steel plate was introduced into the tunnel through the traction wire. Subsequently, the mini steel plate was turned over at the root of the coracoid process. After tightening the #5 fiberwire at the end of the clavicle, the assistant pressed the clavicle and supported the shoulder joint on the elbow to restore the acromioclavicular joint. The operator further tightened all the fiberwire tails, while the assistant maintained the tightening tension of the #5 fiberwire. The operator first knotted and fixed the #2 fiberwire tail line with a pusher. After the radiograph confirmed that the acromioclavicular joint was restored satisfactorily, the #5 fiberwire tail line was tied, indicating closure of the incision (Fig. 6).

Postoperative Treatment and Functional Exercise

After the operation, the shoulder joint of the affected side was fixed with a shoulder elbow sling. Three days later, passive shoulder abduction, flexion, and external rotation exercises were performed. Within 6 weeks, passive activity was performed. After 6 weeks, auxiliary active shoulder exercise was started. This was followed by muscle strength exercise at 3 months. The shoulder joint can typically bear weight after 6 months.[14]

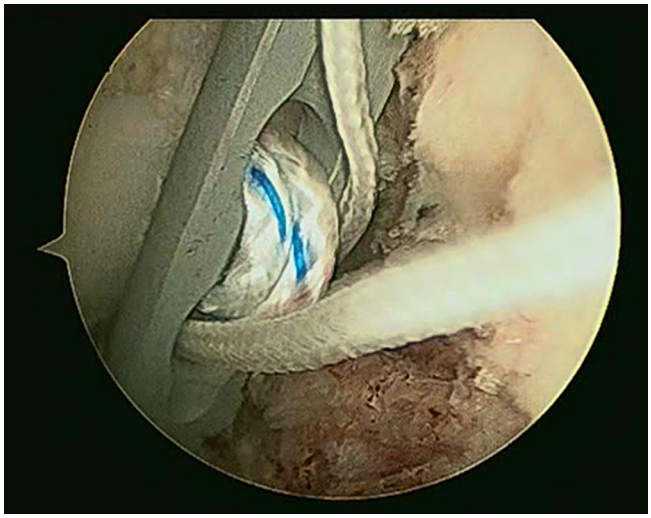

Fig. 5 The inferior surface of the coracoid process and the arthroscopic appearance of the small loop steel plate

Fig. 6 Postoperative incision

Efficacy Evaluation Standards

The radiographs were reexamined, and the American Shoulder and Elbow Surgeons (ASES) and Constant–Murley scores of the affected shoulder were evaluated at 3 months, 6 months, 1 year, and the last follow-up after the surgery.

Statistical Analysis

Statistical analyses were performed using SPSS version 22 (IBM, Armonk, NY, USA). The normality of the data was analyzed using Kolmogorov–Smirnov tests. Differences between the preoperative and postoperative data were compared using paired *t*-tests. The statistical significance threshold was set at $P < 0.05$.

TABLE 1 Basic information of patients

Characteristics	Frequency
Mean age (years)	27.8 (20–42)
Sex	
Male	56
Female	16
Average BMI (kg/m^2)	23.1
BMI (kg/m^2) (n)	
18.5–23.9	46
24.0–27.9	25
>25	1
Cause of injury	
Traffic injury	37
Fall injury	35
The time from damage to operation (days)	4.6 (2–10)
Rockwood classification	
Type III	42
Type V	30
Operation time (min)	45 (25–75)
Follow-up period (months)	32 (24–48)

Results

General Results

This study included 72 patients (56 men and 16 women) with an average age of 27.8 years (range, 20–42 years). There were 45 right-side injuries and 27 left-side injuries, all of which were acute dislocations. The causes of injury were either traffic ($n = 37$) or fall ($n = 35$). The time from injury to operation was 2–10 days, with an average of 4.6 days. All patients had a history of shoulder trauma. The main clinical symptoms were local swelling and pain of the acromioclavicular joint, the eminence of the outer end of the clavicle, local tenderness (+), piano key sign (+), and limited movement of the shoulder joint in all directions. According to the Rockwood classification, there were 42 cases of type III and 30 cases of type V dislocations. Before the operation, the ASES score was 62.4 ± 3.1, and the Constant–Murley score was 40.7 ± 6.4 (Table 1).

Outcomes

The operation time for each of the 72 patients ranged from 25 to 75 min, with an average of 45 min. Postoperative radiography showed that the acromioclavicular joint achieved anatomical reduction. The postoperative follow-up period ranged from 24 to 48 months, with an average of 32 months. The ASES score was excellent (91.1 ± 4.2) at the last follow-up and was significantly improved compared with the preoperative ASES score (62.4 ± 3.1) ($t = 46.65$, $P < 0.0001$). In addition, the Constant–Murley score was excellent (93.1 ± 4.6) at the last follow-up, and was significantly

TABLE 2 Postoperative follow-up results (mean ± SD)

Group	Preoperative	Postoperative	*P*-value
ASES	62.4 ± 3.1	91.1 ± 4.2	<0.0001
Constant-Murley score	40.7 ± 6.4	93.1 ± 4.6	<0.0001

Abbreviations: ASES, American Shoulder and Elbow Surgeons' Form, SD, Standard deviation.

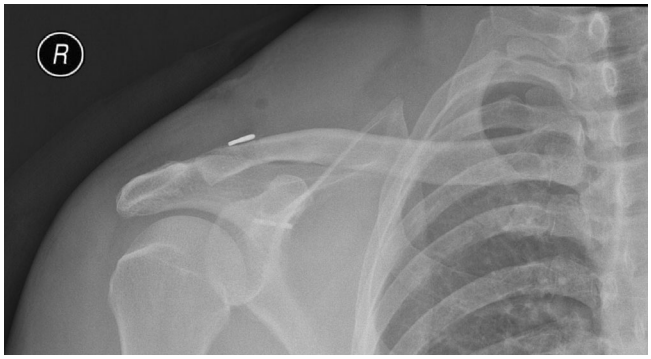

Fig. 7 Three months after the operation, the radiograph shows that the reduction of the acromioclavicular joint was achieved

higher than that before the operation (40.7 ± 6.4) ($t = 56.41$, $P < 0.0001$) (Table 2).

Complications

No complications, such as wound infection, clavicle fracture, or coracoid process, occurred after the operation. Re-examination of radiographs showed no failure of internal fixation or re-dislocation (Fig. 7). Four patients had mild acromioclavicular joint degeneration with no noticeable pain symptoms.

Discussion

Recently, it has been suggested that Rockwood types III and IV AC dislocations be treated by endoscopy as this involves extra-articular surgery.[15,16] It is predicted that anatomic and long-lasting lesion reduction may be achieved with minimally invasive endoscopy while reducing postoperative complications.[17] Cohen *et al.* found arthroscopic-assisted treatment of acute acromioclavicular dislocation to be advantageous, with a Constant score of 91 (60–100) at the last follow-up.[17] Liu *et al.* also discovered that the arthroscopic coracoclavicular ligament augmentation method was an effective treatment for acute type III and V acromioclavicular dislocations, with a significant increase in the mean Constant–Murley shoulder score from 24.3 preoperatively to 91.1 postoperatively.[18] This study investigated the clinical efficacy of a modified minimally invasive endoscopic technique for the treatment of acromioclavicular joint dislocation, and found that all patients were satisfied with postoperative acromioclavicular joint dislocation reduction. The ASES score (91.1 ± 4.2) was significantly improved compared to the preoperative ASES score (62.4 ± 3.1). The Constant–Murley score (93.1 ± 4.6) was also significantly higher than that before the operation (40.7 ± 6.4). No postoperative complications occurred. Re-examination of radiographs showed no failure of internal fixation or re-dislocation. During follow-up, four patients had mild acromioclavicular joint degeneration but no obvious pain symptoms.

A Proposal of the Modified Technique: Advantages, Surgical Difficulty, and Feasibility

Unlike previous procedures, this study made some important improvements to the surgical approach. First, the improved endoscope technology can directly observe the patient without moving the patient to the edge of the operating table, which solves the difficulty of intraoperative fluoroscopy caused by the interference of the edge of the operating table by the traditional endoscope technology. Second, traditional endoscopic techniques generally use a posterior glenohumeral approach.[17] Because the root of the coracoid process is challenging to detect in the posterior channel, arthroscopy needs to be moved anteriorly for observation before proceeding to the next step. In contrast, in this study, arthroscopy used an anterior approach, where patients could lie supine in the middle of the operating table, avoiding problems such as difficult positioning and the need for a special operating table, which was more efficient and convenient. Third, the conventional approach to repositioning the acromioclavicular joint usually involves temporary fixation with a Kirschner wire through the acromion into the distal clavicle. This method may present difficulties in the insertion of Kirschner wires. The temporary fixation of Kirschner wires may also interfere with establishing a tunnel in the distal clavicle. In our study, we pre-installed a #2 fiberwire in the acromioclavicular joint kit and subsequently maintain the reduction by tightening the #5 fiber wire before tightening and securing the #2 fiber wire. As a result, only one radiographic examination is usually required to confirm the satisfactory reduction of the acromioclavicular joint before tightening and securing #5 fiberwire. This improved operation technique is more convenient and quicker. Finally, most operations establish a 3–4 cm-long incision at the distal clavicle to expose the anterior and posterior edges of the distal clavicle before locating the clavicle with a guide and building

the tunnel of the distal clavicle. In this study, we used an epidural needle to mark the anterior and posterior edges of the distal clavicle and a guide to insert Kirschner's needle into the posterior one-third of the distal clavicle. Subsequently, a 1 cm clavicular incision is required to complete the construction of a clavicular tunnel and the placement of a mini-plate. This method is more minimally invasive and able to ensure the correct positioning of the Kirschner wire effectively.

Difference in the Adopted Endoscopic Three-Incision Technique from the Previous Surgical Methods

The endoscopic three-incision technique we adopted is slightly different from the previous surgical methods. This modified endoscopic technique has the following advantages: (i) it reduces the number of surgical incisions, requiring only three minimally invasive skin incisions, imparts less trauma and has better esthetic outcome; (ii) it minimizes the extent of arthroscopic exposure of the lower surface of the coracoid process, further reduces the damage to the surrounding tissue, and is beneficial for early rehabilitation of postoperative function. In addition, the modified technique (the average operation time of this cohort is 45 min) can significantly reduce the procedure time compared with conventional techniques (47–70.6 min)[19,20]; (iii) It was found that arthroscopic techniques may lead to new complications such as coracoid or clavicle fractures and tunnel widening.[21,22] In this study, percutaneous localization of the anterior and posterior edge of the clavicle with an epidural needle can effectively avoid complications such as clavicle fracture caused by mispositioning of the clavicle tunnel (no such complications occurred in this group); and (iv) the use of #2 fiberwire line can initially secure the acromioclavicular joint and facilitate fluoroscopy to ensure a satisfactory reduction of the acromioclavicular joint. Simultaneously, the other wire ring further increases the fixation strength of the acromioclavicular joint kit.

Ways to Avoid Vascular and Nerve Damage

Additional techniques to avoid injury of blood vessels and nerves should be considered, including accurately drawing the body surface position of the coracoid process before operation and establishment of the D approach. The anterior end of the arthroscopic cannula was used to explore the coracoid process, and the soft tissue was moderately dissected above and in front of the coracoid process, resulting in potential lacunae. Subsequently, the structure of the coracoid process can be easily observed after arthroscopy. The operation with the coracoid process as the reference point can also avoid blood vessel and nerve injury. In this context, from the coracoid joint between the tendon and the subscapular muscle into the subcoracoid space, only the lower surface of the coracoid process can be exposed, avoiding the areas beyond the inner edge of the coracoid process.

Limitations and Strengths

This study reports a modified endoscopic technique that avoids the complications of the conventional technique, reduces the number of surgical incisions, shortens the operative time, and is simple and useful in clinical practice. However, there are some limitations to this study. First, the presence of a long-head tendon or rotator cuff injury within the glenohumeral joint may not be sufficiently explored. Second, the Kirschner wires of the distal clavicle were placed by blind percutaneous puncture. Although an epidural needle marked the anterior and posterior clavicle edges, positioning error may still occur. To avoid iatrogenic clavicular fracture, it is necessary to probe the anterior and posterior edges of the clavicle to locate the Kirschner wire.

Conclusion

The improved endoscopic three-incision technique was used to reconstruct the coracoclavicular ligament to restore the anatomical alignment of the acromioclavicular joint. This surgical technique, characterized by stable fixation, fewer problems, and a good treatment outcome, has a lot of clinical potential. Therefore, further applications of this improved endoscopic technique in the clinical setting are recommended.

Acknowledgments

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Authors' Contributions

Jianming Huang designed the research, acquired data and analyzed data and drafted the manuscript. Danlei Huang performed statistical analysis. Jun Wang and Zhiyang Ye designed the research and revised manuscript for important intellectual content. Haoyuan Liu analyzed data. All authors read and approved the final manuscript.

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