

Suture Augmentation of Acromioclavicular and Coracoclavicular Ligament Reconstruction for Acute Acromioclavicular Dislocation

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Abstract

Purpose

The objective of this report was to introduce a new suture augmentation of coracoclavicular and acromioclavicular ligament reconstruction for acute Rockwood grade III to V acromioclavicular dislocations.

Methods

From January 2015 to January 2019, 43 patients with Rockwood III to VI acute acromioclavicular dislocations were retrospective reviewed. The outcome evaluations included coracoclavicular space, loss of reduction, and acromioclavicular space. The Disabilities of the Arm, Shoulder, and Hand questionnaire was used to assess the limb function. Clinical evaluation of patients was performed using the University of California-Los Angeles scoring systems. For comparison, another series of 28 patients treated with double Endobutton technique from January 2011 to December 2014 was reviewed. A $P < 0.05$ was considered statistical significance.

Results

The mean follow-up period of the two series were 39.69 ± 7.42 months (range, 24–54 months) and 37.86 ± 8.23 months (range, 26–48 months) ($P > 0.05$), respectively. There were significant differences regarding coracoclavicular space (11.62 ± 2.54 mm vs 16.78 ± 5.53 mm; $P < 0.05$), coracoclavicular reduction loss (5.56 ± 4.73 mm vs 26.25 ± 4.42 mm; $P < 0.05$), and acromioclavicular space (6.89 ± 1.87 mm vs 7.95 ± 2.37 mm; $P < 0.05$). There were significant differences regarding the Disabilities of the Arm, Shoulder, and Hand questionnaire (3.3 ± 2.8 vs 5.32 ± 4.37 ; $P < 0.05$) and University of California-Los Angeles Shoulder rating scale (31.19 ± 2.48 vs 29.24 ± 2.48 ; $P < 0.05$). The excellent to good percentages were 100 % ($n=32$) and 85% ($n=23$), respectively.

Conclusions

In conclusion, the suture augmentation of acromioclavicular and coracoclavicular ligament reconstruction is reliable technique for acute acromioclavicular dislocation with minimal complications.

Type of study/level of evidence

Therapeutic IIa.

Introduction

Acute acromioclavicular (AC) dislocation typically occurs in young, athletic adults and is one of the most common injuries of the shoulder girdle (4%–12%)¹. The ideal surgical techniques for treating the high-grade acute AC injuries are a matter of ongoing debate².

The original classification of AC injuries was described by Rockwood and Green according to the injured ligament complex, as well as the degree and direction of clavicular displacement ³. Low-grade sprains (type I and II) are usually managed nonoperatively ⁴. Patients with type III injuries are usually evaluated on a case-by-case basis, taking into account the variables like hand dominance, age, occupation, sport requirements, dysfunction, and risk of redislocation ⁵. More high-grade AC instability (type IV and VI) are frequently the result of high-energy injuries. The injuries are complex and may cause persistent shoulder pain and functional impairment.

Many surgical procedures have been described for treat AC dislocations. Among those are screws, plates, muscle transfer, ligamentoplasty procedures, and ligament reconstruction using either autografts or allografts ⁶. With the advancement of shoulder arthroscopy, surgeons are much more capable of performing mini-open or arthroscopically-assisted procedures, allowing patients an earlier return to their daily living activities ⁷. However, the results of conventional open techniques are still comparable. Currently, there is no gold standard for the surgical treatment of AC injuries, because comparison among the techniques are difficult due to limited patients.

The objective of this report was to introduce a new suture augmentation of coracoclavicular (CC) and AC ligament reconstruction for acute Rockwood grade III to V AC dislocations. For comparison, we review another series of 28 patients treated with double Endobutton technique, because it is commonly used for treating AC dislocation.

Materials And Methods

This retrospective study was approved by the institutional review boards of the hospitals involved in accordance with international agreements (World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects," amended in October 2013, www.wma.net). Informed consent and Health Insurance Portability and Accountability Act consent were obtained from each patient.

From January 2015 to January 2019, 43 patients with Rockwood III to VI acute AC dislocations were retrospective reviewed. The diagnosis was established according to the proper history taking, physical examination, and X-ray. Increase of CC distance of 25% to 50% over the normal side on a bilateral Zanca view indicated complete CC ligament disruption.

Our eligibility criteria were: (1) patients aged between 18 and 65 years; (2) an acute AC dislocation within 14 days; (3) Rockwood grade III to VI; (4) normal opposite upper limb for comparison. Our exclusion criteria were as follows: patients younger than 18 years were excluded because of skeletal immaturity (n=3); patients older than 65 years are excluded because of possible osteoporosis (n=1); combined fractures of the joints (n=1); old AC dislocations exceeding 14 days because the treatments may be different; discontinued intervention (n=4); and declined to participate (n=2). Finally, a total of 32 patients were enrolled in this study. All operations were performed by the same senior orthopaedic surgeons.

Surgical Technique

The operation was performed with the patient under general anesthesia. The patient was placed in the beach chair position or supine position with extra padding under the injured shoulder. An 8-cm curved incision was made from the AC joint to the distal anterior clavicle. The base of the coracoid process, AC joint, and distal clavicle were visualized. One coracoid tunnel (#1), four clavicle tunnels (#2, #3, #4, and #5), and two acromion tunnels (#6 and #7) were drilled using a 2.0 mm pin (Fig. 2A). The lateral clavicle was reduced by manipulation (Fig. 2B), and maintained using pointed reduction clamps or a K-wire as needed. We passed two 2/0 braided nonabsorbable polyester sutures (Ethicon, INC., Somerville, NJ, USA) through the coracoid tunnel (#1) using a 1 mm stainless steel wire loop (Fig. 3A). The two free limbs of each suture were passed through the loop of the same suture, and then tightened over the coracoid (Fig. 3B). The four limbs were tied together, and then passed through the clavicle tunnels (#2, #3, #4, and #5) separately to reconstruct the CC ligament (Fig. 3C). Two of the limbs were tied to the corresponding pair (Fig. 3D, E). Two limbs passed through the acromion tunnels (#6 and #7) and another two limbs were tied together over the acromion to reconstruct the AC ligament (Fig. 3F). The ruptured AC, CC, and coracoid ligaments, as well as the capsule were repaired if possible (Fig. 3G, H). The temporary maintenance was removed, and the AC reduction was confirmed on X-ray (Fig. 3I). The wound was closed in layers.

Postoperative managements

After surgery, the limb was supported with a platform brace for 6 weeks to minimize the gravity-induced stress on the AC joint. Gentle passive range of motion was started after 6 weeks. Strength exercises for the scapular muscle were started after 12 weeks.

Outcome Evaluation

Active motions of the shoulder were measured with a goniometer, and all measurements were compared to those on the opposite limb. On the frontal X-ray of the shoulder, the CC space (distance between the superior cortex of the coracoid process and the undersurface of the clavicle) was assessed⁸. Loss of reduction was defined as >25% increase of CC distance developed. The AC space was also assessed. Grip strength of the hand was measured using a dynamometer. To improve consistency between dominant and nondominant grip strength, we based the scores for analysis on the premise that the grip strength was 6% higher at dominant sides compared with the nondominant sides⁹. We used the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire¹⁰ to assess the limb function. Clinical evaluation of patients was performed using the University of California-Los Angeles (UCLA)¹¹ scoring systems. The UCLA score consisted of pain (0–10 points), function (0–10 points), range of motion (0–5 points), strength (0–5 points), and the patient's satisfaction (0–5 points). The total UCLA score is 35 points, and 34 points or 35 points, 29 points to 33 points, and ≤ 29 points indicate excellent, good, and poor results, respectively.

Statistical Analysis

Quantitative variables were described as mean and ranges. The collected data were analyzed with the Statistical Package for Social Sciences 19.0 (SPSS, Inc., Chicago, Ill). A $P < 0.05$ was considered statistical significance.

Results

There were 28 male and 4 female patients who underwent the multiple ligament reconstruction and repair. These patients were comprised of group A. The mean age at surgery was 34 years (range, 18 – 54 years). The causes of injuries included high-energy contact sports ($n=22$), road traffic accident ($n= 8$), and fall from a height ($n= 2$). The AC injuries included type III ($n=2$), IV (11), V ($n=19$), and VI (0) dislocations. (Table 1) No patient was lost to follow-up, and all 32 patients were reviewed with an average follow-up of 39.69 ± 7.42 months (range, 24 – 54 months).

For comparison, we retrospectively reviewed 28 patients who underwent AC ligament reconstruction and repair using double Endobutton technique from January 2011 to December 2014. These patients were comprised of group B. The mean age at surgery was 32 years (range, 18 – 57 years). The causes of injuries included high-energy contact sports ($n=17$), road traffic accident ($n= 6$), and fall from a height ($n= 5$). The AC injuries included type III ($n=1$), IV (7), V ($n=20$), and VI (0) dislocations. No patient was lost to follow-up, and all 32 patients were reviewed with an average follow-up of 37.86 ± 8.23 months (range, 26 – 48 months).

There were no significant differences with regard to patient age, sex, cause of injury, type of injury, preoperative CC space, and duration of follow-up. We found significant differences regarding vertical flexion (93.22 ± 6.68 vs 94.52 ± 4.25 ; $P= 0.006$), external rotation (92.35 ± 7.62 vs 79.53 ± 23.02 ; $P= 0.000$), and internal rotation (90.42 ± 10.55 vs 87.22 ± 6.36 ; $P=0.000$) of the shoulder. We found significant differences regarding CC space (11.62 ± 2.54 mm vs 16.78 ± 5.53 mm; $P=0.000$), CC reduction loss (5.56 ± 4.73 mm vs 26.25 ± 4.42 mm; $P=0.000$), and AC space (6.89 ± 1.87 mm vs 7.95 ± 2.37 mm; $P=0.000$) at the final follow-up. We also found significant differences regarding DASH (3.3 ± 2.8 vs 5.32 ± 4.37 ; $P=0.012$) and UCLA Shoulder rating scale (31.19 ± 2.48 vs 29.24 ± 2.48 ; $P=0.000$). The excellent to good percentages were 100 % ($n=32$) and 85% ($n=23$), respectively. (Table 2)

Discussion

The common mechanism of AC joint separation involves a direct trauma to the posterosuperior part of the shoulder or an indirect mechanism via a fall on an outstretched adducted arm or elbow, which drives the humeral head into the AC joint². This injury occurs five times more frequently in men than in women, with the highest incidence in the 20- to 30-year-old age group. The complete AC dislocations often involves disruption of the AC and CC ligaments. Patients usually complain of pain and tenderness over the shoulder, particularly over the AC joint¹. Stabilizing the AC joint is a challenging technique even several methods are reported in the literature. Currently, the controversy still persists on the optimal treatment, because there is no gold standard for the treatment of AC dislocation.

The CC distance is an indicator of the integrity of the CC ligament¹². The CC space was assessed on the frontal X-ray of the shoulder or clavicle or the coronal projection of a CT or MRI as the distance between the superior cortex of the coracoid process and the undersurface of the clavicle where the CC ligaments insert. Currently there is no gold standard for the surgical treatment of any type of AC injury. In 1972, Weaver and Dunn described a surgical procedure for treating the unstable AC joint¹³. The technique consists of excising the distal part of the clavicle, releasing the coracoacromial ligament from its acromial attachment and transferring it to the distal clavicle. Although several modified techniques had been reported with good outcomes, the rates of loss of reduction were usually up to 20%¹⁴. Anatomical reconstruction of the CA ligament using free grafts provides better stability than other ligament transfer procedures¹⁵. However, the biomechanical studies have suggested that the CA ligament is a weak graft that has approximately 25% of the initial strength of the native CC ligaments and less than 50% of the appropriate stiffness¹⁶. These non-dynamic reconstructions may be failed because the success depends on the primary healing of the CC ligament¹⁷⁻¹⁹. The early surgical techniques for AC joint fixation using K-wires and pins can hold the clavicle in a reduced position. However, owing to the high complication rates of implant migration and loss of reduction, surgeons tend to avoid using the techniques²⁰. Restoring AC joint function using a single or double Endobuttons can reduce the stress-rising effects of titanium buttons around the clavicle and the coracoid, through which to minimize the risk of failure by suture cut-out²¹. Open reduction and internal fixation with hook plate is an effective treatment for AC dislocation, but hook plate had a significant impact on shoulder function. Chen et al²² treated 33 patients using the hook plate, and found subacromial osteolysis occurred in 10 patients, and co-occurrence of subacromial osteolysis and acromioclavicular joint osteoarthritis in 4 patients. The introduction of new arthroscopic equipment provides a great variety of surgical procedures, though every new technique has its own advantages and pitfalls⁷. Few reports have proposed arthroscopic technique to treat AC dislocations. Different materials have been used to maintain the CC reduction, including suture loops, sutures and anchors, and different types of metallic pins, screws, or buttons. The surgeon's expertise is likely to be the most significant factor affecting the outcomes. Possible failures with recurrent clavicular subluxation or dislocation have been reported after some of these procedures, with failure rates up to 50%. Fixation failures have been found to be due to hardware breakage or migration, suture abrasion and breakage, or bone erosion because of the potential sawing action of the sutures through the clavicle or the coracoid²³.

Our technique reconstructed both the AC and CC ligaments. The sutures passing through the bone tunnels can hold the clavicle or coracoid more strongly than bone anchors. Each ligament is repaired with 4 strands of suture, which provides strong strength for maintaining the reduction. The suture method avoids a metal-to-bone impact that may cause the postoperative shoulder pain. The strong suturing allows early joint motion exercises, resulting in a good shoulder function.

The advantages of our technique include strong sutures to support early range of motion and rehabilitation, possibility of early return to work, ligament healing and a nearly anatomic reconstruction,

no hardware removal, and very low morbidity. The disadvantages included slightly complex surgical procedures. The technique cannot be complete through a minimally invasive approach.

The indication of our technique are almost the same as other surgical techniques for treating AC dislocation. Either acute or old Rockwood type IV and VI dislocations, as well as some type III dislocations, are good candidates. Either direct repairing the ligament or repairing with a graft can be used depending on the surgeon's preference. Contraindication is a combined fracture that require a rigid fixation. In order to exclude the biases of the study, we excluded the complex wounds, through those injuries are not contraindication.

The limitation of the study is that kinematics of the sutures needs further studied. Also, surgeon preference, experience, and ability may influence ascertaining the effects of the treatment.

In conclusion, the suture augmentation of AC and CC ligament reconstruction is reliable technique for acute acromioclavicular dislocation with minimal complications.

Abbreviations

AC , Acute acromioclavicular

CC , coracoclavicular

Declarations

Acknowledgments

Not applicable.

Authors' contributions

Conceived and designed the study: Yingliang Liu and Yadong Yu. Extracted the data: Yong Gao, MD., Yanting Wang, MD., and Rong Yang, MD., Vikas Dahwan. Contacted patients follow-up: Yanting Wang. Pictures: Rong Yang. Performed the statistical analysis: Yong Gao. Wrote the manuscript: Yingliang Liu. All authors read and approved the final manuscript.

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Ethics approval and consent to participate

Our research has been approved by the local ethics committee.

Conflict of interest

The authors declare that there is no conflict of interest.

Consent for publication

All authors read the final manuscript and approved it for publication.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. The Baseline Data of Two Groups			
	Group A	Group B	
	(n=32)	(n=28)	P value
Techniques	MLRR	Double Endobutton	
Age (year, mean, range)	34 (18 - 54)	32 (18 - 57)	0.155
Sex (m: f)	28 : 4	26 : 2	0.205
Injured side (R:L)	17 : 15	13 : 15	0.295
Dominance (n)	19 : 13	18 : 10	0.05
TFITS (day; mean, range)	6 (3 - 10)	7 (4 - 13)	0.132
Causes (n)			
Sports	22	17	0.625
Traffic accident	8	6	
Fall from a height	2	5	
Rockwood classification (n)			
III	2	1	0.423
IV	11	7	
V	19	20	
VI	0	0	
MLRR, multiple ligament reconstruction and repair; TFITS, time from injury to surgery;			

Table 2. Outcomes at the final follow-up.			
	Group A	Group B	
	(n=32)	(n=28)	<i>P</i> value
Follow-up (month; mean±SD; range)	39.69±7.42 (24 - 54)	37.86±8.23 (26 - 48)	0.344
ROM (mean±SD; %)*			
Abduction	91.45±8.22	88.11±11.65	0.257
Vertical flexion	93.22±6.68	94.52±4.25	0.006
Flexion	91.73±8.11	90.38±5.69	0.071
Forward flexion	88.32±12.56	85.84±12.23	0.053
External Rotation	92.35±7.62	79.53±23.02	0.000
Internal rotation	90.42±10.55	87.22±6.36	0.000
CC space (mm)			
Preop	19.35±3.37	18.85±4.01	0.133
Immediate postop	10.55±1.62	13.78±1.37	0.054
Final follow-up	11.62±2.54	16.78±5.53	0.000
CC reduction loss (mm)			
Immediate postop	4.11±3.83	16.05±9.23	0.000
Final follow-up	5.56±4.73	26.25±4.42	0.000
AC space (mm)			
Immediate postop	6.32±1.93	7.28±2.44	0.000
Final follow-up	6.89±1.87	7.95±2.37	0.000
Grip strength (%)*	98.22±9.251	97.85±12.57	0.178
DASH	3.3±2.8	5.32±4.37	0.012
UCLA			
Pain (0–10)	9.25±0.82	7.56±2.17	0.000
Function (0–10)	9.02±0.97	8.18±1.59	0.000
ROM (0–5)	4.25±0.61	4.03±1.37	0.021
Strength (0–5)	4.62±0.39	4.28±1.43	0.018
Satisfaction (0–5)	4.25±0.69	3.17±1.27	0.000

Total (n; %)	31.19±2.48	29.24±2.48	0.000
Excellent(34–35)	28 (88)	15 (54)	
Good (29–33)	4 (12)	8 (31)	
Poor (≤ 29)	0	5 (45)	
CC, coracoclavicular; AC, acromioclavicular; ROM, range of motion			
*, comparing to the opposite limb;			
DASH, Disabilities of the Arm, Shoulder and Hand questionnaire.			
UCLA, University of California at Los Angeles Shoulder rating scale;			

Figures



Figure 1

A 47-year-old male patient suffering an acute acromioclavicular (AC) dislocation (left side; anteroposterior view) in a road traffic accident.

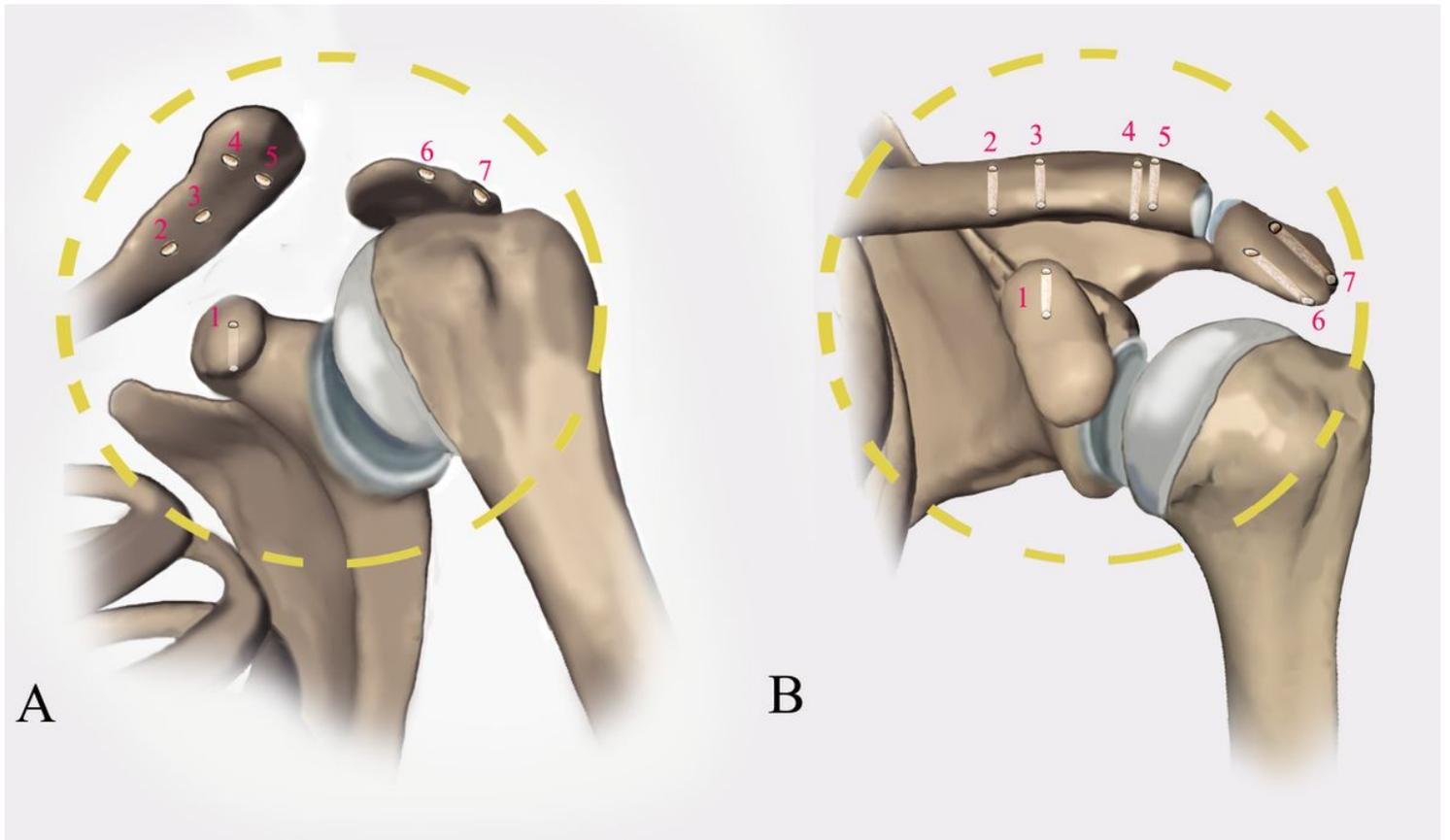


Figure 2

A total of 7 bicortical tunnels (numbered from #1 to #7) are made (the images in the dashed circle will be enlarged in the next figure). A. A 15° cephalic Zanca view showing the left AC dislocation. B. An anterior view showing the clavicle is reduced.

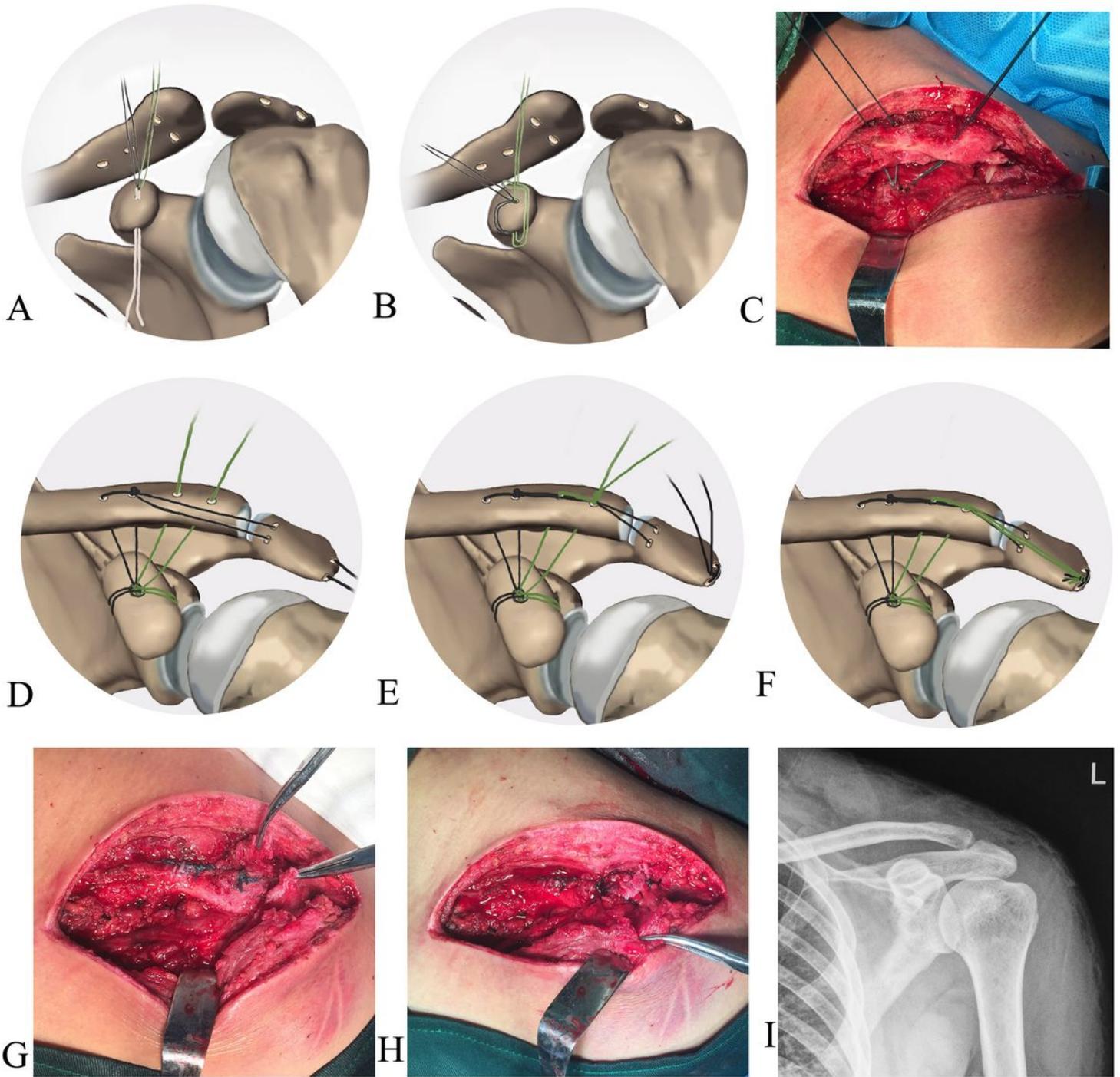


Figure 3

The systematical ligament reconstruction. A. A cephalic Zanca view showing two 2/0 polyester sutures (marked black and green separately for better understanding) passed through the coracoid tunnel (#1) using a 1 mm stainless steel wire loop (white wire). B. Each suture is passed through the loop of the same suture, and then tightened by pulling the free limbs. The four limbs are tied together. C. The four limbs are passed through the four clavicle tunnels separately. D. An anterior view showing the two black limbs passed through the proximal clavicle tunnels (#2 and #3) are tied to each other over the clavicle, and further passed through the two acromion tunnels (# 6 and #7). E. The two green limbs passed

through the distal clavicle tunnels (#4 and #5) are tied to each other over the black limbs for preventing they slide anteriorly. F. The two black limbs tied over the lateral acromion, and then the four limbs are tied together over the lateral acromion. G. The AC and CC ligaments are repaired. H. Ligament reconstruction and repair are complete. I. Anteroposterior X-ray immediately after surgery.

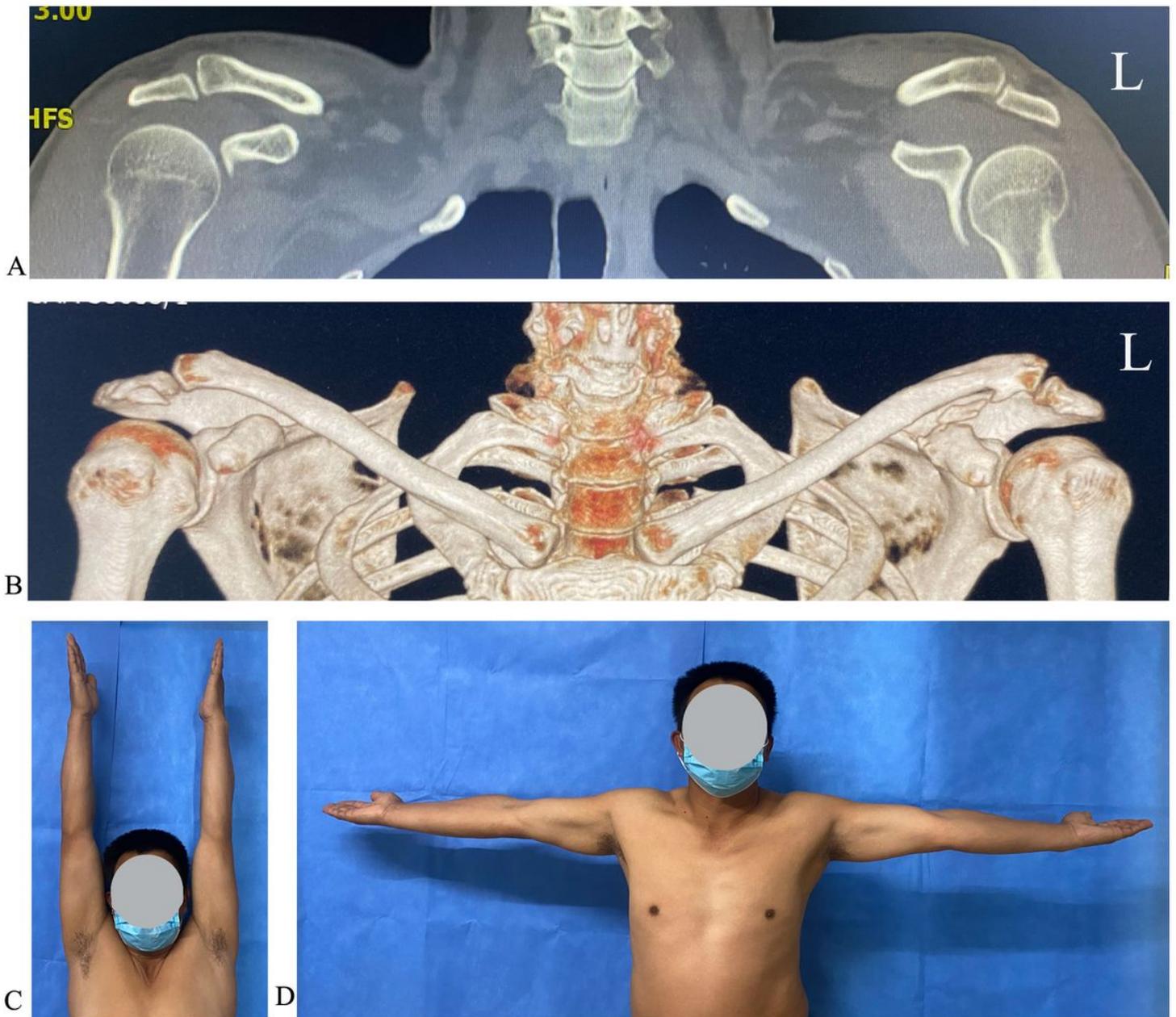


Figure 4

Two years after surgery. A. Coronal CT. B. Three-dimensional CT. C. Vertical flexion. D. Abduction