Anchor moored positioning technique by suture anchor and Endobutton fixation for treatment of acromioclavicular joint dislocation

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Research article

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Abstract

Background Numerous surgical methods have been used for acromioclavicular joint reconstruction.In this study, we analyzed the clinical and radiographic outcomes of truly anatomic coracoclavicular ligaments reconstruction (TACCR) and truly anatomic acromioclavicular ligaments reconstruction (TAACR) using suture anchor and Endobutton fixation for treatment of acromioclavicular joint dislocation. Methods 48 patients (mean age 49 years) with severe acromioclavicular joint dislocation. The patients were classified as Rockwood type III (n=28), IV (n=3) and V (n=17). All patients were operatively treated using anchor moored positioning technique by suture anchor and Endobutton fixation. Clinical and radiographic evaluation include the visual analog scale (VAS), Constant scores (CS) and American Shoulder and Elbow Surgeons (ASES) scores and radiographic outcomes. Results The mean follow-up was 34 months. The VAS decreased from 5 preoperatively to 0 at 24 months ($P < .001$). The CS and ASES scores improved from 43, 44 preoperatively to 96, 97 at 24 months separately ($P < .001$). Meanwhile, 47 patients (97.9%) demonstrated stable anatomical fixation on final postoperative radiographs. Loss of reduction occurred in 1 patient (2.1%), but was not correlated with functional outcome. Conclusions Anchor moored positioning technique with Bi-directional fixations by suture anchor and Endobutton fixation represents a new and reliable treatment of AC joint dislocation.

Background

Acromioclavicular (AC) joint dislocation is a common injury among people with sports injuries and traffic accidents, and it accounts for about 10% of all shoulder injuries [1,2]. The most frequently used classification is the Rockwood classification, ranging from type I to VI [3]. Rockwood type III and V are observed significantly more often than the other types of AC joint dislocation and most commonly occurs in young adults aged 20-39 years [4,5]. Surgical management should be used for type IV, V, VI, while management of type III remains controversial [6]. Numerous surgical methods have been reported in the literature, and more anatomical surgical techniques have been used for AC joint reconstruction.

At present, anatomic coracoclavicular (CC) ligaments reconstruction has become popular [7-11], but the truly anatomic acromioclavicular (AC) ligaments reconstruction (TAACR) has been relatively few. We developed a new TACCR and TAACR method by using 2 suture anchors and 2 Endobuttons for the treatment of high-grade AC joint dislocation. The purpose of our study was to analyze the clinical and radiographic outcomes of AC joint dislocations (Rockwood type III to V) with the anchor moored positioning technique.

Methods

The study protocol and consent form were approved by the hospital institutional review board. All patients provided written informed consent before participating in the study.

Patients

The study was conducted at the Changshu Hospital Affiliated to Nanjing University of Chinese Medicine, Jiangsu, China. Criteria for surgery were (1) Rockwood type Ⅲ to V AC joint dislocation, (2) other concomitant injuries in the ipsilateral upper limb, such as fractures or rotator cuff tears, were excluded, (3) patients aged 18-70 years, (4) the duration between joint injury and surgical treatment less than 2 weeks. Consequently, we retrospectively reviewed the medical records of 60 patients of AC joint dislocation between April 2014 and June 2016. 8 patients did not fulfill the criteria and 4 patients were lost to follow-up between 6 and 12 months, the final clinical trial involved 48 patients (34 men and 14 women, 26 left and 22 right) with AC dislocations by TACCR and TAACR method for the treatment of high-grade AC joint dislocation. (Table I). The diagnoses were confirmed with preoperative radiographs (anteroposterior and axillary views). All operations were performed by the same experienced surgeons.

Anchor moored positioning technique

The operative techniques were shown in Fig. 1–A through 1–D. The operation was performed under brachial plexus anesthesia with the patient in the beach-chair position. A transverse incision of approximately 5 cm in length was made at the distal clavicle to expose the AC joint (Fig. 2-A). And then the cartilage disc was removed. A vertical incision of approximately 3 cm in length was made from the lowest border of the clavicle to the coracoid process (Fig. 2-A). Then a tunnel was drilled with a 4.5-mm drill-bit from superior to inferior through both cortices of coracoid process. The inferior hole of the coracoid tunnel should be at central portion of the coracoid base. The first Ethibond suture was passed through the medial 2 holes of the Endobutton (12mm*4mm, Smith & Nephew Inc., Andover, MA, USA) and the second Ethibond suture was passed through another 2 holes (Fig. 2-B). Both Ethibond sutures were attached with traction sutures. With the help of the traction suture, the Endobutton was passed through the coracoid tunnel and was fixed at the horizontal position close to the coracoid base. A 2.0 mm Kirschner wire was temporary inserted from acromion to the distal clavicle to maintain anatomic reduction of the AC joint. Then a same clavicular tunnel was drilled with a 4.5-mm drill-bit at the lateral 1/5 position of the clavicle. The 2 Ethibond sutures were then pulled through the clavicular tunnel with the use of traction sutures and were tied on the second Endobutton. A 3.5 mm suture anchor (TwinFix Ti 3.5mm, Smith & Nephew Inc., Andover, MA, USA) was inserted approximately 1.0 cm near the coracoid tunnel into the base of the coracoid. A 1.5 mm tunnel was drilled approximately 1.5cm near the clavicular tunnel on the distal clavicle to pass the suture of TwinFix anchor and tied on the clavicle to reconstruct the trapezoid ligament. The surgeons then removed the 2.0 mm Kirschner wire and inserted another 3.5 mm TwinFix suture anchor vertically into the acromion. Another new 1.5 mm tunnel was sagittally drilled on the distal clavicle to pass the suture of TwinFix anchor and tied on the clavicle to reconstruct the AC ligaments. The ruputured AC and CC liagaments were repaired with absorbable sutures. The surgeons then checked the stabilization of the AC joint by testing passive shoulder motion and used a mobile C-arm to confirm the restoration.

Postoperative treatment

The injured arm was kept stable with a triangular sling for 1–2 weeks after the operation. Active hand and elbow movements were encouraged immediately after surgery, and passive exercises including abduction, lifting and circling of the shoulder were initiated 3 days after the operation. The patients were allowed to perform active progressively range of motion exercises of the shoulder after 4 weeks postoperatively. Progressive resistance exercises and weight training exercises were encouraged after 2 months postoperatively. After 6 months, the patients are allowed to back to normal activities.

Functional outcome and radiographic measures

The clinical and radiologic follow-up was at 1, 3, 6, 12 and 24 months after the operation. The visual analog scale (VAS), Constant scores [12] and American Shoulder and Elbow Surgeons (ASES) scores [13] were used as the clinical assessments for shoulder function. Radiographs were performed 2 days after surgery and at each follow-up. Anteroposterior radiographs for the bilateral AC joints and axillary radiographs for the injured side were collected. All radiographic measurements were made using the Picture Archiving and Communications System (GE Healthcare, Chicago, IL, USA). We measured the coracoclavicular (CC) vertical distance (CCD) on the preoperative and postoperative x-rays. The CCD was the vertical distance between the top-most border of coracoid and the lowest border of the clavicle. We compared the CCD of the injured and uninjured sides and defined CCD ratio as $(CCD_{in}-CCD_{un})/CCD_{un}*100\%$. We also measured the clavicular length (CL), which was the length from the medial border of the clavicle to the lateral border, the distance from the lateral border of the clavicle to the center of clavicle bone tunnel (CTD) and defined the clavicular tunnel ratio (CTR) as CTD/CL*100%. The angle between the two midlines of the clavicle bone tunnel and the coracoid bone tunnel (CCα) were also mesdured on the anteroposterior x-ray (Fig. 3).

Statistical analysis

The measurement data were presented as the means ± standard deviation. The CCD, CCD ratio and CL were compared with unpaired Student t test. The functional scores and radiographic differences between preoperative and postoperative results were compared with the paired Student t test and Wilcoxon signed rank test. Statistical analyses were performed using SPSS 22.0 software (IBM, Armonk, NY, USA). $P < .05$ was considered statistically significant.

Results

The study consisted of 48 patients with a mean age of 49 ± 13 years (range, 25-68 years). Most of the patients were men (n=34, 70.8%). The average duration between joint injury and surgical treatment was 4 ± 2 days (range, 2-9 days). The patients were classified as Rockwood type III (n =28), IV (n=3) and V (n=17). The causes of injury included 24 traffic accidents, 16 falls, 5 sports injuries and 3 biking injuries. The mean follow-up was 34 ± 7 months (range, 24-46 months). (Table I)

Preoperative and postoperative functional outcome data were shown in Table II and Fig. 4. The mean VAS decreased from 5 ± 1.6 preoperatively to 2 ± 0.7 at 1 month, 0 ± 0.4 at 12months and 0 ± 0.2 at 24 months ($P < .001$). (Fig. 4-A) The Constant scores improved from 43 ± 12 preoperatively to 60 ± 9 at 1 month, 95 ± 3 at 12months and 96 ± 3 at 24 months ($P < .001$). ASES scores also showed significant advancements from 44 ± 10 preoperatively to 61 ± 8 at 1 month, 95 ± 3 at 12months and 97 ± 3 at 24 months postoperatively ($P < .001$). (Fig. 4-B)

Meanwhile, we also collected the radiographic outcome data (Table II and Fig. 4-C through 4-D). The coracoclavicular distance (CCD) significantly decreased from 15 ± 5.9 mm preoperatively to 8 ± 2.7 mm postoperatively. (Fig. 4-C) We calculated CCD ratio as (CCD_{in}-CCD_{un}) /CCD_{un}*100% and found the average ratio was 90.1% preoperatively and -2.4% postoperatively ($P < .001$). The CCD ratio increased from 1.2% at 1 month to 2.4% at 24 months postoperatively which meant the CCD of the injured side had a slight increase after several months postoperatively. (Fig. 4-D) The mean clavicular length (CL) was 136 ± 21.5 mm and the mean distance from the lateral border of the clavicle to the center of bone tunnel (CTD) was 26 ± 6.8 mm. We calculated the clavicular tunnel ratio (CTR) as CTD/CL*100% and found the average ratio was 19.0%. The CTR represented the accurate location of the clavicular tunnel on the clavicle. According to our results, we found the lateral 1/5 position of the clavicle would be a better choice for the clavicular tunnel. We measured the angle between the two midlines of the clavicle bone tunnel and the coracoid bone tunnel (CCα) and found the mean CCα angle was 8.2 °. The ideal angle would be close to 0 °, which means the 2 tunnels were on a straight line on the coronal and sagittal plane. There would be no cutting stress to the Ethibond suture in an ideal position.

We found loss of reduction occurred in 1 patient (2.1%), which occurred in a 41-year-old man (Fig. 5-A through 5-C). We examined the anteroposterior radiograph of the shoulder 2 days postoperatively and found the CCD decreased from 17.9 mm to 8.2 mm. But the AC joint dislocation happened again at 3 months follow-up and the CCD increased to 16.5mm. The CCα was 22° and the cutting stress to the Ethibond suture might be the cause of the failure. Although the reduction was lost, the VAS, Constant scores and ASES scores still improved at each follow-up.

The total clinical result of the patients was satisfactory, with no patient had complication as clavicular fracture, coracoid fracture, neurovascular injuries or infection.

Discussion

Several researches demonstrated that the AC joint was maintained by the two most important ligaments, the AC ligaments and the CC ligaments [6,14]. Most of the reported studies focused on the reconstruction of the CC ligaments, which consisted of the trapezoid ligament and the conoid ligament [6,10,11]. The truly anatomic reconstruction of the trapezoid ligament and the conoid ligament might successfully restore the stabilization of the AC joint. Rigid fixation techniques like Kirschner wires, screws and clavicular hook plates could not restore the anatomic structure of the CC and AC ligaments and were always required a secondary operation [15]. The Endobutton was first used for the reconstruction of the CC ligaments in 2007 and showed a reliable result for the treatment of AC joint dislocation [16]. Also, the double Endobutton technique showed less pain, less recurrent dislocation and more adequate structural properties than an allogenic graft construct [17].

In the present study, we described a new technique named anchor moored positioning technique by using 2 suture anchors and 2 Endobutton devices for the treatment of AC joint dislocation. We thought the clavicle as the boat and used the anchor moored positioning technique to maintain the clavicle (Fig. 6-A through 6-C). The bow of the clavicle was fixed by the AC ligaments and CC ligaments (Fig. 6-A) and the stern of the clavicle was fixed by the sternoclaviculare ligaments. The AC and CC ligaments act as two orthogonal anchor ropes, when the anchor ropes were broken the clavicle was unstable. We used two orthogonal TwinFix suture anchors to fix the bow of the clavicle like two bow anchors (Fig. 6-B through 6-C). To our knowledge, this study represented a new and stable technique on TACCR and TAACR treatment with a mean follow-up of 34 months. There were several reasons for the encouraging radiographic results. First, the Bi-directional fixations of the AC joint both vertically and horizontally provided a strong stabilization. The truly anatomic CC ligaments reconstruction (TACCR) by using 2 Endobutton devices and 1 TwinFix suture anchor provided a vertical stability and the truly anatomic AC ligaments reconstruction (TAACR) by using 1 TwinFix suture anchor provided a horizontal stability. Second, the position of the clavicular tunnel and the coracoid tunnel needed accurate location. The loadings on the Ethibond sutures may be related to the tunnel placement [18]. The ratio of the distance from the lateral border of the clavicle to the trapezoid ligament center to clavicular length (CL) was 17.6%, and the ratio of the distance from the lateral border of the clavicle to the conoid ligament center to clavicular length (CL) was 23.8% in one anatomic study [19]. In another study, the ratios were 15.6% and 25.5% in Chinese population [20]. In our study, we calculated the mean clavicular tunnel ratio (CTR) was 19.0%. The results support the lateral 1/5 position of the clavicle would be a better choice for the clavicular tunnel which locates inside the anatomic proper attachment of the CC ligaments. The position of the coracoid tunnel should be located at the base of the coracoid and should be in the center of the coracoid to avoid the avulsion fractures. Third, the angle between the midlines of the clavicle bone tunnel and the coracoid bone tunnel (CCα) should be close to 0°. A study reported a lower angle seemed to achieve better clinical outcomes [21]. The direction of the clavicular tunnel and the coracoid tunnel should be strictly monitored [21,22]. In our study, we found the mean CCα angle was 8.2 °. The ideal angle would be close to 0 °. There would be no cutting stress to the Ethibond suture by the 2 bone tunnels. Fourth, former studies usually used only 1 fixation at the coracoid by 1 Endobutton. We used 1 Endobutton and 1 TwinFix suture anchor at the coracoid to make a stable fixation. The use of suture anchors for coracoclavicular fixation was reported to be an easy and reliable method of anatomical fixation and could reduce the risk of neurovascular injury and the surgical time [23,24]. The first anchor should be inserted into base of the coracoid to avoid the pulling out from the coracoid. The second anchor was inserted into the acromion and the sutures were tied on the superior surface of the clavicle to prevent both superoinferior and anteroposterior displacement. This study had several limitations. First, a relatively small sample size of 48 was included and the limited statistical power meant some important predictive factors like CCD ratio, CTR and CCα could not be conclusively tested. A larger patient collective could indicate more convincing evidence. Second, this retrospective study had no control group with other reconstruction techniques.

Third, our follow-up with good clinical outcomes was not sufficient. Long-term follow-up was needed to test and verify the functional outcomes.

Conclusions

In conclusion, the present study shows that TACCR and TAACR by suture anchor and Endobutton fixation represents a new, safe and reliable method for treatment of acromioclavicular joint dislocation. Larger prospective, randomized, controlled studies will be needed to demonstrate this statement.

Abbreviations

AC: Acromioclavicular joint; VAS: visual analog scale; CS: Constant scores; ASES: American Shoulder and Elbow Surgeons.

Declarations

Acknowledgments

Not applicable.

Funding

None.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available because they contain patients' personal information, but are available from the corresponding author on reasonable request.

Authors' contribution

Pu Ying wrote the paper and analyzed the data. Yingchao Shen collected the patients' information. Qiang Wang designed the study. All authors read and approved the final manuscript.

Consent for publication

Not applicable.

Competing interests

All authors declare that they have no competing interests.

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Tables

Table I Patient characteristics

Variable	Mean±SD(range) / No.(%)
Age (yr)	49 ± 13 (25-68)
Sex	
Male	34 (70.8)
Female	14 (29.2)
Injured Side	
Left	26 (54.2)
Right	22 (45.8)
Interval to surgery (d)	4 ± 2 (2-9)
Mechanism of injury	
Car accident	24 (50.0)
Fall	16 (33.3)
Sport	5 (10.4)
Biking	3 (6.3)
Rockwood type	
III	28 (58.3)
IV	3 (6.3)
V	17 (35.4)
Follow-up (mo)	34 ± 7 (24-46)

SD, standard deviation

Table II Preoperative and postoperative functional outcome and radiographic data

Variables	Preoperative	Postoperative	1 mo	3 mo	6 mo	12 mo	24 mo	*P* value
Functional outcomes								
VAS pain score	5 ± 1.6	-	2 ± 0.7	2 ± 0.6	1 ± 0.5	0 ± 0.4	0 ± 0.2	▯.001▯
Constant score	43 ± 12	-	60 ± 9	78 ± 7	87 ± 6	95 ± 3	96 ± 3	▯.001▯
ASES score	44 ± 10	-	61 ± 8	79 ± 7	88 ± 4	95 ± 3	97 ± 3	▯.001▯
Radiographic outcomes								
CCD, mm	15 ± 5.9	8 ± 2.7	8 ± 1.9	8 ± 1.2	8 ± 1.0	8 ± 0.9	8 ± 0.9	▯.001▯
CCD ratio (%)	90.1	-2.4	1.2	1.2	2.4	2.4	2.4	▯.001▯
CL, mm	136 ± 21.5			136 ± 21.5				-
CTD, mm	-			26 ± 6.8				-
CTR (%)	-			19.0				-
CCα, °	-			8.2				-

*CCD= coracoclavicular distance, CCD ratio= (CCD_{in}-CCD_{un}) /CCD_{un}*100%, CL= clavicular length, CTD= clavicle tunnel distance, CTR= clavicular tunnel ratio= CTD/CL*100%, CCα=angle between clavicle tunnel and coracoid tunnel.▯Indicates a significant difference between the preoperative and postoperative population.

Figures

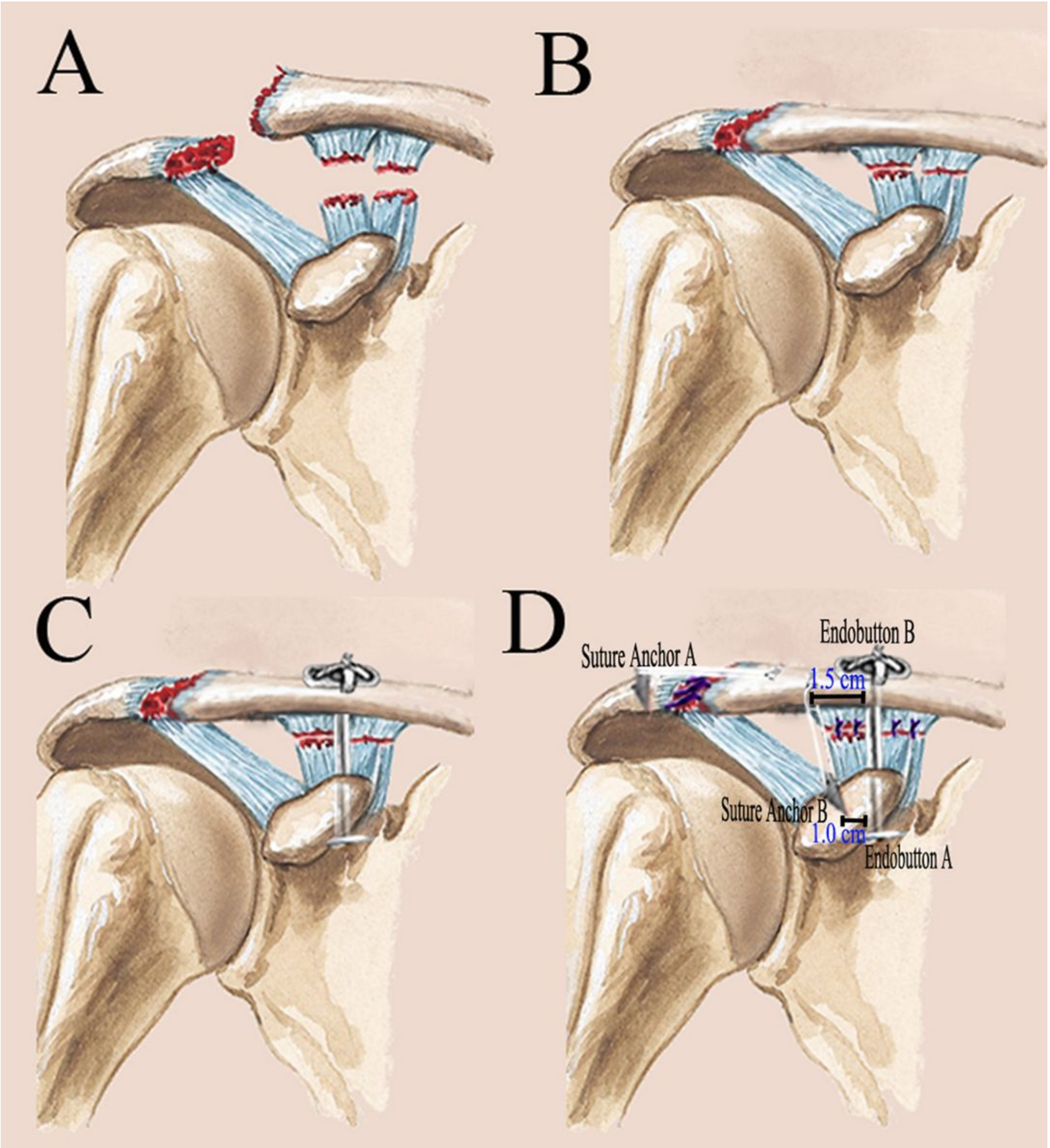

Figure 1

1-A through 1-D Illustrations and photographs showing anchor moored positioning technique for truly anatomic coracoclavicular (CC) ligaments reconstruction (TACCR) and truly anatomic acromioclavicular (AC) ligaments reconstruction (TAACR). Fig.1–A Acromioclavicular joint dislocation. Fig.1-B Restoration of acromioclavicular joint. Fig.1-C The two Endobuttons are placed under the coracoid base and above the clavicle separately. Fig.1-D The two TwinFix suture anchors are inserted into the acromion and coracoid separately.

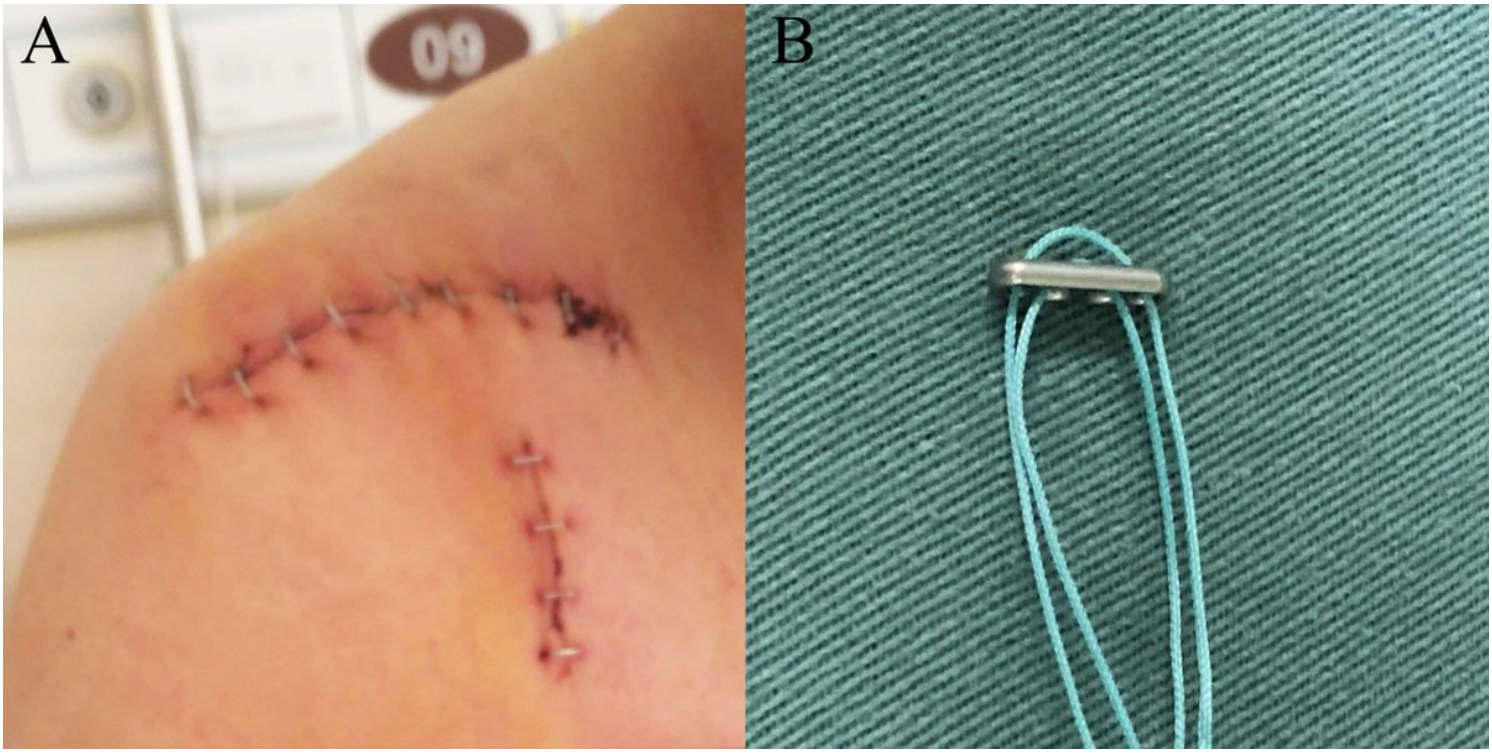

Figure 2

Photograph shows the transverse incision and the vertical incision of the surgery. Fig. 2-B Photograph shows the pass way of two Ethibond sutures and the Endobutton.

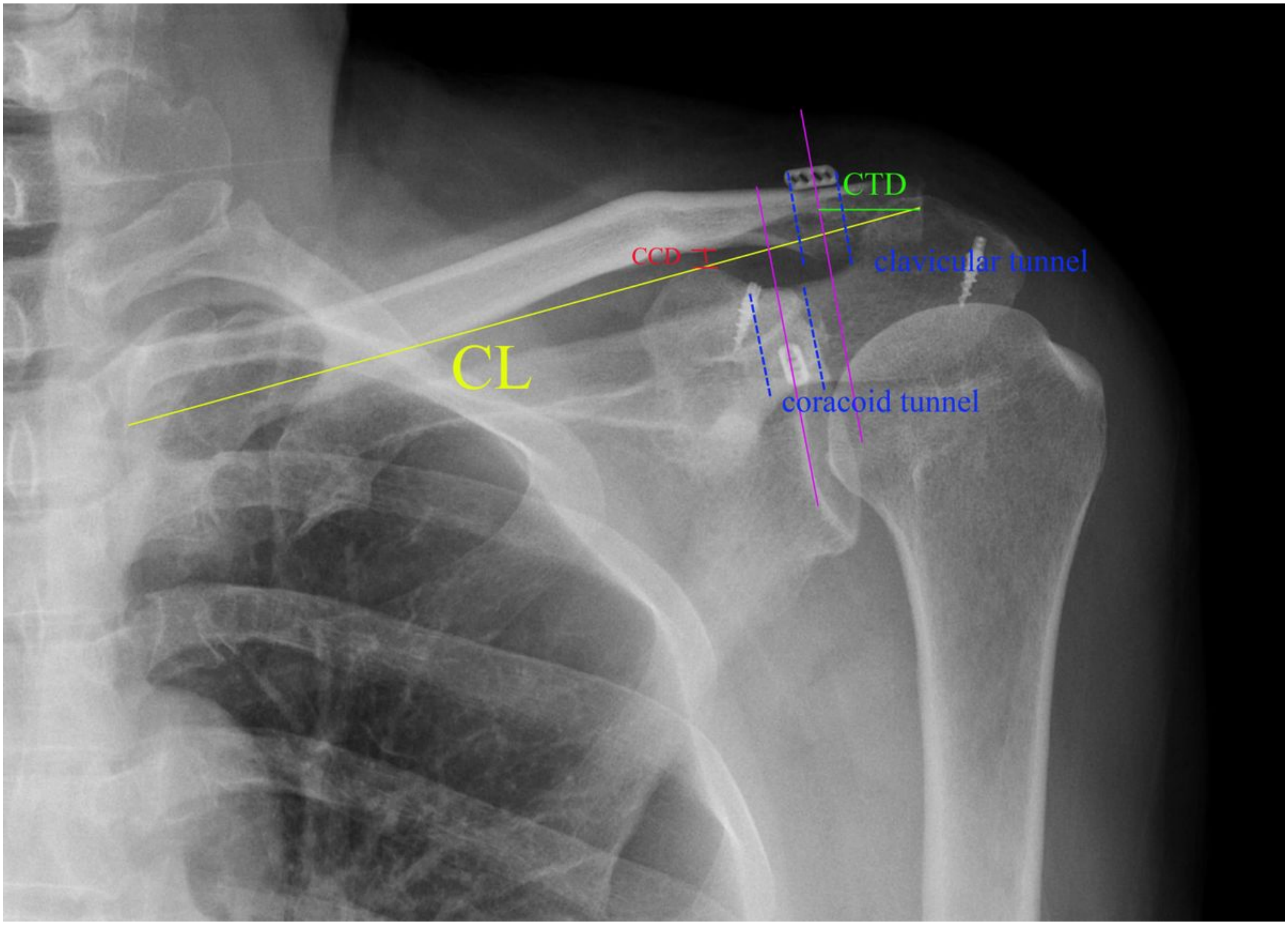

Figure 3

Illustration and radiograph showing the main radiographic measures, including the clavicular length (CL) (a yellow solid line is drawn from the medial border of the clavicle to the lateral border), the coracoclavicular vertical distance (CCD) (a red solid line is drawn between the top-most border of coracoid and the lowest border of the clavicle), the clavicular and coracoid tunnels (blue dotted lines), the distance from the lateral border of the clavicle to the center of bone tunnel (CTD) (green solid line), and the angle between the two midlines of the clavicle bone tunnel and the coracoid bone tunnel (CCα) (the angle between two purple solid line).

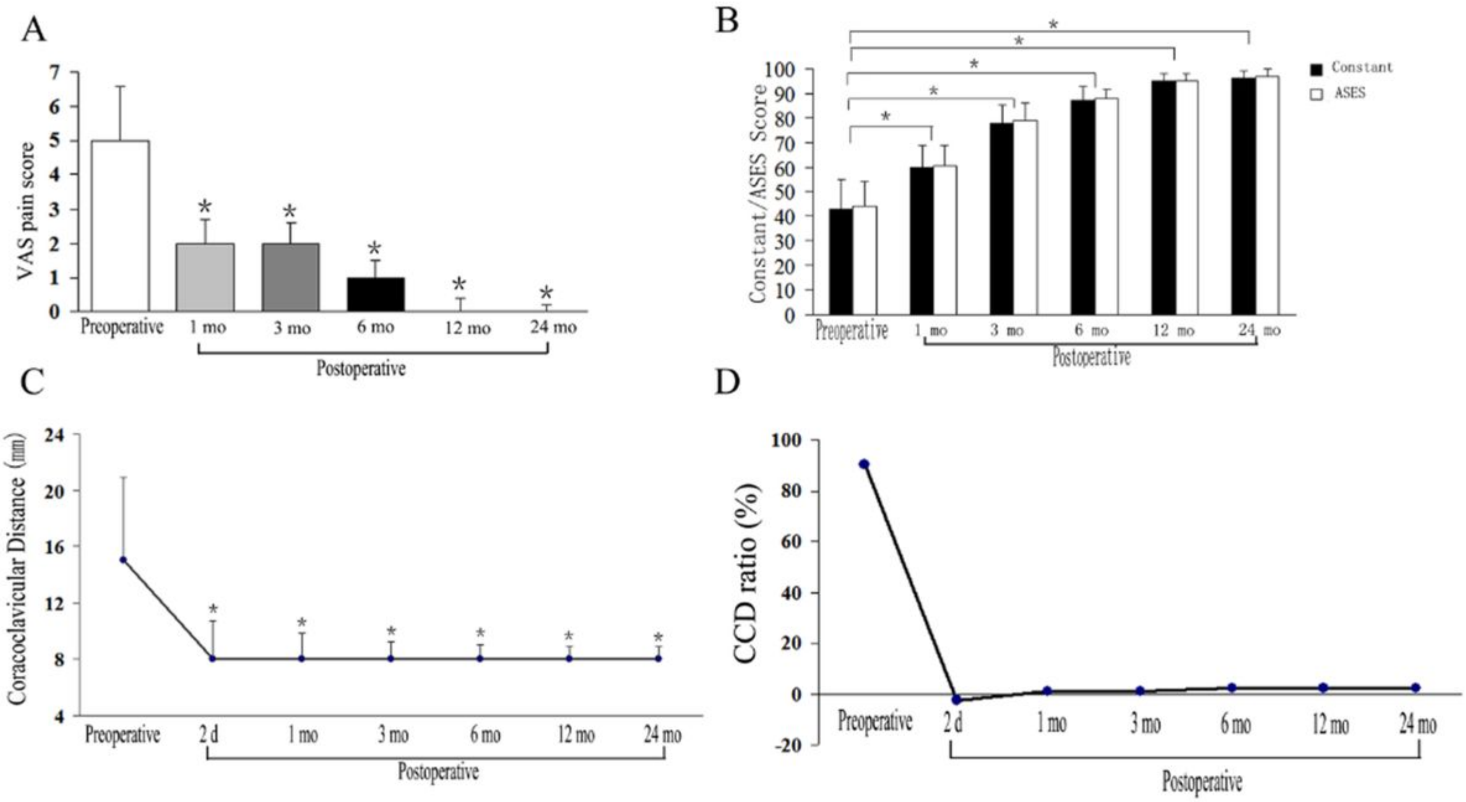

Figure 4

4-A through 4-D Illustration showing preoperative and postoperative functional outcome and radiographic data. Fig. 4-A The mean VAS showed significant reduction postoperatively. Fig. 4-B The mean Constant and ASES scores showed significant improvement postoperatively. Fig. 4-C, 4-D The CCD and CCD ratio showed significant reduction postoperatively. CCD= coracoclavicular distance, CCD ratio= (CCDin-CCDun) /CCDun*100%.Indicates a significant difference between the preoperative and postoperative population.

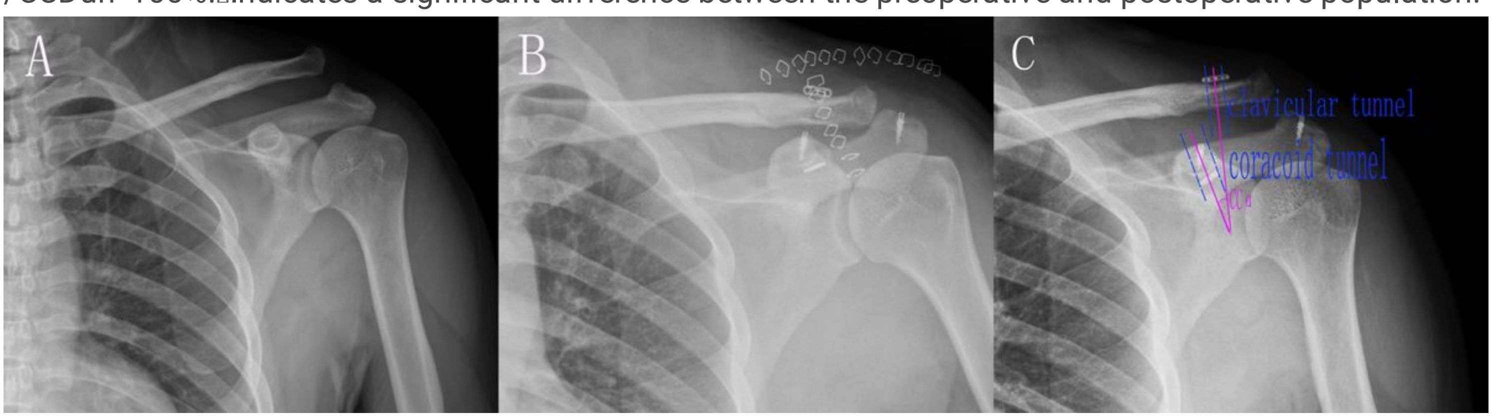

Figure 5

5-A through 5-C Illustration and radiograph showing loss of reduction occurred in a 41-year-old man which was the only failure of all the patients. Fig. 5-A The acromioclavicular joint dislocation on the preoperative anteroposterior radiograph. Fig. 5-B Anteroposterior radiograph made 2 days postoperatively. Fig. 5-C Anteroposterior radiograph made 2 months postoperatively. The clavicular and coracoid tunnels (blue dotted lines), and the angle between the two midlines of the 2 tunnels (CCα) (the angle between two purple solid line) were signed.

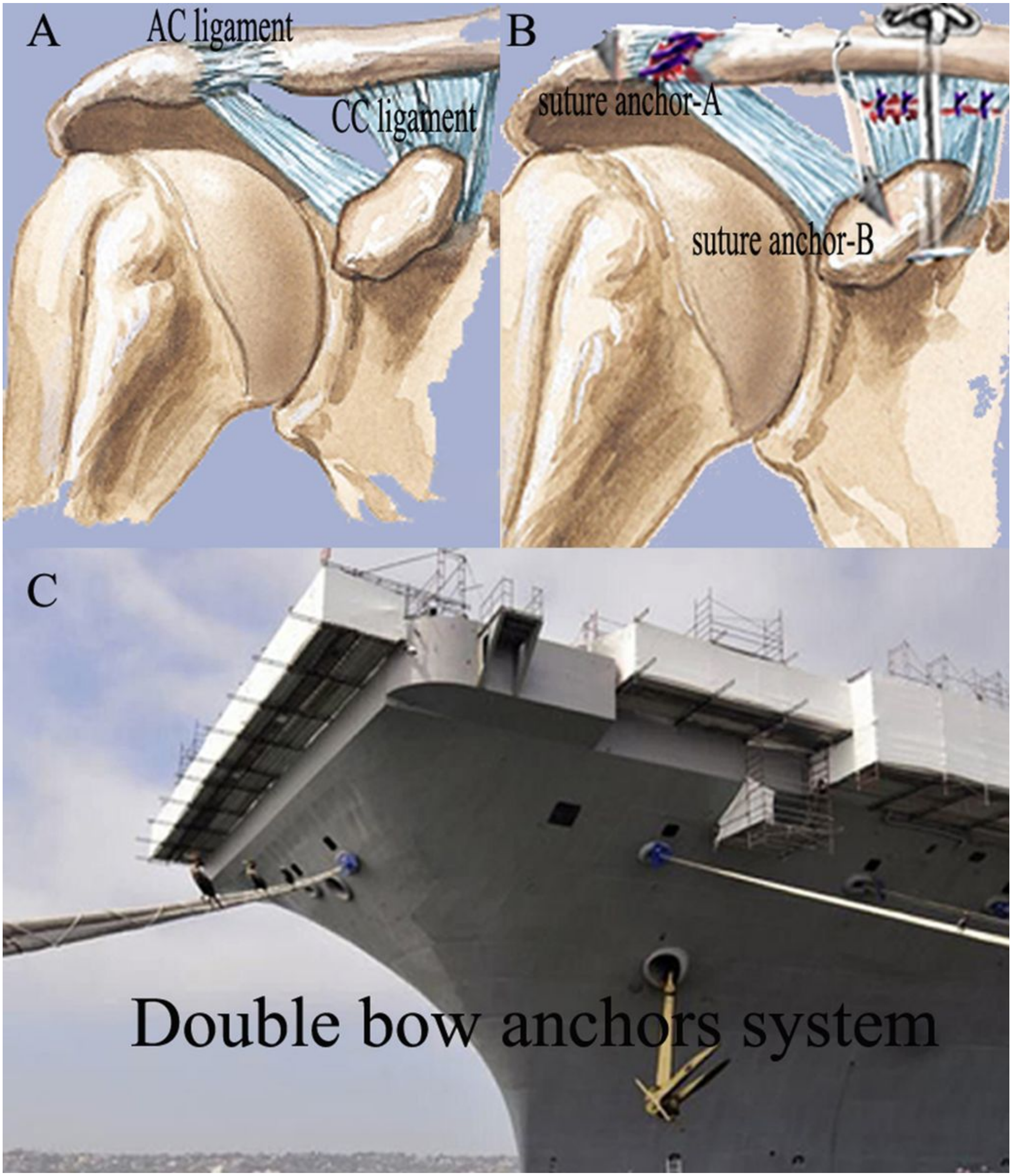

Figure 6

6-A through 6-C Illustration and radiograph showing anchor moored positioning technique based on double bow anchors system. Fig. 6-A The fore of the clavicle was fixed by the AC ligaments and CC ligaments. Fig. 6-B Two orthogonal TwinFix suture anchors was used to fix the fore of the clavicle like two bow anchors. Fig. 6-C The Double bow anchors system of Aircraft carrier Karl Vincent.