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PII: S2666-6391(21)00064-X
DOI: https://doi.org/10.1016/j.xrrt.2021.06.007
Reference: XRRT 62

To appear in: JSES Reviews, Reports, and Techniques

Received Date: 21 April 2021
Revised Date: 9 June 2021
Accepted Date: 29 June 2021

Please cite this article as: Panagopoulos A, Solou K, Nicolaides M, Triantafyllopoulos IK, Kouzelis A, Kokkalis ZT, Coracoclavicular fixation techniques for Neer IIb and ‘extra-lateral’ fractures of the distal clavicle: A systematic review, JSES Reviews, Reports, and Techniques (2021), doi: https://doi.org/10.1016/j.xrrt.2021.06.007.

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Coracoclavicular fixation techniques for Neer IIb and ‘extra-lateral’ fractures of the distal clavicle: A systematic review

Short title: Coracoclavicular fixation for Type IIb/c distal clavicle fractures

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Disclaimers:

Funding: No funding was disclosed by the author(s).

Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent was obtained from all individual participants included in the study.

Institutional review board approval was not required for this review.
Coracoclavicular fixation techniques for Neer IIb and ‘extra-lateral’ fractures of the distal clavicle: A systematic review

Coracoclavicular fixation for Type IIb/c distal clavicle fractures

Abstract

Background

Unstable ‘extra-lateral’ fractures of the distal clavicle (lateral to the coracoclavicular ligaments) are not distinguished in the Neer classification system and are commonly included with Neer IIb fractures. In the literature, there is no optimal surgical technique for managing unstable fractures of the distal clavicle, nonetheless for unique ‘extra-lateral’ patterns. The aim of this study is to evaluate the effectiveness and safety of existing coracoclavicular fixation techniques for managing unstable Neer IIb and extra-lateral (IIc) fractures of the distal clavicle.

Methods

We performed a systematic search of the literature to capture all studies evaluating the safety and effectiveness of existing coracoclavicular loop techniques for unstable Neer IIb and extra-lateral (IIc) fractures of the distal clavicle. We searched the PubMed (Medline and PubMed Central), Scopus, Web of Science, Google Scholar, and Cochrane Central Register of Controlled Trials electronic databases to retrieve studies published between January 2000 and November 2020. Our study was guided by a prospectively developed protocol and reported in accordance with the latest PRISMA guidelines.

Results

Our database search yielded a total of 564 records, out of which 21 were deemed appropriate for inclusion in our qualitative synthesis. The total number of reported IIb/c fractures managed with a coracoclavicular stabilization technique in all studies was 421. In total, 139 (33%) patients received arthroscopic assisted treatment, and 282 (67%) patients were managed with open coracoclavicular stabilization. The reported clinical results were very good to excellent in most
studies, whereas the overall major and minor complication rate was 2.6% and 12.8%, respectively. Major complications were more frequent in arthroscopic assisted techniques (4.3%) compared to open (1.8%).

Conclusion

The present systematic review of coracoclavicular stabilization techniques for unstable Neer IIb and extra-lateral fractures of the distal clavicle demonstrates promising clinical outcomes, including effectiveness and safety. We support the previously proposed modification of the Neer classification to include this unique type of unstable extra-lateral fracture (type IIc) to allow for targeted surgical management.

Level of Evidence: IV

Keywords: unstable extra-lateral distal clavicle fractures, Neer type IIb, Neer type IIc, coracoclavicular fixation

Clavicle fractures account for 2.6-4% of all adult fractures, with the distal third being involved in 10-30% of cases. Given that up to 50% of distal clavicle fractures are displaced, and 10-44% can lead to symptomatic nonunion or malunion, precise classification is paramount to guide surgical management. Distal clavicle fractures are usually classified into 3 types according to Neer’s classification – a system that has been widely used since the 1960s. Type I is an undisplaced fracture lateral to coracoclavicular ligaments, type IIa is located medial to coracoclavicular ligaments, type IIb between the coracoclavicular ligaments, and type III is an intra-articular fracture. Graig later added types VI (epiphyseal fractures in children) and V (avulsed inferior cortical fragment attached to the coracoclavicular ligaments). However, these classifications do not include small fractures lateral to torn coracoclavicular ligaments with displacement of medial clavicle (‘extra-lateral’ type). Cho et al were the first to suggest classifying these as type IIc distal
clavicle fractures, whereas they also proposed that type II
d can replace type V. Nonetheless, Neer
types IIa/IIb and V (or Cho types IIb to IIId) are usually unstable and indicative of internal fixation.

In the literature, there is no optimal surgical technique for managing unstable fractures of
the distal clavicle, nonetheless for unique patterns such as IIc. Several surgical techniques have
been described and are generally distinguished in two main categories; either rigid internal fixation
(T-, locking-, hook-, double-plates, coracoclavicular or acromioclavicular screws, and
intramedullary fixation), or flexible osteosynthesis with or without arthroscopic assistance (tension
band wiring, sutures and bone anchors, tapes, cortical buttons, and synthetic grafts or allografts),
as well as various combinations of these techniques. The evidence is even more vague for extra-
lateral (Cho IIc) fractures, where the lateral clavicle fragment being relatively small, is not always
amenable to hold traditional hardware. Levy et al were the first to report on fractures classified as
Type IIc – out of 48 patients enrolled in the study, 30 were treated with simple coracoclavicular
suture stabilization and the rest underwent plate fixation and coracoclavicular augmentation – and
conclude that there is a need for modifying the original Neer’s classification to include type IIc
fractures.

The aim of this study is to perform a systematic search of the literature to identify all studies
evaluating the effectiveness and safety of coracoclavicular fixation techniques for managing Neer
IIb and extra-lateral (Cho IIc) distal clavicle fractures in skeletally mature patients.

Methods

We performed a systematic review of the literature in accordance with the Preferred Reporting
Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement of 2009 and the
Cochrane Handbook for Systematic Reviews of Interventions. Our study was guided by a
prospectively developed protocol outlining our methodology.

Inclusion criteria

We aimed to capture randomized or quasi-randomized controlled trials, cohort or case-control
studies and case-series, evaluating coracoclavicular surgical fixation techniques for the
management of isolated distal clavicle fractures in skeletally mature patients. Studies were included only if fractures were either between the coracoclavicular ligaments with conoid being torn and trapezoid intact (Neer IIb), or lateral to the coracoclavicular ligaments with both being torn (extra-lateral, or Cho IIc). Studies were only reviewed if the published manuscript was in English, French, German and Spanish. We included only studies that reported both efficacy and safety; measured by objective clinical scores and complication rates, respectively. We excluded any studies which did not meet the above criteria, studies on animals and studies that reported on less than 5 fractures. Furthermore, we excluded studies which recruited solely participants of less than 16 years of age and studies that evaluated other treatment modalities (e.g. hook plates, locking or other types of plates, transacromial or intramedullary fixation). We did not exclude comparative studies of two or more different surgical modalities, given that at least one was a coracoclavicular stabilization technique.

**Study identification and selection**

We performed a comprehensive search of the literature on 15th of November 2020. We searched the PubMed (Medline and PubMed Central), Scopus, Web of Science, Google Scholar, and Cochrane Central Register of Controlled Trials (CENTRAL) electronic databases to retrieve studies published between January 2000 and November 2020. Our search strategy included a combination of keyword terms including ‘distal AND clavicle AND fracture’, ‘lateral AND clavicle AND fracture’. We supplemented the electronic database search by screening the bibliographies of relevant published studies and searching online registries for ongoing clinical trials (Clinical Trials Gov., ISRCTN, EU Clinical Trial Register).

We exported all captured studies into a reference manager library (EndNote X9) and removed all duplicates. The results were screened by two independent reviewers at two levels: title-abstract and full text screening. We resolved any discrepancies during title-abstract screening stage by including the article by default, and during full text screening by discussion and senior author consensus.

**Data collection**

All relevant data were extracted using piloted forms and exported to a digital spreadsheet (Microsoft® Excel). Data extraction was performed by two independent reviewers. We classified
extraction fields into four main categories: study characteristics and methods, population demographics, surgical intervention, and outcomes and results. Any discrepancies in the extracted data were resolved by thoroughly inspecting the manuscripts during reviewer meetings.

**Risk of bias assessment**

Our review did not capture any randomized controlled trials (RCTs), thus the ROBINS-I tool for assessing risk of bias in non-randomized studies was used. We stratified the risk for confounding, selection of participants into the study, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, selection of the reported result and overall bias. Overall risk of bias was considered low risk if all domains were determined at low risk; moderate risk if at least one of the domains was determined at moderate risk but none as serious; serious risk if at least one of the domains was determined at serious risk but none as critical; and critical risk if at least one of the domains was determined at critical risk.

**Data synthesis and analysis**

We synthesized all studies qualitatively using descriptive statistics, where applicable. We categorized the reported surgical techniques in 2 types: arthroscopic assisted coracoclavicular stabilization with buttons, with or without interfragmentary sutures or tension band, and open coracoclavicular stabilization with buttons, subcoracoid sutures, mersilene tapes, cables or suture anchors. We reported findings for two main outcomes: effectiveness and safety. Effectiveness was evaluated by synthesizing and summarizing data from objective clinical scores as reported by the included studies. Safety was assessed by calculating the frequency of complications – we categorized complications into major (new fracture, implant failure, nonunion, coracoid fracture, deep infection) and minor (delayed union, hardware irritation, superficial infection, scar problems, mild osteolysis or button subsidence, malunion, slight loss of reduction, adhesive capsulitis).

**Results**
Our database search following duplicate removal yielded a total of 564 records. We retrieved the full texts of 98 manuscripts to screen in their entity, whereas 466 records were excluded (Figure 1). Only 21 were deemed appropriate for inclusion in our qualitative synthesis (Table 1). The most common reason for exclusion was studies reporting data on management methods other than coracoclavicular surgical fixation techniques \( (n = 49) \) (Figure 1).

**Characteristics of included studies**

The total number of reported Neer IIb/Cho IIc distal clavicle fractures managed with a coracoclavicular stabilization technique in all studies was 421, ranging from 6 to 45 patients. In total, 139 (33%) patients received arthroscopic assisted treatment and 282 (67%) patients open techniques of coracoclavicular stabilization. There were 3 retrospective comparative studies comparing (a) arthroscopic coracoclavicular stabilization with buttons versus hook plate versus locking plate,\(^{16}\) (b) coracoclavicular stabilization with mersilene tapes versus hook plate,\(^{17}\) and (c) coracoclavicular stabilization with suture loop and transosseous sutures versus locking plate.\(^{12}\) In these three reports, only patients who underwent surgery with coracoclavicular stabilization techniques were included in our data synthesis. The mean age of patients was 39.1 years (32-55 years), the male to female ratio 3:1 and the mean follow-up period 30.2 months (4.6-57.3 months).

Key characteristics of the 21 included studies are summarized in Table 1.

We categorized the reported surgical techniques in 2 general types: arthroscopic assisted coracoclavicular stabilization with buttons (Endobutton, TightRope, Zip Tight, Dog bone), with or without interfragmentary sutures/wires or with additional AC joint fixation with KW or tension band (8 studies), and open coracoclavicular stabilization with buttons, subcoracoid sutures, mersilene tapes, cables or suture anchors (13 studies) (Table 1). One arthroscopic study utilized an artificial ligament stabilized with a washer in the clavicle\(^{18}\) and one open technique study a tendon allograft stabilized with a peek screw in the clavicle.\(^{19}\) Supplementary internal fixation in addition to CC stabilization was used in 6 out of 13 open technique studies in the form of interfragmentary sutures,\(^{12, 20, 21}\) interfragmentary wire,\(^{22}\) AC joint tension band with sutures,\(^{23}\) or KW;\(^{24}\) and in 3 out of 8 arthroscopic studies using either interfragmentary sutures,\(^{25}\) AC joint fixation with KW,\(^{26}\) or fiberwire.\(^{27}\)

**Risk of bias assessment**
All studies were retrospective with a high or moderate ROBINS-I overall risk of bias assessment. The heterogeneity of the operative techniques and the different evaluation methods prohibited us from performing a meta-analysis. Thus, our systematic review has a low level of evidence (IV).

**Effectiveness**

Clinical results were reported with various clinical scores, including the Constant score (10 studies), ASES (5 studies), UCLA (6 studies), Oxford score (2 studies), DASH (4 studies), Karlsson’s criteria (1 study) and Modified Shoulder Rating Scale for Clavicle Fractures (1 study) (Table 2). Nine studies utilized more than one score for clinical evaluation. The reported clinical results were very good to excellent in almost all studies; for example, in 10 out of 11 studies utilizing the Constant score, the mean values at the last follow-up evaluation were over 90 points. In both arthroscopic and open techniques, the coracoclavicular stabilization with or without supplementary interfragmentary, or AC joint fixation, turned out to be an effective surgical technique.

**Safety**

The overall major complication rate was 2.6% (8 nonunions, 1 coracoid fracture, 1 fracture between clavicular holes and 1 cable breakage), whereas minor complications were present in 54 out of 421 patients (12.8%) (Table 2). More major complications were found in arthroscopic assisted techniques (6 out of 139 fractures; 4.3%) than the open ones (5 out of 282 fractures; 1.8%). In contrast, fewer minor complications were found in arthroscopic techniques (16 out of 139 fractures; 11.5%) compared to open techniques (54 out of 282 patients; 13.4%). There were no cases of neurovascular compromise or deep infection. Thirteen studies (62%) reported no major complications at all.

**Discussion**

The present systematic review of coracoclavicular stabilization techniques for Neer IIb and extra-lateral (IIc) fractures of the distal clavicle demonstrates acceptable effectiveness and safety. The
reported clinical results were very good to excellent in almost all studies and the overall complication rate was 2.6%.

Treatment for unstable distal clavicle fractures is controversial and numerous techniques have been applied, which are generally divided into five main categories: Hook plate, locking anatomic or T-plate, open or arthroscopic assisted coracoclavicular fixation, interfragmentary/intramedullary fixation and transacromial fixation with pins and/or tension band. The reported clinical outcomes and complication rates varied amongst different studies which have in general a retrospective design, a low level of evidence and a small number of reported cases. Boonard et al performed a systematic review and network metanalysis in 2018, comparing postoperative shoulder function and complication rates between various fixation methods to identify the most effective and safe fixation technique for unstable distal clavicle fractures.28 Among ten comparative studies (505 fractures) and one randomized-controlled trial (42 fractures), the Constant Murley scores for coracoclavicular fixation were significantly higher when compared to hook plate and tension band wiring. In contrast, a systematic review of eleven cohort studies (634 fractures), demonstrated no significant differences in the functional outcome and union rates between hook plate fixation, coracoclavicular stabilization, and locking plate fixation.29 However, hook plate fixation resulted in a higher Constant–Murley score compared with tension band wiring, but was also associated with a higher complication rate compared with coracoclavicular stabilization and the locking plate. Finally, Oh et al in a systematic review on Neer type II fractures found that the complication rate was significantly higher with the use of the hook plate (40.7%) or tension band wiring (20.0%), compared to coracoclavicular (4.8%), intramedullary (2.4%) and interfragmentary fixation (6.3%).11 A limitation of this study was the uncertainty of whether type II fractures were constituted of mainly type IIa or IIb patterns, as most included studies did not specify the type II subclassification.

Special attention is required for some specific complications following coracoclavicular button fixation, including migration, slippage, coracoid or clavicle erosion, and button subsidence though the tunnels. This can lead to re-dislocation of the proximal clavicle and loss of fracture reduction. A similar problem has been encountered with the use of these techniques in acromioclavicular joint dislocations.30 The aforementioned complications may be attributed to the mispositioning of the tunnels and the excessive tension of the paired button bearings, which
increase the force of slippage, especially when laid on the uneven face of the clavicle or the coracoid process. Furthermore, when the tension caused by the button on the clavicle or the coracoid process is too concentrated, this can lead to bone erosion. This phenomenon is usually encountered when a broad tunnel receives a button with a relatively small total area. Dog-ears, flat buttons and two-tail systems (triple buttons) can solve this problem by distributing the tension forces evenly.\textsuperscript{31, 32}

We find that precise interpretation of distal clavicle fracture patterns can guide the surgeon in choosing the most appropriate surgical technique, however, interpretation of unstable types (IIa, IIb, IIc and V) is inherently challenging.\textsuperscript{3-5, 10} Neer’s classification has been widely used over the past decades to classify these fractures, however, according to Bishop et al the interrater agreement is only fair for distal fragment size and type, moderate for stability and treatment approach, and slight for type IIb fractures.\textsuperscript{33} Similarly, Raurer et al found low inter- and intra-observer agreement levels exhibited in all three classification systems that were studied (Neer, OTA, Jäger/Breitner), by two specialist groups (surgeons and radiologists), suggesting that all such classification systems are far from perfect and, arguably, of limited value.\textsuperscript{34} More recently though, Cho et al suggested a new classification system that considers both fracture displacement and stability, in addition to fracture location.\textsuperscript{5} This classification system showed moderate interobserver (\(\kappa = 0.434\)) and substantial intra-observer (\(\kappa = 0.644\)) reliability, while also it is designed to guide surgeons in choosing the most appropriate treatment option and implant type for each type of fracture; for example, coracoclavicular or transacromial fixation for extra-lateral IIc fractures.

We agree with Cho et al\textsuperscript{5} and Levy et al\textsuperscript{12} that the interpretation of the small distal fragment is difficult and a modification of the Neer classification paramount to include this rare type of fracture. Of even greater importance is the selection of an appropriate fixation technique for these unstable extra-lateral fractures, as the lateral fragment is particularly small and usually unable to hold traditional hardware. Cho et al\textsuperscript{5} suggested coracoclavicular stabilization techniques or transacromial intramedullary fixation for this type of fractures, whereas others have suggested traditional hardware (locking plates) but with additional coracoclavicular augmentation.\textsuperscript{9, 35, 36}

The limitations of our systematic review lie with those of the included studies. All included studies were retrospective cohort, or case series, with a moderate to high risk of bias, deeming the level of evidence of our review as low. Furthermore, most studies only had a small sample size
and a short follow-up period. Lastly, although we aimed to synthesize our findings into two distinct fracture patterns (IIb and extra-lateral), this was not possible as most studies (20 out of 21) combined the two in their reported findings.

Conclusions

The present systematic review of coracoclavicular stabilization techniques for unstable Neer IIb and extra-lateral fractures of the distal clavicle demonstrates promising clinical outcomes, including effectiveness and safety. Treatment options for this type of fracture such as locking plate fixation, are limited due to their small size that cannot support firm internal fixation. Open or arthroscopic coracoclavicular loop techniques, augmented in some cases with interfragmentary sutures or tension band techniques seem to provide adequate fixation of the fracture with excellent clinical outcomes and a low complication rate. We support the previously proposed modification of the Neer classification to include this unique type of unstable extra-lateral fracture (type IIc) to allow for targeted surgical management.

References


Legends

**Figure 1:** PRISMA flow diagram of study selection.

**Table 1:** Summary of key characteristics of included studies that report data on Neer IIb/Cho IIc fractures managed with a coracoclavicular stabilization surgical technique. Shaded grey: Arthroscopic assisted coracoclavicular stabilization with buttons, with or without interfragmentary sutures or tension band; Non-shaded: Open coracoclavicular stabilization with buttons, subcoracoid sutures, mersilene tapes, cables or suture anchors.

**Table 2:** Efficacy and safety of coracoclavicular stabilization surgical techniques in Neer IIb/Cho IIc fractures.
<table>
<thead>
<tr>
<th>Author (Country)</th>
<th>Year</th>
<th>Study design</th>
<th>Neer IIB/Cho IIc</th>
<th>Mean age (years)</th>
<th>Male/female</th>
<th>Surgical technique</th>
<th>Follow up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chen et al.(^5) (Taiwan)</td>
<td>2002</td>
<td>Retrospective</td>
<td>11</td>
<td>37</td>
<td>8/3</td>
<td>CC stabilization with Mersilene tape and interfragmentary wire</td>
<td>27</td>
</tr>
<tr>
<td>Shin et al.(^2) (Korea)</td>
<td>2009</td>
<td>Retrospective</td>
<td>19</td>
<td>43.4</td>
<td>14/5</td>
<td>Two suture anchors fixation augmented with fragment suture tension band</td>
<td>4.6</td>
</tr>
<tr>
<td>Li et al.(^1) (China)</td>
<td>2011</td>
<td>Retrospective</td>
<td>29</td>
<td>34</td>
<td>21/8</td>
<td>Open CC stabilization with 2 titanium cables (drill hole in the coracoid)</td>
<td>32</td>
</tr>
<tr>
<td>Yang et al.(^3) (Taiwan)</td>
<td>2011</td>
<td>Retrospective</td>
<td>28</td>
<td>37.9</td>
<td>18/10</td>
<td>Open CC stabilization (mersilene tape)</td>
<td>57.3</td>
</tr>
<tr>
<td>Takase et al.(^4) (Japan)</td>
<td>2012</td>
<td>Retrospective</td>
<td>7</td>
<td>41.9</td>
<td>7/0</td>
<td>Arthroscopic CC stabilization with Endobutton and artificial ligament (+ washer in clavicle)</td>
<td>29</td>
</tr>
<tr>
<td>Motta et al.(^5) (Italy)</td>
<td>2014</td>
<td>Retrospective</td>
<td>10</td>
<td>32</td>
<td>10/0</td>
<td>Arthroscopic CC stabilization with TightRope</td>
<td>24</td>
</tr>
<tr>
<td>Chen et al.(^6) (Taiwan)</td>
<td>2014</td>
<td>Retrospective comparative</td>
<td>40</td>
<td>43.2</td>
<td>28/12</td>
<td>CC stabilization with Mersilene tape</td>
<td>38.2</td>
</tr>
<tr>
<td>Loriaut et al.(^7) (France)</td>
<td>2015</td>
<td>Retrospective</td>
<td>21</td>
<td>33</td>
<td>14/7</td>
<td>Arthroscopic CC stabilization with TightRope</td>
<td>35</td>
</tr>
<tr>
<td>Kanchanatawan et al.(^8) (Thailand)</td>
<td>2015</td>
<td>Retrospective</td>
<td>39</td>
<td>37.5</td>
<td>32/7</td>
<td>Modified CC stabilization with subcoracoid fiberwire sutures tight over 2 endobuttons</td>
<td>35.7</td>
</tr>
<tr>
<td>Choi et al.(^9) (Korea)</td>
<td>2015</td>
<td>Retrospective</td>
<td>13</td>
<td>40.1</td>
<td>8/5</td>
<td>Open CC stabilization with double button (4) or suture anchor (9) and KW-tension band fragment fixation</td>
<td>14.1</td>
</tr>
<tr>
<td>Struhl &amp; Wolfson(^10) (USA)</td>
<td>2016</td>
<td>Retrospective</td>
<td>6</td>
<td>43</td>
<td>4/2</td>
<td>Open CC stabilization with closed-looped double endobutton + suture fixation</td>
<td>40</td>
</tr>
<tr>
<td>Cano-Martínez et al.(^1) (Spain)</td>
<td>2016</td>
<td>Retrospective</td>
<td>12</td>
<td>32.2</td>
<td>10/2</td>
<td>Open CC stabilization with Twin Tail TightRope</td>
<td>26</td>
</tr>
<tr>
<td>Cho et al.(^11) (Korea)</td>
<td>2017</td>
<td>Retrospective</td>
<td>18</td>
<td>48.6</td>
<td>8/10</td>
<td>Open CC stabilization with TightRope</td>
<td>46</td>
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<tr>
<td>Cisneros et al.(^12) (Spain)</td>
<td>2017</td>
<td>Retrospective</td>
<td>9</td>
<td>36</td>
<td>5/4</td>
<td>Arthroscopic CC stabilization with TightRope (+ fragment sutures)</td>
<td>49</td>
</tr>
<tr>
<td>Blake et al.(^13) (USA)</td>
<td>2017</td>
<td>Retrospective</td>
<td>17</td>
<td>41</td>
<td>12/5</td>
<td>Arthroscopic CC stabilization with TightRope + fiberwire AC joint tension band</td>
<td>12</td>
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<tr>
<td>Sautet et al.(^14) (France)</td>
<td>2018</td>
<td>Retrospective</td>
<td>14</td>
<td>34.6</td>
<td>10/4</td>
<td>Arthroscopic CC stabilization with subcoracoid suture and button (Dog Bone)</td>
<td>20</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Study Type</td>
<td>Cases</td>
<td>Rate</td>
<td>Complications</td>
<td>Technique Description</td>
<td>Rate</td>
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<tr>
<td>Xiong et al.</td>
<td>2018</td>
<td>Retrospective</td>
<td>16</td>
<td>NR</td>
<td>NR</td>
<td>Arthroscopic double Endobutton fixation</td>
<td>57</td>
</tr>
<tr>
<td>Mochizuki et al.</td>
<td>2019</td>
<td>Retrospective</td>
<td>45</td>
<td>34.3</td>
<td>NR</td>
<td>Arthroscopic CC stabilization with Zip Tight (+ AC joint KW)</td>
<td>18.6</td>
</tr>
<tr>
<td>Yagnik et al.</td>
<td>2019</td>
<td>Retrospective</td>
<td>18</td>
<td>55.5</td>
<td>14/4</td>
<td>Open CC stabilization with subcoracoid suture and button (Dog Bone) + allograft tendon augmentation (+ peek screw)</td>
<td>30.2</td>
</tr>
<tr>
<td>Sarda</td>
<td>2019</td>
<td>Retrospective</td>
<td>19</td>
<td>38</td>
<td>13/6</td>
<td>All suture modified under-coracoid-around-clavicle technique ± AC suturing</td>
<td>23</td>
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<tr>
<td>Levy et al.</td>
<td>2020</td>
<td>Retrospective</td>
<td>30</td>
<td>NR</td>
<td>NR</td>
<td>CC stabilization with suture loop and transosseous sutures</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td></td>
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<td>Complications</td>
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<td></td>
<td></td>
<td>ASFS</td>
<td>CS</td>
<td>DASH</td>
<td>UCLA</td>
<td>Oxford Score</td>
<td>Modified Shoulder Rating</td>
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<tr>
<td>Arthroscopic assisted coracoclavicular stabilization with buttons, with or without interfragmentary sutures or tension band</td>
<td></td>
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<tr>
<td>Takase et al.⁴²</td>
<td>7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6 excellent, 1 good</td>
<td>-</td>
</tr>
<tr>
<td>Motta et al.⁴³</td>
<td>10</td>
<td>-</td>
<td>95±0.73</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Cisneros et al.¹⁰</td>
<td>9</td>
<td>-</td>
<td>89.7 ± 8.5</td>
<td>11.9 ± 7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Blake et al.²</td>
<td>17</td>
<td>90.1±10.1</td>
<td>-</td>
<td>10.9±11.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
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<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Sautet et al.²⁸</td>
<td>14</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td>91% (85–95) *</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Xiong et al.³³</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Mochizuki et al.²¹</td>
<td>45</td>
<td>92.3 ± 3.2</td>
<td>94.1 ± 3.0</td>
<td>3.8 ± 2.8</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Loriaut et al.²⁰</td>
<td>21</td>
<td>-</td>
<td>94.8±9.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>139</td>
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<td></td>
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</tbody>
</table>

**Table 2**: Efficacy and safety of coracoclavicular stabilization surgical techniques in Neer IIB/Cho IIC fractures.
### Open coracoclavicular stabilization with buttons, subcoracoid sutures, mersilene tapes, cables or suture anchors

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients</th>
<th>Success</th>
<th>Infection</th>
<th>Failure</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chen et al.⁵</td>
<td>11</td>
<td></td>
<td>None</td>
<td>Delayed union (1)</td>
<td></td>
</tr>
<tr>
<td>Shin et al.²⁹</td>
<td>19</td>
<td></td>
<td>None</td>
<td>Nonunion (1)</td>
<td>Delayed union (2), Clavicular erosions (2), Malunion (1), Slight loss of reduction (2)</td>
</tr>
<tr>
<td>Li et al.³⁹</td>
<td>29</td>
<td>A (72.4%)</td>
<td>Breakage of wires (1)</td>
<td>None</td>
<td>Frozen shoulder (1), Protrusion of suture node (removal under local) (1)</td>
</tr>
<tr>
<td>Yang et al.³⁵</td>
<td>28</td>
<td></td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chen et al.⁶</td>
<td>40</td>
<td></td>
<td>None</td>
<td></td>
<td>Superficial infection (1), Frozen shoulder (1), Refracture at clavicle holes (1)</td>
</tr>
<tr>
<td>Kanchanatan et al.¹⁵</td>
<td>39</td>
<td>91.5 (75–100)</td>
<td></td>
<td>None</td>
<td>Superficial infection (1), Tunnel enlargements without buttons migration (9)</td>
</tr>
<tr>
<td>Choi et al.³</td>
<td>13</td>
<td></td>
<td>Refracture at clavicle holes (1)</td>
<td></td>
<td>Clavicular erosion (1), CC calcifications (2), Hypertrophic scar (1)</td>
</tr>
<tr>
<td>Struhl &amp; Wolfson³¹</td>
<td>6</td>
<td>92.5 ± 15.4</td>
<td></td>
<td>None</td>
<td>Wound break down (1), CC calcifications (2), Hypertrophic scar (1)</td>
</tr>
<tr>
<td>Cano-Martinez et al.³</td>
<td>12</td>
<td>95.5 ± 5.2</td>
<td></td>
<td>None</td>
<td>CC calcifications (2), Hypertrophic scar (1), Patient with discomfort (1)</td>
</tr>
<tr>
<td>Cho et al.⁷</td>
<td>18</td>
<td></td>
<td>Nonunion (1)</td>
<td>Delayed union (1)</td>
<td>Bolus loss of reduction (2), Shoulder stiffness (1), Frozen shoulder (1)</td>
</tr>
<tr>
<td>Dataset</td>
<td>N</td>
<td>ASES (range)</td>
<td>UCLA (range)</td>
<td>Fracture (button)</td>
<td>Subsidence (button)</td>
</tr>
<tr>
<td>----------------</td>
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<td>--------------</td>
<td>-------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Yagnik et al.</td>
<td>18</td>
<td>88.1 (82-94)</td>
<td>-</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Sarda</td>
<td>19</td>
<td>-</td>
<td>43</td>
<td>None</td>
<td>Mild osteolysis (1)</td>
</tr>
<tr>
<td>Levy et al.</td>
<td>30</td>
<td>1.8 (0-28)</td>
<td>-</td>
<td>None</td>
<td>Partial loss of reduction (1)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>282</strong></td>
<td></td>
<td></td>
<td><strong>5 (1.77%)</strong></td>
<td><strong>38 (13.4%)</strong></td>
</tr>
</tbody>
</table>

* Weighted CS. All clinical efficacy scores are reported as mean (standard deviation) or mean (range).

ASES: American Shoulder and Elbow Surgeons Shoulder Score, CS: Constant Score, UCLA: UCLA Shoulder rating scale, ACJ: Acomioclavicular Joint.
Records identified through database searching after removal of duplicates (n = 564)

Records screened (n = 564)

Records excluded (n = 466)

Full-text articles assessed for eligibility (n = 98)

Full-text articles excluded, with reasons (n = 77)
- Articles describing other fixation methods (n=49)
- Insufficient data for Neer IIb fractures (n=20)
- Not reported outcomes on efficacy and safety (n=7)
- Less than 5 fractures reported (n=1)

Studies included in qualitative synthesis (n = 21)
Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.