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ORIGINAL ARTICLE

# An effective nonabsorbable suture technique for distal clavicle fractures

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## ABSTRACT

**Objectives:** The purpose of this study was to evaluate the clinical and radiologic outcomes of unstable distal clavicle fractures in patients who underwent indirect fracture fixation by performing augmentation with nonabsorbable sutures.

**Patients and methods:** In this descriptive observational study, 16 patients (11 males, 5 females; mean age: 34.8±12.1 years; range, 18 to 67 years) who underwent indirect fracture fixation using nonabsorbable sutures for Neer type IIB distal clavicle fractures at the Gaziosmanpaşa Training and Research Hospital, Department of Orthopedic Surgery between January 2014 and September 2019 were retrospectively reviewed. Clinical outcomes were evaluated using the Constant-Murley score and Visual Analog Scale.

**Results:** Complete union was achieved in all patients, and mean union time was 45.3± 8.4 (range, 30 to 68) days. There were no patients with loss of reduction, infection, or requirement for additional surgery.

**Conclusion:** The coracoclavicular fixation method, which was applied using nonabsorbent sutures in a limited number of Neer type IIB clavicle fractures, provides a suitable and stable fixation comparable to classical techniques.

***Keywords:*** Coracoclavicular fixation, distal clavicle fracture, Neer IIB, nonabsorbable sutures.

Distal clavicle fractures occur after falling on the open arm or directly on the shoulder and constitute approximately 15 to 20% of all clavicle fractures.[1,2] Neer[3] divided distal clavicle fractures into three groups based on the adhesion location of the coracoclavicular (CC) ligament. Neer type IIB fractures extend to the medial of the CC ligament and are accompanied by the complete rupture of the conoid ligament.[3] This is a rare and unstable type of fracture in which the medial fragment is displaced toward the superior due to the pulling of the trapezius muscle, while the distal fragment tends to displace anteriorly and inferiorly due to the weight of the arm.[4] Nonunion rates of Neer type IIB distal clavicle fractures after conservative treatment have been reported between 25 and 44%, which has been attributed to their unstable nature.[5-7] Today, surgical treatment for this type of fracture has come into prominence after the unsuccessful results obtained from conservative treatment.

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Many techniques have been described in Neer type IIB fractures, including transacromial Kirschner wire (K-wire) fixation, plate fixation, CC screw fixation, tension band method, and CC ligament reconstruction and repair.[8-12] Coracoclavicular ligament reconstruction has become more popular due to mechanical complications encountered in techniques involving the direct fixation of the fracture and instability caused by overlooking CC ligament ruptures, a component of this fracture pattern.[1,9,13] Using CC ligament reconstruction, forces that displace a fracture are eliminated, which stabilizes the fracture and achieves indirect

fracture healing. This study aimed to evaluate the clinical and radiological results of patients who underwent indirect fracture fixation by performing augmentation with non-absorbable sutures for Neer type IIB fractures.

## PATIENTS AND METHODS

In the descriptive observational study, the files of patients who were surgically treated for Neer type IIB distal clavicle fractures at the Gaziosmanpaşa Training and Research Hospital, Department of Orthopedic Surgery between January 2014 and September 2019 were retrospectively analyzed. Sixteen patients (11 males, 5 females; mean age: 34.8±12.1 years; range, 18 to 67 years) with normal shoulder functions before trauma, who underwent indirect fracture fixation using nonabsorbable sutures for Neer type IIB distal clavicle fractures, and attended a follow-up of more than 12 months were included in the study. Patients with open or pathological fractures and those with additional upper extremity fractures were excluded from the study. The causes of the fractures were recorded. Additional systemic diseases and smoking history of the patients were also noted. Clavicle and shoulder anteroposterior radiographs were used for the radiological evaluation of the fractures.

Coracoclavicular fixation was performed in all patients with the technique described in the following section. Union was evaluated based on the presence of both medullary and cortical bone bridging in the fracture line. The Constant-Murley score (CMS) was used for clinical evaluation,[14] and the Visual Analog Scale for pain assessment.

### Surgical technique

The patients were placed in a semisitting position on the operating table under general anesthesia. Support was placed under the scapula of the side of the fracture to raise the shoulder. Intravenous cefazolin was preoperatively administered at a dose of 2,000 mg and repeated at a dose of 1,000 mg at the postoperative 8, 16, and 24 h. After the surgical site was prepared and covered, the fracture line, clavicle, and coracoid process were marked with a marker pen. A longitudinal incision was made through the skin and subcutaneous tissue, starting from the posterior border of the distal of the clavicle and extending 1 cm distal to the coracoid process (Figure 1). The fracture hematoma and surrounding soft tissues, CC ligaments, coracoacromial ligament, and acromioclavicular joint capsule were identified, cleaned, and left intact. Afterward, the coracoid process and the fracture line were reached by

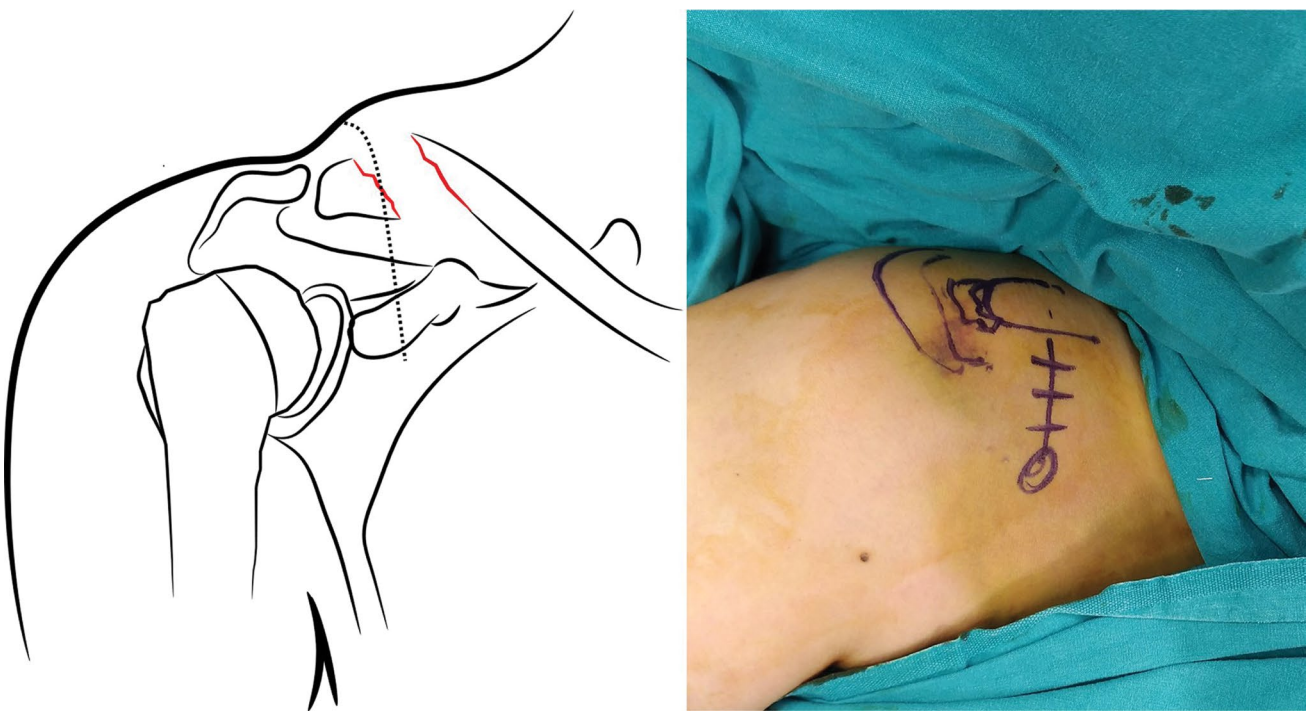

**FIGURE 1.** Skin incision illustration and surgery image.

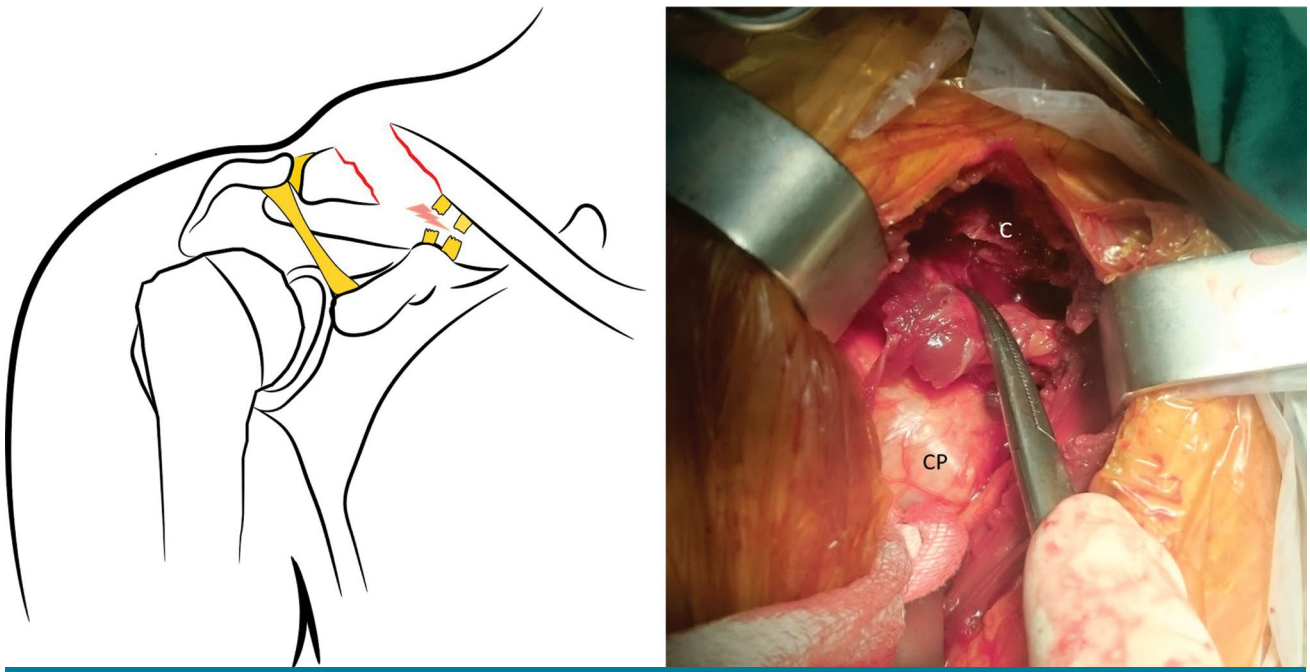


**FIGURE 2.** Illustration of the fracture line (C) and the appearance of the coracoid process (CP) after the incision and during surgery.

blunt dissection (Figure 2). The medial and lateral edges of the coracoid process were released by blunt dissection. In the distal portion, the base of the coracoid process was also bluntly and posteriorly dissected from the posterior tendon to allow for the passage of a right-angled clamp without applying any intervention to the conjoint tendon. The fracture was openly reduced, and temporary fixation of the fracture was performed using a 2-mm Kirschner wire (Figure 3).

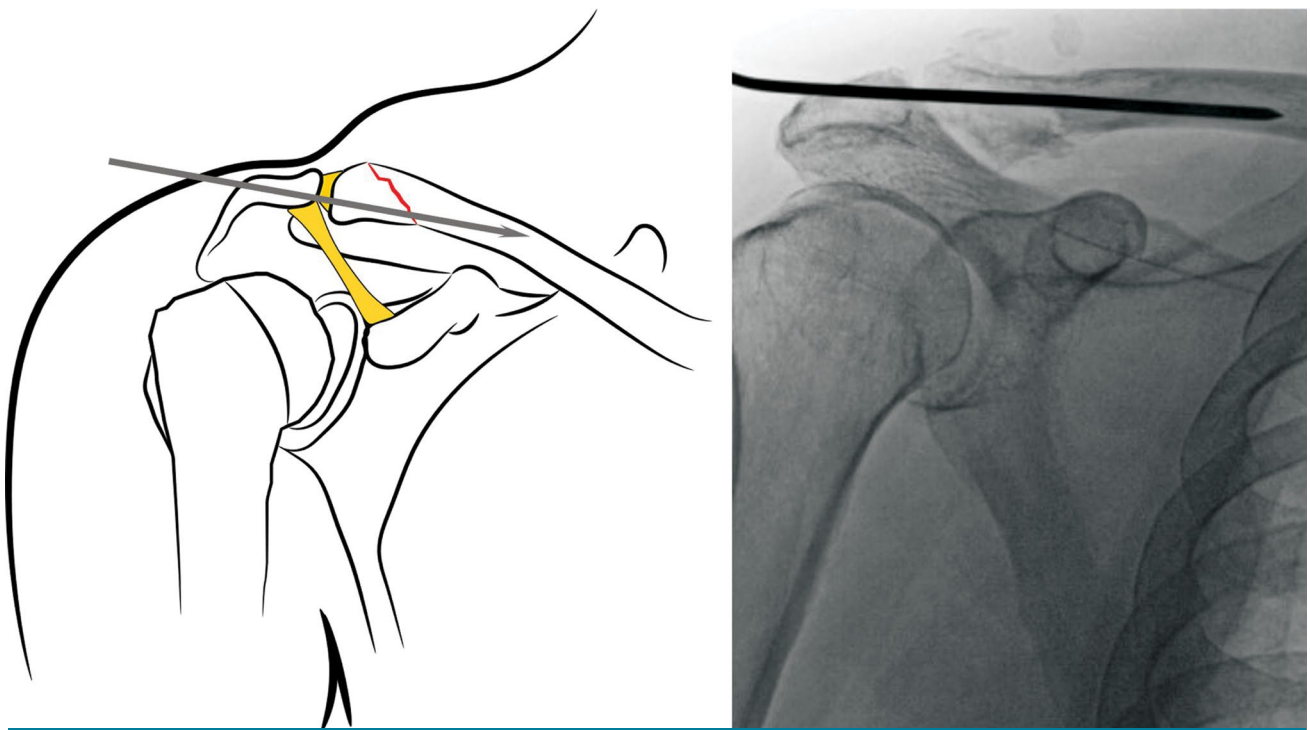

**FIGURE 3.** Illustration and fluoroscopy image of temporary fixation with a Kirschner wire after fracture reduction.

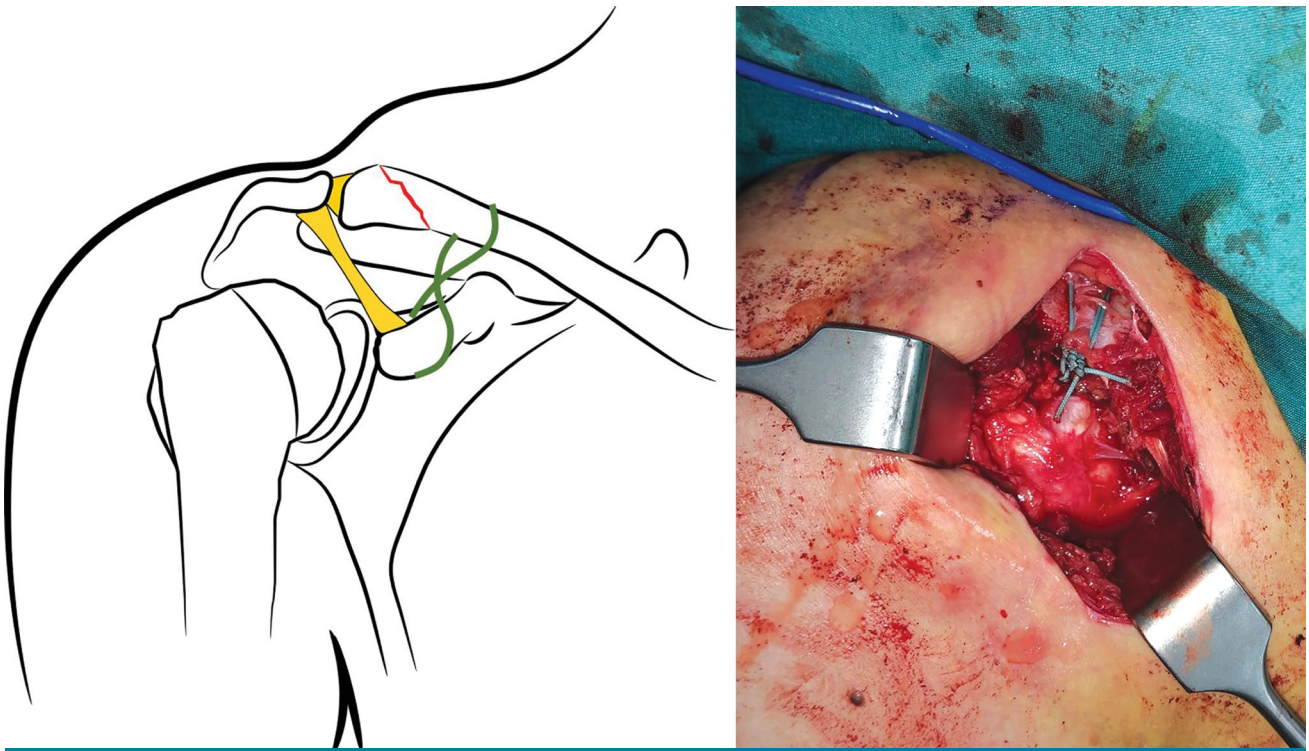

**FIGURE 4.** The illustration of fixation with No. 5 nonabsorbable sutures after fracture reduction and the appearance during surgery.

After the fixation of the fractured fragments with a Kirshner wire, a No. 5 Ethibond suture (Ethicon Inc., Somerville, NJ, USA) was folded in the middle to obtain a double layer. Using the right-angled suture, the suture was kept on the side of the loop and passed under the coracoid process posterior to the conjoint tendon. Then it was crossed and taken around the clavicle to pass both the distal and proximal of the fracture. After a simple surgical knot, the two free ends were folded from the middle, passed through the looped side, tightened, and locked (the Nice knot) (Figure 4).[15] The K-wire that was temporarily used was withdrawn. The deltoid muscle was repaired with absorbable sutures. After

**TABLE I**
General data of the patients

| | Female | | | | Male | | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | Mean±SD | Range | n | % | Mean±SD | Range | n | % | Mean±SD | Range |
| Number of patients | 5 | 31 | | | 11 | 69 | | | 16 | 100 | | |
| Age (year) | | | 31.6±8.8 | 19-41 | | | 36.3±13.5 | 20-67 | | | 34.8±12.1 | 19-67 |
| Affected side | | | | | | | | | | | | |
| Right | 2 | | | | 7 | | | | 9 | | | |
| Left | 3 | | | | 4 | | | | 7 | | | |
| Cause of fracture | | | | | | | | | | | | |
| Sports injury | 2 | | | | 8 | | | | 10 | | | |
| Traffic accident | 3 | | | | 3 | | | | 6 | | | |
| Union time | | | 6.4±1.6 | | | | 6.2±5.2 | | | | 6.3±4.2 | |
| VAS | | | 2.2±1.3 | | | | 2±1.7 | | | | 2.1±1.5 | |

SD: Standard deviation; VAS: Visual Analog Score.

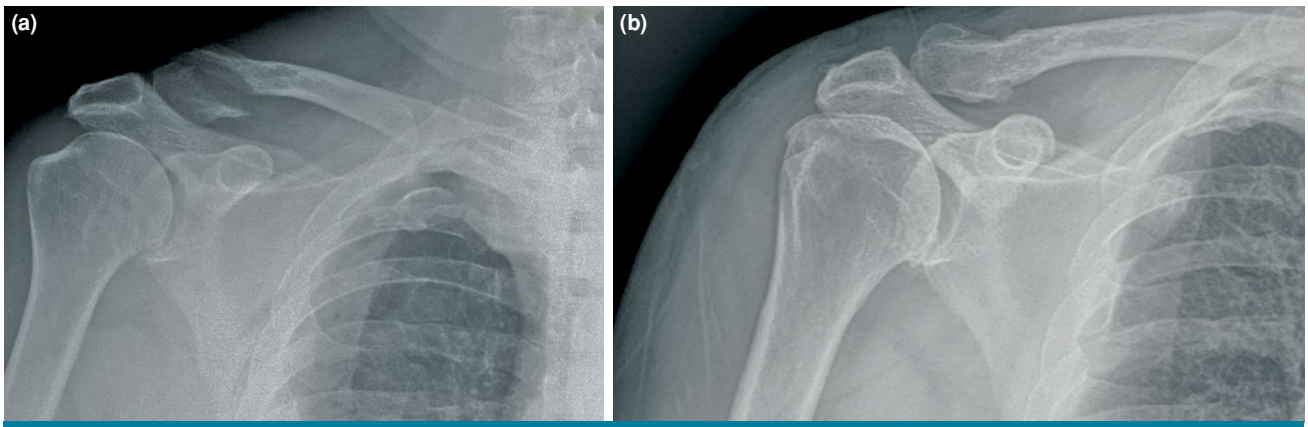


**FIGURE 5. (a)** Preoperative and **(b)** eighth week postoperative radiographs of the Neer type IIB distal clavicle fracture.


**FIGURE 6.** Neer type IIB distal clavicle fracture **(a-c)** postoperative eighth week control images and **(d-g)** another patient's seventh week postoperative control images.

**TABLE II**
Distribution of Constant-Murley Score according to sex

| | Excellent (91-100) | | Good (81-90) | |
|---|---|---|---|---|
| | n | % | n | % |
| Female | 3 | | 2 | |
| Male | 8 | | 3 | |
| *Total* | 11 | 69 | 5 | 31 |

bleeding control, the subcutaneous skin was closed, befitting the anatomical plan, and the operation was completed. The patient was given an arm sling to be used after surgery. The sutures were removed on the 14th day. After the second week, pendulum exercises were actively started.

**Statistical analysis**

Statistical analysis was performed using the IBM SPSS version 23.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation or median (min-max) for continuous variables and in number and frequency for categorical variables. The chi-square test was used to compare the categorical variables. A $p$ value of $<0.05$ was considered statistically significant.

## RESULTS

The mean follow-up duration was 18.6±SD (range, 6 to 35) months. Nine (56%) patients had a right clavicle fracture, and seven (44%) had a left clavicle fracture (Table I). The causes of fractures were traffic accidents in six (37%) patients and sports injuries in 10 (63%). All patients underwent surgery within the first five days of trauma. Complete union was achieved in all patients, and the mean union time was 45.3±8.4 (range, 30 to 68) days (Figure 5). There were no patients with loss of reduction, infection, or requirement for additional surgery. The mean time to achieve total shoulder range of motion was 6.3±4.2 (range, 4 to 11) weeks (Figure 6). At the last follow-up, the mean CMS was 93.4±14.9 (range, 85 to 100). When the patients were grouped based on CMS, 11 (69%) had excellent results, and five (31%) had good results (Table II). There was no statistically significant difference in CMS according to sex ($p>0.05$). The mean Visual Analog Scale score was 2.1±1.5 (0-6).

## DISCUSSION

Neer type IIB distal clavicle fractures are generally displaced and unstable, with nonunion rates of up to 44% after nonsurgical treatment.[16-18] In the current literature, surgical treatment is recommended for this pattern of fracture due to high nonunion and complication rates.[3,16,19] However, the surgical treatment of Neer type IIB distal clavicle fractures is technically difficult since the distal part is small and there is no isolated bone pathology.[8] Surgical treatment options are divided into three groups: fixation with a tension band and K-wire, direct osteosynthesis accompanied by plate fixation or CC ligament augmentation, and CC ligament fixation by indirect reduction.[8] The most frequently used sutures in indirect reduction methods are endobutton, tightrope, and nonabsorbable sutures. The most prominent advantage of CC fixation by indirect reduction is that it does not cause material irritation and does not require a secondary surgical procedure. In addition, secondary complications such as subacromial impingement and rotator cuff tears do not develop due to the absence of an intervention to the acromioclavicular joint.

In this study, in which an indirect reduction method was used with CC fixation, we observed that fixation with nonabsorbable sutures achieved bone union in Neer type IIB fractures by ensuring both vertical and horizontal stability, demonstrating that increased patient satisfaction could be obtained with low complication rates.

Since first recommended by Neer,[3] the transacromial fixation of distal clavicle fractures with a K-wire has become widely used. Although it is easy to apply and minimally invasive, the value of this method has been reduced due to the high rate of complications, such as wire migration, nonunion, and pin infection[8,16,20] and has been replaced by direct osteosynthesis with a plate. However, after plate fixation, the distal part is small, and it is not possible to use enough screws for stability; thus, the use of hook plates has become more prominent. Although high union rates are achieved by hook plates, complication rates of up to 40% have been reported, including plate irritation, subacromial impingement, acromial osteolysis, material failure, and requirement for a second surgery.[21-24] In our study, the absence of implant-related complications and secondary surgery were attributed to the correct use of the selected material and technique.

The problem in Neer type II fractures is not only the deterioration of the integrity of the clavicle but the loss of stability provided by the coracoclavicular ligaments, whose integrity has been disrupted due to injury.[8] In recent years, the high complication rates of classical methods and increased need for

secondary surgery have led CC fixation to gain popularity.[8,9,25-27] With CC stabilization, the forces displacing the fracture are eliminated, and indirect reduction is performed to achieve fracture healing. The efficacy of this technique with its high union and low complication rates have been reported in the literature.[8,9,26-28] Coracoclavicular screw fixation techniques have been described in the literature in cases with Neer type II clavicle fractures.[29] Since the dynamic relationship between the coracoid and the clavicle becomes rigid in screw fixation techniques, it risks low clinical scores or failure. Therefore, it is necessary to extract the screws with secondary surgery.[29,30] In our technique, nonabsorbable sutures that take on fracture fixation coracoclavicular ligaments provide a dynamic but stable fixation, and secondary surgery is not required for reasons such as implant removal.[31]

The use of implants that provide dynamic fixation in the fixation of distal clavicle fractures such as endobutton has recently gained popularity with the development of implant technologies.[32,33] The common advantage of all these techniques is that they do not cause implant irritation.[8] In the application of these implants, the clavicle and coracoid process are drilled, and the implant is loaded to the distal of the coracoid process. In the endobutton method, there is a risk of fracture in the clavicle or the coracoid process due to improper drilling or the endobutton being in an inappropriate position in the clavicle or coracoid process, injury to the conjoint tendon, or implant failure risk due to the shearing of the endobutton.[33] In addition, the fluoroscopy device is intensively used in these techniques, which increases the radiation exposure of the surgical team and the patient. In our technique, we open the coracoid process without damaging the conjoint tendon attachment and pass a nonabsorbable suture with the help of a right-angled clamp behind the tendon and under the coracoid process without damaging the conjoint tendon attachment. Consequently, we avoid the risk of fracture development and implant failure in the clavicle and coracoid process by minimizing radiation exposure.[31]

The difficulty in the learning curve in arthroscopic assisted techniques is another issue. Our technique may seem more invasive than other techniques; however, we think it is advantageous compared to other dynamic techniques in terms of ease in the learning curve and safe applicability.

The study's retrospective nature, absence of a control group, and short follow-up period are among the limitations of the study. In addition, the small sample size can be considered a limitation. Nonetheless, we believe that the study also had strengths in using a current technique and the results being comparable to the samples of previous studies using similar techniques, despite our relatively low number of patients.

In conclusion, the coracoclavicular fixation method, which we applied using nonabsorbent sutures in a limited number of Neer type IIB clavicle fractures, provides a suitable and safe stable fixation comparable to classical techniques without incurring any implant cost. Moreover, we think there will be no need for implant removal since our approach mimics the dynamic structure of the coracoclavicular complex after the union.

**Ethics Committee Approval:** Approval for the study was obtained from the Gaziosmanpaşa Training and Research Hospital Ethics Committee (date: 22/12/2022, no: 392). The study was conducted in accordance with the principles of the Declaration of Helsinki.

**Patient Consent for Publication:** A written informed consent was obtained from each patient.

**Data Sharing Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Author Contributions:** Conception and design, acquisition of data, analysis and interpretation of data, drafting the article, revising it critically for important intellectual content and final approval of the version to be published: A.P.; Substantial contributions to conception and design, acquisition of data, analysis and interpretation of data, drafting the article, revising it critically for important intellectual content; and final approval of the version to be published: F.F.

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