

# The Treatment of Mid-shaft Clavicle Fractures

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## Abstract

**Objective:** Through reviewing the relevant literature from the past decades, to summarize the assessment and management of fractures of the clavicle, and provide an overview of the clinical results of a range of treatment options.

**Data Sources:** The data analyzed in this review are mainly from articles included in PubMed and EMBASE, published from 1960 to 2015.

**Study Selection:** Studies involving assessment of fractures of the clavicle were reviewed. Further literatures were gathered regarding the conservative and surgical treatment of these fractures, including the methods of fixation and the surgical approaches used. Both conservative and surgical treatments were then compared and contrasted.

**Results:** Through retrieving and reading the abstract, a total of 42 representative articles were selected, which covered all aspects of the conservative treatment and surgical treatment, and compared the advantages and disadvantages of different treatment options.

**Conclusions:** Although the majority of recent data suggest that surgery may be more appropriate as it improves functional outcome and reduces the risk of complications, we recommend that the treatment should be individually assessed.

**Key words:** Conservation; Internal Fixation; Intramedullary Fixation; Mid-shaft Clavicle Fracture; Plate; Surgery

## INTRODUCTION

Fractures of the clavicle are common injuries, accounting for 2.6–4% of adult fractures and 35% of injuries to the shoulder girdle.<sup>[1]</sup> Mid-shaft clavicle fractures are the most common, with an incidence of up to 82% of all clavicle fractures.<sup>[2]</sup> There has been an increase in the number of treatment options available and the frequency with which clavicle fractures are treated operatively. A number of technical challenges exist for the surgeon, and clinical results for a range of treatment methods have been variable. There is still controversy about the choice of treatment, which patients are suitable for conservative treatment and whether the clinical outcomes can be improved by surgery, and how to choose the approach and implants during surgery. Here we summarize the assessment and management of fractures of the clavicle, providing an overview of the clinical results achieved using a range of treatment options.

## SURGERY AND CONSERVATIVE TREATMENT

Acute clavicle fractures were traditionally treated nonoperatively. This treatment strategy reportedly achieved high union rate, good functional recovery, and high patient-related satisfaction;

Neer<sup>[3]</sup> reported low nonunion rates after nonoperative treatment of mid-shaft clavicle fracture of 0.1%. Although nonoperative treatment was the major treatment strategy used for a long time, recent studies have identified higher rates of nonunion. In addition, patients treated nonoperatively are at high risk of clinical symptoms such as pain, loss of strength, and rapid fatigability associated with nonunion and malunion of clavicle fractures.<sup>[4]</sup> Thus, outcomes following nonoperative treatment are being increasingly doubted by researchers.<sup>[5]</sup> The available literature reports nonunion rates of up to 15% when nonoperative treatment was used for displaced mid-shaft clavicle fractures.<sup>[6]</sup> However, this does not mean that surgery is definitely better than conservative treatment; it is still not confirmed whether all adult displaced mid-shaft clavicle fractures should be treated by operative fixation.<sup>[7]</sup>

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Surgical treatment of mid-shaft clavicle fracture is most commonly done using plates and intramedullary devices; studies have reported significant advantages using these surgical methods compared with nonoperative treatment.<sup>[8]</sup> Although open reduction with internal fixation (ORIF) was associated with a lower rate of malunion and nonunion, shorter time to union, and better functional recovery, the results from a multicenter trial showed that operative treatment had a complication rate of 34% and a reoperation rate of 18%.<sup>[9]</sup> A report of Timothy *et al.* at the 2014 American Academy Orthopedic Surgeon, analyzed 1,350 patients aged 16–60 years who were treated with internal fixation from 2002 to 2010, and found that the reoperation rate reached up to 25%.

A multicenter trial, initiated by Robinson *et al.*,<sup>[10]</sup> comparing surgery with conservative treatment of fresh displaced mid-shaft clavicle fracture, suggest that conservative treatment should be the first choice for most patients, and ORIF is highly recommended for patients aged 16–30 years. A mean follow-up of 5 years, reported by van der Ven Denise *et al.*<sup>[11]</sup> comparing with conservation, significant superior outcome scores were seen at 6 weeks for the operative group. However, at 24-week and 5-year follow-up no difference was seen in functional outcome scores for both treatment groups.

The only drawback of nonoperative treatment is the higher rate of nonunion compared with surgery.<sup>[12]</sup> Hence, surgical treatment should be chosen for those with a high risk of fracture nonunion, while patients with lower risk of fracture nonunion can be treated conservatively. High risk factors for fracture nonunion are comminuted fracture, displaced fracture, and smoking. In addition, Hill *et al.*<sup>[13]</sup> found that the rate of fracture nonunion was significantly increased if the initial fracture fragments were <20 mm ( $P < 0.0001$ ), while an unsatisfactory clinical outcome of fracture union would be attained if the end fracture fragments were  $\geq 20$  mm. However, Rasmussen *et al.*<sup>[4]</sup> found that a shortening of 20 mm or more was not associated with a poorer clinical outcome.

Thus, ORIF should be considered first for young patients with high activity level, those with a comminuted fracture, displaced fracture, and smokers, while nonoperative treatment should be considered first for others. Traditional conservative treatment involves the use of either a figure-of-eight bandage or a simple sling, both of which are considered equally effective treatments of mid-shaft clavicle fractures.<sup>[4]</sup> Hence, clinicians should choose whichever sling is more comfortable for the patient.

During the past few decades, a variety of internal fixation devices and techniques including plate and intramedullary devices have been used to provide better clinical outcomes for patients with clavicle fracture. Although previous studies have compared the clinical outcomes of plating and intramedullary devices, the choice of surgical approach is still controversial.

## PLATE FIXATION

The plate fixation technique has been used for the treatment of displaced mid-shaft clavicle fractures for a long time, and its effectiveness has been confirmed by clinical outcomes.<sup>[9-11]</sup> Plating is the standard fixation technique for clavicular fracture treatment. This technique is based on the principle of fracture fixation by direct reduction and adding pressure on the fracture to reach biomechanical stability, allowing patients to become active earlier postoperatively.<sup>[14]</sup>

Two prospective studies reported that both plate fixation and conservative treatment have significant advantages.<sup>[10,11]</sup> However, there are some complications reported in plate fixation such as prominent fixation, poor appearance, implant failure, infection (both superficial and deep), and re-fracture after removing fixation.<sup>[15]</sup> In addition, the larger incision needed for plate fixation surgery leads to poor appearance.

Do changing the placement of fixation can reduce complications? Harnroongroj and Vanadurongwan,<sup>[16]</sup> and Lannotti *et al.*<sup>[17]</sup> tested this theory and the results cannot determine which method has overwhelming superiority from a biomechanical standpoint. When the plate was fixed in an antero-inferior position, this resulted in higher patient satisfaction and reduced the irritation, the rate of removal of internal fixation, and vice damage but it did not change the mechanical stability. A 10-year study advocated by Gilde *et al.*<sup>[18]</sup> of 156 cases of mid-shaft clavicle fracture with anterior-inferior plate fixation showed a better clinical outcome with higher fracture healing rate and lower fixation removal, especially using 2.7 mm dynamic compression plates [Figures 1 and 2].

Do changing the fixation model can improve the rigidity? Bravman *et al.*<sup>[19]</sup> compared the biomechanical properties of unicortical and bicortical fixation in precontoured versus manually contoured locking clavicle plates, 48 Sawbone composite human clavicle specimens were used; however, it remains unclear whether these differences will be clinically significant.



**Figure 1:** The postoperative radiograph of a 2.7 mm 10-hole locked plate was performed antero-inferior for a patient with midclavicle fracture. No surgical complications and good clinical outcomes.

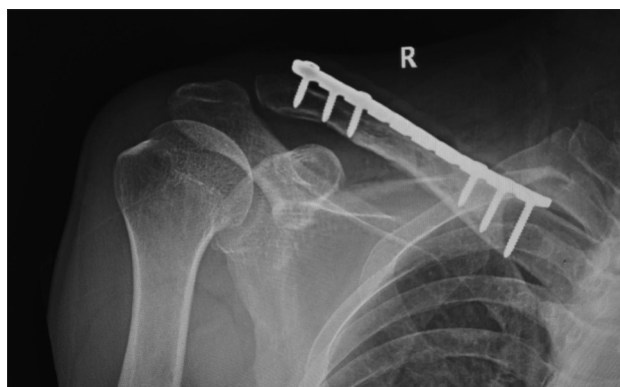
It should be noted that there is no uniform standard regarding the internal plate fixation technique. Clinically, most surgeons choose the fixation technique according to their preference and the development of materials. Thus, it is very difficult to compare the results reported in previous studies. Furthermore, the clinical outcome and complications may be influenced by the type and shape of fixation, and the placement of fixation, which have not been adequately studied.

## INTRAMEDULLARY FIXATION

Intramedullary fixation is another commonly used technique for mid-shaft clavicle fracture treatment. In contrast with the traditional approach of plate fixation, this technique has the advantages of a smaller incision, good appearance, and minor damage to soft tissue. In general, the hematoma sustained in fracture can promote healing.<sup>[20]</sup> However, there are also some disadvantages of intramedullary fixation.<sup>[21]</sup> It has a high technical difficulty and obvious learning curve for surgeons, and open reduction is still needed when using Rockwood nails for fixation. In addition, the rate of successful closed reduction ranged from 60% to 85% using titanium elastic nails.<sup>[12]</sup> Around 50% patients treated with intramedullary fixation had this combined with open reduction.<sup>[20,22]</sup>

There are a variety of intramedullary nail options, including the Kirschner nail, Push nail, Steinmann nail, Hagie nail, Knowles nail, Rockwood nail, elastic intramedullary nail (elastic stable intramedullary nail [ESIN]), and intramedullary screw nail [Figures 3–5].<sup>[23–25]</sup> The intramedullary nail can be divided into two categories according to the application. One category is fixation from the outer rear side, which includes all but the ESIN. This category can be further divided into two nail types. One type is a screw nail like the Knowles nail and Rockwood nail, which can provide pressure on the fracture site. The other is a rarely-used type that cannot supply pressure on the fracture site; the application of this kind of nail requires open reduction, and retrograde reamed and inelastic fastening systems. The screw nail with pressure can provide strong holding force and promote fracture healing. The second category is fixation from the inside, around 1 cm from the sternoclavicular joint, which is the ESIN. This device should be inserted following the “S” shape of the clavicle to gain the three-point fixation support generated by the ESIN.

There are unique complications associated with intramedullary fixation, including skin erosion with pin exposure, screw shifting, loss of reduction, and pin failure with union, other complications include infection (superficial or deep), nonunion, malunion, re-fracture after removing fixation, and neurovascular injury.<sup>[26,27]</sup> A regression study showed that the rate of reoperation caused by complications was <7%, while the rate of other complications such as infection and internal fixation stimulation was as high as 31%.<sup>[15]</sup>



**Figure 2:** A young male patient with displaced mid-shaft clavicle fracture was treated with open reduction with internal fixation using a locked superior plate. A postoperative radiograph shows reduction is perfect.



**Figure 3:** A young female patient with displaced mid-shaft clavicle fracture was treated with closed intramedullary technique using a flexible nail. A postoperative radiograph shows reduction with elastic stable intramedullary nail application.



**Figure 4:** A postoperative radiograph shows reduction with Rockwood pin application.

Just like in plate fixation, the materials and methods used in intramedullary fixation are developing over time and continue to progress in order to reduce the incidence



of complications. For instance, Frigg *et al.*<sup>[28]</sup> avoided irritation problems by adding a cap on the end of the elastic nail [Figure 6]. As there are a variety of internal fixation and surgical approaches, as well as different study designs and minor related cases, it is very difficult to conduct a meta-analysis because of insufficient data.

## COMPARISON OF PLATES AND INTRAMEDULLARY FIXATION

Present studies cannot determine whether a plate or an intramedullary device is better for the treatment of mid-shaft clavicle fractures, because of the different fixation materials and surgical approaches used. Ferran *et al.*<sup>[22]</sup> compared the outcomes with 12 months follow-up and found that there was no obvious functional difference between patients treated with Rockwood nail versus those treated with plate fixation. However, they claimed that all patients treated with Rockwood nail fixation required removal of the internal fixation, while only 53% of plate fixation patients required fixation removal.

Some researchers believe that the ESIN has obvious advantages compared with plates. For instance, Chen *et al.*<sup>[29]</sup> reported that ESIN use resulted in faster recovery, higher satisfaction, and better appearance of the shoulder. Moreover, a retrospective study by Targ *et al.*<sup>[30]</sup> showed that application of ESIN can provide sufficient stability, release pain quickly, and obtain functional recovery of the affected limb compared with plate fixation; however, a similar complication rate was reported for both techniques. In addition, Liu *et al.*<sup>[31]</sup> reported no significant difference between plate and intramedullary fixation in operation time, fracture healing time, recovery, nonunion, malunion, infection, rate of fixation removal, failure of early fixation, time taken to return to work, Constant score of the shoulder, and Disabilities of the Arm, Shoulder, and Hand score; Duan *et al.*<sup>[32]</sup> and Houwert *et al.*<sup>[33]</sup> also reported similar

results. However, it is still difficult to determine which fixation is better, as there has been only one randomized controlled trial.

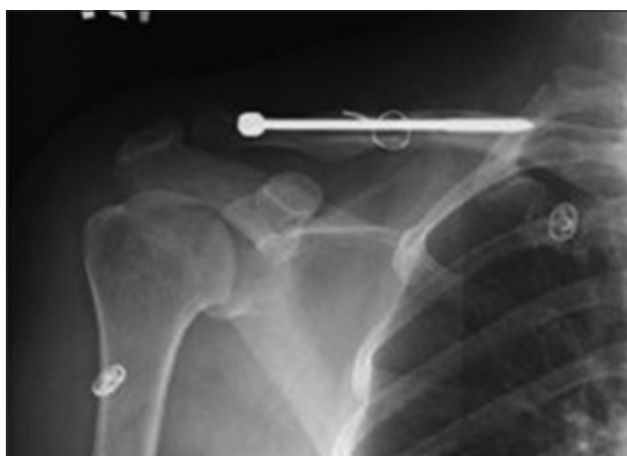
Saha *et al.*<sup>[34]</sup> and Narsaria *et al.*<sup>[35]</sup> compared the outcomes using ESIN and plate fixation; although there was no statistical difference because of small sample size, they still claimed that the application of ESIN was safer, less invasive, and caused fewer complications than plate fixation.

Zeng *et al.*<sup>[36]</sup> analyzed the biomechanical characteristics involved in TEN fixation and reconstruction plate fixation for mid-shaft clavicular fractures, presented by biomechanical finite element analysis, showed that reconstruction plates and ESIN yielded similar functional results, time to union, level of postoperative pain, and patient satisfaction rates. Both methods were safe in terms of major complications.

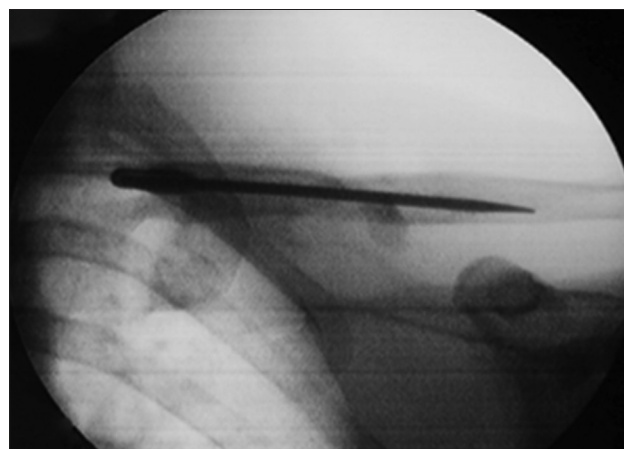
In all of the aforementioned studies, the operative methods, approach, and materials used were totally different between the plate and intramedullary fixation. Therefore, it is difficult to determine which technique is better. Despite the lack of strong evidence, the percutaneous fixation characteristics indicate that the application of an intramedullary device is better for transverse or short oblique fractures. However, intramedullary fixation is not suitable for comminuted fractures, one-third medial or lateral fractures, open fractures, and fractures that are over 3 weeks old as it is difficult to achieve reduction even by surgical incision. For those fractures for which both intramedullary and plate fixation could be used, the surgeon should choose the approach that they are most familiar and comfortable with, as this will result in the best clinical outcome and reduce the incidence of complications.

## EXTERNAL FIXATION

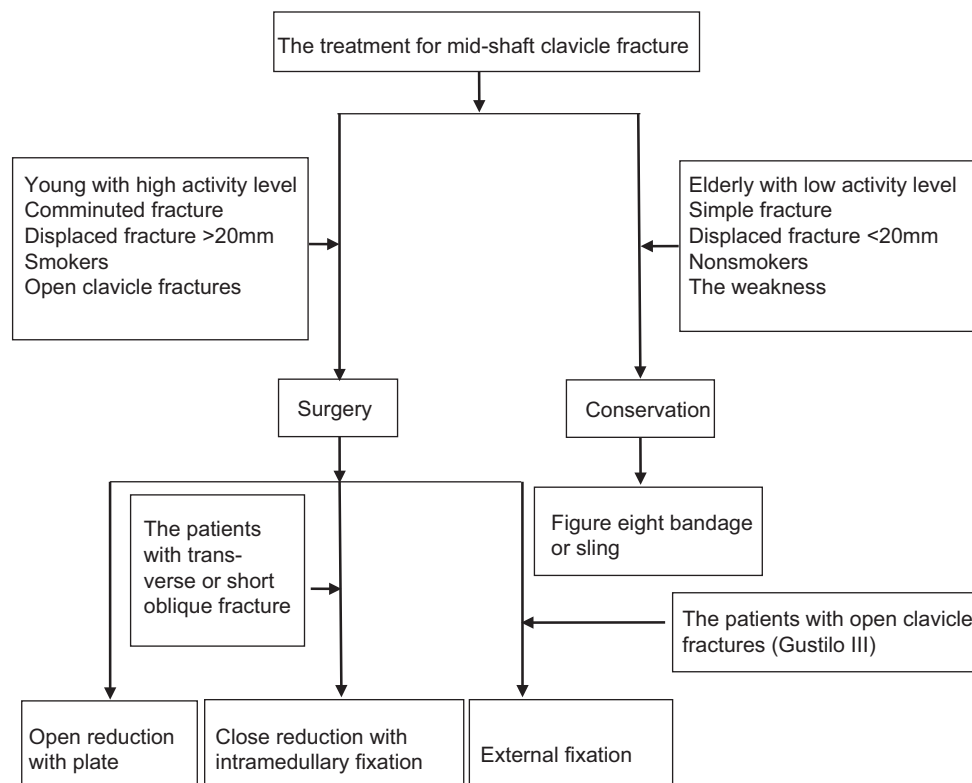
Open clavicle fracture is uncommon and is mostly caused by severe direct trauma. Generally, surgical intervention with debridement and fracture repair is required. In cases with bony exposure and significant contamination concomitant



**Figure 5:** A 45-year-old female patient with right midclavicular comminuted fracture that presented with severe displacement was treated with a Knowles pin and cerclage wire. Radiography at 12-week postoperatively showed fracture healing without Knowles pin migration.



**Figure 6:** Modified elastic stable intramedullary nail with an end cap was used to avoid the skin irritation.



**Figure 7:** Algorithm for the treatment of mid-shaft clavicular fracture.

with severe soft tissue damage, external fixation is the treatment of choice.<sup>[37]</sup> However, traditional external fixation causes some potential problems, as its bulkiness and sharp edges cause discomfort to the patient. Previous studies have presented cases of open clavicle fracture successfully treated with external fixation using reconstruction with a locking compression plate as definitive treatment.<sup>[38,39]</sup>

## CONCLUSIONS

Although more surgeons support the application of internal fixation to the displaced mid-shaft clavicle fracture, young patients with high activity level, accompanied with comminuted fracture, displaced fracture more than 20 mm, and smokers should be treated ORIF firstly, while others should be considered nonoperatively.

It is still unclear whether intramedullary fixation or plate fixation is better for treating mid-shaft clavicle fracture, and further appropriately designed studies are needed to differentiate the clinical outcomes.<sup>[40,41]</sup> At present, the application of plate fixation in antero-inferior fractures can achieve good mechanical properties, and reduce complications. The locking compression plate can also be used for open clavicle fractures. In the future, intramedullary fixation should be more widely used with better-designed instruments. We recommend the treatment of mid-shaft clavicle fracture according to the individual circumstances [Figure 7].

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## Conflicts of interest

There are no conflicts of interest.

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