Evaluation of Complications in Clavicle Fractures Following Open Reduction and Internal Fixation

Abstract
Background & Objective: Open reduction and internal fixation of clavicle fractures are associated with various complications. The present study aimed to evaluate the prevalence of the complications caused by internal fixation, including infections, dissatisfaction with the surgical site, and nonunion and malunion in clavicle fractures.

Materials and Methods: This cross-sectional study was conducted on 52 patients with clavicle fractures undergoing open reduction and plate internal fixation. Constant shoulder score (CSS) was used to determine the range of motion, and union was detected based on shoulder strength, shoulder pain, and radiography.

Results: In total, 12 females and 40 males were enrolled in the study. Clavicle hook-plates were used in one-third of the patients, and mean CSS was 84±2 (95% CI: 83-84). Most complaints were due to poor scar cosmesis (96%), followed by skin numbness (80%) and pain in the surgical site (73.1%). In addition, the rate of infections was remarkably low.

Conclusion: According to the results, the most common complications associated with internal fixation were moderate pain, poor cosmesis, and skin numbness in the surgical site, which were minor issues in the majority of the patients.

Keywords: Clavicle Fractures, Complication, Open Reduction, Operative Treatment, Internal Fixation

Received: 5 months before printing; Accepted: 2 month before printing

Clavicle is a long bone that forms the shoulder girdle along with the scapula, arms, and sternum. Clavicle has no marrow canal and is entirely membranous. This bone is connected to the sternum from inside and to the scapula from the outside. In addition, clavicle is the only bone between the trunk and upper limbs, and its surface is palpated subcutaneously. It is notable that the clavicle assumes a gentle S shape[1].

According to statistics, clavicle fractures account for 10-15% of the fractures in children[2-6] and 2-5% of the fractures in adults[7,8]. Therefore, clavicle fractures are common injuries among children and adults, with an incidence of 29-64 cases per 100,000. However, clavicle fractures have been reported to be more frequent in the individuals aged less than 30 and more than 70 years. In adults, more than two-thirds of these fractures are of the diaphyseal type, which is associated with a higher risk of displacement compared to medial and lateral fractures.

Clavicle fractures are often caused by severe trauma due to traffic collision or intense exercise, while falling on an outstretched arm is also a common cause of these injuries. In most cases, clavicle fractures are healed without the need for treatment or by using an arm sling or figure-of-eight strap bandaging. This method has proven successful in the treatment of clavicle fractures, and several studies in this regard have reported that more than 95% of the fractures have acceptable union in terms of aesthetics and performance[7-10].
Plate fixation is used for the displacements of more than two centimeters, shortness of more than two centimeters, fractures of more than three pieces, open fractures, and scapular malposition\(^\text{41}\). Moreover, fixation by a clavicle hook plate is one of the common treatment methods for the fractures of the distal clavicle. In general, hook plates are applied for the displacement of distal clavicle fractures, fractures extending to the acromioclavicular (AC) joint or fractures in the proximity of the AC joint\(^\text{39}\).

In a research by Jasper et al., nonunion and malunion were observed in less than 10% of the participants. In the mentioned study, most of the complications were related to the plate, leading to the loss of plate stability in 9-64% of the cases\(^\text{10}\). In this regard, the results obtained by David Luo et al. (2015) demonstrated that among all the cases of clavicle fractures during 2005-2013, 153 patients were within the age range of 14-17 years, 23 of whom (15%) underwent surgery. In addition, various postoperative complications were observed in 21.7% of these patients, including re-fractures, need for plate removal due to the protuberance of the implant, and nonunion\(^\text{3}\).

According to George et al. (2009), favorable outcomes could not be achieved in all types of clavicle fractures. Displaced and comminuted fractures were associated with other complications, such as subclavian vessel injury, hemopneumothorax, torn brachial plexus, nonunion, malunion, postoperative arthritis, and re-fractures\(^\text{13}\). In another study by Asadollahi et al., the total rate of the complications associated with clavicle fractures were estimated at 14.5%, while the rates of non-union and infections were reported to be 6% and 3.6%, respectively. Furthermore, the incidence of the complications caused by plate fixation was 10% (11-110), while the complications associated with intramedullary nail fixation were observed in 32% of the cases. It is also notable that 35% of the complications were associated with the inadequacy of surgical techniques. In the mentioned study, an implant removal surgery was performed on 23% of the patients\(^\text{12}\).

The study by Persico et al. (2014) was conducted on 56 patients (41 males and 15 females) receiving treatment for clavicle fractures during 2010-2012. According to the findings, 21% of the patients experienced postoperative complications. In addition, five patients required secondary surgery, and nonunion was reported in two of these cases. Furthermore, two patients experienced plate re-fracture due to trauma, one of whom had severe pain due to the plate use. According to the results of the mentioned study, four patients had progressive superficial infections, and one patient had deep tissue infection\(^\text{13}\).

Current studies on adults have demonstrated that the surgical management of clavicle fractures along with displacement may lead to various complications (e.g., nonunion and reduced performance) compared to healthy individuals. In some cases, the clavicle was shortened by more than two centimeters due to the fracture\(^\text{6, 14-19}\). In general, surgeries have proven effective in the treatment of clavicle fractures in adults, especially adolescents and younger adults\(^\text{10}\). However, surgical repair is less common among children and the elderly\(^\text{4, 20}\).

Considering the high rate of the complications associated with clavicle fractures, lack of similar studies in this regard, and the controversies over surgical and nonsurgical treatments and complications caused by the surgical treatment of clavicle fractures, the present study aimed to evaluate the prevalence of the complications caused by clavicle fractures after internal fixation by a plate. The secondary objective of the research was to assess the incidence of infections, dissatisfaction with the surgical site, and nonunion and malunion in the patients.
Methods

This cross-sectional study was conducted on 52 hospitalized patients with clavicle fractures. Subjects were selected randomly, and the exclusion criteria were as follows: 1) previous fractures; 2) neurovascular disorders; 3) smoking habits; 4) underlying diseases and 5) use of specific medications increasing the possibility of nonunion. Initially, written informed consent was obtained from the participants, and they were ensured of confidentiality terms regarding their personal information. Following that, the questionnaires were completed by the researcher via interviews with the participants. Data collection tools included the constant shoulder score (CSS)\(^{(21)}\) to determine the range of motion, shoulder strength, and shoulder pain. In addition, radiography was used to assess union. Items in the CSS are scored within a range of 0-100 in different sections of pain (score: 15), daily activities (score: 20), range of motion (score: 40), and
shoulder strength (score: 25) \(^{(22)}\).

Data analysis was performed in SPSS version 22 using descriptive statistics (frequency, mean, and standard deviation) to assess the incidence rate of the complications associated with clavicle fractures. In all the statistical analyses, P-value of less than 0.05 was considered significant.

## Results

In total, 12 females (23%) and 40 males (76%) were enrolled in the study. Mean CSS was 84±2 (95% CI: 83-84), and hook plates were used in 19 patients (36%). According to the results, the majority of the patients had complaints about poor cosmesis (96%), as well as numbness (80%) and pain in the surgical site after the first four weeks postoperatively (Table 1). However, no impairment was observed in the daily activities or range of motion of the shoulders in the participants.

<table>
<thead>
<tr>
<th>Complaints</th>
<th>Without Hook (N=23)</th>
<th>With Hook (N=19)</th>
<th>Total (N=52)</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of Discharge or Wound Infection in Surgical Site</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Complaints of Poor Cosmesis</td>
<td>96</td>
<td>5</td>
<td>96</td>
</tr>
<tr>
<td>Complaints of Numbness</td>
<td>75</td>
<td>89</td>
<td>80</td>
</tr>
<tr>
<td>Complaints of Pain</td>
<td>96</td>
<td>100</td>
<td>98.1</td>
</tr>
<tr>
<td>Discomfort in Scar When Using Underwear</td>
<td>21</td>
<td>26</td>
<td>23.1</td>
</tr>
<tr>
<td>Union after Six Months Postoperatively</td>
<td>100</td>
<td>84</td>
<td>94</td>
</tr>
<tr>
<td>Pain after First Four Weeks Low</td>
<td>33</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Postoperatively</td>
<td>66</td>
<td>84</td>
<td>73.1</td>
</tr>
</tbody>
</table>

## Discussion

The present study aimed to evaluate the prevalence of the complications caused by clavicle fractures following internal fixation. The secondary objective of the research was to assess the incidence of infections, dissatisfaction with the surgical site, and nonunion and malunion in the clavicle fracture after internal fixation \(^{(2)}\). In general, clavicle fractures are categorized into three types based on their location, including the interior-third, middle-third, and exterior-third clavicle fractures. Considering that middle-third clavicle fractures are the most common type, they were investigated in the current research. According to the results of the present study, mean CSS was 84, which is in line with the results obtained by the Canadian Orthopaedic Association (COA). In COA, a research was performed on 52 patients, and the CSS was determined to be 80, 90, and approximately 100 at week six, 12, and 52, respectively. According to the mentioned study, the individuals with clavicle fractures who underwent surgery obtained better results compared to the subjects receiving nonsurgical treatment \(^{(23)}\).

In the current research, union was achieved in all the patients after six months, with the exception of three patients in the non-hook group. In addition, nonunion and malunion were not observed in the patients with hooks, which is in concordance with the previous studies in this regard \(^{(3, 11-15, 24-29)}\). Application of hook plates is a common method for the treatment of distal clavicle fractures. In the present study, hook plates were used due to the extension of the clavicle fracture into the inside portion of the AC joint \(^{(39)}\).

In the research by David Luo et al., nonunion was reported in one patient, which was associated with defects in the implant \(^{(3)}\). In this regard, Coupe et al. followed-up 89 patients for nine years, reporting nonunion in only one case \(^{(26)}\). It is notable that in the mentioned study, most nonunion cases were malunion since the patients mainly experienced fatigue, weakness, and overhead activities \(^{(14, 25, 29-33)}\). In the studies by Carter et al. and Charles et al., it was demonstrated that the level of nonunion was higher in the patients with clavicle fractures undergoing fixation surgery...
compared to those who selected nonsurgical treatments\textsuperscript{(16, 18)}.

According to the results of the present study, postoperative infections had a low prevalence among the patients (3%), which is consistent with the previous studies\textsuperscript{(26,28,34,35)}. In the research by Coupe et al., postoperative infections were observed in only one patient\textsuperscript{(26)}. Similarly, in the study by Fuchs et al., which was conducted on 46 patients with clavicle fractures, infection was reported in only one patient with nonunion\textsuperscript{(28)}. While infections are generally superficial\textsuperscript{(35)}, Bostman et al. reported no difference between superficial and deep infections\textsuperscript{(36)}.

In the current research, 73.1\% of the patients experienced moderate pain, and complaints of pain were observed in 84\% and 66\% of the patients with and without hooks, respectively. In general, pain is a common discomfort in patients after surgery, and our findings in this regard are in congruence with the results of similar studies\textsuperscript{(14,25,30,37,38)}. Naturally, pain originates from the where the bone is located; therefore, it is normal for patients to have complaints of pain.

In the present study, the majority of the patients (96\%) had complaints of poor cosmesis, which is in line with the results obtained by Mouzopoulos et al.\textsuperscript{(11)}. However, Der Tavitian reported that only 8\% of the participants had such complaints\textsuperscript{(34)}, which might be due to differences in cultural background, gender, and age of the participants.

According to the results of the current study, 80\% of the patients had complaints of numbness in the surgical site. While 75\% of the complaints were in the individuals without hooks, 89\% of the complaints were in those with hooks. Nevertheless, only two patients had complaints of numbness in the research by Der Tavitian et al.\textsuperscript{(34)}. This discrepancy could be due to the shorter interval between the surgery and examination or higher accuracy and greater use of incision in the Iranian healthcare system compared to the mentioned study.

Recent studies have confirmed that the fractures caused by the displacement of the middle third of the clavicle in adults cannot be efficiently improved without surgery, and nonunion has been reported to be remarkably high among these cases. In addition, lack of surgical treatments may lead to the formation of masses with an unpleasant appearance in the proximity of the clavicle and shoulder ptosis, as well as limited range of motion and dissatisfaction of patients. It seems that surgical treatments enhance the function and reduce the risk of malunion or nonunion in the patients compared to nonsurgical methods\textsuperscript{(7-10)}.

The differences in the complications observed between older findings and recent studies could be due to the changes in the type of the traumas that causes fractures (e.g., new sports), which might have added to the severity of the inflicted traumas, thereby causing more acute forms of fractures and damages to the surrounding tissues. Therefore, nonsurgical treatments are associated with a higher prevalence of postoperative complications compared to surgical treatments. Another cause of this difference is the increased expectations of patients today, which leads to their dissatisfaction with nonsurgical treatments.

Another effective surgical treatment for clavicle fractures is plate fixation, which could accelerate the recovery of the shoulder, increase the possibility of union, and decrease postoperative complications. Increased complications and lack of patient satisfaction are rooted in the modernization of physical activities and changes in the culture and expectations of individuals. Therefore, it is recommended that other scoring techniques be used in further investigations in this regard, and the obtained scores be compared.
Conclusion

According to the results, treatment of clavicle fractures by open reduction and internal fixation could yield positive outcomes. In the present study, the CSS was high, union occurred in the majority of the patients six months after the surgery, and level of infections was significantly low in the surgical site. However, complaints of moderate pain, poor cosmesis, and numbness were observed in the majority of the patients.

Acknowledgements

Hereby, we extend our gratitude to the participants and hospital staff for assisting us in this research project.

References