Long-term Functional Outcomes and Complications in Operative Versus Nonoperative Treatment for Displaced Midshaft Clavicle Fractures in Adolescents: A Retrospective Comparative Study

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Introduction: Traditionally, midshaft clavicular fractures in adolescents are treated nonoperatively. In later years, a trend toward operative treatment can be observed. Documentation of the benefit of surgery in this group is scarce. The purpose of this study is to evaluate the long-term patient reported functional outcomes and complications for patients treated operatively and nonoperatively for displaced midshaft clavicular fractures. Using the same outcomes we also compared the operative methods.

Methods: One hundred nine adolescents aged 12 to 18 years sustaining displaced midshaft clavicular fractures in the period 2010 to 2016 were identified in our computerized files. Sixty-one were treated nonoperatively, 48 operatively (22 plate and 26 intramedullary nail). Their radiographs and patient journals were examined for fracture classification, wound infection, sensory affection, surgery duration, hardware removal, and nonunion (n = 109). Long-term function, pain, and satisfaction were measured with Quick Disability of Arm, Shoulder, and Hand (QuickDASH), Oxford Shoulder Score and Visual Analogue Scale (n = 87).

Results: Operative treatment: We could find no difference in functional score outcomes. The main outcome QuickDASH was excellent in both groups (median 0 nail vs. 2.26 plate). Surgery duration was shorter with intramedullary nail. We found 2 infections and 2 sensory affections in the plate group, and 1 infection and 1 sensory affection in the intramedullary nail group. There were 2 refractures in the nail group. Operative versus nonoperative treatment: there were no differences in functional outcomes between the operative and nonoperative groups. For the main outcome QuickDASH both groups scored excellently (median 1.12 operative vs. 0 nonoperative). The nonoperative group was more satisfied with the cosmetic result. There was 1 nonunion in the nonoperative group that later was operated.

Conclusions: Adolescents aged 12 to 18 years with displaced midshaft clavicular fractures show good long-term functional results after plate fixation, intramedullary nail, and nonoperative treatment. No additional benefit is demonstrated for surgery in our material. Nonoperatively treated patients are more satisfied with the cosmetic results. Little difference is seen between the operative methods in our study. We conclude that surgery should rarely be the choice of treatment for displaced midshaft clavicular fractures in adolescents.

Level of Evidence: Level III study—retrospective comparative study.

Key Words: adolescent, clavicle, fracture, surgery, non-operative, plate, intramedullary nail, PROMS, Quick-DASH, complications

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Clavicular fractures in children are common, constituting about 8% to 15% of all pediatric fractures.[1,2] Studies show that these fractures heal adequately in almost all cases.[1,3–5] In adults, there has been a shift toward more operative treatment of displaced clavicular fractures in the recent decade. One argues that anatomic reduction and fixation of the fracture will give better long-term functional results. This trend also applies to the adolescent population, resulting in an increasing rate of operative treatment.[6] In the time period 2010 to 2016, 109 adolescents with displaced midshaft clavicular fractures were treated either nonoperatively, with plate osteosynthesis or with intramedullary nail at our hospital. Owing to lack of evidence of the superiority of any treatment method, choice of treatment varied with daily decision-making. This resulted in 3 fairly similar groups receiving either nonoperative treatment, nail, or plate.

The purpose of this study is to evaluate the long-term patient reported functional outcomes and complications for patients treated operatively and nonoperatively for displaced midshaft clavicular fractures. Further, using the same outcomes, we want to compare the outcomes from the different operative methods.

METHODS

Inclusion criteria were patients aged 12 to 18 years with displaced midshaft clavicular fractures treated at our

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hospital in the period 2010 to 2016. Displacement had to be 1 bone-width or more. Open fractures were excluded.

After approval from the Norwegian Regional Ethical Committee (REK), all patients with clavicular fractures were identified by a computerized search in the electronical patient journal. International Classification of Diseases (ICD) code S42 was used for the search. Patients who received surgery were identified in the same search engine with the NCSP (Nordic Medico-Statistical Committee Classification of Surgical Procedures) codes NBJ62 and NBJ52. All initial plain radiographs were evaluated to identify patients with a midshaft fracture displaced 1 bone-width or more. All included fractures were then classified by the AO system.

A letter containing patient reported functional outcome scores (PROMS) were sent to all included patients. Our main outcome variables were the Quick Disability of Arm, Shoulder, and Hand score (QuickDASH score) and Oxford Shoulder Score (OSS). Secondary outcome variables were Visual Analogue Scale (VAS) for pain, cosmetic result, and overall satisfaction. Eighty-seven of 109 patients responded to our letter. Patient journals of all included patients (n = 109) were also searched for the following secondary outcome variables: surgery duration, open or closed surgery, infection, removal of hardware, sensory complications to surgery, re-fractures and nonunion. Our hospital is the only institution in the region offering treatment and follow-up for clavicle fractures. It is therefore likely that most of these variables are registered in our system.

The QuickDASH Questionnaire is validated and translated to Norwegian.[7,8] It contains 11 questions addressing different aspects of upper-extremity pain and function. The scale spans from 0 to 100, where 0 is considered the best possible score. According to the Institute for Work and Health there are no divisions to categorize scores as excellent, good, fair or mild, or disability as moderate or severe in QuickDASH.[9] To our knowledge, only 1 study has looked at the minimally clinically important difference of the QuickDASH and reported that a change exceeding 8 points is the most accurate change in score to discriminate between improved and stable patients.[10]

The OSS consist of 12 questions addressing function and pain in the shoulder. It has also been validated and translated to Norwegian.[11–13] The score ranges from 12 to 60, where 12 is the best possible score. The minimal clinically important difference is considered to be 6.[10]

The VAS was used to ask patients the following questions. (1) How satisfied are you with the cosmetic appearance of the injured area of your shoulder/collar bone? (2) How much pain have you had in your shoulder the last 4 weeks? (3) How satisfied are you with the treatment you have received for your injury? The VAS ranges from 0 to 10. We asked the patients to consider 0 as the best possible outcome and 10 the worst possible for all 3 questions.

Statistical Analysis

Statistical analysis was executed using SPSS version 25.0, IBM, Armonk, NY.

TABLE 1. Group Characteristics—109 Included Patients

	1 (Nail)	2 (Plate)	3 (Non-OP)
N	26	22	61
Median age (y) (range)	15 (12-17)	15 (12-17)	14 (12-17)
Percentage females	15	23	20
Share AO 15.2 B-fractures (%)	19	36	15
Mean follow-up (mo) (95% confidence interval)	58 (49-68)	85 (74-97)	68 (61-75)
Reply rate PROMS, n/N (%)	20/26 (77)	18/22 (82)	49/61 (80)

OP indicates operative; PROMS, patient reported functional outcome scores.

Parametric data are presented as mean with SD. *T* test were used for comparison.

Nonparametric data are presented as median with range. Mann-Whitney *U* test were used for comparison and differences were considered significant with $P < 0.05$.

Categorical data were analyzed using the χ^2 test.

RESULTS

Group Characteristics

Three hundred sixty-three patients were identified through a computerized search for ICD code S42 in the electronical patient journal system. A total of 109 patients with displaced midshaft clavicular fractures were included after scanning all radiographs for complete displacement and patient journals for patients who received surgery. Twenty-six patients were operated with an intramedullary nail, 22 patients were operated with an anatomic plate and screws, and 61 patients were treated nonoperatively. Eighty-seven patients responded to the questionnaires of the study. Table 1 sums up group characteristics.

There is no difference in AO fracture characteristics between nail (1) and plate (2) ($P = 0.18$) or between the operative group (1+2) and the nonoperative group (3) ($P = 0.11$). However, when comparing nonoperative treatment (3) to plate (2) exclusively we found significantly more B fractures in the plate group ($P = 0.03$). No other differences in fracture characteristics could be found when comparing nonoperative treatment (3) to nail (1) ($P = 0.60$). There were no C-fractures found in our material. No difference in sex between nail (1) or plate (2) ($P = 0.516$) or between operative groups (1+2) nonoperative group ($P = 0.904$). No difference in reply rate between nail (1) and plate (2) ($P = 0.677$) or between operative group (1+2) and nonoperative group (3) ($P = 0.880$) group. No difference in mean follow-up time between operative group (1+2) and nonoperative group (3) ($P = 0.491$). Significantly longer follow-up time for plate group (2) than for nail group (1) ($P < 0.001$). The operative group (1+2, median 15 y) are older than the nonoperative group (3, median 14 y) ($P = 0.01$).

Plate Versus Intramedullary Nail

We found no differences between the operative methods in our primary outcome variables QuickDASH and OSS. Cosmetic appearance, pain, and general satisfaction measured with VAS were also the same in both groups (Table 2).

TABLE 2. Primary and Secondary Outcomes

Outcome (Median)	1 (Nail, n = 20)	2 (Plate, n = 18)	*P*
QuickDASH	0	2.26	0.943
OSS	13	12.5	0.696
Appearance (VAS)	3.5	5	0.072
Pain (VAS)	0	0.5	0.696
General satisfaction (VAS)	1	2	0.532

Nail versus plate.
OSS indicates Oxford Shoulder Score; QuickDASH, Quick Disability of Arm, Shoulder, and Hand; VAS, Visual Analogue Scale.

Duration of surgery was significantly lower in the nail group. One of the presumed advantages of intramedullary nailing is the possibility to do closed mini invasive surgery. Surprisingly, the rate of open reduction in the nail group was 77% in our material. Ninety-two percent of the intramedullary nails and 41% of the plates were removed. The rate of infection and sensory affection were 4% versus 9% in nail versus plate. There were 2 refractures in the nail group, and none in the plate group (Table 3).

Operative Versus Nonoperative Treatment

Primary Outcome Variables

We found no difference in QuickDASH between the operatively treated group (1+2) and nonoperatively treated group (3) (Table 4). $P = 0.395$ using the Mann-Whitney analysis.

For OSS we found a significantly lower median score favoring nonoperative treatment ($P = 0.024$). However the difference of 0.5 is far less than the minimal clinically important difference of 6.

Similar findings were made when exclusively comparing nail (1) to nonoperative treatment (3) for QuickDASH ($P = 0.54$) and OSS ($P = 0.04$), and plate (2) to nonoperative treatment (3) for QuickDASH ($P = 0.45$) and OSS (0.083).

Secondary Outcome Variables

We found better scores for all VAS questions in favor of nonoperative treatment (Table 4).

We found 1 nonunion in the nonoperative group that later was operated with a satisfactory result. In the operative group there were no nonunions. There were no refractures in the nonoperative group.

TABLE 3. Surgery Duration and Complications

	1 (Nail, n = 26)	2 (Plate, n = 22)	*P*
Surgery duration (min)	65	89	0.013
Open reduction (%)	77	100	
Hardware removal (%)	92	41	< 0.001
Infection, n (%)	1 (4)	2 (9)	0.454
Sensory affection, n (%)	1 (4)	2 (9)	0.454
Refractures, n (%)	2 (9)	0	

Nail versus plate.
No refractures were seen in the nonoperative group.

TABLE 4. Primary and Secondary Outcomes Operative Versus Nonoperative Treatment

Outcome	Median Score Operative (1+2) (n = 38)	Median Score Nonoperative (3) (n = 49)	*P*
QuickDASH	1.12 (0-25)	0 (0-18)	0.395
OSS	12.5 (12-20)	12 (12-21)	0.024
VAS appearance	4 (0-10)	1 (0-10)	< 0.001
VAS pain	0 (0-7)	0 (0-5)	0.026
VAS general satisfaction	1 (0-8)	0 (0-10)	0.026

The range of scores are presented in parentheses.
OSS indicates Oxford Shoulder Score; QuickDASH, Quick Disability of Arm, Shoulder, and Hand; VAS, Visual Analogue Scale.

DISCUSSION

Our material shows good long-term functional results in both operative and nonoperative treatment for dislocated clavicular fractures in adolescents. For the primary outcome variables QuickDASH and OSS the median scores showed almost perfect function and little pain in all groups. The secondary outcome variables VAS for cosmetic results, pain, and general satisfaction show results favoring nonoperative treatment.

Our study supports the conclusions of the very few other studies that have compared surgical treatment to nonoperative treatment for midshaft clavicular fractures in adolescents. Parry et al[14] found no differences in QuickDASH and Constant shoulder score in their retrospective comparison of 16 patients. Herzog et al[15] found no significant differences in their retrospective comparison of DASH, ASES, and isometric testing in 20 patients. Although not directly comparable regarding time to follow-up and arsenal of PROMS, the results of our study support these findings. Hagstrom et al[16] demonstrated in a retrospective study an almost equal time to radiographic union, time to return to sports and mean DASH score, for adolescents treated with plate (n = 46) and nonoperatively (n = 32) for their clavicle fracture. There was 1 delayed union in the nonoperative group. Vander Have et al[17] found in his retrospective study on operated versus nonoperatively treated midshaft clavicular fractures, that the operative group (n = 17) (plate fixation) had faster union and quicker return to sports. The nonoperative group (n = 25) had 5 painful malunions, where 4 underwent corrective osteotomies and internal fixation. Heyworth et al[18] retrospectively analyzed 641 adolescents with clavicle fractures, where 115 were treated operatively. Only 1 patient in each group developed nonunion. Our study is not directly comparable to these studies because it only focuses on long-term results. However, in our nonoperative group of 61 patients, only 1 was operated for a nonunion.

Some noncomparative retrospective studies have described successful results with surgically treated midshaft fractures.[5,19–21] Luo and colleagues [22,23] showed a high rate of complications in the operatively treated clavicle fractures in adolescents. Rapp et al[24] showed that 24 patients, operated with intramedullary nail, returned to sports after 1 month, but there was a high rate of

implant-related complications. Heyworth et al[18] also showed a fairly high rate of implant-related complications leading to removal of plates. In our study we also find good long-term functional results in operatively treated clavicular fractures. However, consistent with findings mentioned above, the rate of complications is fairly high. Infection and sensory affection ranged from 4% to 9%. Forty-one percent of patients in the plate group and 92% of the nail group had their hardware removed. In the plate group this was related to discomfort from the implant, and in the nail group it is mostly related to the departments standard procedure of removing intramedullary nails when the fracture has healed adequately.

The good long-term results of our nonoperative group also coincides with findings in other studies on nonoperative treatment for clavicular fractures in adolescents. Randsborg et al[1] show mainly good long-term results with nonoperative treatment, but that increased shortening of the fracture may lead more long-term pain and less satisfaction with cosmetic result. Stepanyan et al[25] showed excellent DASH scores at an average of 12 months in 25 displaced midshaft clavicular fractures treated nonoperatively. Bae et al[26] studied function in 16 adolescents with malunion after midshaft clavicular fracture and found that function was well conserved. As radiographic control of patients was not part our study protocol, the rate of malunions in the nonoperative group is not known in our study.

To our knowledge, no study exists comparing different methods of fixating clavicular fractures in adolescents. Comparing anatomic plate fixation and intramedullary nail fixation we could find no differences in neither primary nor secondary self-reported outcome variables. However, the rate of hardware removal was higher in the intramedullary nail group. Surgery duration, infection, and sensory affection was higher in the plate group. Surprisingly, the rate of open surgery was also high (77%) in the intramedullary nail group.

The level of evidence in this study is limited by its retrospective design. The distribution of patients in groups for plate, intramedullary nail, and nonoperative treatment must not be confused with randomization. In our study, groups were formed as a result of daily decision-making in the department of orthopaedics. Consultant orthopaedic surgeons and residents, present at any given day, participated in both decision-making and surgery. Considering the small amount of investigation done on the subject, little evidence-based data could be used in decision-making. The department had, to our knowledge, no greater internal disagreements nor formal guidelines on how to treat these fractures. None of the departments surgeons consistently insisted on either operative or nonoperative treatment. There was a tendency to operate comminuted displaced fractures with plate and screws and simple displaced fractures with intramedullary nail. Young age, simple fractures, and little shortening of the displaced fracture were usually given nonoperative treatment. However, the decision-making varied from time to time and was based on the opinion of the surgeons in charge at any given day. A pro and con discussion with patient and family and consideration of the patient's preference also affected decisions. Retrospectively, we see that this resulted in 3 groups that were not equal, but fairly similar. We could not find a significant difference in AO fracture patterns between the operative and nonoperative groups, but more B-fractures could be found in the plate group when compared with nonoperative treatment alone. In our opinion, considering the limited amount of data existing for these patients, comparing these groups gives us useful information. Many factors seem to be similar and some level of evidence can be extracted from this. Making a randomized controlled trial in this age group is also considered difficult.

In many of the studies mentioned above[1,14,15,17] the shortening of the fracture has been considered an important factor. In our study, the degree of shortening has not been taken into consideration. The dynamic nature of these fractures makes measuring of shortening unreliable. Therefore, all midshaft fractures with displacement of a bone-width or more were included. Schulz et al[27] recently demonstrated in a small study that the degree of shortening of the fracture did not affect level of function compared with noninjured arm. Although not conclusive, this may support our decision in not taking shortening into consideration. However, the tendency of operating the more shortened fractures might produce differences in fracture characteristic between our study groups. Not evaluating this is of course a weakness of the study and must be taken into consideration when interpreting the results.

Another challenge in performing a study in adolescents is the heterogenicity of the study population. Anatomic and physiological variations are great within the age span of 12 to 18 years. Between boys and girls, we also find different rates of development and skeletal maturity. The categorization child-adolescent-adult is not clear-cut but subjugated to a gradual transition. McGraw et al[28] show in his study that the clavicle reaches 80% of its full length at 9 years for girls and 12 years for boys. This shows that our group is at a late stage of bone maturity. One can argue that girls of younger ages should be included in the study. We have chosen to keep the cut-off at the same age for both sexes, mainly to make it easier to compare results to previous studies.

The mean follow-up time were 58, 85, and 68 months in the different groups. The reason for this was that surgery with plate was the standard method for the department at the beginning of the period. Intramedullary nail was gradually introduced as an alternative. Although statistically different, we argue that the differences are irrelevant considering that they all are definitely long term. One cannot argue that much change occurs in function from 4.8 to 7 years after the injury. We have not considered short-term results, time to return to sports, radiographic healing, and objective functional assessment in our study. We argue that the best possible way to assess the success of a treatment is to measure how the patient considers his/her own function and level of pain. Radiographs and objective assessment of movement does not directly correlate with patient satisfaction.

The QuickDASH and OSS are not validated for children, however most patients responding to our questionnaire were over 18 years old. The OSS is mainly used to evaluate the result of shoulder joint surgery, but it has gained widespread use to evaluate the results of clavicular fractures in adults.[1] The QuickDASH is used for the whole upper extremity and has also been widely used in assessing function after clavicle fractures in adolescents.[1] As both groups score almost perfectly in QuickDASH and OSS, one can argue that we see a "ceiling effect," concealing potential smaller differences between the groups.

In our secondary self-reported outcomes we found no differences between the plate and intramedullary nail group. The nonoperative group scored significantly better on all 3 questions. Median self-reported pain is equal in the groups, so the significant *P*-value cannot be considered too important. There is however a great and significant difference in satisfaction with the cosmetic results. The scarring resulting from surgical treatment is obviously something that bothers many patients many years after their injury. Nonoperatively treated fractures usually leave a lump at the healing site. According to our findings this is not as cosmetically troublesome as the scarring from surgery. The VAS results concerning general satisfaction are hard to interpret. The question is not precise, and patients can refer to a variety of different factors when they reply. We have chosen not to read too much into that specific result.

According to our findings, and many of the studies mentioned above, plate fixation, intramedullary nailing, and nonoperative treatment all give good long-term functional results for adolescents treated for dislocated midshaft clavicular fractures.

CONCLUSIONS

Adolescents aged 12 to 18 years with displaced midshaft clavicular fractures show good long-term functional results after plate fixation, intramedullary nail, and nonoperative treatment. No additional benefit is demonstrated for surgery in our material. Nonoperatively treated patients are more satisfied with the cosmetic results. Regarding the heterogenicity of the patient group one cannot completely exclude surgery as an option for treatment for some patients. Factors like age, sex, skeletal maturity, fracture pattern, and functional demands must be considered individually and cautiously before deciding to perform surgery. We have shown that surgery have a relatively high rate of complications. Little difference is seen between the operative methods in our study.

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