



Lateral approach for intramedullary nailing of displaced midshaft clavicle fractures; a retrospective cohort study

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Abstract

Purpose Midshaft clavicle fractures represent about 4% of all fractures in the emergency department. Non-operative treatment of displaced midshaft clavicle fractures (DMCF) can result in a relatively high non-union rate. Several operative techniques, including intramedullary fixation (IMF) using elastic stable intramedullary nailing (ESIN), have therefore been established. IMF through the medial approach is less suitable for fractures of the lateral diaphysis. IMF of DMCF of the lateral diaphysis through a lateral approach can be an alternative approach for these fractures. The aim of this study is to describe the technique of IMF from the lateral side and to present the functional outcome and complications.

Methods A retrospective cohort study was performed. All patients with a traumatic DMCF treated with IMF using ESIN through a lateral approach between 2014 and 2019 were included. Endpoints were the functional outcome (QuickDASH, Subjective Shoulder Value (SSV)), pain (numeric rating scale (NRS)), daily impairment (activities of daily living (ADL)), complications and implant removal.

Results Forty out of 43 patients were available for follow-up. Mean follow-up was 37 months. Mean age was 24 years (range 13–70). The median QuickDASH score was 0 (IQR 0.0–0.0) and the median SSV was 100 (95–100). The median ADL score was 1 (1–4) and the median NRS was 0 (0–0). No non-union occurred. Implant related irritation occurred in 11 patients (27.5%). Implants were removed in a total of 38 (95%) patients; in 10 cases due to irritation, in 28 cases routinely or on patient's request.

Conclusion IMF of DMCF of the lateral diaphysis through a lateral approach leads to excellent functional results and seems to be a suitable option for internal fixation. However, as with IMF from the medial side, it is not without complications and implant-related irritation.

Keywords Lateral approach · Intramedullary nailing · Displaced midshaft clavicle fracture

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Introduction

Clavicle fractures represent about 4% of all fractures in the emergency department and are mostly located in the midshaft (80%). Approximately one half of those cases are displaced midshaft clavicle fractures (DMCF) [1]. Non-operative treatment of DMCF is associated with relatively high non-union rates (10–23%) [2–4]. Therefore, a shift towards operative treatment has occurred and various operative techniques have been developed and implemented [5–10]. Frima et al. [11] proposed a treatment algorithm for clavicle fractures in adults based on current literature in 2019. In addition to plating, intramedullary fixation (IMF), using an elastic stable intramedullary nail (ESIN), usually performed through a medial approach, has proven to be a valuable and safe option for simple diaphyseal fractures. Comminuted fractures and simple diaphyseal fractures of the more lateral part of the midshaft, however, are known to be less suitable for IMF from a medial approach due to higher rates of implant-related irritations [12]. Consequently, IMF is not recommended as a suitable surgical advance to treat such type of fractures, especially in comminuted fracture pattern. For simple DMCF located more laterally in the diaphysis, however, IMF can be performed from the lateral side of the clavicle. Theoretically, IMF of simple DMCF from the smaller lateral fragment into the larger medial fragment is more stable than the other way around. This could result in less migration of the nail and less implant-related irritation. Before one can study this in a larger series we should know if this technique has at least equal or better union rates and functional results. Therefore, we hypothesize, that a lateral approach for IMF can result in a high level of functional outcome without an increase in complications.

The aim of this study is to describe the surgical technique of IMF of DMCF from the lateral side and to present the functional outcome and complications.

Materials and methods

Study design

A retrospective cohort study at a level 1 trauma centre was performed. All patients who were operated on for a traumatic DMCF with IMF using ESIN through a lateral approach between 2014 and 2019 were eligible for inclusion. Exclusion criteria were mal- or non-union and absence of written informed consent. This study was approved by the local ethical committee (Kantonale Ethikkommission Zürich, BASEC-Nr. 2020-01044).

Data collection

Patients were identified using our prospective trauma database. Baseline characteristics (patient age, gender, trauma mechanism, type of fracture including concomitant injuries, treatment and complications) were retrieved from the electronic hospital patient files. Fractures were classified according to the official AO/OTA classification system [13]. Fractures were, therefore, categorised by their localization as AO/OTA 15.2 (Fig. 1). The first number defines the clavicle, the second number describes the diaphyseal segment. Furthermore, fractures were sub-classified into A, B and C for simple, wedge and comminuted fractures. Additional information for the assessment of long-term functional outcome after operative stabilisation was obtained during regular follow-up in an outpatient setting or by telephone interview. Standardised questionnaires (Quick Disabilities of Arm, Shoulder and Hand (QuickDASH) score, Subjective Shoulder Value (SSV), Numeric Rating Scale (NRS), Activities of Daily Living (ADL), Hulsman's implant removal score) have been used [14–19].

Indications for operative treatment

Indications for operative stabilisation of simple DMCF with IMF in our hospital follow the algorithm as presented in Fig. 2. Displaced diaphyseal fractures directly located in the midshaft or medial from it are approached from the medial side of the clavicle. Fractures that are more laterally from the midshaft, but still in the diaphyseal segment, are addressed from lateral (Fig. 3).

Operative procedure

Operations were performed with patients placed in a supine position on a radiolucent operation table. The image intensifier was positioned to project the entire clavicle in two directions (caudo-cranial and cranio-caudal) [20]. The entry point for the nail was the postero-lateral end of the clavicle as defined by x-ray or palpation. Following a stab incision and sparse dissection of the soft tissue, the cortex was manually opened using a bone awl or a drill bit. After defining the size of the nail according to the width of the medullary canal, the titanium elastic nail (TEN) (DePuy Synthes, Zuchwil, Switzerland) was then entered from the lateral side

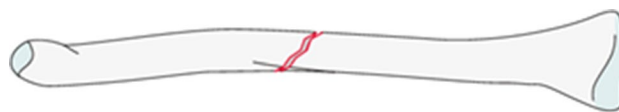
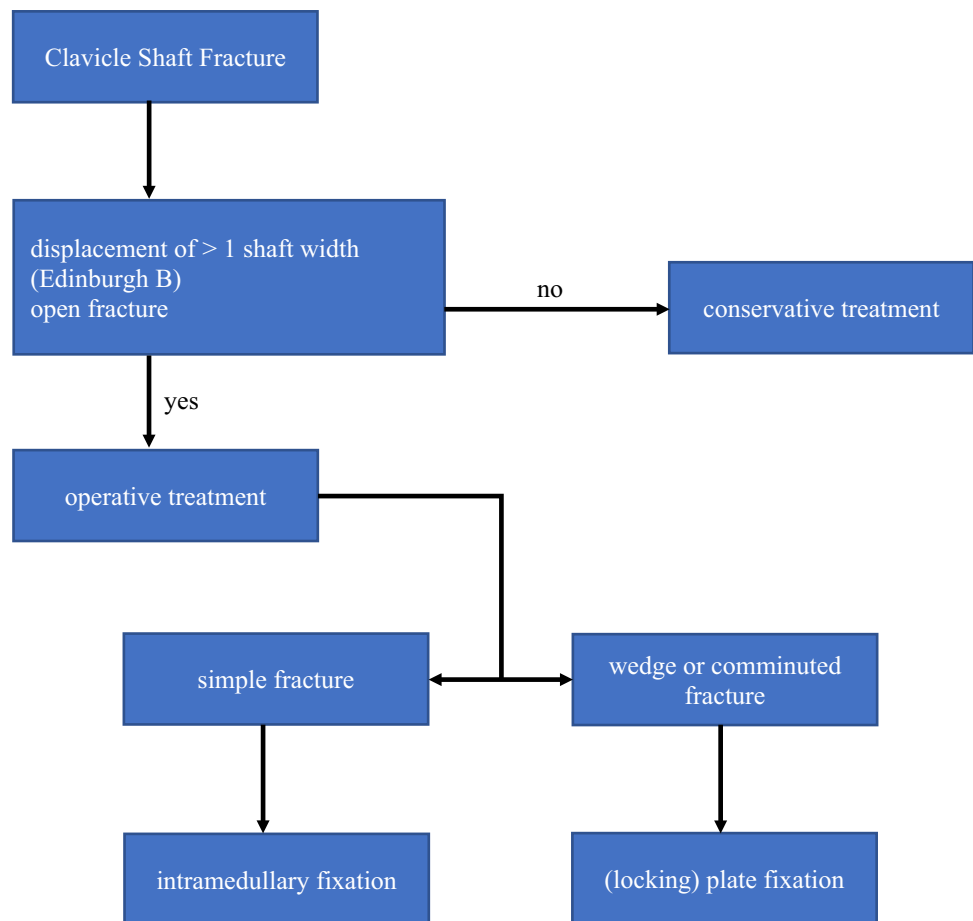


Fig. 1 Fracture pattern AO/OTA 15.2 [13]

Fig. 2 Indication algorithm



and slowly moved towards the medial side using the attached T-handle. Reduction of the fracture was, whenever possible, performed closed with or without the use of percutaneous inserted pointed reduction forceps. If closed reduction was not successful, a small incision at the fracture site was performed to allow direct open reduction. The nail was shortened with respect to the covering soft tissue. To facilitate later implant removal excessive shortening was avoided. End caps were not routinely applied but inserted on discretion of the treating surgeon if applicable. After fluoroscopic control of the correct intramedullary nail position and length of the nail, the wound was closed in layers.

Postoperative treatment

Pain-dependent mobilisation was permitted immediately after the operation without weight bearing for 6 weeks. For comfort reasons, a mitella sling was handed out routinely. Patients conducted functional rehabilitation with range of motion limited to 90° abduction and elevation 6 weeks postoperatively, starting on the first day after operation. On the first or second postoperative day, reduction and nail positioning were verified with clavicle x-ray in caudo-cranial

and cranio-caudal direction (Fig. 4a, b). Return to normal everyday activity and to sports were usually allowed after 6–8 weeks postoperatively, if osseous consolidation was verified radiologically.

Follow-up and implant removal

Routine clinical and radiological follow-up examination took place 6 and 12 weeks after surgery in the outpatient department. Implant removal was routinely performed 4–6 months postoperatively if fracture consolidation was verified by a clinical and radiological examination (Fig. 5). Earlier removal was executed due to specific indications (e.g. implant-related irritation).

Outcome measures

Primary outcome was the shoulder function using the QuickDASH score and the SSV [14–17]. The QuickDASH score ranges from 0 to 100. A score of less than 10 is considered an excellent result, whereas a score of over 40 indicates strong impairment and poor shoulder function. The SSV is a single measure score ranging from 0

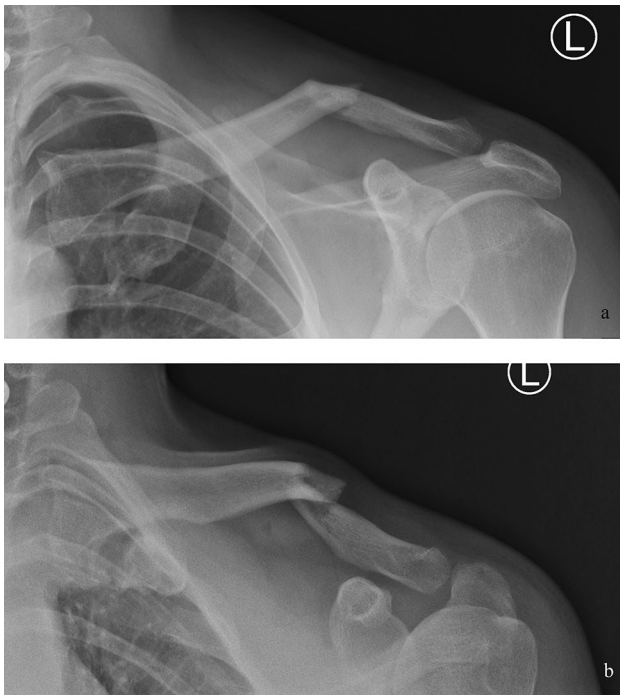


Fig. 3 Radiological examination preoperatively; left clavicle caudo-cranial (a) and cranio-caudal (b)

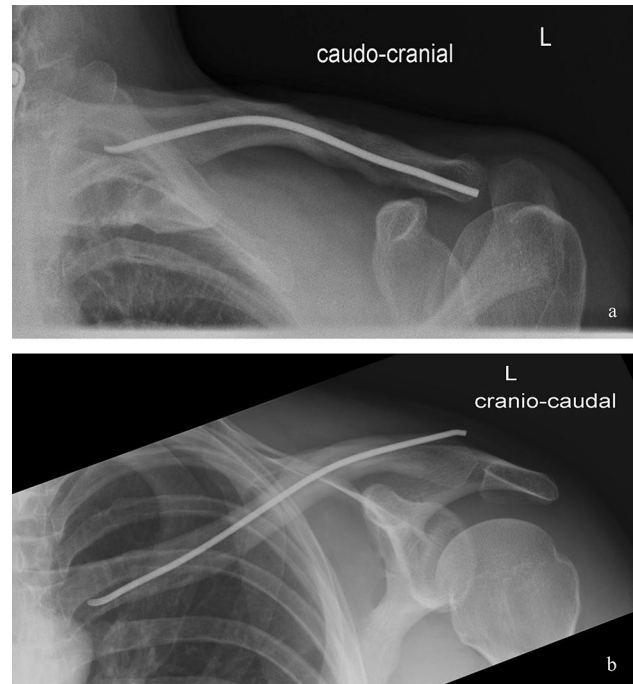


Fig. 5 Radiological examination 6 months postoperatively; left clavicle caudo-cranial (a) and cranio-caudal (b)

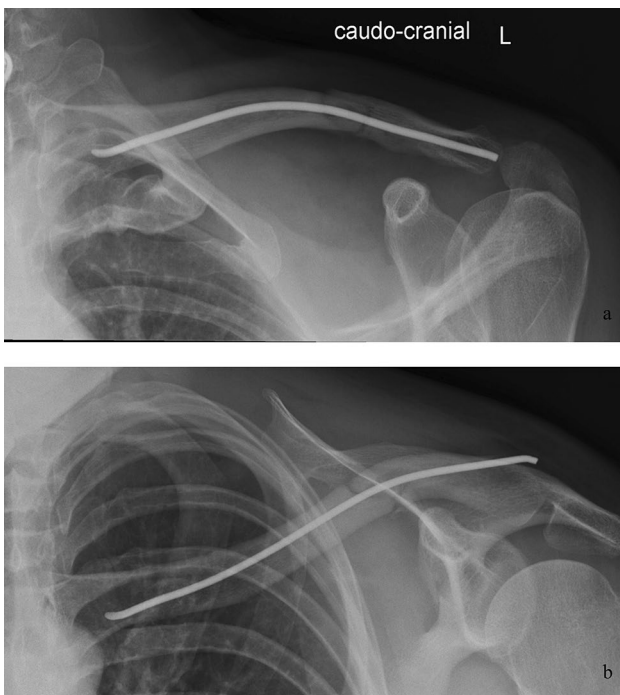


Fig. 4 Radiological examination postoperatively; left clavicle caudo-cranial (a) and cranio-caudal (b)

to 100, whereas 100 indicate unlimited shoulder function. Secondary outcome parameters were pain, analysed by the NRS [18], whereas 0 demonstrates “no pain” and 10 the “worst pain imaginable”. The daily impairment was evaluated using the ADL score [19], which ranges from 1 to 4. One indicates no impairment, whereas 4 demonstrates strong impairment. Furthermore, complications and implant removal analysed by the algorithm of Hulsmans et al. [21] were documented and interpreted. This algorithm was developed to investigate the existence of local irritation due to an implant.

Complications

Complications like infection (superficial or deep), non-union, revision surgery (e.g. nail shortening) and implant irritation were recorded. Superficial infection was defined as redness, swelling and/or purulent discharge from the wound that could be treated with antibiotics. If surgical wound drainage was required, it was considered a deep infection. Lacking evidence of radiological osseous consolidation and pain 6 months after intramedullary nailing was considered as non-union. Therapeutic interventions needed to treat complications were documented. Any operation in which the initial osteosynthesis had to be corrected or a different operative technique had to be used was considered revision surgery.

Statistical analysis

Data are described using frequencies and percentages for dichotomous and categorical variables, mean and standard deviation (SD) for normally distributed continuous data, and median and interquartile range (IQR) for non-normally distributed continuous data. The analyses were performed with SPSS, version 25.0 (IBM Corp., Armonk, NY, USA) for Windows.

Results

During the inclusion period, a total of 43 patients were treated with intramedullary nailing through a lateral approach. Forty patients were available for follow-up and therefore included. Three patients were lost to follow-up. The mean follow-up was 37 months (SD 19.4, range 9–69). Baseline characteristics are presented in Table 1. The mean

age was 24 years (SD 11.4, range 13–70). Patients were predominantly male (65%). Functional results were excellent with a median QuickDASH score of 0 (IQR 0.0–0.0) and a median SSV of 100 (IQR 95–100). The NRS and ADL scores showed very good results with median scores of 0 (IQR 0–0) and 1 (IQR 1–1), respectively (Table 2). All fractures appeared consolidated and no non-union could be detected.

Unfortunately, several complications occurred (Table 3). Eleven (27.5%) patients presented with implant-related irritations. Six patients (15%) experienced a near and 3 (8%) a complete perforation of the skin at the location of the primary entry point, which were observed at a time range of 3–4 months postoperatively. In 3 of the 6 patients suffering from near perforation of the skin the TEN had to be shortened. In 1 of these patients the TEN was removed 6 weeks after shortening due to persistent irritation without re-implanting another internal fixation. These certain patients' further course was uneventful and functional results were excellent. One patient with an early skin perforation developed a deep infection and was treated with antibiotics. Three weeks after the insertion of the nail, it was removed under general anaesthesia. No other internal fixation was inserted due to a stable situation. He recovered uneventfully with excellent functional scores. In 2 (5%) patients, irritation was caused by prominent end caps. Overall, implant removal was performed in 38 (95%) patients. In 10 (25%) cases due to implant-related irritation, in 28 (70%) cases routinely or on patient's request. For 2 patients without registered implant removal this procedure was planned to be performed 2 months after data collection for follow-up. One patient did not want to have the implant removed in absence of irritation.

Table 1 Baseline characteristics

	<i>n</i> = 40
Age, years, mean (SD, range)	24 (11.4, 13–70)
Male/female (%)	
Male	26 (65)
Female	14 (35)
Trauma mechanism (%)	
Ski/snowboard	19 (47)
Bike	10 (25)
Different sport	4 (10)
Motorbike	1 (3)
Pedestrian	2 (5)
Others	4 (10)
AO classification (%)	
15.2A	35 (88)
15.2B	4 (10)
15.2C	1 (2)
Follow-up, months, mean (SD)	37 (19.4)
Time to surgery, days, mean (SD)	1.4 (2.3)
Operation time, minutes, mean (SD)	63 (31.8)
Closed reduction (%)	
Yes	17 (43)
No	23 (57)
Implant thickness (mm) (%)	
2.0	8 (20)
2.5	26 (67)
3.0	4 (10)
3.5	1 (3)
End cap application (%)	
Yes	21 (52)
No	19 (48)

Discussion

Osteosynthesis of DMCF with IMF through a lateral approach mostly results in excellent functional outcome.

The QuickDASH score and the SSV, as well as the NRS and ADL scores, are very promising. It is a feasible option

Table 2 Functional results

	Median (IQR)
QuickDASH	0.0 (0.0–0.0)
SSV	100 (95–100)
NRS	0 (0–0)
ADL	1 (1–1)

DASH disabilities of arm, shoulder and hand, *SSV* subjective shoulder value, *NRS* numeric rating scale, *ADL* activities of daily living

Table 3 Complications

	<i>n</i> (%)
Re-operation for shortening of TEN	3 (8)
Infection	
Superficial	0
Deep	1 (2)
Non-union	0
Skin irritation	
No	31 (78)
Yes	9 (22)
Near perforation	6 (15)
Perforation	3 (7)
Other	2 (5)
Implant removal	
Implant not removed, no irritation	2 (5)
Implant not removed, irritation but implant removal not necessary	0
Implant not removed, irritation, no request for removal due to fear of surgery	0
Implant not removed, irritation, considering removal	0
Implant routinely or on patients request without irritation	28 (70)
Implant removed due to implant irritation	10 (25)
Time to implant removal, months, mean (SD)	5.2 (3.6)

to plate fixation for simple DMCF of the lateral part of the diaphysis of the clavicle. To our knowledge, this is the first study to report on intramedullary nailing of DMCF through a lateral approach using ESIN.

Intramedullary fixation has been proven to be a feasible treatment option for simple midshaft fractures of the clavicle [12, 22]. Compared to plate fixation, IMF of diaphyseal fractures shows equally good long-term functional outcomes and union rates [23]. Benefits of IMF are, among others, lower rates of major re-interventions and less re-fractures after implant removal [22]. Hulsmans et al. demonstrated that fracture comminution and a more lateral diaphyseal fracture location (> 58% from the medial cortex) are predictive values for the development of implant-related irritation after medial nail insertion [12]. They concluded that IMF through a medial approach might not be appropriate for DMCF located more lateral in the diaphyseal midshaft. At our institution, the lateral approach was implemented for simple fractures of the lateral midshaft (AO/OTA 15.2A). Trauma surgeons applying this technique hypothesised that fractures located more laterally in the midshaft were suitable for intramedullary fixation rather through a lateral instead of a medial approach. In our consideration, which is not scientifically proven, the lateral insertion seemed anatomically and biomechanically more suitable when implanting the IMF from a (lateral) smaller/shorter fragment into the (medial) larger/longer fragment.

Fracture consolidation was 100% successful, no non-union occurred. The rate of other postoperative complications is at least comparable with IMF from the medial side

[12]. Perforation of the skin occurred in 3 patients and in 3 patients shortening of the TEN at the entry site was necessary. Unfortunately, because of the retrospective character of this study, it is hard to identify the reason for the irritation. Nails could have had too long ends, migrated laterally or were just ‘sharp’ after cutting. Some patients did have an end cap. However, they also had irritation and numbers were too small to perform a statistical analysis. Implant removal rates are high (95%); on the one hand because of implant-related irritation, on the other hand, because of routine removal according to the applied protocol. One could suggest to change the future protocol and to abandon the routine implant removal. As already discussed in several previous studies, implant-related irritation and migration of the nail are well-known complications when using the traditional technique [23–25]. Compared to the medial approach, the rate of implant-related irritation seems slightly lower (27.5 vs. up to 58%) [12]. However, the small number of patients and the retrospective character of this study do not allow us to draw solid conclusions about this. Also, the high rate of routine postoperative removal of the intramedullary device decreases the rate of developing further implant-related complications.

Several limitations need to be addressed. First, since it is a retrospective study, it has its obvious drawbacks. Second, it is a single centre study and the size of the cohort including only 40 patients might be too small to be representative. However, the high follow-up rate (93%) with a mean follow-up of over 3 years is a positive aspect of this study. Third, the number of included patients is too small to draw any

conclusions about the influence in implant-related irritation. This study only presents the technique and functional outcomes as a kick-off for a different approach for these simple DMCF in the lateral diaphysis. Our results will have to be confirmed and approved in other and larger studies to determine its value for future clavicle fracture treatment.

Conclusion

IMF of DMCF of the lateral diaphysis through a lateral approach leads to excellent functional results and seems to be a suitable option for internal fixation. However, as with IMF from the medial side, it is not without complications and implant-related irritation.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by NK, AR, HF, CS and CM. The first draft of the manuscript was written by NK, MK and CM and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local ethical committee (Kantonale Ethikkommission Zürich, BASEC-Nr. 2020-01044).

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

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