ORIGINAL PAPER
PŮVODNÍ PRÁCE

Functional Results Following Titanium Elastic-Stable Intramedullary Nailing (ESIN) of Mid-Shaft Clavicle Fractures

Funkční výsledky hřebování zlomenin střední části klíční kosti elastickým stabilním nitrodřeňovým hřebem (ESIN)

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ABSTRACT

INTRODUCTION

While plate fixation remains the gold standard for surgical treatment for displaced mid-shaft clavicle fractures (DMCF), intramedullary fixation has emerged as a promising alternative. However, due to its more demanding technique and depending on the fracture's nature, an open reduction can be necessary. Aim of this study was to compare the outcome of open reduction versus closed reduction of DMCF using ESIN.

PATIENTS AND METHODS

Titanium Elastic Nail (TEN) were used to treat 40 patients undergoing minimally invasive ESIN between December 2006 and July 2009. A total of 19 patients were treated with a closed reduction and 21 patients required open reduction.

RESULTS

Open reduction increases operative time and fluoroscopy time significantly versus closed reduction (open 80.8 ± 35.9 min; closed 30.5 ± 8.5 min). No significant differences were found regarding strength measurement (75.7 ± 22.0 N in the closed group and 74.2 ± 26.0 N in the open group), DASH score (5.1 ± 6.5 closed group vs. 5.8 ± 7.3 open group) and Constant score (87.4 ± 9 points closed group vs. 85.3 ± 7.2 points open group). No major complications were observed.

CONCLUSION

There was no significant difference comparing patients who were treated with an open versus a closed technique. If appropriately indicated we believe that using ESIN is an adequate and successful operative technique for DMCF. There were no significant differences in shoulder function after either procedure.

Key words: clavicle fractures, elastic-stable intramedullary nailing.

INTRODUCTION

Clavicular fractures account for 2.6–10% of all fractures, and around 80% are located in the middle third of the clavicle (13). Traditionally, conservative treatment was indicated for displaced mid-shaft clavicle fractures (DMCF). However, recent studies have shown poor outcomes consisting of non-union, shoulder shortening, disappointing cosmetic results and/or functional deficits in up to 30% of patients (9, 11). Furthermore, Smekal et al. reported superior results after plate fixation and elastic-stable intramedullary nailing (ESIN) for displaced mid-shaft clavicle fractures when compared to non-operative treatment (15).

Over the last decade, intramedullary fixation using a titanium elastic nail has emerged as a promising alternative procedure versus plate fixation. The advantages of ESIN are keeping the periosteum and fracture hematoma intact, maintaining vascular integrity of fracture site, decreasing infection rates and good cosmetic results (6, 9). Nonetheless, the risk of medial or lateral nail mi-

gration resulting in sensoric irritation or skin perforation and the secondary shortening of the clavicle needs to be mentioned (19).

The purpose of this retrospective study was to review our functional, radiological and cosmetic results of displaced mid-shaft clavicle fractures treated by ESIN.

MATERIAL AND METHODS

Within a period of three years, 40 Patients presenting with a primary unilateral mid-shaft clavicle fracture (type 15-B according to OTA) (20) were treated by ESIN. Of these patients, 10 were female and 30 were male with a mean age of 42.2 ± 13.6 years. The mechanism of injury was a fall during sporting activities in 16 cases, a traffic accident in 14 cases and a fall from a standing height in 10 cases. These DMCF consisted of 14 fractures with 2 fragments (35%), 15 fractures with 3 fragments (37.5%), 9 fractures with 4 fragments (22.5%) and 2 fractures with 5 or more fragments (5%). The interval between operation and trauma was 3.8 ± 3.3 days on average.

For surgical management all patients were placed in the "beach-chair-position" with the ipsilateral arm set free. A 1-cm incision was made over the sternal end of the clavicle. After soft tissue dissection the ventral cortex of the medial clavicle was opened using a bone awl. A titanium elastic nail (TEN – DepuySynthes, Umkirch, Germany) was then introduced into the medullary canal. The thickness of the TEN (2.0 – 3.0 mm) was matched to the diameter of the clavicular diaphysis. For closed fracture reduction the medial and lateral main fracture fragment was manually repositioned by hand or sometimes by using a percutaneous clamp. In case of a not feasible closed reduction a longitudinal incision along the axis of clavicular shaft (2 – 3 cm) was made directly over the fracture site to allow for open reduction. After opening and TEN positioning into the medullary canal of the lateral main fragment, we advanced it using oscillating movement as distally as possible. Gentle counterforce was created by fixing the lateral fragment with hand pressure on the shoulder to prevent distraction of the fracture. To prevent perforation of the nail throughout the lateral cortex, the TEN position was checked during surgery using an image amplifier. The TEN was finally cut close to the entry point. Of 40 evaluated patients, 19 patients received a closed reduction. In 21 patients an open reduction had to be performed.

Tab. 1. Complications after ESIN

Complications	Number (n)
Infection/Hematoma	0
Medial migration	12
Sensoric irritation	5
Non-union	0

Tab. 2. Functional outcome after ESIN

	Closed reduction	Open reduction
Constant	87.4 ± 9	85.3 ± 7.2
DASH	5.1 ± 6.5	5.8 ± 7.3
Strength (N)	75.7 ± 22.0	74.2 ± 26.0

Postoperatively, all patients received a sling for comfort for 14 days after surgery. Active range of motion was limited to 90° of abduction and elevation for 6 weeks. We suggested TEN-removal after the fracture was consolidated at 3 months earliest and 12 months latest.

At a minimum follow-up time of 3 months, patients were invited to return for clinical evaluation. Personal interviews and physical examinations were carried out by an independent investigator not involved in the patients' initial management. The functional outcome was rated by the Constant score and the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH). Additionally a Visual Analogue Scale (VAS) between 0 and 10 (indicating 0 = no pain, 10 = maximum pain) was used for qualitative pain scoring postoperative and follow-up radiographs were retrospectively evaluated for fracture healing, implant failure and loss of reduction.

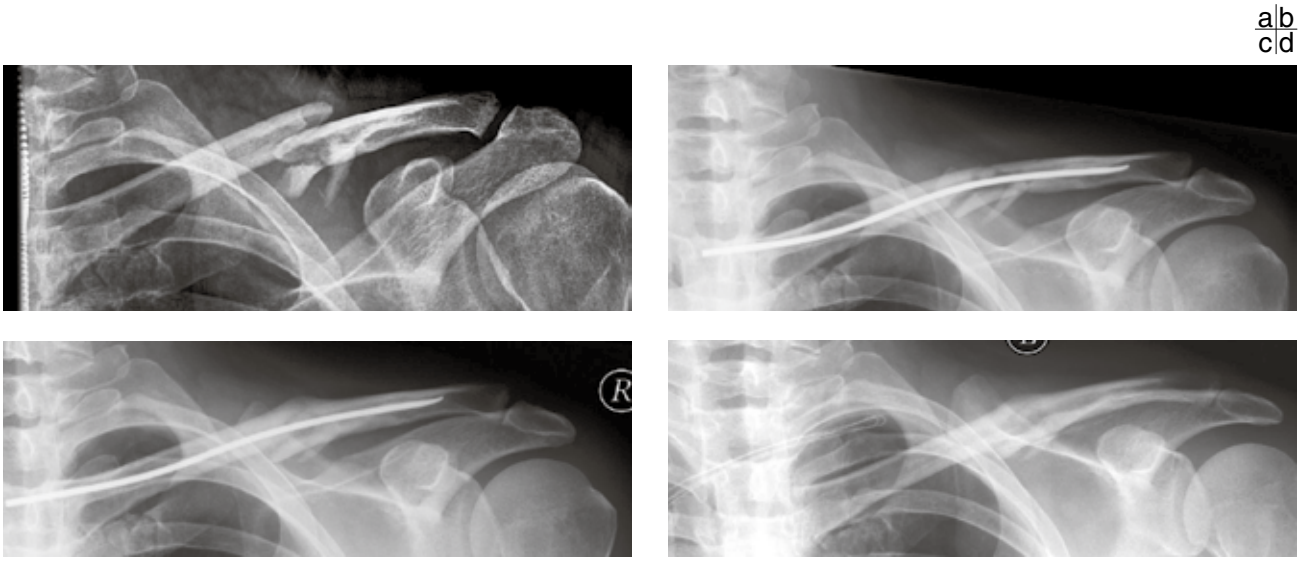

Fig. 1. X-ray of displaced mid-shaft clavicle fractures (a) and after closed ESIN procedure (TEN: 2.5 mm) (b), 3 Month postoperative (c) and after TEN-removal (d).

RESULTS

Patients were followed for 13.4 ± 6.9 months postoperatively. The DASH score was 5.1 ± 6.5 for closed reduction and 5.8 ± 7.3 for open reduction, respectively. The Constant score was 87.4 ± 9 points (closed reduction) vs. 85.3 ± 7.2 points (open reduction). No significant reduction measuring strength was observed in neither of the two groups (closed reduction: 75.7 ± 22.0 N vs. open reduction: 74.2 ± 26.0 N). (Tab. 2).

All fractures healed by primary intention (Figs 1 and 2). No revision surgery was necessary in any case. The mean operating time for closed reduction (n =19) was 30.5 ± 8.5 min and 80.8 ± 35.9 min for open reduction (n =21), respectively. Accordingly, intraoperative fluoroscopy was 0.6 ±1.3 min versus 2.0 ± 1.4 min.

The postoperative complications are illustrated in Table 1. Medial nail migration occurred in 12 patients (30%) irritating the skin in 3 patients (7.5%) and leading to skin perforation in 2 patients (5%). Therefore 3 patients (7.5%) requested the nail to be removed or locally shortened in local anaesthesia. Local skin numbness occurred in 4 patients (10%).

Fractures with 2 fragments were reduced as many times in an open as in a closed technique. This verifies as well for all other fracture types, except fractures with very large fragments. A closed reduction was not possible in these cases.

Only 5 patients reported mild pain (VAS = 1) while 35 patients had a VAS of 0 at the time of physical examination. 93% were pleased with their cosmetic results of their scars.

DISCUSSION

Due to the poor outcome of DMCF treated conservatively and with increasing patients' expectations, operative treatment of DMCF becomes more and more popular (3, 10). Plate fixation is an established technique and still remains the gold standard for DMCF. However, recent data suggest that minimal-invasive procedures such as ESIN show no difference regarding functional outcome and complications when compared to plate fixation (4, 16). Typical complications of plate fixation include infection, hypertrophic scars, implant loosening and re-fracture after implant removal with an incidence of up to 23% (2). Furthermore, due to the implant design, patients report skin irritation and hardware prominence causing unnecessary pain (8). Henceforth, ESIN appears to be a promising alternative. One of its imminent advantages is a reduced operative and fluoroscopy time, as seen in our results. Furthermore, the aesthetic results with smaller scars, even when an additional open reduction is necessary, account for the great acceptance of this procedure in patients.

Certainly, ESIN is a more demanding and challenging technique. The main difficulties encountered when inserting an intramedullary implant are the anatomy of the clavicle and the fixation strength to resist fracture site motion during the healing period (9). Furthermore, there is a risk of perforation of the lateral cortex fragment due to the stiffness of the implant. However, with more flexible devices such as the TEN and by carefully advancing in an oscillating manner by hand, obtaining intraoperative oblique radiographs to rule out lateral perforation, excellent results can be obtained. Additionally, limiting range of motion postoperatively for 6 weeks to 90° abduction and elevation limits length shortening and aids fracture consolidation (7, 12). Reported rates for major complications like bone-healing problems and deep infections requiring implant removal were no higher than 7% (5). Non-union rates for ESIN range from 0 – 1.7% compared to plate fixation with 2.2 – 3% (1, 17).

According to Liu et al. minimally invasive fixation of DMCF with TEN should be used carefully in pa-

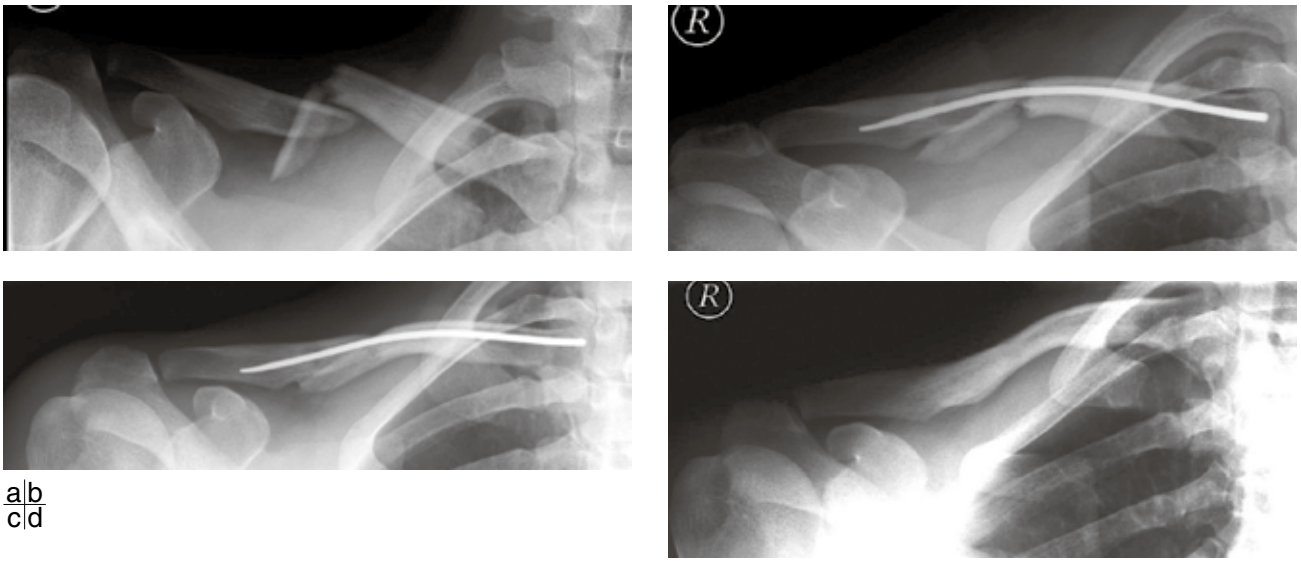

Fig. 2. X-ray of displaced 3-part mid-shaft clavicle fractures (a) and after closed ESIN procedure (b), 4 month postoperative (c) and after TEN-removal (6 month postoperative) (d).

tients with a small clavicular canal, a distal claviular fracture and a comminuted clavicular fracture (9). In our series, we used a TEN with a diameter of 2.0 in three patients due to smaller medullary canals, even though the nail diameter should be between 33% and 40% of the diameter of the medullar space (14). If additional open reduction was performed, no differences regarding functional outcome were observed (DASH, Constant, strength (N)).

One of the major complications using ESIN is irritation of the skin at the medial entry point due to migration, telescoping and protrusion (18). In our collective we had to remove or shorten the TEN in 3 cases with an overall medial protrusion in 12 patients, though no reoperation was needed.

CONCLUSION

Our results clearly demonstrate that ESIN is a safe and minimally-invasive technique when appropriately indicated of DMCF – even when additional open reduction is needed. Good cosmetic and functional results are achieved while less operative time and fluoroscopy time are used. ESIN is a promising alternative to plate fixation.

Authors declaration

The authors certify that they have not signed any agreement with a commercial interest related to this study/publication and have not received benefits in any form. Parts of this study have already been published in Der Unfallchirurg 116: 102–110, 2013.

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