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Locking Nail versus Plate Fixation in Calcaneal Fractures: Brief report on a Retrospective Analysis of Treatment Characteristics and Radiographic Correction Potential

Zajištěný hřeb versus dlahová fixace u zlomenin patní kosti: stručná informace na podkladě retrospektivní analýzy charakteristik léčení a potenciálu rentgenologické repozice

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ABSTRACT

PURPOSE OF THE STUDY
Minimal and limited access techniques are gaining increasing interest for the treatment of displaced intra-articular calcaneal fractures. The ideal treatment method is however still debated and largely based on individual case factors and surgeon experience. Aim of this study was thus to compare the treatment characteristics and radiographic correction potential of a locking nail system with a sinus tarsi approach to plate fixation via an extended lateral approach.

MATERIAL AND METHODS
We retrospectively reviewed 39 cases of patients with calcaneal fractures that received primary fracture treatment for displaced intra-articular calcaneal fractures between July 2017 and March 2020. Patient characteristics, time to surgery, time to discharge, OR time and the correction achieved were analyzed and comparative statistics performed.

RESULTS
In total 19 patients treated with the locking nail and 20 patients treated with plate fixation were analyzed. Patient age and fracture severity according to the Sanders classification were comparable between the groups. Overall surgical time, as well as the achieved reduction was equal between both groups. Time to surgery, as well as time from surgery to discharge was significantly shorter in the locking nail group. 2 additional soft tissue procedures were necessary in the extended lateral approach group.

DISCUSSION AND CONCLUSIONS
The results with the locking calcaneus nail and sinus tarsi approach suggest, that similar treatment results can be achieved as with plate osteosynthesis and an extended lateral approach. Soft tissue management, as well as pre- and postoperative timing and discharge management can be improved with the nail. Further controlled trials comparing the long-term outcome between the treatment options are needed.

Key words: calcaneus fracture, sinus tarsi approach, calcaneal nail, C-Nail.

INTRODUCTION

The treatment of displaced intra-articular calcaneal fractures can be pursued in four general treatment categories: nonoperative management, open reduction internal fixation (ORIF), minimally, or less invasive fixation and ORIF combined with subtalar arthrodesis (20). Currently a trend towards less invasive fixation methods and minimally open reduction can be observed (20, 23). Perceived advantages of these techniques are equal reduction capabilities to open techniques with adequate case selection, as well as a reduced complication rate in patients with severe soft tissue compromise, or systemic conditions precluding the safe use of an extended lateral approach (12, 17). A multitude of techniques have been described with different exposures, such as through the sinus tarsi approach, Ollier's approach, minimally invasive longitudinal approach and stab incision, as well as different osteosynthetic constructs, with K-wires, screws, external fixator assisted and with calcaneal nails reported (1, 7, 8, 10, 11, 13, 14, 19, 23, 24, 26, 27).

The use of nails in the treatment of calcaneus fractures has first been described in 1882 by Carl Gussenbauer (2). With the recent advent of new nailing techniques this treatment modality has gained increasing interest as a minimally invasive procedure, with two general options available in the form of a nail to primarily support the posterior talar articular surface and an axially implanted calcaneal nail (5, 27). Both have been shown to provide equal to favorable biomechanical properties

compared to locked plating (6, 18), and study results point toward good clinical outcome and reduced soft tissue complications (21, 27). Due to the reduced reliance on the soft tissue envelope minimally invasive procedures in general have been shown to be able to reduce the time to surgery, as well as the time from surgery to discharge in select patients (25).

Aim of this study was thus to examine the treatment and timing characteristics as described in other minimally invasive techniques, as well as radiographic correction potential of an axially implanted locking calcaneal nail with sinus tarsi approach reduction compared to plate osteosynthesis with a standard, extended lateral approach.

MATERIAL AND METHODS

A retrospective chart review was performed for all patients treated between July 2017 and March 2020 either with a calcaneus nail via a sinus tarsi approach (CN group) as previously described (C-Nail; Medin, Nove Mesto na Morave, Czech Republic) (16), or locked plating via an extended lateral approach (LP group). Included were all patients treated within the timeframe that had calcaneus fractures Sanders II through IV and complete charts concerning pre- and post-operative radiographs to determine Sanders Classification, angles of Bohler and Gissane, as well as time of injury, discharge timing and wound status. Radiographs were reviewed, graded and measured by four surgeons independently. The mean of all values was taken for analysis Statistical analysis was performed with JASP (Mac Version 0.14.1; JASP, University of Amsterdam). Data was tested for normal distribution with the D'Agostino & Pearson normality test, accordingly comparative statistics were performed with the Mann-Whitney-U, or t-test. $P < 0.05$ was defined as statistically significant.

Table 1. Patient characteristics concerning age, gender, Sanders classification and preoperative joint angles are shown along with p-values of the comparative analysis

	Calcaneal nail (n=19)	Locking plate (n=20)	p-value
Age	50.16 (30–66)	52.75 (30–87)	0.55
Sex			
w	5	7	
m	14	13	
Sanders classification			0.46
II	4	3	
III	9	7	
IV	6	10	

RESULTS

Overall 39 patients were included, 19 treated with the nail implant, 20 with a locking plate. The average age was 50.2 years in the CN group and 52.8 years in the LP group. No significant differences were seen in the gender distribution and Sanders classification angles (Tab. 1). Additional soft tissue procedures were required in 2 patients in the LP group. No wound complications were documented in the CN group.

Time from injury to surgery was significantly shorter in the CN group (CN 6.7±3.6 days vs. LP 16.4±7.6 days; $p<0.001$) (Fig. 1a). No difference was seen in the OR (operating room) procedure time between the CN and LP group (CN 122.6±43.2 minutes vs. LP 140.0±35.3 minutes; $p=0.178$). However, when excluding procedures in which the treating surgeon used the nail implant for the first time this becomes significantly different (CN 108.8±21.2 minutes vs. LP 136.4±35.1 minutes;

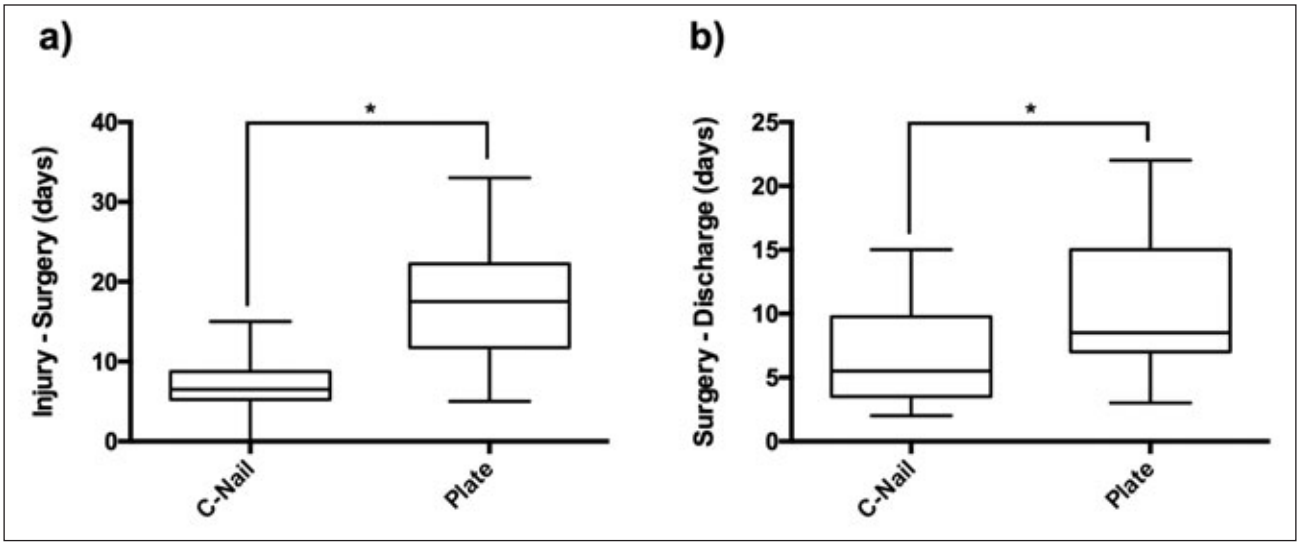

Fig. 1. Differences between patients treated with the calcaneal nail (C-Nail) and locking plate (Plate) regarding time from injury to surgery (a) and time from surgery to discharge (b) are shown. Boxes show mean, as well as 1st and 3rd quartile.

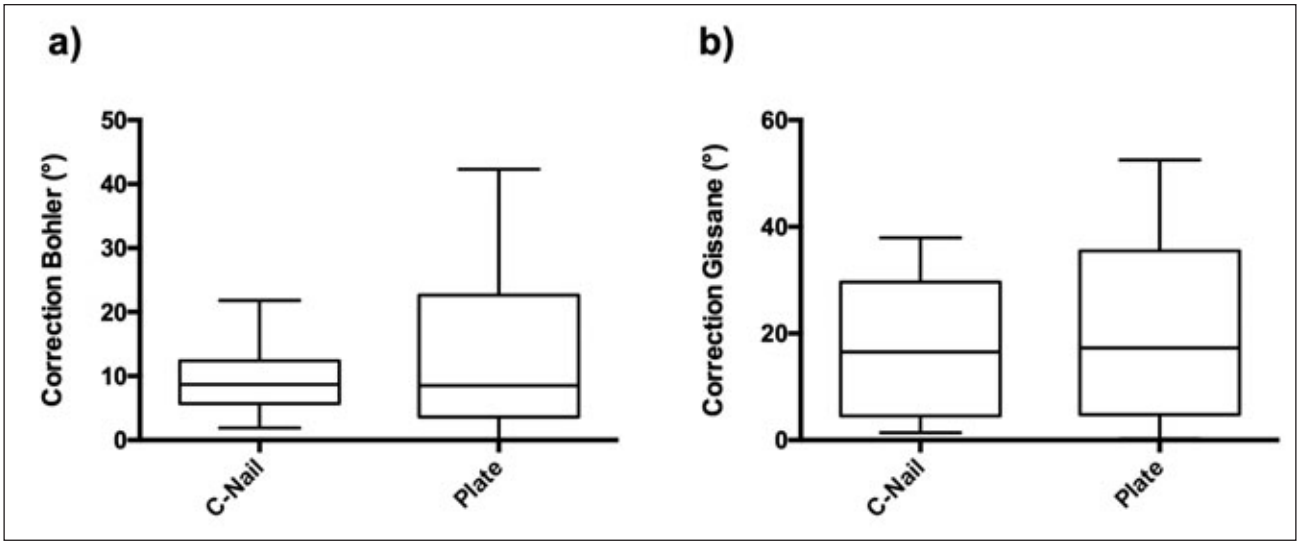

Fig. 2. Differences between patients treated with the calcaneal nail (C-Nail) and locking plate (Plate) regarding correction of Bohler's angle (a) and Gissane's angle (b). Boxes show mean, as well as 1st and 3rd quartile.

p=0.006). Time from surgery to discharge from our institution was shorter in the CN group (CN 6.1±3.4 days vs. LP 10.3±5.5 days; p=0.007) (Fig. 1b).

Adequate reduction was possible in all cases. The delta between pre- and post-operative angles was not significantly different between the groups for both Bohler's (CN 14.7±10.8° vs. LP 17.4±13.3°; p=0.504) and Gissane's angles (CN 11.9±11.4° vs. LP 15.9±15.2°; p=0.355) (Fig. 2).

DISCUSSION

With the general trend towards more soft tissue sparing, less invasive treatment techniques for calcaneus fractures (20, 23), different nailing options for the calcaneus have been developed, with either a nail in the form of a pillar to primarily buttress the posterior talar articular surface, or an axially implanted system (5, 27). Compared to locked plating both nailing systems displayed high primary stability that was comparable to the plate, with the C-Nail, also used as part of our study, showing the highest stability in a dynamic failure testing sequence, as well as in load to failure testing (23).

General patient characteristics in our study were comparable to other nail analyses concerning age, gender and fracture severity distribution and showed no differences between our patient groups (20, 23). However, the time from injury to surgery, as well as from surgery to discharge was significantly reduced for the nail implant in our study. This is in line with other studies comparing general less invasive systems to extended lateral approaches (10, 15), however, has not been shown for the C-Nail treatment, as only non comparative case series have been published to our knowledge. With C-Nail implantation and sinus tarsi assisted reduction earlier surgery, with less dependence on soft tissue status can be possible. The shorter times not only have the potential to reduce the early burden of disease, but also have socioeconomic implications potentially sparing hospital and personal resources. Furthermore, after adjusting for a learning phase with the implant faster surgical times with the nail system are suggested by our results. This is confirmed by the large cohort studies with the system that have shown further improved surgical times (22).

The correction angle achieved in our cohort was comparable to other surgical techniques, minimally invasive approaches and also other nailing works (3, 4, 27). Follow up imaging was available for analysis as part of our study, but publications looking at longer term radiographic data after C-Nail implantation have shown minimal subsidence over the treatment course (3, 22, 27). Clinical outcome could not be determined from the chart review and was not part of our analysis. However, non comparative studies with the same implant system have already reported favorable clinical outcome in similar fracture situations, whenever an adequate correction of the Bohler angle was achieved (22, 27). Apart from clinical scoring the minimally invasive approach and nail osteosynthesis with similar reduction has also shown to improve gait and post-operative weight-bearing (9).

This analysis was a single center, retrospective chart review, with limitations in this regard. Furthermore, implant and approach choice were not standardized and selection bias is possible potentially influencing the results of the timing characteristics and reduction achieved. Additionally, as is the case with all studies evaluating radiographic outcomes and correction angles observer bias is possible, despite the use of multiple reviewers. Procedural surgical times might have been influenced by the fact that the surgeries were performed at a teaching institution, as well as the timing from trauma to surgery, as the analysis was performed at a level 1 trauma center and many cases are secondary referrals after initial treatment elsewhere.

CONCLUSIONS

Within the stated limitations our results indicate that similar reduction results can be achieved with a locked calcaneus nail and sinus tarsi approach assisted reduction. Soft tissue, as well as pre- and post-operative timing and discharge management were improved with the treatment compared to standard extensile approach plate osteosynthesis in our setting. Further controlled trials comparing the long-term clinical outcome between the treatment options are needed.

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