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TRAUMA SURGERY

Decrease surgery time by using an alternative lateral parapatellar approach for tibia shaft fracture nailing

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Abstract

Introduction Medial parapatellar or transpatellar ligament approaches are commonly used for nail osteosynthesis in tibia shaft fractures. The lower leg is normally in a hanging position to allow guide wire insertion and reaming of the tibia. However, this position complicates fracture reduction and retention, as well as image intensification throughout the procedure. A lateral parapatellar approach with the lower leg in a semi-extended, horizontal position has been previously described for proximal tibial fracture fixation. The purpose of the presented study was to share the lateral parapatellar approach technique used in our institution and to analyse its feasibility for tibia shaft fracture fixation when compared to a medial parapatellar and transpatellar incision technique.

Materials and methods All patients with tibial shaft fractures treated at our institution between 2009 and 2012 by intramedullary nailing through either a transpatellar, a medial parapatellar or a lateral parapatellar approach were reviewed. Demographics, injury pattern and the operative procedure, especially operation and fluoroscopy time, were analysed.

Results 73 patients were enrolled into the study. Twenty-six patients were treated by use of a lateral parapatellar approach, whilst a transpatellar or a medial parapatellar approach was chosen in 29 and 18 cases, respectively. Patients' characteristics were similar regarding gender and body mass index. When compared to the transpatellar (126 ± 30 min) or the medial parapatellar approach (105 ± 29 min), surgical time was significantly shorter in the lateral parapatellar approach group (96 ± 29 min). Likewise, shorter image intensifier time was documented when a lateral parapatellar approach was chosen (211 ± 189 s) compared to the transpatellar (347 ± 204 s) or the medial parapatellar approach (241 ± 222 s).

Conclusion The extra-articular semi-extended tibial nailing technique using a lateral parapatellar approach was associated with a significant decrease in time of surgery, while fluoroscopy time was shorter but not significantly different between the three groups.

Keywords Tibia fracture · Treatment · Intramedullary nail · Approach · Operation time · Image intensifier time

Introduction

Intramedullary nailing is commonly used for treating fractures of the tibial shaft [1–3]. Multiple surgical approaches to nail insertion have been described, including intra- and extra-articular, transtendinous, paratendinous and suprapatellar approaches using varying knee positions [1, 4–6]. At our institution, the medial parapatellar and the transpatellar approaches have been used successfully for years. Starting from 2009, intramedullary fixation of tibial shaft fractures has also been performed using a lateral parapatellar extra-articular approach. While the lower leg is in a hanging position for medial parapatellar and transpatellar nail insertion, a semi-extended position is chosen when the lateral parapatellar extra-articular approach is used. Although a favourable influence of the lateral parapatellar approach with regard to pain and functional outcomes could not be shown so far [1, 4], we suggest that the extra-articular semi-extended tibial nailing technique simplifies and improves fracture reduction, maintenance of reduction, fluoroscopic imaging and insertion of the intramedullary implant. To our knowledge, there is no published data so far analysing the influence of the lateral parapatellar semi-extended knee position regarding surgical or fluoroscopy time. The purpose of this study was to assess whether the medial parapatellar, transpatellar

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and lateral parapatellar approaches differ in those aspects of surgical management.

Materials and methods

We conducted a single center, retrospective review of all patients treated by intramedullary tibial nailing through either a transpatellar, a medial parapatellar or a lateral parapatellar approach for tibial shaft fractures AO type 42 A–C between 2009 and 2012. Institutional review board approval was obtained. A research of our institution's prospective database was performed, and clinical records of eligible patients were reviewed. Patients without documented operating and/or fluoroscopy time could not be included into the study. In addition, multiple injured patients had to be excluded if additional surgical fracture treatment in the same procedure was performed, and fluoroscopy and operating time for the tibial fracture treatment was not assessed separately. 73 patients met the aforementioned inclusion criteria and were included in the study.

Patients' characteristics included age, sex, body mass index, mechanism of injury and ASA score. Fractures were categorized according to the AO classification, while soft tissue damage was graded according to Gustilo/Anderson (open fractures) [7] or Tscherne (closed fractures) classification system [8]. Total time of surgery as well as fluoroscopy time and duration of hospital stay were recorded in every case. In addition, complications and the need for further postoperative procedures were reviewed.

All fractures were treated using the Expert Tibial Nail (Synthes®, Oberdorf, Switzerland). A thigh tourniquet was placed but not necessarily inflated, and the extremity was draped free. A lateral parapatellar, medial parapatellar or transpatellar approach was performed according to the surgeon's preference. For the lateral parapatellar approach, the lower limb was positioned horizontally in a semi-extended manner on a radiolucent table (Fig. 1).

A 4–6 cm-long incision was made from the inferior patellar pole towards distal along the lateral edge of the patellar tendon. Dissection of the retinacular layer was performed in line with the skin incision. The infrapatellar fat pad was identified and retracted superomedially for exposure of the proximal tibial ridge. When using the medial parapatellar or the transpatellar approach, the lower lag was kept in a hanging position with a bolster under the thigh.

The skin incision length in those approaches was the same as with the lateral parapetallar approach. The incision was centred on the medial edge or centrally above the patellar ligament, respectively. The radiographic guide wire entry point was set at the medial edge of the lateral tibial spine on an AP view and on the anterior border of the articular surface on the lateral view. Sequential reaming was performed before nail insertion. The number and position of the proximal and distal interlocking screws were dependent on fracture pattern.

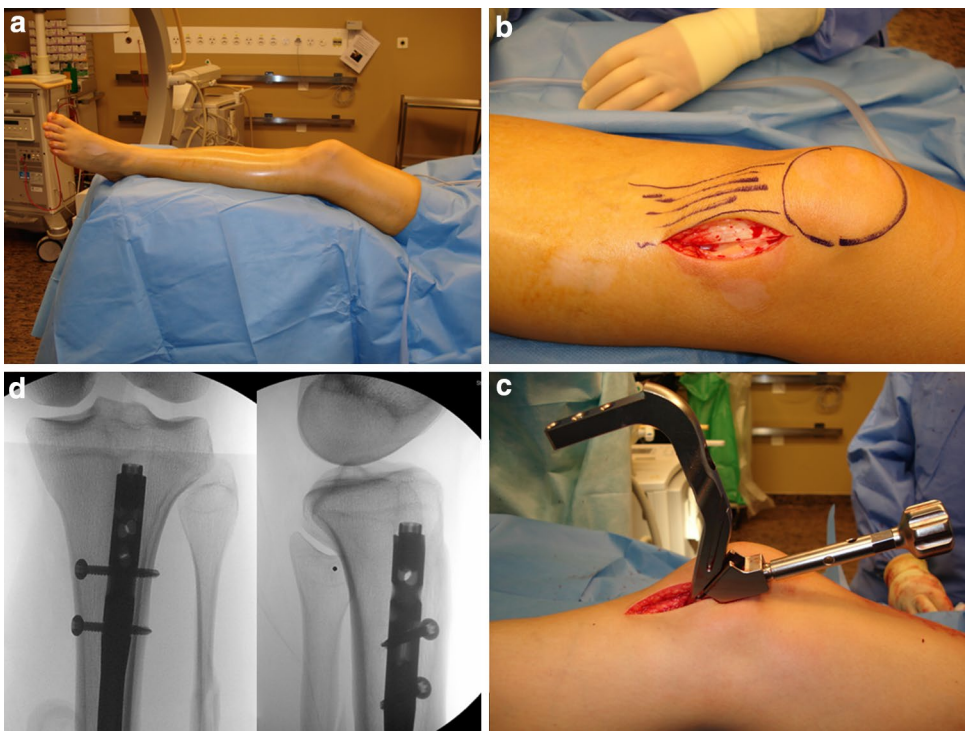

Fig. 1 Nail insertion technique using the lateral parapatellar approach: positioning (**a**), approach (**b, c**) and postoperative X-rays of the lower leg (**d**) for the lateral parapatellar approach

Statistical analysis was performed using SPSS® (version 21, IBM, Chicago, Illinois, USA). Descriptive statistics included means, standard deviations, ranges and proportions.

Comparative statistics included one-way analysis of variance (ANOVA) according to Bonferroni for outcome in multiple groups. The confidence level for rejecting null hypotheses was set at 95% (p value < 0.05). Data are reported as n (%) or $n \pm$ SD.

Results

Forty men and 33 women with overall mean age of 44 years met the inclusion criteria. The average body mass index was 24.6 ± 4.3. Demographic data are given in Table 1.

Most injuries occurred during sporting activities ($n = 38$), with skiing being the most common cause ($n = 28$) when compared to sledging ($n = 3$), snowboarding ($n = 1$) or other sports ($n = 6$). Road side accidents accounted for the second most common cause of injury ($n = 24$), with pedestrians involved in 12 cases, motorcyclists in 10 and cyclists and car driver in 1 each. Less common causes were fall from standing or sitting position ($n = 6$) or occupational accidents ($n = 5$).

The overall most common fracture types were a simple spiral fracture (AO 42 A1, $n = 13$), spiral wedge fracture (AO 42 B1, $n = 13$) or bending wedge fracture (AO 42 B2, $n = 12$). Open fractures were seen in 18 of the 73 cases (24.7%). 45 of the 55 closed injuries were classified as Tscherne Grade 0 or 1. Fracture classification in detail is shown in Table 2.

There were no statistically significant differences regarding sex, age or body mass index between the three groups. Demographics including ASA, AO classification and Gustilo/Anderson and Tscherne classification were similar between the groups, and with the numbers available, no significant difference regarding these factors was found.

Surgical procedures were performed by a total of 18 experienced trauma surgeons at our institution. The surgical approach of choice was a lateral parapatellar approach in 26 and a medial parapatellar approach in 18 patients. Nail insertion through a split patellar ligament was performed in 29 patients.

The overall mean operating time was 110 ± 32 min, with a mean operating time of 96 ± 29 min for the lateral parapatellar approach, 105 ± 29 min for the medial parapatellar approach and 126 ± 30 min for the patellar tendon splitting approach. Comparing the operation times, a significant difference arose between the lateral and transpatellar approach ($p < 0.001$) (Fig. 2).

When analysing the fluoroscopic time, there was no significant difference between the three groups (Fig. 3). The overall mean fluoroscopic time was 267 ± 209 s (211 ± 189 s within the lateral approach group, 241 ± 222 s for the medial parapatellar approach and 347 ± 204 s for the transpatellar approach).

Regarding the time of hospitalization, there was no statistic significant difference between the three groups.

Table 1 Demographics

	Total	Subgroups		
		Lat. parapatellar	Med. parapatellar	Transpatellar
Patients (n)	73	26	18	29
Side				
Right	36	16	10	10
Left	37	10	8	19
Age (years)				
Mean (SD)	44 ± 15.9	49 ± 17.5	42 ± 17.1	41 ± 12.9
Range	18–92	23–92	18–84	18–64
Sex				
Female	33	13	7	13
Male	40	13	11	16
Body mass index				
Mean (SD)	24.6 ± 4.3	25.2 ± 5.8	23.9 ± 2.9	24.8 ± 3.4
Range	17.6–46.6	17.6–46.6	19.9–30.4	20.5–33
Mechanism of injury				
Sports	38	17	10	11
Road accidents	24	8	7	9
Simple falls	6	0	0	6
Labour related	5	1	1	3
ASA score				
Mean	1.63	1.53	1.77	1.62

Table 2 Fracture classification

	Total	Subgroups		
		Lat. parapatellar	Med. parapatellar	Transpatellar
Fracture pattern (AO)				
42 A (%)	28 (38.4)	9 (34.6)	4 (22.2)	15 (51.7)
42 A1	15	6	1	8
42 A2	8	2	2	4
42 A3	5	1	1	3
42 B (%)	34 (46.6)	13 (50)	11 (61.1)	10 (34.5)
42 B1	14	5	4	5
42 B2	14	6	4	4
42 B3	6	2	3	1
42 C (%)	11 (15.1)	4 (15.4)	3 (16.7)	4 (13.8)
42 C1	4	2	1	1
42 C2	3	1	0	2
42 C3	4	1	2	1
Open fractures (Gustilo/Anderson)				
Total (%)	18 (24.7)	3 (11.5)	7 (38.9)	8 (27.6)
Grade I	6	1	1	4
Grade II	6	1	3	2
Grade IIIa	5	1	2	2
Grade IIIb	0	0	0	0
Grade IIIc	1	0	1	0
Closed fractures (Tscherne)				
Total (%)	55 (75.3)	23 (88.5)	11 (61.1)	21 (72.4)
Grade 0	16	7	3	6
Grade I	29	10	5	14
Grade II	8	6	1	1
Grade III	2	0	2	0

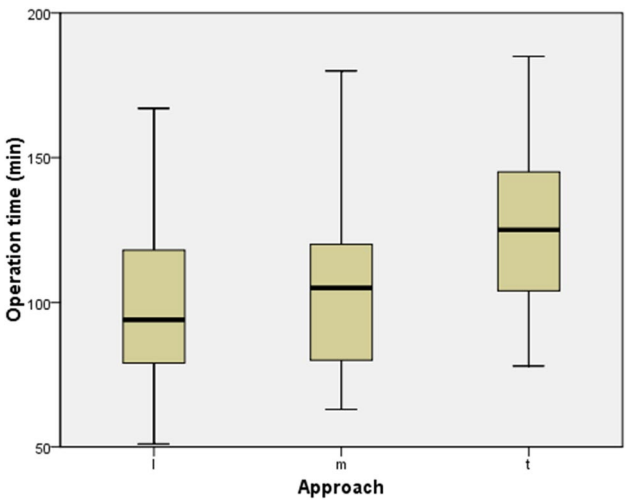

Fig. 2 Box plot comparing operation time (in minutes) and approach (*l* lateral parapatellar, *m* medial parapatellar, *t* transpatellar approach)

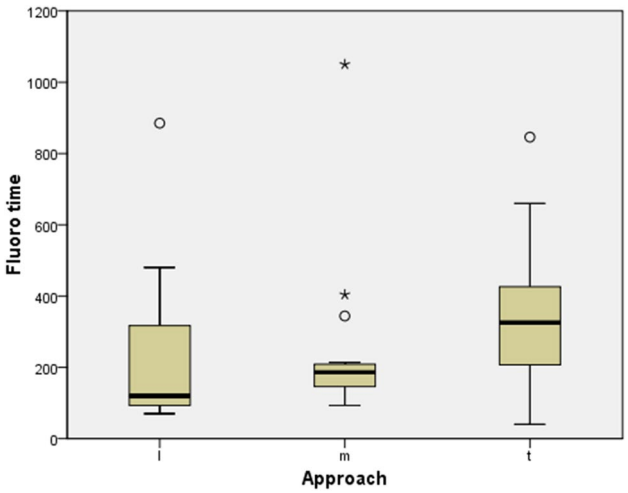

Fig. 3 Box plot comparing fluoroscopic time (in seconds) and approach (*l* lateral parapatellar, *m* medial parapatellar, *t* transpatellar approach)

Overall complication occurred in 6 of 73 patients (8.2%). One patient suffered wound-healing problems without operative revision. Four patients underwent revision surgery because of malalignment of the fracture, one patient suffered from superficial and one from deep wound infection needing revision. On assigning complications to the different approaches, malalignment usually occurred in patients operated through a transpatellar approach ($n=3$) or a medial parapatellar approach ($n=1$). One deep infection was seen with the transpatellar approach, and a superficial infection occurred in the lateral approach group.

Discussion

Intramedullary nailing is the treatment of choice in stabilizing diaphyseal tibial fractures because of reliable bone healing and superior biomechanics compared to other forms of osteosyntheses [5, 6, 9]. The presented study shows that in our institution, the extra-articular semi-extended tibial nailing technique using a lateral parapatellar approach is feasible and associated with several advantages regarding surgery and fluoroscopy time. In our experience, the semi-extended position of the leg used in the lateral parapatellar approach facilitates achievement and maintaining fracture reduction, because the horizontal position allows more accurate angulation and translational control [1, 10]. The advantages of this approach are further enhanced as it also facilitates fluoroscopic imaging in the anteroposterior and lateral projection, because it is obviously much easier to achieve perpendicular views using a horizontal limb position [1, 11]. This, together with the fact that the knee can be kept in the original semi-extended

position throughout the procedure without the need for repositioning for nail insertion or fluoroscopic imaging, might be the cornerstones on why this approach showed significant shorter surgical procedure time and a trend towards less radiation exposure [1, 10]. The overall mean surgery time in this series was comparable to operative procedure times reported throughout the literature [12, 13]. The lateral parapatellar approach showed a tendency towards lower radiation exposure in our series, but no significance was achieved. Mean fluoroscopic time in our series was 4.45 min for all approaches. Although Williamson reported a lower mean fluoroscopy time of 2.16 min in his series of 37 patients [14], our times are comparable to previously published studies. Kempf et al. reported a mean fluoroscopy time of 3.43 min per operation in 452 tibia fractures [15], whilst Müller et al. showed a mean fluoroscopy time of 4.16. min [16].

Interestingly, Williamson et al. found that the suprapatellar nailing technique lowers the use of intraoperative fluoroscopy as measured by time and dose and thus potentially lowers radiation exposure to the operating surgeon, assistants and patient when compared to a patella ligament splitting, infrapatellar approach [14]. The authors stated that fracture reduction in the semi-extended technique was more accurate especially in the coronal plane, and explained their findings may be in part due to easier reduction and easier intraoperative fluoroscopy, as the knee can be kept in the original semi-extended position and does not need to be repositioned for the anteroposterior and lateral radiographs. The positioning of the leg for suprapatellar tibial nail insertions as described by Williamson et al. is basically the same as the position used in our setup when performing a lateral parapatellar approach.

It is clear that surgical treatment method should not be guided by surgical or fluoroscopy time alone. In our opinion, radiographic parameters considering (time to) fracture healing, malunion or malalignement as well as clinical parameters such as range of motion, pain or function and patient-reported outcome measurements are considerably more important when deciding the treatment method of choice. The presented study did not consider the mentioned clinical and radiographic outcome parameters. This is mainly due to a lack of available data, because a large amount of the patients treated were tourists having their follow-up abroad, but it was also not within the scope of the given study. Whilst we cannot report from our own data, recent literature shows that there are no significant differences between the semi-extended lateral parapatellar approach, the medial parapatellar and the transpatellar approach in terms of severity and location of postoperative knee pain, or overall function at a minimum 1 year follow-up [1, 17]. Bakhsh et al. [1] shared an experience similar to ours, showing that the semi-extended lateral parapatellar approach vastly simplifies many technical aspects of nailing compared to knee hyperflexion approaches and does not violate the knee joint.

Weil et al. stated that the lateral parapatellar approach had the potential to significantly reduce anterior knee pain [10]. However, recent literature confirmed that the prevalence of chronic anterior knee pain or functional impairment did not differ between the parapatellar and transpatellar approaches, as no significant differences in knee pain severity, localization or overall function could be found [1, 4, 9]. A recent meta-analysis performed by Chen et al. indicates favourable results for suprapatellar nail insertion techniques over the different infrapatellar approaches.

Overall, intramedullary nailing of diaphyseal tibial fractures has a proven low, but not negligible, complication rate [1–3, 18]. In our own series, intra- and early postoperative complication occurred in 8.2% of cases. Whilst anterior knee pain is an often reported entity, intraoperative fracture malalignment does not attract great attention throughout the literature, but is a complication which may lead to serious results [9, 19, 20]. Especially, rotational malreduction is a potential complication following intramedullary nailing of tibial shaft fractures. The literature shows an incidence of rotational malalignment greater then 10° to occur in about 20% [20, 21]. In addition, the commonly used position with a hanging lower leg and flexed knee joint can result in antecurved malalignement due to extension forces of the quadriceps muscle. The semi-extended position of the lower leg rested horizontally on the operation table eliminates these extension forces of the proximal fragment and therefore facilitates reduction [22]. Accordingly, Franke et al. found the same advantages of the leg position as described here in patients undergoing suprapatellar tibial fracture nailing [23, 24]. In our series, we experienced no revision for malalignment in patients treated with the semi-extended lateral approach, whilst malalignement was found in patients treated through a medial ($n=1$) or transpatellar approach ($n=3$). Other important complications of tibial nailing reported throughout the literature such as iatrogenic fractures of the tibial head upon nail insertion (0–8.3%), intraoperative compromise of neurovascular structures or development of compartmental syndromes of the lower leg (0–8.6%) [9, 19] did not occur in our series.

This study certainly has some limitations. First of all, some factors may have influenced surgical or fluoroscopy time that might not have been considered. Open fractures need additional time for debridement and definitive or temporary wound closure, which might have an impact on our results. The percentage of open fractures was less in patients undergoing nailing through a lateral parapatellar approach. Although this was not significant, it has to be considered when interpreting the results. On the other hand, open fractures are often easier to reduce, whilst achieving a proper alignement in closed fractures can be quite time

consuming. Therefore, the net effect of this factor remains unclear. Other factors such as global health as described by the ASA score did not differ between the three groups. The lack of available clinical, radiological or patient-reported outcome measurements are another limiting factor, but (as stated above) this was not within the scope of the study. Recent literature shows that these parameters do not significantly differ between the three approaches analysed in this study [1, 17]. Lastly, the retrospective manner of the investigation, the high number of surgeons involved in the surgical procedures as well as the limited number of participants are further limitations that have to be considered. An ongoing prospective data collection on the presented topic could allow for further investigation and thereby address the given limiting factors.

Conclusion

The semi-extended tibial nailing technique has been previously described for proximal tibia fracture stabilization [11], but several advantages of the semi-extended position make this approach a feasible alternative to the commonly used approaches also for tibia shaft fracture fixation. Positioning of the C-arm is very simple. In our institutional setup, the lateral parapatellar approach for nail osteosynthesis of tibia shaft fractures facilitates the surgical procedure, resulting in significant shorter operation time. There was a trend towards less intraoperative radiation exposure, but no significant difference could be detected between the three groups with the given number of patients.

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Compliance with ethical standards

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

Ethics This study was approved by the local research ethics committee.

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