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Suprapatellar tibial nailing: intraoperative arthroscopic evaluation and results at a minimum of 12 months follow-up

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To arthroscopically evaluate the intra-articular structures before and after placement of an intramedullary tibial nail using the suprapatellar approach and to assess the 1-year results.

All patients with a tibial fracture that underwent intramedullary tibial nailing using the suprapatellar approach with a minimal follow-up of 12 months were included. Diagnostic intraoperative knee arthroscopy was performed before and immediately after insertion of the IMN. A radiological and clinical evaluation and VAS score of the patients was collected postoperatively.

In total, 36 patients were included. The mean follow-up period was 14.9 ± 4.9 months. The mean age of the patients was 45.5 ± 18.8 years. The mean visual analog scale (VAS) score at 12 months was 1.0 ± 1.5. The complication rate was 19.4% and the reoperation rate was 16.7%. Union of the fractures was achieved in 33 patients (91.6%) after primary surgery after a mean of 6.1 ± 1.8 months. A change in the patellofemoral cartilage after insertion of the nail was seen in 1 patient.

The suprapatellar procedure for tibia fractures resulted in excellent VAS scores and union rates at 1-year follow up, with a complication of articular damage to the PF joint in 2.8%.

Keywords: suprapatellar nailing, tibia fracture, arthroscopy, results.

INTRODUCTION

Reamed intramedullary nailing is a common procedure for diaphyseal fractures of the tibia. The infrapatellar (IP) approach has been the gold standard for inserting an intramedullary nail (IMN) into the tibia[1]. However, the suprapatellar (SP) approach with the knee in a semiextended position has been increasingly adopted over the last decade due to its benefits; including easier fracture reduction, better intraoperative fluoroscopic visualization of the tibia and a lower radiation dose exposure[2-6].

Recent studies have suggested favorable outcomes associated with a SP approach[2,4,7-9]. The concern of potential damage to the cartilage of the patellofemoral (PF) joint due to placement of instrumentation through the knee remains a significant drawback of the SP approach. This approach places direct pressure on the cartilage and can result in damage via either excess compressive force or abrasive injury upon trocar placement, reaming and nail insertion[10-13]. This could theoretically lead to PF osteoarthritis or postoperative knee pain. The aim of this study is to assess peri-operative patellofemoral cartilage damage after insertion of an IMN and to assess 1-year clinical and radiological results of the treatment of tibial fractures after intramedullary nailing using the SP approach.

MATERIALS AND METHODS

This is a single surgeon, retrospective, consecutive, observational study. Patients with a tibial fracture that underwent intramedullary tibial nailing from February 2015 to March 2019 in our hospital were included. Inclusion criteria for the study were: Extra-Articular AO/OTA classified type 42 A, B, C, or 43 A type fractures with a minimal follow-up of 12 months. In total, 36 patients were included. All patients underwent reamed intramedullary nailing using a SP approach in a semiextended position. All operations were performed by one experienced orthopedic trauma surgeon, familiar with this technique. Informed consent was obtained prior to the operation. The tibial fractures were graded according to AO/OTA Classification and the Gustilo-Anderson system[14]. Open and closed fractures were included. All patients were skeletally mature.

To evaluate the cartilage of the PF compartment, diagnostic intraoperative knee arthroscopy was performed before and immediately after insertion of the IMN. The intraoperative images were saved. The intraarticular PF damage was graded according to the Outerbridge scale[15].

A radiological and clinical evaluation of the patients was performed at two weeks, six weeks, three months, six months and twelve months postoperative. The following parameters were collected during the consultation: birth date, sex, complications and re-operations. A Visual Analog Scale (VAS) score for anterior knee pain was collected at twelve months post-operative.

The time to consolidation of the fracture was evaluated on radiographic imaging. Standard tibial radiographs consisted of anteroposterior (AP) and lateral projections. Union of the fracture was defined as bridging bone on all radiographic views. The alignment of the tibia was measured on the AP and lateral radiographs obtained after the surgical fixation of the injury. Angular deformity was defined as >5° in the sagittal or coronal plane. All data were imported into IBM SPSS version 26 for further statistical analysis. The Research Ethics Committee of the regional hospital approved the study.

Technique: the patient is installed in dorsal decubitus on a fluoroscopy table with a knee roll under the injured knee to obtain slight knee flexion. No tourniquet is applied. After disinfection, draping and antibiotic prophylaxis, a 3-4 cm incision is made proximal to the patella (figure 1). The quadriceps tendon is split to directly reach the anterior femur. Electrocautery is used for hemostasis and the knee joint is opened through the suprapatellar pouch. After the SP approach, a standard

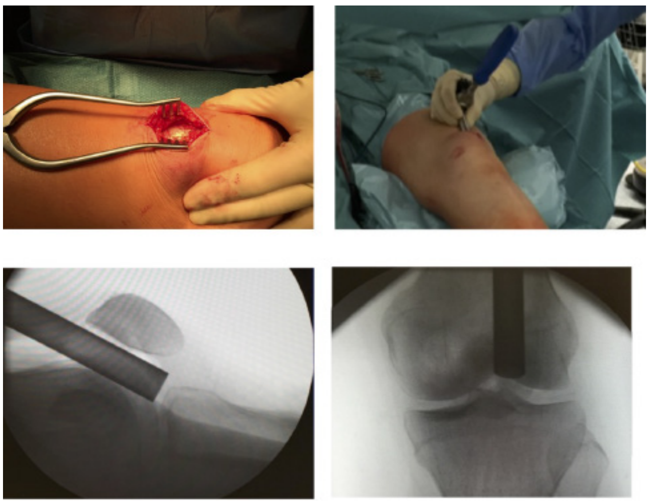

Figure 1. — a) the suprapatellar approach. b) insertion of the trocar and protection sleeves inside the knee joint. c) lateral fluoroscopic view of the trocar inside the knee joint. d) AP view of the trocar inside the knee joint.

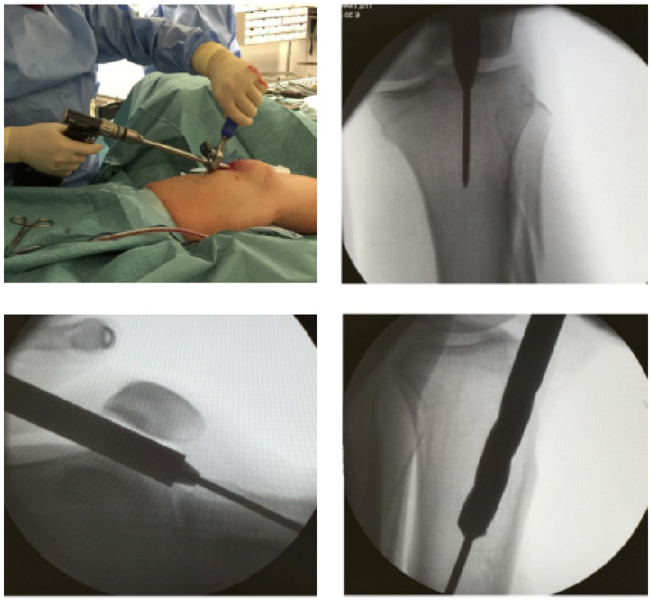

Figure 2. — a) proximal reaming is performed after insertion of a 3.2 mm guide wire. b-c) fluoroscopic images of the knee showing correct position of the guide wire. d) fluoroscopic image of the knee after insertion of the proximal reamer.

anterolateral portal for knee arthroscopy is made and an arthroscopic evaluation of the knee is performed. Arthroscopic images of the patellofemoral joint are taken before reaming and insertion of the nail. After arthroscopic evaluation of the knee joint, an inner and outer protection sleeve and trocar are inserted into the knee at the suprapatellar region. The protection sleeve and trocar are slid down the trochlear groove until they come in contact with the proximal tibia. After exchanging the trocar for a guide pin centering sleeve, a 3.2 mm guide pin is drilled into the proximal tibia (figure 2). The pin is not drilled farther than 3-5 cm, otherwise, the pin will function as a monorail, and correcting malposition during reaming is not possible. The position of the entry point is then confirmed on AP and lateral fluoroscopic views. The guide pin sleeve is removed and the proximal reamer is introduced under visualization to open the medullary canal. The guide pin is replaced by a guide wire, that can reach beyond the fracture. The fracture is then reduced, and the guide wire is introduced distal from the fracture. The nail length and diameter are determined, and intramedullary reaming is performed up to 1.5-2 mm beyond the chosen nail diameter. The Synthes Expert Tibial Nail is inserted under AP and lateral fluoroscopic visualization until the desired depth is required. The guide wire is removed. After optimal position of the nail and reduction of the fracture, distal Angular Stable Locking System (ASLS) screws are inserted. Distal ASLS screws were used in all patients. If compression of the fracture is needed, the nail is carefully backslapped before insertion of the proximal locking screws. After insertion of the proximal locking screws, the guide wire is reinserted, the aiming arm is removed and an end-cap is inserted under fluoroscopic visualization. The cannula is removed after final fluoroscopic imaging. The arthroscope is brought back into the knee and the PF cartilage, nail insertion point and damage to the surrounding structures are carefully examined. Any changes to the intraarticular structures or cartilage after insertion of the nail are documented. The knee is rinsed thoroughly. Complete range of motion and patellar tracking are evaluated. The wounds are closed in a layered matter. Postoperatively, weight-bearing was permitted guided by pain.

RESULTS

A total of 36 patients were included in this study, with a minimal follow-up of 12 months. Descriptive data are shown in table I. Two patients were lost to follow-up (5.3%). Thirteen fractures (36.1%) were open. In 12 patients (33.3%), a temporary external fixator was used for temporary fixation of the fracture, with an early conversation to an IMN. 10 patients (27.8%) required additional fibula fixation with a fibular plate. Diagnostic arthroscopy before and after nail insertion, to evaluate the patellofemoral joint, was performed in all patients.

The complication rate was 19.4% (7 patients), with short-term complications in 11.1% (4 patients). One patient (2.8%) had a postoperative wound infection after a Gustilo-Anderson type 1a open fracture, for which irrigation of the wound and antibiotic therapy was needed 1 week after surgery. One patient (2.8%) developed psoriasis around the scar. Two patients (5.6%) developed complex regional pain syndrome (CRPS), which resolved after treatment with subcutaneous injections of calcitonin. Three patients (8.3%) developed a delayed union of the fracture. The reoperation rate was 16.7% (6 patients). After fracture union, 3 patients (8,3%) required screw removal at respectively 9 (distal), 14 (proximal and distal) and 22 (distal) months due to irritation or low-grade infection around the screw entry points. One patient (2.8%) required wound irrigation. Dynamization of the nail was required in 2 patients (5.6%) due to a delayed union, in which the proximal screws of the nail were removed.

On the radiographic evaluation, none of the patients had an angular deformity of > 5 degrees in the sagittal or coronal plane. Union of the fractures was achieved in

Table I. — Patient demographics

Number of patients	36
Male (# of patients) Female (# of patients)	23 (63.9%) 13 (36.1%)
Left (# of joints) Right (# of joints)	10 (27.8%) 26 (72.2%)
Open Closed Gustilo Anderson type	13 fractures (36.1%) 23 fractures (63.9%) Grade I in 7 patients (19.4%) Grade II in 2 patients (5.6%) Grade IIIa in 4 patients (11.1%)
Follow-up (months)	14.9 ± 4.9
Mean age at surgery (years)	45.5 ± 18.8
AO/OTA classification type	Type 42A: 28 patients (A.1=19, A.2= 5, A.3= 4) Type 42B: 3 patients (B.2= 3) type 42C: 3 patients (C.2= 1, C.3= 2) type 43A: 2 patients (A.1= 1, A.3= 1)
Complications	7 patients (19.4%)
Reoperations	6 patients (16.7%)
Union rate	91.6%
VAS score at 12 months postoperatively for anterior knee pain	1.0 ± 1.5

Figure 3. — a) intraoperative image of insertion of the nail. b-c) fluoroscopic images of the nail in place after reduction.

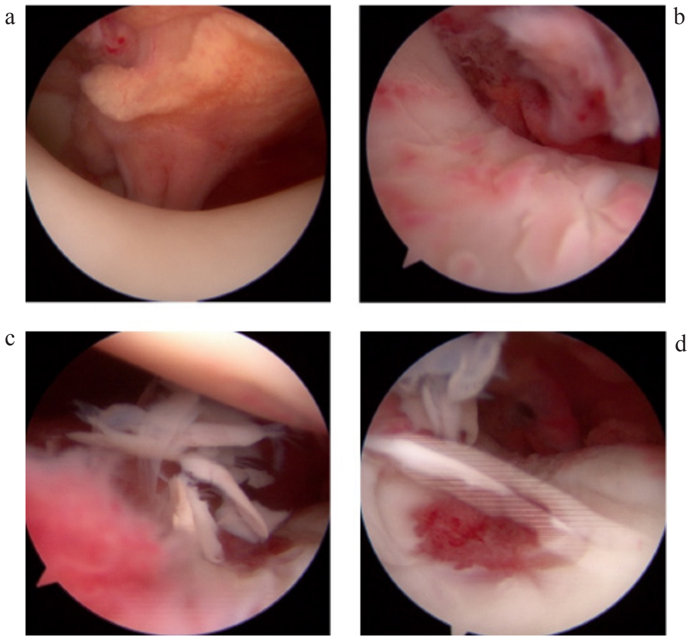

Figure 4. — a) pre-nail insertion arthroscopy showing no cartilage damage. b-d) post-nail insertion arthroscopy showing a grade 4 cartilage leasion in 1 case.

33 patients (91.6%) after primary surgery after a mean of 6.1 ± 1.8 months. The first patient with a delayed union was treated nonoperatively and healed after 12 months postoperatively. In the second patient, the remaining nail and proximal screws had to be removed due to a secondary infection after dynamization of the nail. The patient reported significantly less pain and could weight bear better after removal of the nail. Therefore, further conservative therapy was pursued and radiological follow-up showed a pseudarthrosis at 26 months follow-up. In the third patient, an IMN with a wider diameter (+ 2 mm) was placed after intramedullary reaming, combined with an ipsilateral non-vascularized fibula bone graft after ruling out an infection. At 1-year follow-up, full consolidation of the fracture was seen at radiographic imaging.

Preoperative evaluation of the cartilage showed 18 patients with grade 0 cartilage, 9 patients with grade 1, 8 patients with grade 2 and 1 patient with grade 3 according to the Outerbridge scale[15]. A change in the PF cartilage after insertion of the nail was seen in 1 patient (2.8%). This lesion was classified as an Outerbridge grade 4. The patient had a grade 0 cartilage before insertion of the nail (figure 4).

DISCUSSION

We evaluated a total of 36 patients with a mean follow-up of 14.9 ± 4.9 months who were treated using a semiextended SP approach for intramedullary nailing of a tibial shaft fracture. All the fractures could be reduced with simple traction without the use of additional reduction techniques. An important advantage of the SP approach compared to the IP approach is that this technique allows the entire nailing procedure to be performed without repeated limb manipulation. Therefore, the fracture can be reduced and continuously maintained during intramedullary canal preparation and IMN placement. Moreover, the benefit of operating in a semiextended position is the reduction of the deforming forces acting on the proximal fracture fragment. In contrast, it is necessary to flex and extend the knee to visualize the fracture reduction in the IP technique which can lead to loss of reduction[5,6].

Additionally, multiple studies have shown that suprapatellar intramedullary nailing could significantly reduce total blood loss, time of surgery, lower rate of malalignment and fluoroscopy times compared to the infrapatellar approach[3,5,6,9,16-19]. Some studies even show that the suprapatellar approach is associated with superior functional outcomes[9,16-20]. Nevertheless, several studies showed no significant differences in pain, knee range of motion or knee functional score between the SP and IP approaches[4,7,8]. To date, there is no consistent data about whether one approach is superior to another.

The greatest concern when using a SP approach is the potential for damage to the PF joint surface due to placement of instrumentation through the knee[10]. Franke et al.[21] recommend the use of a trocar system with a smooth and elastic material to avoid iatrogenic damage to the PF joint. If the patellar and femoral trochlear surfaces are well protected with a cannula, friction-related iatrogenic damage can be avoided, but there is still a risk of exposure to compressive pressure. A biomechanical cadaveric study by Gelbke et al.[11] showed that mean PF pressures and forces are higher with SP nail insertion than IP nail insertion, but no significant risk concerning the structural integrity and vitality of the PF joint cartilage was seen.

In this study we observed one case (2.8%) of PF cartilage damage after reaming and insertion of the nail after a SP approach. The possible reason for the damage might be that the trocar was not well-fixed at the moment of retraction of the intramedullary reamer. The wide reamer head can catch the distal end of the trocar and pull it proximally. If at that time the reamer is engaged, the trochlear cartilage can be damaged. In this particular case, the cannula was not fixed to the femur with a Kirschner wire. In the following 32 cases, the trocar was fixed routinely to the femur with a 2 mm Kirschner wire to prevent movement of the cannula during reaming, and no subsequent cases of patellofemoral cartilage damage were observed. Using proper technique with cannula systems and guide pins is therefore essential to lower the risk of damage to intraarticular structures. Although the patient did have a grade 4 cartilaginous defect, this patient did not have any complaints of knee pain at 1-year follow-up.

Changes in the PF cartilage after IMN insertion using the SP technique are reported to be as high as 13.3-33%[2,7,12,13,22,23]. Gaines et al.[12] compared medial parapatellar and SP approaches and reported a rate of intra-articular injury formed with the SP approach of 20% in a cadaver study. Chan et al.[7] reported a change in the articular cartilage in 25% of their patients after postnail insertion arthroscopy using the SP approach. A cadaveric study by Zamora et al comparing the IP and SP approach showed cartilage damage in 33% of the cases after SP IMN insertion[22]. Sanders et al.[2] reported grade II chondromalacia of the trochlea immediately after the procedure in 13.3% of the patients, but these did not correspond with either MRI scans or clinical findings at 1 year. Jakma et al.[13] similarly observed cartilage damage during post-nail insertion arthroscopy using the SP technique, but the affected patients did not have any pain. Kuechly et al.[10] similarly described a 1.8 cm full-thickness chondral defect of the right lateral trochlear surface as the result of intramedullary tibial nailing via a SP approach which required arthroscopic treatment. It is currently unclear whether these PF cartilage damages have significant clinical consequences, and current studies include a small number of patients. More long-term consecutive follow-up data is needed.

Another concern after intramedullary tibial nailing is anterior knee pain, with rates as high as 71% reported in the literature following IP nail placement[24,25]. Reduced rates of anterior knee pain have been reported by studies comparing the SP and IP technique[2,7-9,26]. We measured an average VAS score for anterior knee pain of 1.0 ± 1.5 at 1 year postoperatively, which are in line with results of other research groups[23,26].

Union of the tibial fractures was achieved in 91.6% after primary surgery after a mean of 6.1 ± 1.8 months with a delayed union in 3 patients which required dynamization of the nails in 2 patients. Similarly, in the group of Serbest et al.[23] there was a full fracture union in a mean time of 17.6 ± 2.8 weeks, with a delayed union in 9.5% of the patients which required dynamization of the nails. In the group of Sanders et al.[2], an union rate of 94.6% was reported with 1 radiographic malunion.

The limitations of our study are a low number of patients and no control group. Secondly, we did not evaluate the PF joint after fracture union by MRI-scan or diagnostic knee arthroscopy. Thirdly, we did not evaluate other clinical outcome scores other than the VAS-Score, as well as certain important perioperative outcome scores including fluoroscopy and operation time. Lastly, this study had a minimal follow-up of 1 year postoperatively, complications or rates of anterior knee pain might be higher after a longer follow-up.

CONCLUSION

In conclusion, the 1-year results indicate that the SP procedure for tibial fractures in a semiextended position resulted in excellent VAS sores and union rates, with a rare complication in the PF joint based on immediate arthroscopy. This complication might be prevented by fixing the trocar to the femur with a Kirschner wire to prevent movement of the cannula during reaming.

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