Comparison of Insertional Trauma Between Suprapatellar and Infrapatellar Portals for Tibial Nailing

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abstract

The purpose of this study was to determine differences in insertional articular trauma in infrapatellar tibial portal and suprapatellar portal intramedullary tibial nail insertion techniques. A cadaveric study was performed on 10 matched pairs of fresh-frozen adult cadaver lower extremities with intact extensor mechanisms.

Two study groups with 10 limbs each were created: left lower limbs were treated with a standard medial parapatellar nailing portal and right lower limbs were treated with a suprapatellar tibial nailing portal. Start points were created under fluoroscopic guidance in anteroposterior and mediolateral planes. A start wire was placed and opening reaming was performed on the specimens using instrumentation specific to the nailing portal. Specimens were then dissected by medial parapatellar arthrotomy, revealing the intra-articular condition of the knee structures. The border of the tibial entry reamer hole was measured to the anterior horns of the menisci, anterior cruciate ligament root, and intermeniscal ligament using a digital caliper accurate to 0.02 mm. The structure was considered damaged if the structure was obviously damaged on visual inspection or if a measurement was less than 1 mm. Impact to intra-articular structures was numerically lower in the suprapatellar group (2/10) compared with the infrapatellar group (4/10), but the difference was not statistically significant between the 2 groups ($P = .629$).

The suprapatellar portal approach to the tibial start point demonstrated a lower overall incidence of damage to intra-articular structures, but no significant statistical difference existed between the 2 treatment groups.

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Tibial nailing has become the standard of care for the treatment of diaphyseal tibial fractures. As a device, the tibial nail is advantageous in its intramedullary position, sharing physiologic loads and allowing weight bearing of the injured extremity immediately after placement. Although this device is ideal in the management of the fracture, significant sequelae exist with its insertion. Injury to intra-articular structures and the articular surface itself with nail insertion is well known. A significant percentage of patients report knee pain after tibial nail insertion. The etiology of this knee pain has not been elucidated.

Fluoroscopically, the desired start point for tibial nailing is between the tibial spines in the anteroposterior view and on the proximal edge of the tibia just distal to the articular surface on the lateral view. Multiple start portals to obtain this start point have been described. Specific fracture patterns affect what the optimal approach is for the insertion of the tibial nail. Medial paratendonous approaches have an increased risk of valgus malunion in proximal tibia fractures, leading some surgeons to use a lateral or transtibial paratendonous approach. Opponents to this tibial nail entry point for tibial nailing are treated via a suprapatellar tibial nailing portal and the left lower extremity. This study investigated the potential for tibial nailing to rule out intra-articular injury before the nailing start point. The standard soft tissue protector from the Tri-Gen tibial nail is advantageous in the management of the fracture, since it intramedullary position, sharing physiologic loads and allowing weight bearing of the injured extremity immediately after placement. Although this device is ideal in the management of the fracture, significant sequelae exist with its insertion. Injury to intra-articular structures and the articular surface itself with nail insertion is well known. A significant percentage of patients report knee pain after tibial nail insertion. The etiology of this knee pain has not been elucidated.

Fluoroscopically, the desired start point for tibial nailing is between the tibial spines in the anteroposterior view and on the proximal edge of the tibia just distal to the articular surface on the lateral view.5 Multiple start portals to obtain this start point have been described.1,6,8 Specific fracture patterns affect what the optimal approach is for the insertion of the tibial nail.9 Medial paratendonous approaches have an increased risk of valgus malunion in proximal tibia fractures, leading some surgeons to use a lateral or transtibial paratendonous approach.10 Others maintain a medial paratendonous approach for all tibial fractures and use adjuncts, such as blocking screws, to help obtain and maintain fracture reduction.11 A suprapatellar start point has recently been used with proximal fractures by keeping the leg in the same position throughout the nailing procedure and allowing fracture alignment to be maintained.6 Opponents to this tibial nail entry portal cite the potential for intra-articular injury as a reason to avoid this technique.2

This study investigated the potential injury to intra-articular structures near the preferred start point for tibial nailing, comparing a medial paratellar tendon approach to a suprapatellar approach. The authors also evaluated the potential damage to the undersurface of the patella and the trochlear groove due to nail insertion through the knee using a cadaveric model.

**Materials and Methods**

Ten matched pairs of fresh-frozen, adult cadaver lower extremities with intact extensor mechanisms were separated into 2 study groups: the right lower extremities were treated via a suprapatellar tibial nailing portal and the left lower extremities were treated via a medial infrapatellar paratendinous incision. Each specimen was first placed into a cadaveric leg holder for arthroscopic investigation of the articular structures. Diagnostic arthroscopy was standardized for all specimens, with standard anteromedial and anterolateral arthroscopic portals and a superolateral outflow portal. For each specimen, arthroscopy including investigation of the joint surfaces of the undersurface of the patella, the femoral and tibial condyles, the anterior meniscal horns, the footprint of the anterior cruciate ligament, and the intermeniscal ligament. Each area was photographed and recorded with arthroscopic instrumentation to ensure the state of the native structure of the knee, rule out intra-articular injury before the study, and retain a repository of images to compare after instrumentation.

In the suprapatellar group, incisions were performed 2 cm proximal to the superior pole of the patella into the suprapatellar pouch. The knee was standardized in 30° of flexion for the procedure, measured with an external goniometer. A specialized suprapatellar insertion cannula (Smith & Nephew, Andover, Massachusetts) placed through the incision, under the surface of the patella, and on the desired start point for tibial nailing (Figure 1).

In the standard medial paratellar group of the study, incisions were performed through the skin over the patellar tendon and then continued just medial to the border of the patellar tendon. The knees were placed in 90° of flexion to gain the nailing start point. The standard soft tissue protector from the Tri-Gen tibial nailing set (Smith & Nephew) was used for these specimens. Fluoroscopy was used to ensure the position of the starting guidewire. For each specimen, a start wire for tibial nailing was placed in the appropriate position on the anterior edge of the proximal tibia on the lateral view and just lateral to the medial tibial spine on the anterior view. The 12.5-mm opening reamer (Tri-Gen) was then used through the appropriate soft tissue protector to establish the start point for the tibial nail.

Specimens were dissected with care through a complete medial paratellar arthrotomy, allowing eversion of the patella and revealing the intra-articular condition of the knee structures (Figure 2). This dissection was performed by the investigator (J.R.) who performed the arthroscopic evaluation of the specimen. The border of the tibial entry reamer hole was measured with digital calipers, accurate to 0.02 mm, to the anterior horns of the menisci, anterior cruciate ligament root, and intermeniscal ligament; these were measured by a second investigator (C.E.) blinded to the portal used for nailing. This investigator was a board-certified orthopedic sports medicine surgeon familiar with the normal morphology of these structures. The structure was considered damaged if the structure was obviously damaged on visual inspection or if a measurement less than 1 mm from the reamer site to the structure was measured by digital calipers. The patellofemoral joints were visually evaluated for any chondral damage or scuffing and annotated. All specimens were photographed for comparison to the pretest...
RESULTS

The lateral meniscus and anterior cruciate ligament root were undamaged in all specimens. No gross patellofemoral joint cartilage damage was noted on dissected specimens that was not documented by pretest arthroscopy. Of the 10 specimens in the standard entry portal group, the anterior horn of the medial meniscus was injured in 1 and the intermeniscal ligament was injured in 3. Of the 10 specimens in the suprapatellar portal group, the intermeniscal ligament was injured in 2, and the medial meniscus was injured in 0.

Impact to intra-articular structures was numerically lower in the suprapatellar group (2/10) compared with the standard portal group (4/10), but the difference in damage was not statistically significant using a 2-tailed Fisher exact test due to the small sample size (P = .629).

When looking at the distance of the start point to intra-articular structures, the specimens in the infrapatellar group had a statistically significant closer distance to the anterior horn medial meniscus (P = .002), anterior horn lateral meniscus (P = .004), and anterior cruciate ligament root (P = .036). The distance to the intermeniscal ligament was not significantly different between the 2 groups (Table).

DISCUSSION

Tibial nailing through a suprapatellar insertion portal has advantages in proximal fracture patterns. This difficult fracture pattern is well known for potential malalignment.9,11 The suprapatellar modification allows the entire nailing procedure to be performed without moving the operative extremity and allows easy positional insertion of blocking screws if desired. The concern with this technique is the placement of instrumentation through the knee with the potential for injury to the articular cartilage of the undersurface of the patella and to the femoral trochlea. Other concerns are that the start point obtained would increase the known potential injury to adjacent structures, such as the anterior horn of the medial meniscus. Investigations have elucidated the optimal insertion point for tibial nailing. Tornetta et al12 used a starting awl in cadaveric specimens and reported injury to the medial or lateral meniscus to 2.5% and lateral articular damage to 5% of specimens when using a lateral parapatellar approach. When using a medial parapatellar approach, they reported injury to the medial meniscus, anterior cruciate ligament footprint, and medial articular surface in 5% of specimens.1

In another study using a more anterior start point, Hernigou and Cohen2 used lateral and medial parapatellar and transpatellar approaches to the tibial start point. They reported a 4.2% incidence of injury to the lateral and medial menisci and a 12.5% incidence of injury to the intermeniscal ligament. Changing the vector of nail insertion to a more proximal point in the current study produced rates of intermeniscal ligament injury comparable with those of Hernigou and Cohen.2 However, the medial meniscus was not injured in any specimen in the current study using a suprapatellar approach. When using the medial parapatellar approach, 10% of the specimens in the current study had injury to the medial meniscus, and the rate of intermeniscal ligament injury was similar to that in the suprapatellar group.
Arthroscopy was used to evaluate the articular surfaces of the specimens prior to instrumentation to ensure that overt injury was not caused to the cartilaginous surface by introducing the suprapatellar instrumentation. No differences in pre- and postinstrumentation specimens were found. Gelbke et al.12 investigated the increase in patellofemoral contact pressures using a suprapatellar portal for tibial nailing. They found that nail insertion through an infrapatellar portal caused a mean peak infrapatellar contact pressure of 0.9 MPa, whereas the suprapatellar portal caused a mean peak contact pressure of 1.84 MPa.12 Although an increase occurred, it was well below the 25 MPa threshold that is known to cause chondrocyte cell compromise in animal models.12

Two other cadaveric studies have evaluated the suprapatellar start point in relation to tibial nailing. Eastman et al.13 evaluated the angle of knee flexion to maximize the entrance vector to the start point on the proximal tibia. They found an increase in the ability to obtain a proper start point for nailing with knee flexion up to 50°, with statistical significance reached at 23° of knee flexion.13 In the current study, the knee flexion was standardized at 30°, which is in this effective range.

In a separate study, Eastman et al.14 evaluated the risk of intra-articular structures using a suprapatellar portal. They measured the distance from the start point to important intra-articular structures with digital calipers and found a mean distance to the anterior horn of the medial meniscus of 6.6 mm. The current study had the same mean distance of 6.6 mm. Eastman et al.14 reported a medial meniscal injury rate of 12.5% and an intrameniscal ligament injury rate of 81.2%. This differs from the current study, which had no injuries to the medial meniscus and a 20% injury rate to the intermeniscal ligament.

To the authors’ knowledge, this is the first cadaveric study to compare injury to intra-articular structures using the suprapatellar starting portal and the standard medial parapatellar portal. Pretest arthroscopy was performed to ensure that macroscopic articular injury was not caused with the passage of intra-articular instrumentation. The study found that the intermeniscal ligament is the structure most at risk through this proximal portal.

More importantly, no increase was found in the rate of structures at risk through the proximal portal compared with the parapatellar portal. Although this difference was not statistically significant, no injury occurred to the medial meniscus, and a statistically significant difference in injury rates would likely be found with a larger sample size.

This study has all of the limitations of a cadaveric study. In vivo cartilage may be more susceptible to injury than that in a cadaveric model; therefore, the authors cannot directly correlate this portion of the study to clinical applications. Also, the age of the cadaveric specimens was inconsistent, which could cause differences in cartilage behavior between cadavers. The authors attempted to minimize the differences by using matched pairs of lower limbs. Thus, the ages of each cadaver pair were the same for the 2 approaches.

CONCLUSION

This study demonstrates no overt injury to the cartilage surface in the cadaver model. A smaller rate of intra-articular injury occurred with the suprapatellar portal approach compared with the medial parapatellar approach.

REFERENCES


