Advances in Intramedullary Nailing: Suprapatellar Nailing of Tibial Shaft Fractures in the Semiextended Position

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Abstract: Reamed locked intramedullary nailing remains the standard treatment for displaced tibial shaft fractures. Suprapatellar tibial nailing in the semiextended position has been suggested as a safe and effective surgical technique that allows mitigating certain challenges of the standard subpatellar approach. Suprapatellar nailing seems to facilitate achieving and maintaining fracture reduction, particularly in proximal third tibia fractures. Preliminary investigations have suggested that this technique is associated with a low rate of complications, including a reduced incidence of postoperative anterior knee pain. Further clinical investigations are necessary to establish overall complication rates and long-term subjective outcomes. [Orthopedics. 2015; 38(12):751-755.]

Tibial shaft fractures represent a relatively common injury, and are the result of high-energy trauma.\(^1,2\) Intramedullary nail fixation remains the treatment of choice for displaced and unstable tibial shaft fractures in the adult population. Intramedullary nail fixation provides the advantage of minimal surgical dissection with preservation of the extraosseous blood supply to the fracture. The indications for intramedullary nailing become more limited for fractures involving the proximal and distal metaphysis. Recent advances in nail design and reduction techniques have expanded the indications for intramedullary nail fixation to more proximal as well as more distal tibia fractures involving the metaphyseal area. However, proximal third tibia shaft fractures in particular seem to be at risk for valgus and apex anterior deformities.\(^3\) Establishing an anatomic starting point appears to be crucial in these fracture patterns. Suprapatellar nailing in the semiextended position has recently been suggested as a safe and effective surgical technique. The technique allows for establishment of an appropriate starting point, and the semiextended position facilitates the fracture reduction of apex anterior deformities. Preliminary clinical data have shown promising results with a low rate of postoperative anterior knee pain.\(^4,5\) This article reviews the current concepts of suprapatellar nailing of tibial shaft fractures in the semiextended position.

Initial Evaluation and Management

Patients with high-energy tibial shaft fractures must be evaluated for associated injuries according to Advanced Trauma Life Support (ATLS) guidelines. From the orthopedic standpoint, the injured lower extremity must be thoroughly examined. A detailed neurovascular examination must be documented. Associated open fractures must be promptly identified. Patients must be carefully checked for acute compartment syndrome, and serial examinations are war-
ranted. The risk of associated compartment syndrome has been reported to be as high as 11.5%.\(^6\) In particular, younger patients with high-energy tibial shaft fractures seem to be at risk for associated compartment syndrome.\(^6,7\)

The radiographic evaluation of tibial shaft fractures requires anteroposterior and lateral radiographs of the injured tibia. In addition, dedicated radiographs of the adjacent knee and ankle joints are mandatory. If an associated tibial plateau fracture is suspected, a computer tomography scan may provide useful information for the further treatment of the injury. Similarly, computer tomography scans of the ankle may be useful for identifying associated noncontiguous ankle injuries or for detecting extension of the tibial shaft fracture into the tibial plafond.\(^8\)

**Surgical Considerations**

**Tibial Nail Starting Point**

Establishing an appropriate starting point plays a key role in intramedullary nailing procedures. Several anatomic investigations have contributed to understanding of the ideal starting point for intramedullary nailing of tibia fractures.\(^9,11\) In most patients, the ideal starting point lies at the anterior edge of the tibial plateau and just medial to the lateral tibial spine. Tornetta et al\(^11\) further reported on a “safe zone” with a width of 22.9±8.9 mm that allows for nail insertion without risk of damage to adjacent intra-articular structures. Traditionally, the starting point is established through an infrapatellar approach that allows access to the proximal tibia by either splitting the patellar tendon (transtendinous approach) or dissecting just adjacent to the patellar tendon (paratendinous approach). This traditional technique requires that the knee be resting over a radio-opaque triangle and in a flexed or fully flexed position. The positioning, however, may exaggerate apex anterior deformities that are frequently complicating the treatment of proximal third tibia fractures. Moreover, the infrapatellar starting point has been reported to be associated with a high rate of postoperative anterior knee pain.\(^12\) Therefore, the use of a starting point that has the potential to facilitate the fracture reduction and at the same time minimize the risk of postoperative anterior knee pain seems desirable.

Nailing in the semiextended position has recently gained increased attention in the orthopedic literature.\(^4,5,13,14\) Tornetta and Collins\(^15\) suggested tibial nailing in the semiextended position using a medial parapatellar approach as a method to avoid apex anterior deformities. Recent reports have adopted this concept, suggesting a suprapatellar portal and nail insertion through the patellofemoral joint with the knee in the semiextended position.\(^4,5\) During the past few years, specific instrumentation has been developed for this technique with the goal of allowing the procedure to be performed in a soft tissue-friendly fashion and with minimal damage to the surrounding structures.

**Surgical Technique**

Suprapatellar nailing is performed with the knee flexed in approximately 15°. An approximately 3-cm incision is made about 1 to 2 fingerbreadths above the patella. The quadriceps tendon is split longitudinally and the patellofemoral joint is entered. A cannula system with a blunt trochar is then inserted through the patellofemoral joint and advanced to the apex anterior angle. The K-wire is retrieved from the cannula system using anteroposterior and lateral fluoroscopic images, an opening reamer can be inserted through the cannula system. The K-wire is retrieved and a ball-tipped guidewire is inserted through the cannula system into the proximal fracture fragment. The ball-tipped guidewire is advanced across the fracture site to the level of the knee joint. The remaining surgical procedure, including the reaming process and insertion of the nail, is performed through the cannula system, allowing for appropriate protection of the surrounding soft tissues and intra-articular structures. At the conclusion of the surgical procedure, a thorough irrigation of the surgical site is advised to avoid retained debris within the knee joint. An appropriate repair of the longitudinal split within the quadriceps tendon is performed. The postoperative treatment protocol is identical to established protocols of tibial nailing, and early range of motion exercises of the knee and ankle are encouraged.

**Potential Advantages and Disadvantages**

Semiextended tibial nailing through a suprapatellar portal offers several potential advantages. It potentially facilitates the fracture reduction, especially in proximal tibia fractures with an apex anterior deformity. In these types of injuries, the use of a radiolucent triangle and hyperflexion of the knee may exaggerate the existing deformity, whereas the semiextended position may eliminate the extension force of the quadriceps and may greatly facilitate the reduction of the apex anterior angulation. Moreover, the leg resting in near extension on the operating room table may ease the maneuvering of the leg during surgery and facilitate the access of the fluoroscopic image intensifier. In addition, associated soft tissue injuries involving the infrapatellar area may make it undesirable to place a surgical incision in this area; the suprapatellar portal may provide a reasonable alternative in these situations (Figure 3).

Despite these potential advantages, concern remains
regarding associated injuries to the patellofemoral cartilage and the long-term consequences associated with this. In a cadaveric study, Gelbke et al\textsuperscript{14} measured the peak contact pressures in the patellofemoral joint during suprapatellar and infrapatellar nailing. Although the peak pressures appeared higher with the suprapatellar nailing technique, Gelbke et al\textsuperscript{14} reported that the peak pressures observed were well below the threshold determined to be detrimental to the articular cartilage.

**Outcomes**

Satisfactory outcomes and reproducible results can be achieved with intramedullary nail fixation of tibial shaft fractures. The reported union rates of intramedullary tibial nailing vary among studies. With contemporary implants and appropriate surgical techniques, union rates above 90\% can be expected.\textsuperscript{16} Despite these favorable union rates, the functional outcomes following intramedullary nail fixation leave room for improvement. In particular, postoperative knee pain seems to be a limiting factor during the recovery process.\textsuperscript{12,17-21} A review of the literature with pooled data from publications including the years 1990 until 2005 suggested that postoperative knee pain may occur in approximately 47\% of patients following intramedullary nailing.\textsuperscript{12} Currently, the exact etiology of postoperative anterior knee pain following tibial nailing is not fully understood. Several contributing factors have been suggested, such as traumatic and iatrogenic damage to intra-articular structures, injuries to the infrapatellar branch of the saphenous nerve, thigh muscle weakness secondary to pain-related neuromuscular reflex inhibition, fat pad fibro-

**Figure 1:** Schematic drawing (A; © UTHSCSA) and intraoperative image (B) showing the suprapatellar starting point through a longitudinal split of the quadriceps tendon. Intraoperative fluoroscopic lateral (C) and anteroposterior (D) views of the starting point.

**Figure 2:** A multiholed cannula (A) allows for fine adjustments (B) of the starting point.
sis leading to impingement, reactive patellar tendonitis, bending strain exerted by the nail on the proximal part of the tibial bone, and proximal protrusion of the nail.\(^{10,12,18,22-24}\) It must be assumed that the etiology of postoperative anterior knee pain may be multifactorial and that any of the above named factors may potentially contribute to this phenomenon.

Regarding postoperative anterior knee pain, intriguing results have been reported in preliminary clinical investigations of suprapatellar tibial nailing in the semi extended position. In a prospective clinical study including 56 consecutive patients undergoing suprapatellar tibial nailing, Sanders et al\(^5\) did not identify any patients with postoperative anterior knee pain at a minimum of 12 months of follow-up. However, 1 patient reported peri-incisional pain around the knee. In a retrospective cohort study, Jones et al\(^4\) reported on 38 patients undergoing suprapatellar nailing vs 36 patients undergoing infrapatellar nailing. Patients were followed for a minimum of 12 months. Jones et al\(^4\) did not identify any statistically significant differences regarding anterior knee between patients undergoing suprapatellar vs infrapatellar nailing. However, Jones et al\(^4\) observed a trend toward greater symptomatic knee pain in the infrapatellar group. Moreover, significantly better reductions and more accurate starting points were found in the suprapatellar nailing group.\(^4\)

These promising data suggest that appropriate clinical and radiographic outcomes can be achieved with suprapatellar nailing in the semi extended position. The technique allows for establishment of an accurate starting point, may facilitate fracture reduction, and appears to be associated with a relatively low rate of anterior knee pain. Although these preliminary data seem encouraging, the theoretical concern remains of iatrogenic cartilage damage to the patellofemoral joint associated with this procedure.\(^13,14\) Therefore, larger clinical investigations with long-term follow-up are necessary to substantiate the impact of suprapatellar nailing on long-term patellofemoral pain.

### CONCLUSION

Reamed locked intramedullary nailing remains the standard treatment for displaced tibial shaft fractures.\(^16\) A correct starting point remains a crucial part of the surgical procedure.\(^25\) Suprapatellar nailing in the semiextended position offers an alternative to the traditional infrapatellar approach.\(^5\) Specific instrumentation with a cannula system allows for nail insertion in a safe fashion and minimizes the risk of iatrogenic damage to intra-articular structures. Accurate starting points can be established using this technique. The semiextended position may facilitate fracture reduction in particular in proximal third tibia fractures. Preliminary clinical data suggest a low rate of postoperative anterior knee pain.\(^4,5\) However, concern remains regarding iatrogenic damage to the patellofemoral joint. Trials are needed evaluating the long-term functional outcomes associated with this new, innovative technique.

### REFERENCES


