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Our experience in suprapatellar nailing: Surgical techniques

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Abstract
Tibial shaft fractures are conventionally treated with intramedullary nailing. The classical approach for intramedullary nailing with knee in 90-degree flexion, challenges the surgeons in reduction and shortcomings of post-operative malalignment, especially for proximally tibial shaft fractures due to quadriceps tendon pull. The advent of a new suprapatellar approach with knee in a semi-extended position overcomes this disadvantage. Since then, many advancements in techniques and instrumentation have been developed for the suprapatellar approach. The practice of accurate nail entry, reduction procedure, nail insertion and locking have shown good outcomes. This article discuss about the prerequisites and surgical technical knowledge that we gained in our experience.

Keywords: surgical techniques, suprapatellar approach, semi-extended knee position

Introduction
The use of intramedullary nailing is one of the standard techniques for the fixation of the tibial shaft fractures. The routine approach for the intramedullary nailing for tibial shaft fractures is an infrapatellar approach with knee in 90-degree flexion. The flexion during the infrapatellar approach has to lead to an increased malalignment in proximal 1/3rd tibial shaft fractures fixation due to the pull of quadriceps tendon. Fixation of proximal 1/3rd tibial shaft fractures has been great challenge for surgeons for years. Followed which, the development of this suprapatellar approach has been made. Various attempts have been made in view of reduction of this anterior malalignment such as plating, blocking screw, uncortically placed compression plate (anteriorly) with nailing, splitting the retinaculum and subluxing the patella laterally and nailing in an extended position [2], operating through percutaneous lateral approach [21], suprapatellar pouch[12] which was later changed to suprapatellar approach by dean cole [16].
Conventional open reduction and fixing by plate has good anatomical reduction but has a high risk of post-op infection, and axial stability is low [3, 9, 10, 13], Matthews *et al.* has employed dynamic compression plate (four to six holed) which is placed unicortically on the anterior aspect, followed by infra-patellar nailing. But the disadvantage is same as conventional plating, that is a high rate of post-op infection [4]. Applying a blocking screw followed by nailing can overcome this disadvantage. As stated by Ricci *et al.* using intramedullary nailing and blocking screws for the treatment of proximal 1/3rd tibial shaft fracture and successively treated 12 patients, but the placement of blocking screws, complication of screw breakage is demanding and technically burden some [6, 11].
In order to overcome this issue, tornetta and collins in the year 1996 have discovered a new approach for the proximal 1/3 rd tibial shaft fractures with knee in semi- extended position. In the study done by Tornetta and Collins, a partial medial parapatellar arthrotomy (subluxing the patella laterally) was done in 25 patients with knee joint in a semi-extended position (15-degree flexion of the knee) [2]. Fractures are easily fixed with knee in 15 degree flexion as the pull of patellar tendon gets eliminated. Initially, concerns were araised regarding damaging the patellofemoral joint and chances of septic arthritis. However, recent evidences and various studies have shown no evidence of these problems. Epdimiologically being one of the fore most common long bone fracture [1, 5, 7], various studies on rate of union, infection rate [8], knee

mobilization mechanical axis/alignment of the tibia were done[14,20]. Despite the challenge of new access and various concerns raised and chances of intra-articular cartilage damage [15], the use of suprapatellar nailing has been widespread these days and recent advances have also developed globally.

As Sanders *et al*. reported, Dean Cole was the one who started the suprapatellar approach by employing a midline quadriceps tendon incision [16]. This approach overcomes the issues of reduction in 90-degree flexion with posterior malalignment of the distal fragment. Extra-articular fracture with simple intra-articular extension can be managed by nailing through a suprapatellar approach after fixing the condyles with a screw [19].

Suprapatellar nailing with midline incision of the quadriceps tendon was done by sanders *et al.*, which overcomes the problems of reduction with the knee in 90-degree flexion and posteriorly displaced distal fragment.

The purpose of this article is to discuss prerequisites surgical technique and tricks in operating patients with suprapatellar with various tibial fractures by nailing through the suprapatellar approach.

Indication

Extra-articular fractures of the proximal tibia (AO type 41A) (proximal tibial fracture located entirely in the metaphysis is a classical indication for suprapatellar nailing of the tibia) (AO type 41 A2 and A3) Simple and comminuted fractures of the tibial diaphysis (AO type 42A,C) Segmental diaphyseal fracture of the tibia (AO type 42C) Extra-articular fracture of the distal tibia Fractures with simple intra articular extension

Flexion deficit of the knee joint Patella Baja Ossification in the patellar tendon Abrasion, laceration, contaminated wound over the infrapatellar region (fig-1)

Fig 1: Abrasion over infra patellar region

Contraindications

Severe soft tissue laceration, contamination or infection in the suprapatellar area Knee arthrodesis Extension deficit of the joint more than 20 degrees Fractures of the tibial plateau involving the entry point of the nail Grade 3 open fractures of the tibia proximally (having increased risk of joint infection) (relative contraindication)

Advantages

Simpler to perform in proximal tibial fractures Simple positioning of the patient (perfect fracture reduction can be achieved in nearly every case by positioning the extremity in slight extension) [2].

As feasible as a Single surgeon procedure Interval between the site of soft tissue trauma (1st hit) and the suprapatellar skin incision (2nd hit) helps to prevent secondary trauma due to (2nd hit) surgical access, which acts in favour of fracture healing.

Shorter operating time (implied by low fluoroscopic time), which is stated by ionising radiation (medical exposure) regulations 2017 – UK government [18].

Fig 2: Easier manipulation of C-Arm in semi-extended knee position

Easier to manipulate the C-ARM in a semi-extended knee position Provides a better access to the proper entry point and the extremity remains in the same position throughout the entire procedure, no other manipulation is needed during distal locking (fig-2).

No damage to the patellar tendon (which is considered to be one of the strongest extensors of the knee) and no incidence of anterior knee pain (avoids the risk of infrapatellar nerve damage/ hoffa's pad not removed) [17].

Disadvantages

In case of implant removal, a different approach may be required (infrapatellar approach) Intraoperative displacement of the protection sleeve may sometimes lead to damage to the cartilage and the intra articular knee structures, Increased chance of joint infection, Patellofemoral arthritis.

Pre-op evaluation and planning

Patient info

Evaluate for general surgical risks of hematoma infection, damage to neurovascular structures and other thromboembolic complications. Explain about the damage to the cartilage and the intra-articular knee structure and Risk of joint infection. Explain about implant removal, which may require a different (infrapatellar) approach. Other risks like delayed Union, malunion, nonunion, implant failure.

Pre-Operative Workup

Pre-operative X-rays of the joint above and below in both the planes should be taken Computed tomographic scan should be done in case of any concern about intra-articular fracture extension Appropriate antibiotics Measure the nail size. Preoperatively assess for the patellar mobility/laxity for any injury, arthritis (patellofemoral) that might interfere in

accessing the patello femoral space to accommodate the protective sleeve.

Instrument and Implant

C – arm /image intensifier Quadriceps board/Bolster to keep the knee in proper semi extended position

Fig 3: (a) Straight awl, (b) protective sleeve

Protective sleeve that helps in protecting the intra-articular structures while reaming Straight awl (fig 3 a), so that it goes through the protective sleeve (fig 3 b) Point reduction clamps for reduction Extra long Rigid reamers as well as flexible reamers (advisable for segmental fractures) is mandatory Supra patellar jig set (we augmented regular infrapatellar nail set to the suprapatellar jig by extending a couple of centimeters)

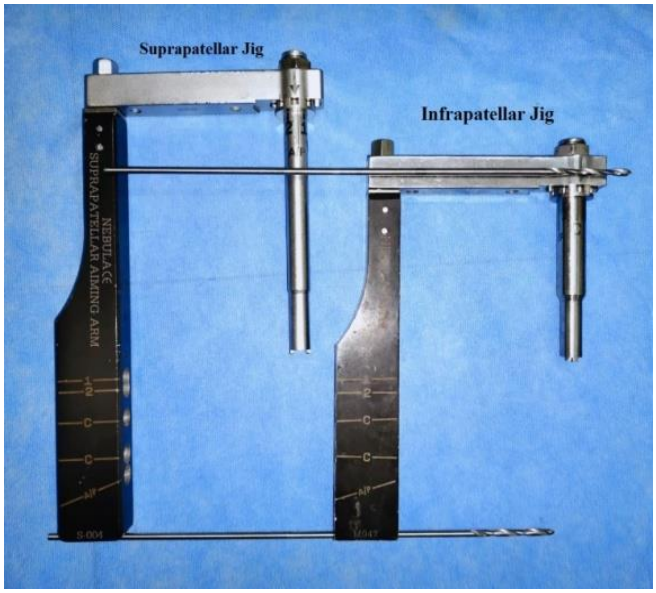

Fig 4: Augumentation of infrapatellar to suprapatellar jig Position

The patient is kept in supine on a radiolucent table with the quadriceps board/ bolster, to keep the knee in 15 to 20 degrees of flexion, bump under the ipsilateral hip to be kept to ensure the patella is facing upwards, which allows to take a proper lateral radiograph.

Proper positioning is needed to allow easy access for an optimal entry point, easier imaging and less difficulty in reduction of the fracture.

Fig 5: 15 to 20 degrees of flexion

Technique and Instrumentation

Preoperatively check the patella for laxity/mobility, clinically as well as radiologically to rule out any stiffness, instability, ossification, joint space involvement, arthritis that interferes with the placement of a protective sleeve. Under anesthetic control, Tourniquet was applied in the ipsilateral thigh, under sterile aseptic precaution, patient on a radiolucent table in the supine position, parts painted and draped.

Fig 6: (a) Quadriceps board

Fig 6: (b) Bolster

Keep a adjustable quadriceps board (fig 6 a) / bolster (fig 6 b), under knee joint to keep the knee in a semi-extended position that aids in decreasing the proximal pull of the patellar tendon, which keeps the knee in 20 to 30 degree of flexion. If needed, place a bump under the ipsilateral hip so that the patella faces upwards.

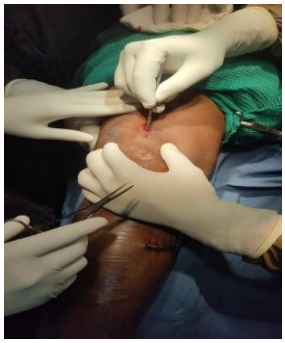

Fig 7: Midline vertical incision

Palpate midline of the base of patella (superior pole) just a

finger breadth above the midline make a vertical incision of 1.5 to 2.5 cm.

Fig 8: Quadriceps tendon

The Quadriceps tendon is visualized, which is split vertically in line with the fibers.

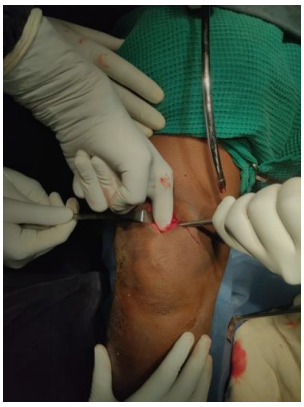

Fig 9: Finger in Patello femoral space

Patello femoral space is reached ideally it should be checked by insinuating a finger under patella-femoral space to pass the protective sleeve (fig 9), if it is not, make a 2/3rd retinaculum split medially as suggested by tornetta and Collins, which subluxes the patella and allows enough space for instrumentation.

Fig 10 a: Protective sleeve placed

Fig 10 b: Protective sleeve placed

Pass the protective sleeve with the blunt trocar, so it doesn't damage the patellofemoral articular surface (fig 10 a, b). Place and hold the sleeve in a position which should be kept in place throughout the procedure either by an assistant or by kirschner wire. A proper entry point determines the nature of fixation.

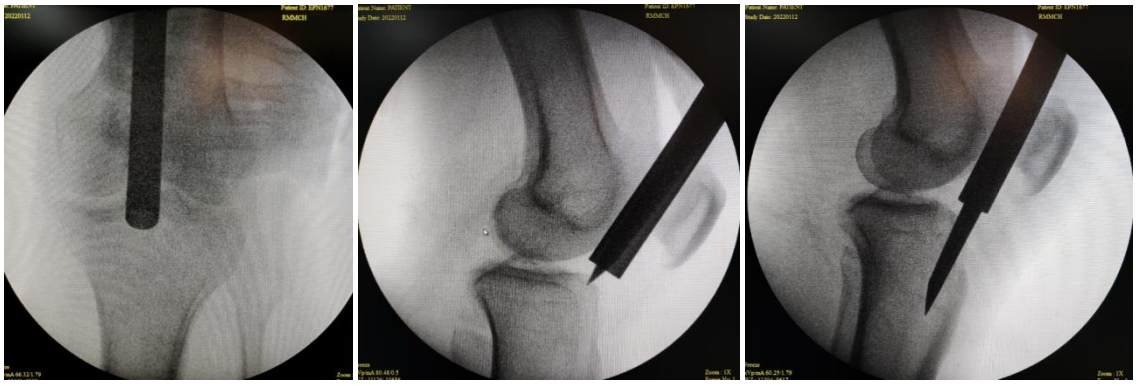

Fig 11: Ideal entry point AP and Lateral view

For an ideal entry on an anteroposterior view it should be in line with the medullary canal that is 3mm medial to the tibial crest and in the lateral view it should be just anterior to anterior articular margin (fig 11). Ideal entry point is the crucial step of the procedure. Entry to be taken with the guidance of a c-arm with a straight awl. Guidewire to be passed, which should be centered in both planes.

Ball tipped guide wire in case of segmental fractures for reaming through flexible reamer .long reamers are needed because the entry is higher up. As the patient's knee is in semi extended position (extended) easier to hold the fracture fragments in alignment, no distracting forces by the muscles or the gravity (reduction) as the leg lies flat on the operating table.

Fig 12: Reamed with fracture in reduction

Confirm the reduction under the guidance of C arm, hold the fracture fragments with a percutaneous reduction clamp or with the help of an assistant and serially (sequentially) ream it while keeping it in position (fig 12) Check the appropriate nail size per operatively under C-arm and place it after removing the protective sleeve (depends on the jig). Reduction to be cross-checked after insertion of nail.

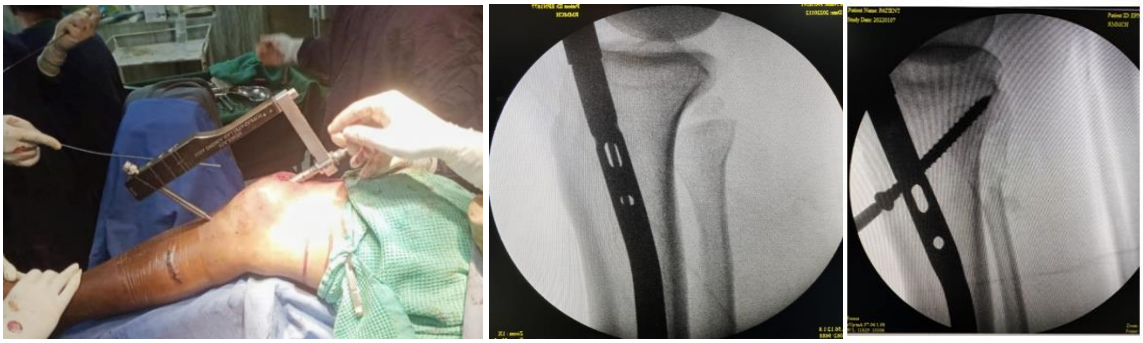

Fig 13: Applying anteroposterior locking bolt

Proximally locked with an anteroposterior, mediolateral and oblique locking bolt with the aid of the jig, if needed, the fracture can be jammed from foot (heel) for docking.

Fig 14: Distal free hand technique (without manipulating fracture site)

Distal locking bolt is fixed without the help of a jig (freehand technique), as the leg is in the extended position it is easier to manipulate the c-arm and introduce distal locking bolt without disturbing or manipulating the fracture reduction (fig 14). Thoroughly wash the knee joint with normal saline to remove the debris and blood from the knee joint.

Complications

If there is any displacement of the protective sleeve intraoperatively, it may damage the articular surface /cartilage /intraarticular knee structures.

Nail cannot be inserted with the protective sleeve on, which may cause deadlocking of the nail, so the nail should be inserted without the protective sleeve (depends upon the jig).

Summary

This article describes the workup and surgical techniques (hints) of suprapatellar approach in semi extended knee position for various tibial fractures.

We recommend suprapatellar nailing in tibial diaphyseal fractures (simple and segmental). Suprapatellar nailing is a effective option for proximal 1/3rd tibia fractures due to its inherent advantages of positioning, perfect nail entry and placement [17]. There is no much difference in complication of supra patellar versus infra patellar nailing as a stated in recent studies [20].

It can be an excellent alternative to other management modalities as it overcomes the shortcomings of the classical approach. Now a days it is also attempted in intraarticular proximal tibial fracture with simple extension (Garnavos 2017) [19]. It results in excellent clinical outcomes.

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