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Arthroscopic tibial spine fracture fixation: Novel techniques

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ABSTRACT

Proper knee kinematics depends upon the integrity of ACL at its femoral and medial tibial spine attachments. Tibial spine fractures disrupt this complex and if untreated can lead to pain, instability and functional limitation. So proper diagnosis and early treatment of tibial spine avulsion fracture is important.

Tibial spine fractures are often associated with intra-articular injuries which are more common in adults. Diagnosis and treatment of these associated injuries along with proper fixation of tibial spine fractures are essential. Surgical options for tibial spine fractures include reduction and fixation through arthrotomy or arthroscopic technique. Arthroscopic technique is now more popular as it allows accurate diagnosis and treatment of associated injuries, reduction and fixation of all types of tibial spine fractures and reduced morbidity compared with open techniques.

1. Introduction

Tibial spine [1] fractures were first described by Poncet in 1875. Initially they were thought to represent childhood equivalent of the anterior cruciate ligament (ACL) tear in adults. It is now known to occur with much greater frequency in adults than previously thought. Kendall et al 2 reported that 40% of these fractures occur in adults. The mechanism of injury is thought to be a hyperextension injury with rotational component.[3] In children this occurs more frequently as a result of twisting injuries during falls and sports activities. In adults it occurs due to motor vehicle accidents, falls or sport injuries. Studies have shown that tibial spine fractures are more common in women. Weak osteochondral junction in children makes them more susceptible to this injury, with osteopenia being a major contributor to this injury in middle-aged women by weakening the bone in the tibial spine region.

Meyers and McKeever [4] were the first to classify these injuries in 1959. In 1970, they described their experience in treating 70 tibial spine fractures. Type I (undisplaced) and type II fractures (anterior third to half elevated) were treated with aspiration of hemarthrosis and long-leg casting with the knee in 20° of flexion. Type III fractures (complete displacement) required arthrotomy with open reduction and fixation. Ten of 22 adults with a type III injury treated with arthrotomy had a poor result. Zaricznyj later described a type IV injury, which represents rotation and comminution of the fragments.[5] More recently, arthroscopic fixation has been advocated for type II, III, and IV injuries.[6,7]

With the advent of arthroscopy and magnetic resonance imaging, it is now known that associated soft tissue injury is common with tibial spine avulsion fractures.[8] These include meniscal injury, ACL injury, and chondral injury. Diagnosis and treatment of these injuries are of utmost importance for successful outcome. Arthroscopy allows for identification and treatment of these soft tissue injuries, as well as reduction and fixation of displaced type II, III, and IV fractures. Hunter and Willis and Jung et al. have reported good results with arthroscopic treatment of type II and III fractures. Various arthroscopic methods of fixation using cannulated screws or suture fixation have been described in the literature. Hunter and Willis reported a 44% reoperation rate in patients treated with cannulated screws. Here we describe the technique of arthroscopic fixation of tibial spine fracture using stainless steel wires.

2. Materials and methods

We have done a study in 10 patients with tibial spine fractures (types 2,3,4) who were managed surgically with arthroscopic tibial spine fixation using stainless steel wires in the year 2014/2015. We used Cerclage wire technique and Figure of Eight technique which was based on the type of fracture fragment (comminuted or not). Post operative functional outcome was analyzed.

3. Preoperative planning

The planning is similar to other intra-articular fractures. These patients present with sudden onset of gross effusion (haemarthrosis) in the

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concerned knee after a history of trauma. Tense hemarthrosis requires aspiration which may contain fat globules and when tibial spine fracture is suspected it is better to take standard radiographs before performing clinical stability tests (to avoid iatrogenic displacement of fractured tibial spine). Once tibial spine fracture is evident on X-ray, an MRI along with CT cuts if needed is done to get additional information regarding comminution, displacement, size of fragments, involvement of the medial or lateral tibial articular surfaces, ACL/PCL/meniscal involvement, bony contusion etc. Patient is immobilized in cylinder slab (knee in 20–30 ° of flexion) with synthetic material (prelude) for 1week to tide over the initial phase of traumatic inflammation.

4. Technique

After spinal anaesthesia, the patient is positioned supine with the thigh stabilized in leg holder and leg hanging free. Tourniquet is routinely used in our centre. Using standard AL/AM portals intra-articular hematoma is evacuated and thorough joint lavage is done while the shaver system is used whenever required. We use inflow and outflow through the same arthroscopic cannula. Adrenaline saline (1 ml in 3 l) is used for proper visualization by reducing the intra-articular bleed. Diagnostic arthroscopy is done meticulously.

Visualization is established through a standard anterolateral (AL) portal. The medial and lateral tibiofemoral compartments, intercondylar notch, suprapatellar pouch, lateral gutter, medial gutter and under surface of the patella are examined. An anteromedial (AM) portal is then established. With the scope through the AL portal, the tibial spine with ACL attachment is probed through the AM portal to determine the amount of displacement, comminution and soft tissue involvement. The medial meniscus, lateral meniscus, and inter-meniscal ligaments are examined and probed to determine their relationship to the fracture fragments. The ACL should be examined for ecchymosis and attenuation.

A 3.5 mm motorized shaver is used to debride loose fragments from the fracture base. If needed, meniscus or inter-meniscal ligaments incarcerated in the fracture is probed and removed through standard AM portal. The fracture is then reduced using a probe/90 ° artery forceps/ ACL jig. An ACL tibial guide/jig is placed through the AM portal over the reduced tibial spine fragment's lateral half using the scope through the AL portal. It is important to keep the guide at an appropriate angle (50–60°) so that the drill hole is made in the lateral half of avulsed tibial spine fracture fragment. This allows for easier retrieval of wires.

Once appropriate intra-articular position of the guide is established, a 1-cm incision is made over the proximal anteromedial tibia. The extra-articular portion of the ACL tibial guide is then secured at the anteromedial tibial cortex at the level of the tibial tuberosity. This gives a stable construct and holds the guide in a secure position with the fragment reduced.

The appropriate guide pin (2.4 mm drill bit) is used to penetrate the fracture fragment through its lateral half. The drill guide is then removed carefully and 22G steel wire is passed through the drill hole into the knee (exiting through the lateral half of the fragment). The steel wire is passed medially as a needle through the lower part of ACL substance and retrieved out through the AM portal(using straight artery forceps/needle holder/shoulder arthroscopy instruments as and when needed).Then with the scope through the AM portal and tibial guide through the AL portal over the anteromedial half of the fracture fragment keeping it reduced and stabilized, the extra-articular portion of the tibial guide is placed in the anterolateral tibia after making a 1 cm incision. 2.4 mm drill bit is passed through the jig to penetrate the fracture through its medial half. A loop wire of 26G is passed through the guide hole into the knee and delivered out through AM portal. The initially retrieved out wire (22G) is looped and secured in between the looped second wire (26G).It is then fed and shuttled out through the anterolateral proximal tibia at the level of tibial tuberosity. The looped second wire (26G) is then removed. The two ends of the wire are twisted and secured in the proximal tibia passing them over the tibial tuberosity under the soft tissues at appropriate tension maintaining a good reduction visualized through the scope. This completes a figure of eight construct and a stable fixation of tibial spine fracture fragment with minimal comminution.

The knee joint is again viewed arthroscopically. The fracture reduction and stability are evaluated by probing and placing the knee through 0–130 ° of ROM. Under image intensifier the fracture reduction and steel wire tension and position are assessed. Anteroposterior view of the knee is taken with the knee in full extension while lateral view of the knee is taken in both full extension and 90 ° flexion. The portals and incision are closed with 2-0 vicryl and skin with staples. Dressings and pressure bandages are applied. The knee is then immobilized in the same synthetic cylinder slab for 3–4weeks with 20–30 ° of knee flexion. First wound inspection is done on postop day 3 and suture removal is done at 2 weeks.

The other technique used is the Cerclage Wiring for comminuted fracture. Here, by placing the ACL tibial guide through the AM portal and securing the extra-articular portion of the guide over the anteromedial portion of the proximal tibia, 2.4 mm drill bit is used to penetrate the intact tibia plateau just medial to the fracture fragment. Looped steel wire (26G) or single wire (22G) is passed through the tunnel made and delivered through the AL portal after passing through ACL substance or above the approximated and reduced fracture fragment. Another tunnel hole is made just lateral to the fracture fragment by placing the tibial guide in the AL portal and securing the extra articular portion of guide in the anterolateral portion of proximal tibia. 22G steel wire/26G looped steel wire is passed through this tunnel hole on the lateral aspect and steel wire retrieved out through AL portal. The initially retrieved out loop(26G)/wire(22G) at the AL portal is looped and secured with the second wire/loop and is then fed and shuttled out through anterolateral proximal tibia at the level of tibial tuberosity. The two ends of the wire (22G)/loop (26G) is secured at the proximal tibia passing over tibial tuberosity, under the soft tissues giving appropriate tension and maintaining good reduction visualized through the scope. This completes the cerclage wire concept and a stable fixation of comminuted tibial spine fracture fragment with ACL attached. The fixation is checked under image intensifier by the same way as mentioned above.

(The concept of using 26G loop wire is that, it can be spread to two different areas over the tibial spine fracture fragments before tensioning and completing the cerclage wire construct).

Passing the steel wire through the tibial tunnel is always tough and challenging as it is a trial and error method. Tips to follow are:

1. Always use tensioned straight and fresh steel wires without curves and bends
2. Take care at entry-hole site, not to miss it
3. At times we can use cannulated 4.5 mm drill bit over 2.4 mm guide wire up to the inner cortex (tibial spine fracture), removing the 2.4 mm guide wire and keeping the 4.5 mm cannulated drill bit in place, and passing the steel wire through it.
4. Use bone marrow biopsy needle of adequate bore size

5. Post operative management

Post operatively, the knee is placed in a synthetic cylinder slab(with prelude), with knee in 20–30 ° of flexion for 3–4 weeks. Touch weight bearing (maximum up to 30% of body weight) is started from the second post operative day using bilateral axillary crutches/quadrangular walker along with muscle strengthening exercises-static quadriceps(QS), active straight leg rising(SLR), hamstring(Hm) and Tensor fascia lata(TFL). Staple removal is done after 2 weeks post operatively.

After 4 weeks, the slab is removed and x-ray is taken to access the union. The patient is then started on with gradual rehabilitation protocol which includes mobilization to full weight bearing, range of movement exercises and muscle strengthening exercises. This protocol is continued up to 6 weeks. From 6–12 weeks period we follow aggressive physiotherapy which includes tip toe squatting, quadriceps strengthening by weight training exercises starting with ½ kg and progressing to 3 kg. By 12 weeks most of the patients regain near normal range of movements. Physiotherapy for QS/Hm/TFL muscle strengthening exercises are continued up to 6 months which mainly includes tip toe squatting and weight training with 3–6 kg (maximum up to 10 kg). By 6 months patients return to full function and after clinical assessment they are allowed to go back to unlimited activity. Periodic check x-rays are taken after 3 months and 6 months. After 6 months period steel wire removal can be done as a day care surgery under local anaesthesia (given at tibial entry site near tibial tuberosity where the steel wire is twisted, tensioned and secured) with or without IV sedation.

6. Results

We have done a total of 10 cases during the year of 2014/2015, out of which 6 were adults and 4 were children. Male to female ratio was 7:3.We used cerclage wire technique in 6 cases and figure of eight technique in 4 cases which was based on the type of fracture fragment (comminuted or not).

Patients do well after fixation of tibial spine fracture. They develop knee scores better than that of post ACL reconstructed knees (proprioception is better in patients with ACL repair compared to ACL reconstruction). The main complication is initial restriction of motion due to arthrofibrosis, however on long term follow up (6 months), patient regains near normal range of motion. Pain and restricted motion can be overcome by aggressive postoperative rehabilitation programs, between 6 weeks to 3 months period. Loss of extension due to scarring in the anterior compartment can occur. Displacement or mal union resulting in functional disability has not been recorded. Non unions with other implants have been described in the literature but are rare.[9]

7. Discussion

Use of steel wire helps us to reassess the patient during each follow up by correlating clinical assessment (Lachman and Anterior drawer test) with that of the x-ray taken at that time. In serial x-rays we should be looking for the fracture reduction maintenance, tension and position of steel wire and also for its breakage if any.

The disadvantage is that it is not MRI competent and needs implant removal. Presently titanium wires of 24G are available in the market which are mainly used for occipito-cervical implant fixation. Other trends include the use of No:2 fibre wire(ARTHREX) or No:2 ultra-braided sutures(Smith & Nephew). A better assessment of ACL repair during follow up is possible with steel wires compared to that of fibre wire/sutures.

8. Conclusion

Tibial spine fractures represent a disruption of ACL complex.[10]Any residual displacement can lead to knee laxity and functional compromise. It has been shown that anatomically reduced (closed) fractures have a tendency to displace with time. For this reason reduction and fixation of all type 2, 3 and 4 fractures are recommended. Arthroscopic approach allows for the complete inspection of the joint, anatomic reduction and fixation, decreased morbidity and fast rehabilitation.

Conflict of interest

None.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jor.2018.01.056.

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