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Novel technique of PCL avulsion fracture fixation using a modified double pulley method

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Abstract

Background: Posterior Cruciate Ligament (PCL) avulsion fractures are a rare injury and are seen to occur commonly in younger patients. Traditionally these injuries were treated conservatively and that resulted into malunion of avulsion piece and resultant PCL laxity and posterior tibial sag. This on longer run caused altered knee biomechanics, instability and early arthritis. Newer techniques are being tried in treatment in Posterior cruciate ligament avulsion fractures to prevent all these complications.

Methods: We present here a surgical technique which makes use of suture anchors in a modified double pulley technique for the reduction and fixation of PCL avulsion fractures. In our institute we conducted a prospective study of 100 patients having PCL avulsion fracture in which all patients were in young age group and had a traumatic injury, less than 7 days old and followed them up at 6 weeks, 3 months, 6 months and 1 year post surgery to check for their functional and radiological outcomes. All were operated by same surgeon by same method and got the same physiotherapy protocol in same ward and come under same age group.

Results: It was found that our technique showed excellent functional and radiological outcomes at 1 year follow up.

Conclusions: By using this modified double pulley technique for fixation of the PCL avulsion fracture, the surgeon can achieve adequate compression and absolute stability of the fracture fragment. This method has several advantages over the other techniques used for fixation and produces equivalent or better functional and radiological outcome with very minimal complication rate.

Keywords: Posterior cruciate ligament (PCL) avulsion fracture, suture pull out technique, suture bridge technique, modified double pulley technique

1. Introduction

Avulsion fractures of posterior cruciate ligament (PCL) represent a specific form of PCL injuries. Improper treatment of this injury results in an incompetent PCL that leads to knee instability and osteoarthritis. Therefore, previous reports recommend surgical treatment of displaced tibial avulsion fractures of the PCL for achieving anatomical reduction and knee stability. Many operative methods of these fractures are reported. Conventional techniques using direct posterior or posteromedial approach are widely used despite the potential risk of complication, such as damage to the neurovascular structure, tearing of the gastrocnemius muscle and scarring of the wound. Arthroscopic surgery has an advantage of less soft tissue damage, however, it requires specialized equipment, experience and steep learning curve. Optimal fixation with this method is another controversial issue. Cancellous screws or cannulated screws are generally used for open reduction and internal fixation. However, screw fixation is indicated only for the large and noncomminuted fragment. Small or comminuted fragments are difficult to fix; in addition, there is a potential risk of fragmentation of the fracture fragment and post-operative impingement inside the joint. In this study, we introduced a surgical technique, consisting of open reduction using posteromedial approach and internal fixation with a modified double pulley technique for tibial avulsion fracture of the PCL. This method is useful for small as well as large fragment, comminuted as well as non comminuted fragment, does not cause fragmentation of the avulsed piece, no hardware inside the joint and hence no impingement inside the joint and finally the stability achieved by this technique is so great that the knee can be mobilised immediately post-surgery without any fear of displacement of the avulsed fragment.

Corresponding Author: Dr. Parth B Trivedi Consultant Orthopaedic Surgeon Rhythm Hospital, Kadi, Mehsana, Gujarat, India Objective of this study is to compare different methods used for fixation of PCL avulsion and their post-operative follow up with clinical and radiological data.

2. Materials and Methods

We carried out a prospective study of 100 consecutive patients having acute isolated PCL avulsion fracture of less than 7 days duration in young aged patients and followed them up at 6 weeks, 3 months, 6 months and 1 year post surgery to check for their functional and radiological outcomes. All were operated by same surgeon by same method and got the same physiotherapy protocol in same ward and come under same age group. The results were compared with other series using various other modalities of fixation.

The indications for our approach were as follows:

- 1) Isolated PCL avulsion fracture.
- 2) Posterior tibial sag present at 90° of knee flexion.

Intra-articular lesions except PCL avulsion fracture were excluded using preoperative magnetic resonance image because this technique requires use of posteromedial approach and the consequential prone position. Surgeries were carried out under spinal or general anesthesia. A C-arm device was used to avoid the penetration of growth plate by the anchors in pediatric or adolescent patients. Patients were placed in the prone position, with the knee flexed 20° to 30°. A lazy L shaped incision of <10cm was made just medial to the medial head of gastrocnemius. After incising the skin and subcutaneous tissue in line with the incision, taking care and protecting the long saphenous vein and saphenous nerve, the gastrocnemius fascia is divided. Then the gastrocnemius muscle belly is retracted laterally to expose the soleus muscle belly. Now the soleus muscle belly is retracted laterally to expose the muscular fibres of popliteus muscle.



Fig 1: Prone position and posteromedial approach for PCL avulsion fracture fixation

- A) Prone position
- B) Posteromedial incision
- C) Exposure of belly of medial head of gastrocnemius
- D) Semi tendinosus tendon with an intact gastrocnemius band

Now the fibres of popliteus are divided to expose the posterior capsule and then the fracture site is exposed. After assessment of the fracture site, 2 suture based anchors (5mm double loaded metal anchors) were inserted into the most medial and most lateral portion of the fracture crater. 4 out of the 8 suture tails were passed through the osteoligamentous junction of PCL in a mattress fashion. The remaining 4 suture tails are brought out inferior to the fracture fragment. Now the superior and inferior suture tails are tied with each other under tension over the anatomically reduced fracture fragment itself after manually compressing the fracture fragment into the crater with a blunt bone graft punch. Then the knee is moved in from full extension till 90 degrees of flexion to assess the stability of repair. Only then the suture ends are cut, wound lavage given and closed layerwise under negative suction drain. A sterile heavily padded dressing is applied and then limb is immobilised in a specially modified long knee brace. The routine long knee brace is modified for these patients by sticking a small soft pack onto the brace in such a way that it abuts over the posterior aspect of the proximal calf region. This type of brace when applied properly, the pack pushes and supports the proximal tibia anteriorly and thus de-tensions the repair of the PCL avulsion piece.



Fig 2: PCL avulsion piece fixation

- A) The PCL avulsed fragment and the crater seen.
- B) The fragment compressed against the crater while tying the suture tails.
- C) The final fixation of the fragment after cutting suture tails.

2.1 Other treatment options and techniques

A) Arthroscopic PCL avulsion repair

After spinal anesthesia the leg is draped in the standard fashion with the use of tourniquet. Arthroscopic examination of the knee is done using an anterolateral and anteromedial portals. Associated injuries if present is documented and managed in the same time. Through the posterior trans-septal approach with posteromedial and posterolateral portals the posterior tibial avulsion of the posterior cruciate ligament is exposed and the fracture site is freshened with the shaver. Using the PCL tibial guide introduced through the anteromedial portal the fragment is reduced in place and fixed with K wire drilled through the anteromedial tibia through the fragment. Then another guide wire is passed through the fragment and the substance of the PCL and then this guide wire is over drilled with a 4.5mm drill after which an AC Tight Rope is passed through the 4.5mm drill tunnel. The button is then flipped under vision over the fragment and the fibers of the PCL. Tightening of the AC tight rope is done

from outside on the tibial side while applying anterior drawer force and knee flexed to 60 degrees to compress the fragment. After which the posterior stability of the knee is checked.

The advantages of our method over this arthroscopic method are

- 1) The arthroscopic method requires a long learning curve
- 2) Requires specialised instruments
- 3) Implants are costly
- 4) Also there is a high chance of tibial tunnel coalition if the same patient has a concomitant ACL injury requiring ACL reconstruction.

B) Open screw method

After spinal anesthesia the leg is draped in the standard fashion with the use of tourniquet. The patient in prone position a posteromedial knee approach taken and the interval between the medial head of gastrocnemius and semimembranosus developed. The posterior fragment exposed after opening the posterior capsule of the knee and fixed with one or two partial threaded 4.0mm cancellous screws and a washer or a single 6.5mm cancellous screw. The wound closed in layers over a drain for 24 hours.

The advantages of our method over this technique are

- 1) Unlike this method, our method does not have any retained implant inside the knee joint which may become loose and cause impingement.
- Also drilling a small avulsion piece may shatter it and result in weaker construct, whereas in our technique, we bypass the fracture fragment and hence no chance of piece getting shattered.
- 3) The construct resulting out of the placement of a single screw through the avulsion piece is rotationally unstable unlike the rotationally stable configuration achieved after fixation using our method.

C) Open or arthroscopic suture bridge technique using suture anchors

In this technique, just like our method two suture anchors are placed in the crater of the fracture and the sutures are taken out from the osseo-ligamentous junction and then a suture bridge is created and then the sutures are passed through a knotless suture anchor which is placed distally and the piece is compressed into the crater during impaction of the knotless anchor. The advantage of our method over this method is that we reduce the cost of application of a knotless suture anchor.

D) Open or arthroscopic suture pull out method

In this technique, the sutures are passed through the substance of the PCL near the osseo-ligamentous junction either arthroscopically or by open method, then the sutures are brought out through the tibial tunnel exiting at the anteromedial aspect of proximal tibia and then tied there over an endobutton or a bony bridge.

The advantages of our method over this method are

- 1) There is a high chance of tibial tunnel coalition if the same patient has a concomitant ACL injury requiring ACL reconstruction.
- 2) Also if open method is used to perform this suture pull out method then there is a problem in positioning the patient as the sutures need to be passed through posterior incision and the sutures retrieved and tied using an anterior incision.

2.2 Post-operative protocol and rehabilitation

Patient's knee is immobilised using a modified long knee brace in which a small soft pack is stuck onto the brace in such a way that it abuts over the posterior aspect of the proximal calf region. This type of brace when applied properly, the pack pushes and supports the proximal tibia anteriorly and thus de-tensions the repair of the PCL avulsion piece. Continuous cryo-compression is given for 48 hours post-surgery. Due to the high degree of fracture stability achieved by this method, we start all physiotherapy immediately post-surgery which includes starting STQ and ankle pumps on the same day of surgery, SLR and quadriceps and hamstring strengthening exercises on the second day of surgery and knee bending exercises from full extension upto 90 degrees of flexion in prone position from the third day of surgery. Dressing is changed on the third day of surgery and patient is discharged. The patient is kept absolutely nonweight bearing till 6 weeks post-surgery because PCL is a weight bearing ligament of the knee. Full knee range of movement is achieved by 6 weeks post-surgery. Partial weight bearing using a walker and with the long knee brace on is allowed after 6 weeks and the brace is taken off at 10 weeks post-surgery. After that the patient is allowed full weight bearing. Muscle strengthening exercises are started from 6 weeks post-surgery and continued till 3 months postsurgery. The progress of healing was followed by X-rays done at 1.5 month and 3 month and 6 months. Lysholm score, Tegner score and IKDC subjective and objective score were used to assess the knee function of the patient.



Fig 3: Pre-operative CT scan images of the displaced avulsed PCL fragment



Fig 4: Post-operative Antero-posterior and lateral views of the knee showing anatomical reduction and stable fixation of the avulsed PCL fragment under compression

2.3 Bony union

All the cases in our series achieved complete bony union with no cases of non-union. The mean time for healing was around 8 weeks.

2.4 Range of motion

The average range of motion of the knee joint achieved in the patients in our series was 5-135 degree flexion. None of the patients had any fixed flexion deformity. The mean time needed for the patients to achieve this range of movement was around 7 weeks. All the patients were able to sit cross legged and squat at the end of 10 weeks.

2.5 Symptoms and return to activity

All the patients had full range of movement (except 2 patients) and only one of them had pain at final follow up and excluding these two patients, everyone returned to their pre injury activity levels.

2.6 Complications

There were no vascular complications in either perioperative or postoperative period. No patient developed any neurological complication or DVT. Two patients developed superficial infection which recovered completely by local dressing and antibiotics. No patient had any fixed flexion deformity and most of the patients have no loss of knee range of movement at final follow up.

3. Results

A total of 100 consecutive patients of acute PCL avulsion fracture were included in this prospective study. Evaluation of the patients was done at 6 weeks, 3 months, 6 months and 1 year post surgery. Evaluation was carried out to assess functional outcome of our surgical technique using VAS score for pain, Lysholm, Tegner and IKDC scores. Radiological outcome in the form of fracture healing on X Rays were also evaluated.

Parameters (Average)	6 weeks	3 months	6 months	1 year
Knee range of movement	10-130°	5-140°	0-140°	$0-140^{\circ}$
Extensor lag	10°	5°	0°	0°
Weight bearing	Partial	Full	Full	Full
Fracture healing (on X Rays)	Uniting	United	United	United
Lysholm score	62	88	92	93
Tegner score	3	4	5	6
IKDC score	69	83	90	94
Pain (VAS score)	2	1	0	0

4. Discussion

On evaluation of these patients, we see that most of patients in our series achieve full range of movement of knee at 6 weeks post-surgery. This is possible only because the stability of fracture fixation in our technique is so great that we can allow mobilization of the knee joint immediately post-surgery. None of the patients have fixed flexion deformity at the end of final follow up.

As PCL is a weight bearing ligament of the knee, the patient was kept non weight bearing for 6 weeks and then partial weight bearing at 6 weeks and full weight bearing by 10 weeks post-surgery.

All the patients had complete fracture union of the avulsed fragment at 3 months post-surgery. All patients were back to normal function of the affected knee at final follow up and could go back to pre-injury level of activity, work and sports.

The results achieved in our patients were compared to other studies in which they fixed this fracture using arthroscopic methods, suture pull out method and the ones where they used open screw method and found out that the results achieved were similar to the some studies and sometimes even superior to few other studies.

Compared to the other methods practised for the treatment of this fracture, following are the advantages of our method:

A) The advantages of our method over arthroscopic method are

- 1) The arthroscopic method requires a long learning curve
- 2) Requires specialised instruments
- 3) Implants are costly
- Also there is a high chance of tibial tunnel coalition if the same patient has a concomitant ACL injury requiring ACL reconstruction.
- B) The advantages of our method over the open screw technique are
- 1) Unlike this method, our method does not have any retained implant inside the knee joint which may become loose and cause impingement.
- 2) Also drilling a small avulsion piece may shatter it and result in weaker construct, whereas in our technique, we bypass the fracture fragment and hence no chance of piece getting shattered.
- 3) The construct resulting out of the placement of a single screw through the avulsion piece is rotationally unstable unlike the rotationally stable configuration achieved after fixation using our method.

C) The advantages of our method over the suture pull-out method are

- 1) There is a high chance of tibial tunnel coalition if the same patient has a concomitant ACL injury requiring ACL reconstruction.
- 2) Also if open method is used to perform this suture pull out method then there is a problem in positioning the patient as the sutures need to be passed through posterior incision and the sutures retrieved and tied using an anterior incision.

5. Conclusion

By using this modified double pulley technique for fixation of the PCL avulsion fracture, the surgeon can reproducibly achieve adequate compression and absolute stability of the fracture fragment. This method has several advantages (as mentioned above) over the other techniques used for fixation of this fracture and produces equivalent or better functional and radiological outcome with very minimal complication rate.

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