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# Arthroscopic Fixation of Tibial Spine Avulsion in Skeletally Immature Patients by Double Tunnel Pull-out Suture Technique

Orthopedic

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**ABSTRACT**

**Background**: Tibial spine fracture is frequently seen by arthroscopic surgeons in pediatric population. The incompletely ossified tibial spine which is biomechanically weaker than the native highly elastic ACL fibers leads to this injury. Different fixation methods for tibial spine avulsion were illustrated in literature but worry remains about passing through the tibial physis. The most common fixation methods reported in this age are screws and pullout sutures.

**Aim of the study**: is to evaluate the efficiency of arthroscopic tibial spine fixation by double tunnel pull-out suture technique in skeletally immature patients.

**Subjects and methods:** From September 2019 to March 2020, an intervention clinical study was carried out at Al Azhar University Hospital and Alexandria Sporting Hospital, A number of 10 adolescent patients had avulsion tibial spine fracture classified Meyers & McKeever Type II and III were involved in our study.

**Results**: the results revealed that there is major improvement of Lysholm score post operatively and post operatively there is important improvement of mean anterior tibial translation.

**Conclusion**: Arthroscopic fixation by Double Tunnel Pull-out Suture technique for tibial spine avulsion is a simple technique which offers secure fixation and reasonable clinical outcomes.

**Keywords**: tibial spine avulsion; pullout suture; arthroscopic fixation

## INTRODUCTION

Tibial spine fractures classically occur at the bony ACL insertion on the tibia. Commonly, Avulsion fracture of tibial spine occurs in young adolescent than adults as those are skeletally immature. These injuries can occur at an expected frequency of about 3 per 100,000 and are mostly found in children of 8 to 14 years old. The typical mechanism of injury is hyperextension of the knee with valgus or rotational force, often incurred in a fall from a bicycle, in a motor vehicle accident, or in sports such as skiing and soccer. The injury generates traction forces along the ACL and causes avulsion of the tibial spine. The bony avulsion fracture seen in pediatric age group is believed to result from the relative weakness of the incompletely ossified tibial spine which is biomechanically weaker than the native ACL fibers [1].

Although mid-substance ACL tear may occur in children, tibial spine avulsion fractures are invented by slower loading conditions. In that situation, the tibial spine is avulsed and the ACL fibers remain intact, although the forces responsible for the fracture may initially strain the ACL and lead to long-lasting deformation and laxity. [2]

Generally, there are 2 methods of fixation: screw fixation and suture-based fixation. Although latest studies have revealed the biomechanical advantages of the newer suture-based methods of fixation, several methods were mentioned for tibial spine avulsion fixation of like cannulated screws, suture anchors [3], and pullout sutures. Seon et al.[4] discovered that the clinical outcome was the same for screw & suture fixation. However Bong et al.[5] described fiber wire fixation had a superiority to cannulated screw fixation.

By any suture fixation method, there are many concerns like fixing the small fragment in its anatomical position during drilling and suture passing. We are presenting an easy technique of arthroscopic suture-based fixation of tibial spine fracture with fiber wire by double tunnel.

## PATIENTS AND METHODS

This is a clinical case series study that was held at Al Azhar University Hospital and Alexandria Sporting Hospital from September 2019 to March 2020, a number of 10 adolescent patients had avulsion tibial spine fracture classified Meyers & McKeever Type II and III were involved in our study.

Skeletally mature patients, patients with congenital anomalies in knee joint or rheumatoid arthritis and & those who had avulsion tibial spine fracture classified Meyers & McKeever type 1 or 4, were excluded from the study.

The diagnosis of the tibial spine avulsion was made by a mixture of history, clinical evaluation & radiographic imaging of the patient. The history entails mode of trauma which was either hyperextension injury or valgus internal rotation twisting of their knees. All Patients presented with pain, knee swelling and inability for weight bearing on the involved limb. Lachman and anterior drawer tests were found positive. Radiographic imaging classically showed an avulsion of anterior tibial spine. A CT and MRI scan was done in all patients.

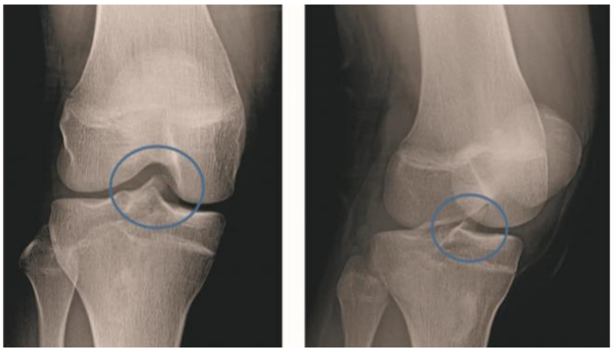

**Fig. 1**: AP (A) and lateral (B) radiographs demonstrating tibial avulsion

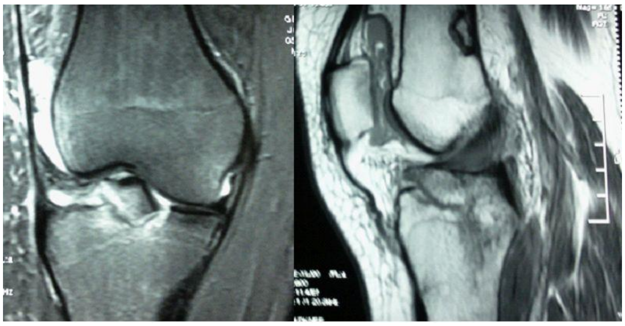

**Fig. 2**: Coronal & sagittal MRI cuts of tibial eminence fracture

*Surgical technique:*

Surgery was performed under spinal anesthesia. Firstly, examination under anesthesia was done for the affected knee. Most patients showed anterior knee instability and positive Lachman test grade II or III. The patient was positioned supine with thigh support. The lower limb was put into a holder & high level pneumatic tourniquet was applied to decrease blood loss and increase visualization. Sterilization & draping was done to the operated leg from foot to the tourniquet. After that, the tourniquet pressure was raised to 100 mm Hg above the patient's systolic blood pressure.

Standard knee arthroscopy was done using a 30 degree, 4.0-mm knee arthroscope. Ordinary anteromedial & anterolateral portals were used. The anterolateral portal was created by making a vertical incision (by a No. 11 blade) at the lateral patellar tendon border and at the level of the inferior patellar pole. The joint was entered by a blunt trocar and its sheath, and these were smoothly directed to the supra-patellar pouch. A spinal needle was used to make antero-medial portal under visualization of the arthroscope, and a vertical incision was made. Thorough lavage was accomplished to empty hemarthrosis or any loose fragments such as osteochondral fragments. Debridement of fat pad was done to enhance the visualization. Ordinary arthroscopic knee examination was completed to assess related injuries, inspect for chondral injury, loose fragments, and meniscus injuries.


**Fig. 3:** Arthroscopic debridement of the footprint using 4 mm shaver

Trial for reduction was done with the probe in 90 degree knee flexion; by gradually extending the knee to 40 degree fracture could be reduced, once verification of reduction, a K-wire could be used as a preliminary fixation for the tibial spine into its bed. A 45° Suture Lasso hook loaded with a steel wire was introduced from the anteromedial portal. Close to the tibial insertion of ACL & posterior to mid-coronal plane of ACL, the closed steel wire was passed from medial to lateral. Then it was introduced while the suture hook was concurrently withdrawn. Both ends of the steel wire which had captured the fibers of ACL were brought outside the knee using a grasper. The steel wire was used to pass a non-absorbable Fiber-Tape loop within the ACL fibers. The two split ends of the suture were held with a clamp for identification.

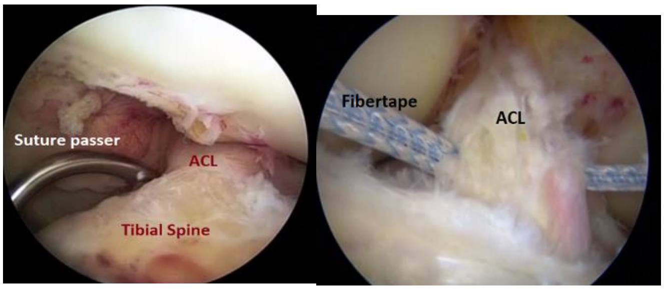


**Fig. 4**: A suture lasso is used to shuttle Fiber-Tape inside ACL fibers

A 3-cm oblique incision was done over the antero-medial side of the tibia at the level of the tibial tuberosity. An ACL tibial tunnel C-guide was accustomed to 55° and applied through the antero-medial portal making its tip resting on the tibial eminence. In this technique, we do not use a 4-mm guide-wire. Instead, we use an ACL Tight-Rope 4-mm drill pin wire (Arthrex). This has 2 benefits: a shorter surgical time and decreased physeal morbidity through a single penetration.

ACL tibial guide was used to put 4-mm drill pin wire directing towards the midcoronal plane of the avulsed fragment under arthroscopic visualization. Two tibial tunnels were done one medial another lateral to tibial spine footprint. A malleable steel wire loop was presented through the tibial tunnel, and its articular end was grasped with a grasper, which was introduced through the antero-medial portal; this was used to bring the loop outside the knee.

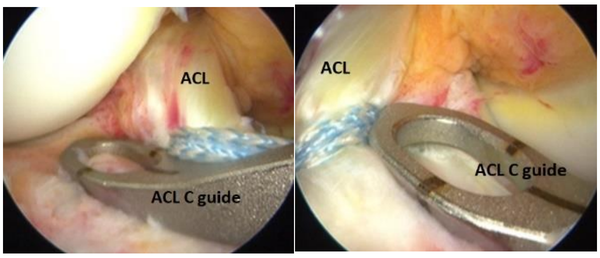


**Fig. 5:** ACL guide used to make the lateral tunnel & the medial tunnel though AM portal

The medial tunnel loop would capture the lateral end of the suture and the lateral tunnel loop will capture the medial end of the suture. The resulting crossing stitch reduced the tibial spine to its native footprint. While the arthroscope was inside the joint, the fracture reduction was tested and anatomic reduction was achieved. A probe was used to retract anterior horn of the medial or lateral meniscus or the transverse meniscal ligament, which is commonly trapped within the fracture bed, preventing anatomical reduction. The assistant held the reduction firmly by probe while the surgeon firmly ligates the 2 limbs over 1 cm bone bridge with the knee in 30° of flexion.

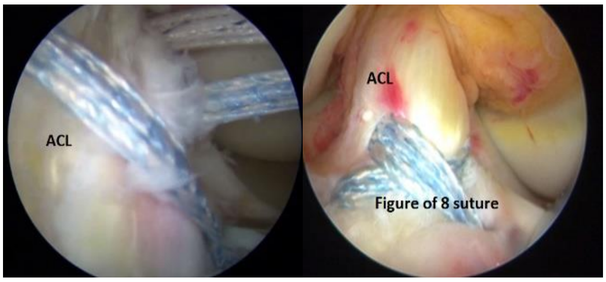


**Fig. 6:** The medial shuttle suture retrieved the lateral end of the FiberTape The resultant Crossed Figure of 8 stitch

**Fig. 7:** Pull-out suture through double tunnel

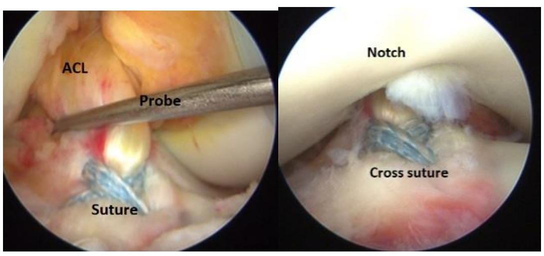


**Fig. 8:** Assessment of ACL tension & impingement after fixation

Final intra-operative examination, the knee was flexed and extended to ensure stability and re-examined under arthroscopic visualization. Finally, intraoperative radiographic image of the knee was taken to make sure that the tibial spine avulsion remained anatomically reduced. The wounds were then closed in the ordinary fashion.

**Fig. 9:** Final intraoperative lateral radiograph confirming a successful reduction of the anterior cruciate ligament tibial spine avulsion

*Postoperative Management:*

All patients hired for this study followed the same ordinary postoperative rehabilitation protocol. Knee immobilization in a static ACL knee brace with knee in full extension was achieved for 3 weeks, simultaneously with isometric quadriceps contraction and straight leg raising exercises with absolute non-weight bearing. Then partial weight bearing was allowed for another 3 weeks with a hinged knee brace with gradual knee flexion. Finally, full weight bearing and a gradual return to activity starting after the completion of the 2nd postoperative month. At the end of the 3rd postoperative month, radiographs showed good reduction & solid union.

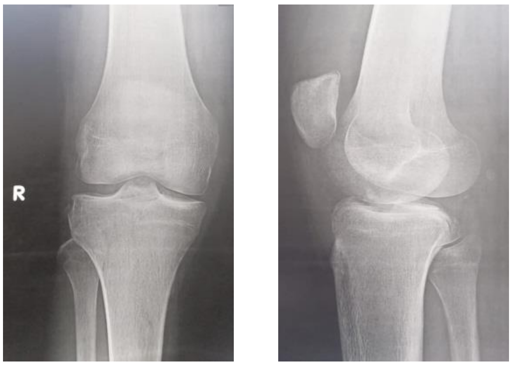


**Fig. 10:** Two weeks postoperative x-ray of arthroscopic fixation of tibial spine avulsion by double tunnel pull-out suture technique showing good reduction

*Statistical analysis:*

Analysis of data was done using Statistical Program for Social Science version 20 (SPSS Inc., Chicago, IL, USA). An informed verbal consent from all participants was taken and confidentiality of information was assured. An official written administrative permission letter was obtained from dean of faculty of medicine, Al Azhar university hospital manager and Alexandria Sporting Hospital manager. The title and objectives of the study were explained to them to ensure their cooperation.

## RESULTS

Table (1) shows that 30.0% of cases had minimally displaced with intact posterior hinge, 40% completely displaced and 30% of cases had Type III fracture with rotation.

Table (2) shows that there is major improvement of postoperative Lysholm score.

Table (3) shows that there is obvious improvement of mean pre-operative anterior translation of tibia post operatively.

Table (4) shows that there is no vital difference found between mean pre-operative anterior translations of tibia of operated side post operatively and normal side.

Table (5) shows that all studied cases had excellent radiological union.

Table (6) shows that there is no statistically considerable correlation between the post-operative Lysholm score and age or the duration before the operation.

| | No. | % |
|---|---|---|
| Classification | | |
| Minimally displaced with intact posterior hinge | 3 | 30.0 |
| Completely displaced | 4 | 40.0 |
| Type III fracture with rotation | 3 | 30.0 |

**Table 1**: Distribution of cases on Modified Meyers and McKeever Classification

| Variable | pre -operative (n=10) | post-operative (n=10) | Paired T test | P value |
|---|---|---|---|---|
| Lysholm score | | | | |
| Mean ± SD<br>Range | 50.7 ±1.3<br>(35-59) | 96.2 ± 2.7<br>(92–100) | -45.5 | <0.001<br>(HS) |

**Table 2:** Comparing the pre and post-operative Lysholm score in studied group

| Variable | pre -operative (n=10) | post-operative (n=10) | Paired T test | P value |
|---|---|---|---|---|
| Mean pre-operative anterior translation of tibia: | | | | |
| Mean ± SD | 7.5 ± 1.24 | 3.3 ± 0.81 | 8.96 | <0.001 (HS) |

**Table 3:** Comparing the pre and post-operative mean anterior translation of tibia

| Variable | operated side (n=10) | normal side (n=10) | Student T test | P value |
|---|---|---|---|---|
| Mean pre-operative anterior translation of tibia: | | | | |
| Mean ± SD | 3.3 ± 0.81 | 3.1 ± 1.1 | 0.462 | 0.648 |

**Table 4:** Comparing the mean pre-operative anterior translation of tibia of operated side post operatively and normal side

| Variable | (n=10) | |
|---|---|---|
| Radiological findings | **No.** | **%** |
| Union of avulsed tibial spine in reduced position | 10 | 100.0 |
| Non union | 0 | 0.0 |
| Malunion | 0 | 0.0 |

**Table 5:** Post-operative radiological findings of the studied cases

| Variable | Post-operative MRC score | |
|---|---|---|
| | **r** | P |
| Age: | 0.284 | 0.253 (NS) |
| CRP: | 0.13 | 0.268 (NS) |

**Table 6:** Correlation between the post-operative Lysholm score and age and the duration before the operation

## DISCUSSION

Tibial spine avulsion is habitually seen by arthroscopic surgeons in pediatrics & young adolescents. Conservative management has a restricted role and requires close observing as it commonly leads to reduction loss and ligament laxity [8]. Surgical intervention is recommended for Meyers and McKeever Type 2 and Type 3 fractures [9]. several methods were mentioned for tibial spine avulsion fixation of like cannulated screws, suture anchors [10], and non-absorbable pull-out sutures [11].

Our study verified that there is major improvement of postoperative Lysholm score. This comes in consistence with what reported by Sinha et al., [12] who confirmed that union of avulsed tibial spine in all cases, stability success and considerable improvement in Lysholm score refer to the efficiency of our technique. All the cases returned to previous activity level. The presented technique is simple, applicable, and very cost-effective.

Sawyer et al., [13] informed that a suture bridge method using multiple anchors accomplished effective compression at the fracture site and rigid anatomical fixation in the management of tibial spine fractures.

Koukoulias et al.,[14] stated effective treatment strategy using suture arthroscopic fixation of tibial spine fractures in adults.

In the presented study there is obvious improvement of mean pre-operative anterior translation of tibia post operatively. Hunter and Willis , [15] in their study found that 88% of the fractures were managed using arthroscopic fixation; only 2 cases required an ORIF to attain proper visualization of the tibial spine fracture. It has been detected that drill holes of about 3% of the cross-sectional area of the physis don’t cause growth disturbance. McConkey et al., [16] detected that tunnel size of 6–7 mm that is perpendicular to the physis, reduces the harm to the growth plate. Shea et al., [17] reported that it is also safe to drill 9 mm tunnel during ACL reconstruction in open physis.

We also demonstrated that there was almost no considerable difference between mean pre-operative anterior translation of tibia of operated side post operatively and normal side. Sinha et al., [12] showed that the anterior translation of tibia (ATT) of operated knee was nearly the same as that of the normal opposite knee, which was in range of 1–5 mm with a mean of 3.1 ± 1.1.

There was no statistically important difference of ATT between operated and normal knee.

This study demonstrated that 100% of cases showed union of avulsed tibial spine in reduced position. Sinha et al., [12] reported that radiologically, all cases of tibial spine avulsion had union in reduced position at postoperative follow up & they could return to their own previous activity level. Hunter and Willis, [15] detected that at follow-up interview, all patients were satisfied with their outcome, and no complications were found.

In this study we found there was no considerable correlation between the post-operative Lysholm score and age or the duration before the operation. Hunter and Willis, [15] reported that the best clinical outcomes were found in younger patients. Seon et al., [4] found no important variance in clinical outcome of screw tibial spine fixation or suture based fixation. Bong et al., [5] described that fiber wire fixation has superiority to cannulated screw fixation.

## CONCLUSION

Tibial spine fracture is frequently seen by arthroscopic surgeons in pediatric population. It is important that they are diagnosed early. Several treatment options exist and the results are usually good when an anatomic stable reduction is achieved. Arthroscopic fixation by Double Tunnel Pull-out Suture technique for tibial spine avulsion is a simple technique which offers secure fixation and reasonable clinical outcomes.

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