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Prospective study of functional outcome of arthroscopic suture pull out fixation of displaced tibial spine avulsion fracture

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Abstract
Background: Tibial eminence avulsion fractures commonly occur in children and adolescents aged between 8 and 14 years. A valgus-directed force associated with an external torsion when the knee is in hyperextension is the most frequently referred mechanism, which closely resembles the one for anterior cruciate ligament (ACL) tears. This happens because the epiphyseal ossification process reaches the tibial eminence only in late childhood or adolescence, leaving this area more vulnerable to tensile forces than the ACL itself. In adults, this lesion is rare and associated either with high- energy trauma, boot-induced injuries in skiers or forced internal rotation with a flexed knee. Avulsion fractures may either involve the intercondylar depression where the ACL insertion lies only or, less frequently, the entire tibial spine with medial and lateral plateau.
Materials and Methods: From November 2019 to December 2020, an intervention clinical study was carried out at Sanjay Gandhi institute of trauma and orthopaedics, A number of 30 patients having avulsion tibial spine fracture classified Meyers & McKeever Type II, TYPE III and IV were involved in our study.
Results: Fractures were united within 3 months after surgery in all 30 cases. The Lysholm score was improved to 98(98.17 ± 1.599). In 2 patients, post operative knee stiffness was noted and arthrolysis was done for the same. All patients returned to their pre-injury physical activities at the last follow-up.
Conclusion: Arthroscopic suture pull-out fixation for type III and IV tibial spine avulsion results in excellent clinical and radiological outcomes in patients with open and closed physis without any significant complications.

Keywords: Tibial spine avulsion, pullout suture, mayers and mckeever

Introduction
The tibial spine or anterior cruciate ligament (ACL) bony avulsion is usually a result of low-velocity injuries, such as falls from bicycles or motorcycles and sports. It occurs wean an axially loaded knee undergoes hyperextension, and the femur rotates externally [1].
Meyers and McKeever classified avulsion into three types [2]. Type I as undisplaced, type II as partially displaced with an intact posterior hinge, type 3 as completely displaced. Zaricznyi proposed a fourth category for comminuted avulsed fragments [3].
A complication of such untreated and displaced type III and type IV avulsion fracture include nonunion and malunion, which may lead to significant disability in the form of flexion deformity, loss of extension, instability.
Hence it is important to reduce accurately fix type III and type IV and prevent complication [4].
In the following prospective study, we describe the clinical and radiologically outcomes of arthroscopic fixation of ACL bony avulsion with suture pull-out technique using two high strength, nonabsorbable sutures.

Aims and Objectives
To evaluate "functional outcome of arthroscopic suture pull out fixation of displaced tibial spine avulsion" with regards to
1. Pain relief, functional capacity, range of motion, absence of deformity, radiological

assessment and comparing pre- operative and post-operative functional status with the Lysholm score system.
2. To record any complications peri-operatively and in the early post-operative period.

Materials and Methods

Study design: Prospective study.
Study period: November 2019 TO DECEMBER 2020.
Place of study: Sanjay Gandhi Institute of Trauma and Orthopaedics, Bangalore.
Sample size: It is a hospital-based study with a sample size of 30. (Calculated based on previous studies) who are fulfilling the inclusion criteria?

Inclusion criteria

1. Pain and disability resulting from tibial spine avulsion inactive patient type II, type III and type IV
2. Age: < 60 years
3. The patient must able to use crutches / walker
4. The patient should have sufficient muscle strength and motivation to carry out a rehabilitation program
5. Closed injuries.
6. Ability to understand the content of the subject information / informed consent form and to be willing to participate in the clinical investigation.
7. Written informed consent

Exclusion criteria

1. Type I tibial spine avulsion according to Meyers and McKeever classification
2. Associated with Proximal tibia fracture
3. Associated with Multiple ligaments injuries
4. Present or past history of inflammatory arthritis
5. Open injuries
6. Previous operated or infected knee for any reason

Surgical Technique

Diagnostic arthroscopy was performed under spinal or general anesthesia through the standard anterolateral portal. The joint and fracture bed was cleared of hematoma using continuous irrigation. Then, the standard anteromedial portal was established. Chondral and meniscal injuries were assessed and managed as per established guidelines. The tibial spine avulsion was identified, and the type of fracture was confirmed by probing.

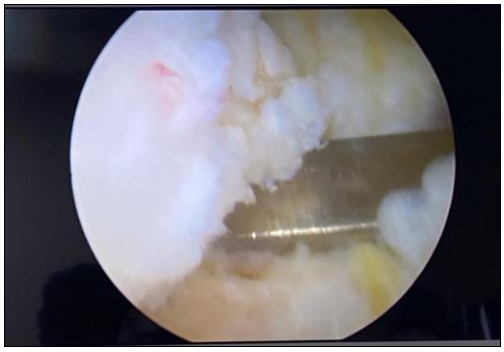


Fig 1: Tibial eminence fragment

Next, 1-inch-long skin incision was made parallel and medial to the tibial tuberosity. The remaining dissection was done with care to arrive up to the periosteum protecting the pes anserinus tendons and underlying medial collateral ligament. The tip of the ACL tibial guide was subsequently placed via an anteromedial (AM) portal on the medial-most edge and at the equator of the avulsion crater. Next, a tibial tunnel was drilled using a 1.8 mm K-wire. Once the K-wire tip was visualized emerging out at the crater edge, the tibial guide was disengaged and the K-wire was left *in situ*. A similar step was performed for the lateral edge of the crater with another K-wire keeping 1 cm of the bone bridge intact between two tunnels over the tibia.

Fig 2: Drilling tibial tunnel

Once the needle tip was visualized on the lateral side of ACL, the PDS suture was advanced through the lateral PDS loop. The advanced end of the PDS was pulled out of the joint via AM portal using an arthroscopic grasper. Frequently, the suture grasper was used to pull the PDS out of the lateral loop in a case where it did not enter into the lateral loop. A similar step was repeated by taking a bite through the anterior third of the ACL substance, and PDS was pulled out via AM portal.

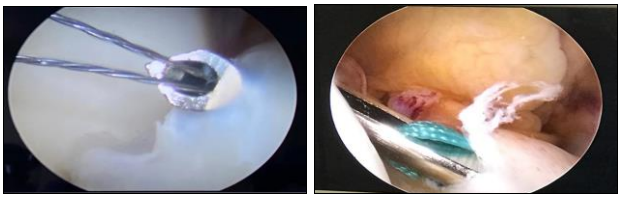


Fig 3: Inserting PDS suture and making loop Replacing PDS with ethibond suture

Next, the shuttling technique replaced the two PDS sutures by ethibond. Then, the needle and PDS loops were pulled out of the tunnel, which further pulls the ethibond sutures out of the joint through the tibial tunnels. Ethibond sutures were tied one by one over the bone bridge or suture button keeping the knee in 30-degree flexion.

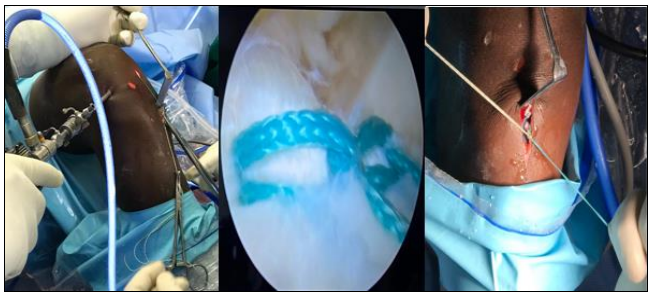


Fig 4: The ethibond sutures pulled out of the joint through the tibial tunnels

Results

The study was conducted in the Department of Orthopaedics, Sanjay Gandhi Institute of Trauma and Orthopaedics, Bengaluru. 30 patients with tibial spine avulsion were operated on with arthroscopic pull out suture technique. Following are the results obtained.

Age Distribution

Table 1: Age distribution of subjects

		Count	%
Age	18 to 20 years	10	33.3%
	21 to 30 years	12	40.0%
	31 to 40 years	5	16.7%
	>40 years	3	10.0%
	Total	30	100.0%

The mean age of subjects was 27.13 ± 10.298 years. The majority of subjects were in the age group 21 to 30 years (40%).

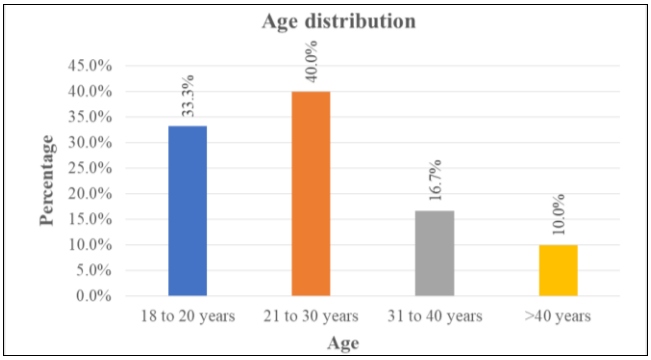


Fig 5: Bar diagram showing the Age distribution of subjects

Table 2: Sex distribution of subjects

		Count	%
Sex	Female	3	10.0%
	Male	27	90.0%
	Total	30	100.0%

In the study, 90% were males and 10% were females

Table 3: Mode of trauma distribution

		Count	%
Mode of trauma	Fall from Cycle	2	6.7%
	Fall from Motorbike	22	73.3%
	Fall While Playing	6	20.0%
	Total	30	100.0%

In the study 6.7% had Fall from the cycle, 73.3% had fallen from Motorbike and 20% had Fall While Playing.

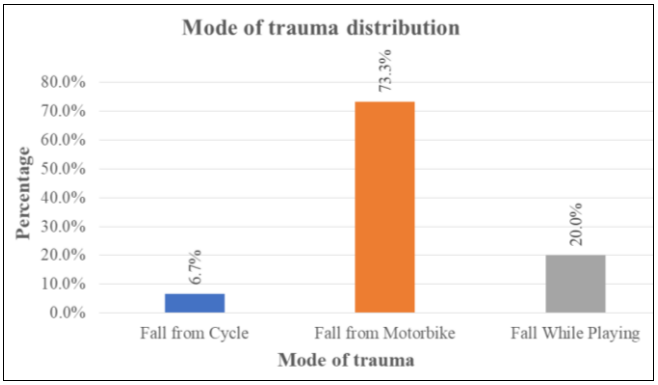


Fig 6: Bar diagram showing Mode of trauma distribution

Table 4: Status of Physis distribution

		Count	%
Status of Physis	Closed	20	66.7%
	Open	10	33.3%
	Total	30	100.0%

The study Status of Physis in 66.7% was closed and open in 33.3%.

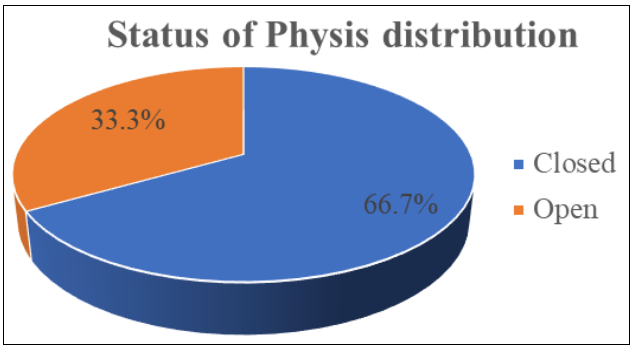


Fig 7: Pie diagram showing Status of Physis distribution

Table 5: Meyers and McKeever's classification distribution

		Count	%
Meyers and McKeever's classification	Type III	21	70.0%
	Type IV	9	30.0%
	Total	30	100.0%

In the study 70% had Type III and 30% had Type IV Meyers and McKeever's classification

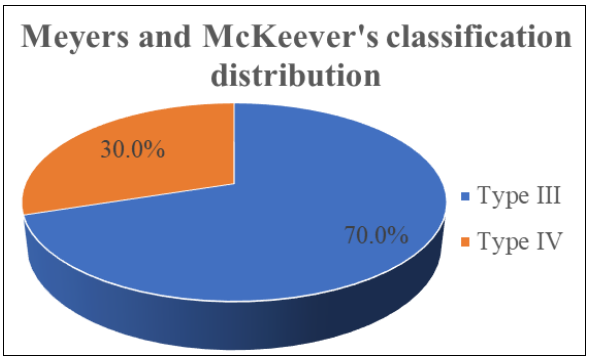


Fig 8: Pie diagram showing Meyers and McKeever's classification distribution

Table 6: Post op Lysholm score distribution

		N	Mean	SD	t test	P value
Post op Lysholm score	3 months	30	86.07	1.760		
	6 months	30	97.87	2.047	-27.112	<0.001*
	12 months	30	98.17	1.599	-1.608	<0.001*

Paired Samples Test

At 3 months, the mean Post op Lysholm score was 86.07 ± 1.760, at 6 months was 97.87 ± 2.047 and at 12 months was 98.17 ± 1.599. There was a significant increase in Post op Lysholm score at 6 months and 12 months.

At 12 months When compared to 6 months Post op Lysholm score, there was no significant increase in Post op Lysholm score.

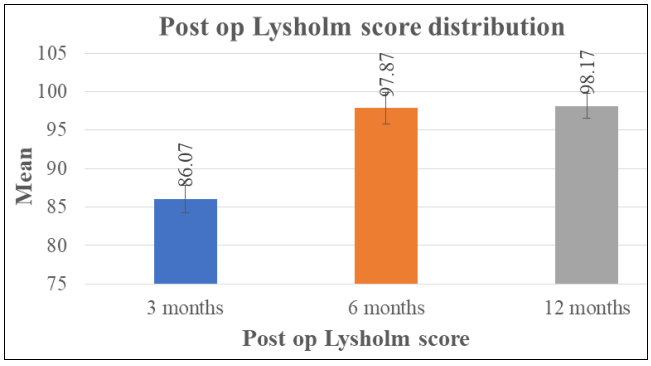


Fig 9: Bar diagram showing Post op Lysholm score distribution

Table 7: Complication distribution

		Count	%
Complication	Nil	28	93.3%
	Post Op Knee Stiffness	2	6.7%
	Total	30	100.0%

In the study 6.7% had Post Op Knee Stiffness.

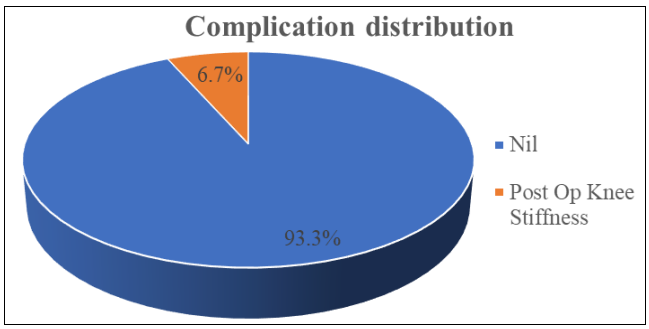


Fig 10: Pie diagram showing Complication distribution

Discussion

The most significant finding of our study, which concurs with the available literature, is that suture pull-out fixation of displaced ACL avulsion from tibia utilizing an I.V. cannula needle gives excellent results in all age groups (skeletally immature and mature) without any significant complications.

The mean subjective Lysholm scores reported in our series in all age groups and all types of fractures (McKeever type III and IV) were similar to the ones written by other authors who used the suture pull-out technique to fix ACL bony avulsion, suggesting that arthroscopic suture fixation provides excellent clinical outcome after ACL bony avulsion [5].

Although various implants (screws, staples, wires, anchors, and sutures) have been used for arthroscopic fixation of the tibial spine, currently arthroscopic suture pull-out fixation seems to be the most recent preferred fixation method in all age groups [6].

The I.V. cannula needle used in all our cases is readily available in all operating rooms. The diameter of the 18 gauge I.V. cannula needle is quite narrow to damage the ACL substance even if the bite has to be repeated. It is also easy to take a bite from the medial to the lateral side of the ACL in a straight line, and it does not require the use of complex maneuver inside the knee joint [7]. Furthermore, this technique can also be safely employed in patients with open physis as the diameter of the two tibial tunnels is only 1.8 mm each, which is less than 7 to 10% of the growth plate size. Several authors have determined that a physeal lesion of size less than 7 to 10% of the physeal diameter is not likely to cause growth changes [8].

The majority of the patients reported in our series were males (27 cases; 90%). However, we believe that this factor may have no clinical relevance. The mean age of subjects was 27.13 ± 10.298 years. The majority of subjects were aged 21 to 30 years (40%).

ACL avulsion is more common in children than adults (3:2) because of the relatively unossified state of the tibial eminence and the highly elastic nature of ACL [9]. In our study Status of Physis in 66.7% was closed and open in 33.3%. In the study, there was no significant difference in the mean Post op Lysholm score with respect to the Status of Physis at 3 months, 6 months and 12 months.

However, many studies have documented a higher incidence in adults too, and many authors have published their series in an exclusive adult population only. In our study 6.7% had fall from the cycle, 73.3% had fall from Motorbike and 20% had Fall While Playing. With significant number is seen among motorbike injuries.

There can be associated injuries to menisci, cartilage, capsule, and MCL in up to 59% of the patients in the children and adolescent age group [10]. Meniscal tear is the most frequently associated intraarticular pathology along with tibial spine avulsion. In our study 10% had Partial Damage to ACL and 3.3% had Lateral Meniscus Posterior Third Longitudinal Tear and Oblique Small Tear in Posterior Third of Medial Meniscus.

Displaced ACL tibial avulsion fractures result in anterior knee instability and occasionally in loss of knee extension [11]. Therefore, surgical treatment is recommended for all Meyers and McKeever type III and IV fractures and should be considered in all cases of displaced type II fractures.in our study 70% had Type III and 30% had Type IV Meyers and McKeever's classification [12]. In the study there was no significant difference in the mean Post op Lysholm score with respect to Meyers and McKeever's classification at 3 months, 6 months and 12 months.

The Lysholm knee scoring system was used to analyze subjective symptoms. The mean preoperative Lysholm score in the 30 knees was 38 (range, 28 to 54); the mean postoperative Lysholm score was At 3 months, mean Post op Lysholm score was 86.07 ± 1.760, at 6 months was 97.87 ± 2.047 and at 12 months was 98.17 ± 1.599. There was a significant increase in Post op Lysholm score at 6 months and 12 months. At 12 months when compared to 6 months Post op Lysholm score, there was no significant increase in Post op Lysholm score.

The postoperative laxity is attributed to an initial stretch of ACL before giving away at the tibial attachment site, unrecognized intra-substance tears, and improper anatomical reduction [12]. Even though literature reports suggest increased postoperative laxity up to 6 mm in 10 to 20% of the patients treated with tibial spine fixation, we did not find such increased laxity tendency in our patients [13]. Postoperative stiffness of the knee is the most common complication observed in many series, and is because of arthrofibrosis or mechanical impingement of displaced bony fragment.

However, recently many authors report the minimal incidence of arthrofibrosis after arthroscopic rigid fixation and early mobilization within 2 to 4 weeks, indicating that early mobilization can reduce the rate of arthrofibrosis and improve the outcome [14]. In our study, 6.7% had postoperative knee stiffness who recovered completely after arthroscopic adhesiolysis. Also, we did not find any growth disturbance or deformity in our series of patients with open physis following the pull-out suture technique.

The mean follow-up period in our study was 15 months. We consider the follow-up period in our study sufficient for both clinical and radiological follow-ups because even patients with postoperative stiffness returned to normalcy by 6 months from the index procedure. The uneventful patients achieved their final stability, ROM, and radiological union by 3 to 6 months itself and maintained an almost same postoperative state since then. At 3 months, the mean Post op Lysholm score was 86.07 ± 1.760, at 6 months was 97.87 ± 2.047 and at 12 months was 98.17 ± 1.599. There was a significant increase in Post op Lysholm score at 6 months and 12 months. At 12 months when compared to 6 months Post op Lysholm score, there was no significant increase in Post op Lysholm score.

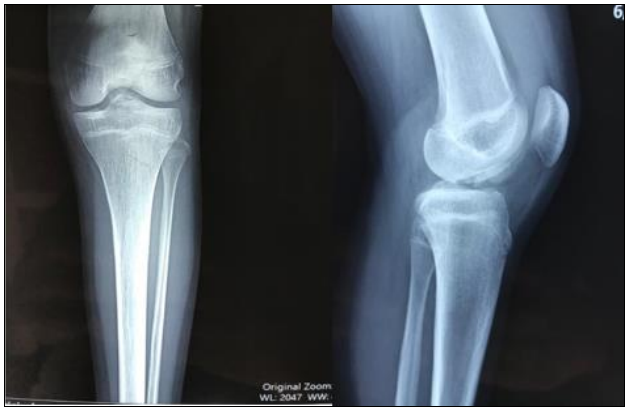
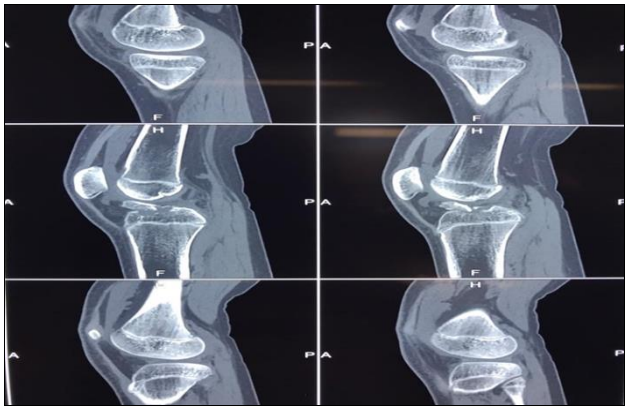


Fig 11: Pre operative x-ray



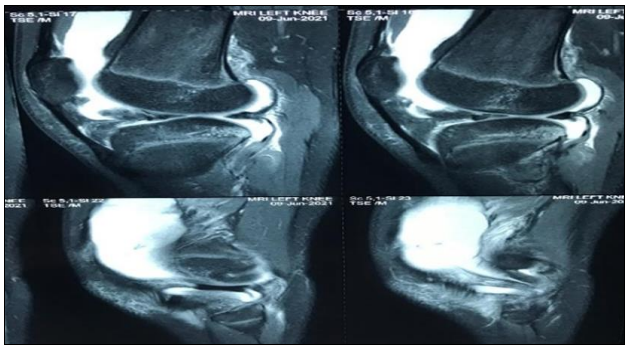


Fig 12: Pre op MRI

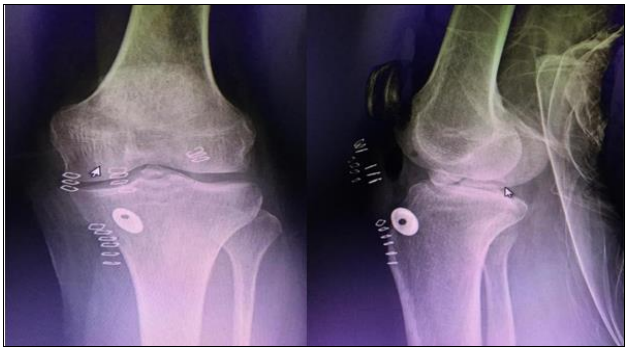


Fig 13: Post operative x-ray

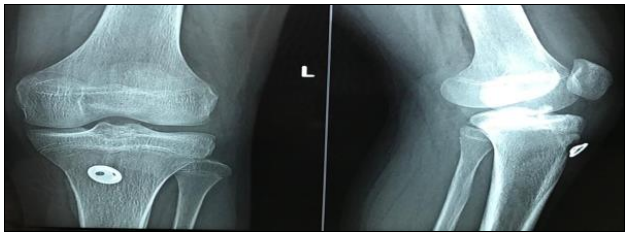


Fig 14: Fallow up x-ray after 3 months

Conclusion

The goal of the treatment should be an anatomic reduction to restore joint congruity. This technique of arthroscopic fixation with transosseous sutures is very useful in treating these fractures. Approaching these injuries arthroscopically allows for complete inspection of the joint and dealing with associated injuries, early mobilization, fast rehabilitation, and decreased hospital stay. Suture fixation has the advantages of being more versatile and biomechanically superior to screw fixation and has the ability to fix not only isolated large but also small and comminated fractures and to incorporate the ACL into the fixation structure. Also, there is minimal risk of damage to the epiphyseal plate in children, and there is no need for hardware removal. Furthermore, sutures allow for stable fixation and aggressive early rehabilitation. Arthroscopic suture fixation uniformly leads to excellent outcomes.

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