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Arthroscopic Repair of Tibial Spine Avulsion Fracture

Atef Mohamed Morsy[1], Emad Gaber Elbana[2], Walid Reda Mohamed[3], Mohamed Ahmed Abdelkader[4], Ayman Zein El Abdein Sayed[5]

[1]*Professor of orthopaedic surgery and Dean of Faculty of medicine Beni-seuf University*
[2]*Professor and Chairman of orthopaedic surgery, Faculty of medicine Beni-suef University.*
[3]*Assistant professor of orthopaedic surgery, Faculty of medicine Cairo University.*
[4]*Lecturer of orthopaedic surgery, Faculty of medicine Beni-suef University*
[5]*M.B.B.CH, M.S*

Background: Tibial spine fractures are additionally called tibial eminence fractures or ACL avulsion fractures. They are a form of anterior cruciate ligament injury.
Aim: This study aimed to evaluate arthroscopic repair of avulsed tibial spine fractures using the pull-through suture method tied over a bone bridge or endobutton, focusing on union, functional outcomes, and complications.
Patients and methods: This was a prospective study conducted on 25 patients to investigate the functional outcome of arthroscopic repair of avulsed tibial spines from October 2017 till October 2020 at Beni Suef University Hospital.
Results: At 6 months postoperatively, 68% had no pain, while 4% had marked pain walking >2 km, 4% with severe exertion, 4% on giving way, and 20% with mild pain. Preoperatively, 92% couldn't climb stairs; at 6 months, 76% climbed without issues. Instability improved: 92% had none, 4% rare, and 4% frequent. Lysholm scores rose significantly: preoperatively (11.86±3.55), 6 weeks (55.57±13.37), 3 months (85.68±15.50), and 6 months (93.54±7.84), with significant P-values. Functional recovery was substantial.
Conclusion: Arthroscopic reinsertion of avulsed tibial spine fractures using pull-out sutures tied over the tibial cortex with Ethibond No. 5 or Fiberwire 2 provides strong fixation, enabling early mobilization and excellent clinical outcomes, including significant Lysholm score improvements. This technique reduces morbidity, facilitates debridement, and ensures stable fixation without implant removal. While most patients achieve a full range of motion, one case of notable laxity may require ACL reconstruction, underscoring the importance of individualized follow-up.
Keywords: Arthroscopic repair, Tibial spine, Avulsion fracture, Outcomes

1. Introduction

Tibial eminence fractures, or ACL avulsion fractures, are additionally referred to as tibial spine fractures. They are a form of anterior cruciate ligament injury (1).

Tibial spine fractures are categorized by Mayer and Mckeevrs (2) into Type I, which indicates a minimally dislocated fragment. In type II injuries, the fracture fragment is elevated anteriorly, while in type III and IV injuries, the fragment is completely separated from the tibia. Type IV injury also encompasses a rotational component or fragment comminution (3).

Different lines of treatment are used for these fractures, ranging from conservative (non-operative) management in the form of cylindrical casts or different immobilizers to arthroscopic or even open fixation by many types of fixation methods according to the classification of injury and related injuries (4).

It is hypothesized that the elevated frequency among kids is secondary to the relative weakness of incompletely ossified tibial eminence in comparison to native ACL fibers (5).

Proper knee kinematics depend on the integrity of the ACL at its femoral and medial tibial spine attachments. Tibial spine fractures disrupt this complex and, if left untreated, may result in pain, instability, and functional limitation. Appropriate diagnosis and early management of tibial spine avulsion fractures are crucial. Intra-articular injuries are more prevalent in adults and are frequently related to tibial spine fractures. It is crucial to diagnose and manage these related injuries, as well as to ensure that tibial spine fractures are properly fixed. Reduction and fixation through arthrotomy or arthroscopic methods are surgical options for tibial spine fractures (6).

Hunter and Willis, as well as Jung et al., demonstrated good results for the management of type II and III fractures through arthroscopic methods (7).

This investigation aimed to assess the results of arthroscopic repair of avulsed tibial spine fractures using the pull-through suture method tied over a bone bridge or end button in the tibial cortex regarding union, functional outcome, and complications.

2. Patients and methods

This was a prospective investigation conducted on 25 cases to investigate the functional outcome of arthroscopic repair of avulsed tibial spines from October 2017 till October 2020 in Beni Suef University Hospital.

Inclusion criteria: Age 10-50 years old, males and females, Type II, III, and IV Meyers and Mckeever.

Exclusion criteria: open fractures, multi-ligamentous injury, and inflammatory conditions.

Methods

All patients were subjected to the following:

Patients' preoperative evaluation: The diagnosis of avulsed tibial spine was established through history-taking, complaint analysis, trauma history, and a systematic physical examination. A general examination was conducted to detect other injuries, followed by a detailed local knee assessment, including inspection, palpation, evaluation of active and passive range of motion, and assessments for ligamentous and meniscal injuries. Functional assessment has been carried out using the Lysholm score during a preoperative interview. Imaging investigations included utilizing anteroposterior and lateral knee radiographs, computed tomography (CT) for fracture classification, and magnetic resonance imaging (MRI) to detect associated injuries. Patients were assessed for surgical fitness through a comprehensive evaluation involving history, clinical examination, and laboratory tests, including CBC, PT, PC, INR, urea, creatinine, AST, and ALT; ECG was conducted for patients over 40 years. Any identified chest, cardiac, or systemic comorbidities were addressed prior to surgery. Surgical implants utilized included Ethicon nonabsorbable suture No. 5, fiber wire 2, and an endobutton.

Consent: Standard consent was obtained from all patients, including detailed explanations of the procedure and potential complications. Patients were specifically informed about the risks of neurovascular injury, residual laxity, postoperative infection, knee stiffness, hemarthrosis, and nonunion, ensuring they were fully aware of possible outcomes before proceeding with surgery.

Surgical technique

Surgery was conducted under spinal or general anesthesia, with the case positioned supine and a thigh tourniquet applied at 350 mmHg. After sterilization and draping, an examination under anesthesia confirmed associated ligamentous injuries. Standard anterolateral and anteromedial portals were established, hemarthrosis was evacuated, and a superolateral portal was used for better visualization. Diagnostic arthroscopy assessed meniscal, chondral, or ligamentous injuries, and organized hematoma and fat pad at the fracture site were removed. A traction suture around the intermeniscal ligament improved visualization and facilitated reduction of the avulsed fragment. An ACL tibial guide was used for fragment reduction, and a 2-cm anterior tibial incision enabled provisional fixation with a threaded wire. Prolene no. 1 was passed through a 90° suture lasso and retrieved via a trans-patellar portal to shuttle three Ethibond no. 5 filaments around the ACL. Two tibial tunnels were created using a cannulated drill, and the Ethibond sutures were shuttled through the tunnels and tied over a medial tibial bone bridge after the provisional wire was removed. The knee has been held at 20° flexion, achieving anatomic reduction and stable fixation.

Postoperative care

The drainage has been removed within two days postoperatively, and patients were discharged with a hinged brace locked in full extension for walking, which was worn for six weeks. Range of motion exercises began immediately, with knee flexion limited to 90° during the first six weeks. At six weeks, the brace was removed, and patients started straight-leg raising, vastus medialis exercises, and proprioception training, resuming normal daily activities. Non-contact sports were allowed at three months, and contact sports at six months' post-surgery. Follow-ups occurred at 2 weeks for wound care and stitch removal and at 4, 6, and 12 weeks for rehabilitation consultation, with functional evaluation and radiographic assessments at 3 and 6 months to monitor union. Knee function was assessed at six months using the Lysholm rating scale.

3. Results

Table (1): Demographic data of studied patients

		Count	%
sex	M	21	84%
	F	4	16%
age groups	Adolescents	16	64%
	Young adults	4	16%
	Adults	5	20%
type of trauma	Twisting injury = Sport	6	24%
	RTA	6	24%
	MCA	1	4%
	MBA	9	36%
	FFH	3	12%
side of trauma	RT	18	72%
	LT	7	28%
Associated injuries	Yes	9	36%
	No	16	64%
Associated injuries details	Fracture Spine	3	12%
	Fracture Tibia	2	8%
	Fracture Tibial Plateau	1	4%
	Lateral Meniscus	1	4%
	Medial Meniscu	2	8%
type of fracture according to Meyers and Mckeever	2	5	20%
	3	16	64%
	4	4	16%

There were 25 patients (21 males, 4 females), aged 19-25, with tibial spine fractures, primarily from motorbike accidents. Surgery occurred within 2-12 days (mean 5.6). Injuries were graded II (5), III (16), or IV (4); 9 had associated injuries. Follow-up averaged 12 months, showing positive outcomes with early radiological and functional recovery. (Table 1)

Table (2): Assessment of limping

	Limping						P
	Severe and constant=0		Slight/periodical=3		None = 5		
	Count	Row N %	Count	Row N %	Count	Row N %	
preoperative	21	84%	4	12%	0	.0%	
6 weeks	13	52%	12	48%	0	.0%	
3 months	2	8 %	9	36%	14	56%	

6 months	0	0%	2	8%	23	92 %	<

Before surgery, 84% of patients had severe limping, and 16% had slight limping. At 6 weeks' post-surgery, 52% had constant limping, and 48% had slight limping. By 3 months, only 8% had severe limping, 36% had slight limping, and 56% had no limping. At 6 months, 92% had no limping, and 8% had slight limping, showing significant recovery. (Table 2)

Table (3): Assessment of pain

	Pain														P value
	constant and severe = 0		marked after walking less than 2 kilometers = 5		marked on or after walking more than 2 kilometers = 10		marked during severe exertion = 15		marked on giving way = 20		inconstant and slight during severe exercise =25		none = 30		
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
Preoperative	23	92 %	2	8%	0	.0%	0	.0%	0	.0%	0	.0%	0	.0%	< 0 .001
6 weeks	2	8%	4	16%	5	20%	14	56%	0	.0%	0	.0%	0	.0%	
3 months	0	.0%	0	.0%	1	4%	3	12%	4	16%	5	20%	12	48%	
6 months	0	.0%	0	.0%	1	4%	1	4%	1	4%	5	20%	17	68%	

After 6 months postoperatively, 1 patient (4%) had marked pain with walking more than two kilometers, 1 case (4%) had marked pain with severe exertion, 1 case (4 %) had pain on giving way, 5 cases (20%) had mild pain with severe exertion, and 17 cases (68%) had no pain. (Table 3)

Table (4): Assessment of scoring of stair climbing

Stair climbing									
	Unable = 0		one step at a time = 2		slightly impaired = 6		Normal = 10		P value
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
preoperative	23	92%	2	8%	0	0%	0	0%	
6 weeks	2	8%	18	72%	5	20%	0	0%	
3 months	0	0%	4	16%	12	48%	9	36%	

6 months	0	.0%	2	8%	4	16%	19	76%	< 0 .001

Preoperatively, 92% of patients were unable to climb stairs, and 8% could manage one step at a time. At 6 weeks postoperatively, 8% remained unable to climb stairs, 72% could manage one step, and 20% had slight impairment. By 3 months, 16% could manage one step, 48% had slight impairment, and 36% had no issues. At 6 months, 8% could manage one step, 16% had slight impairment, and 76% had no problems climbing stairs, showing significant functional improvement over time. (Table 4)

Table (5): Instability scoring of studied participants

	Instability														P value
	with every step = 0		often in daily activities= 5		occasionally in daily activities= 10		Unable to practice sport = 15		frequently during athletic or other severe exertion = 20		rarely during athletic or other severe exertion = 25		never giving way=30		
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
preoperative	2	8 %	21	84 %	2	8 %	0	0%	0	0%	0	0%	]0	0%	
6 weeks	0	0%	0	0%	0	0%	2	8%	0	.0%	3	12%	20	80%	
3 months	0	.0%	0	.0%	0	.0%	1	4 %	0	0%	2	8 %	22	88 %	
6 months	0	.0%	0	.0%	0	.0%	0	0%	1	4 %	1	4 %	23	92 %	<0 .001

Before surgery, 8% of patients had instability with every step, 84% had frequent instability during daily activities, and 8% had occasional instability. At the six-month postoperative follow-up, 92% of patients had no instability, 4% experienced rare instability during severe exertion, and 4% had frequent instability during athletic activities. Instability was assessed using the Lachman test, with ACL laxity graded as mild (0-5 millimeters), moderate (6-10 millimeters), or severe (>10 millimeters). (Table 5)

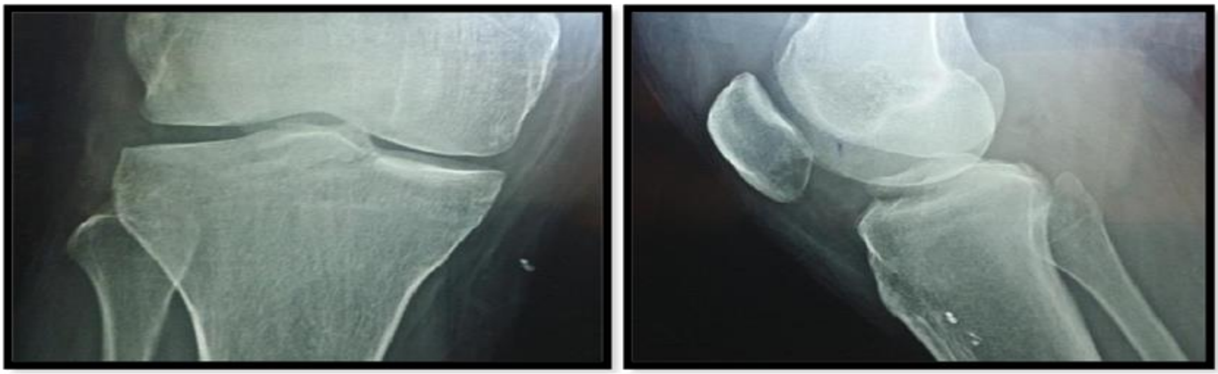
Table (6): The results of the Lysholm score preoperatively and during follow-up periods.

	total		P value compared to preop
	Mean	Standard Deviation	
preoperative	11 .86	3 .55	
6 weeks	55 .57	13 .37	<0.001
3 months	85 .68	15 .50	<0.001
6 months	93 .54	7 .84	<0.001

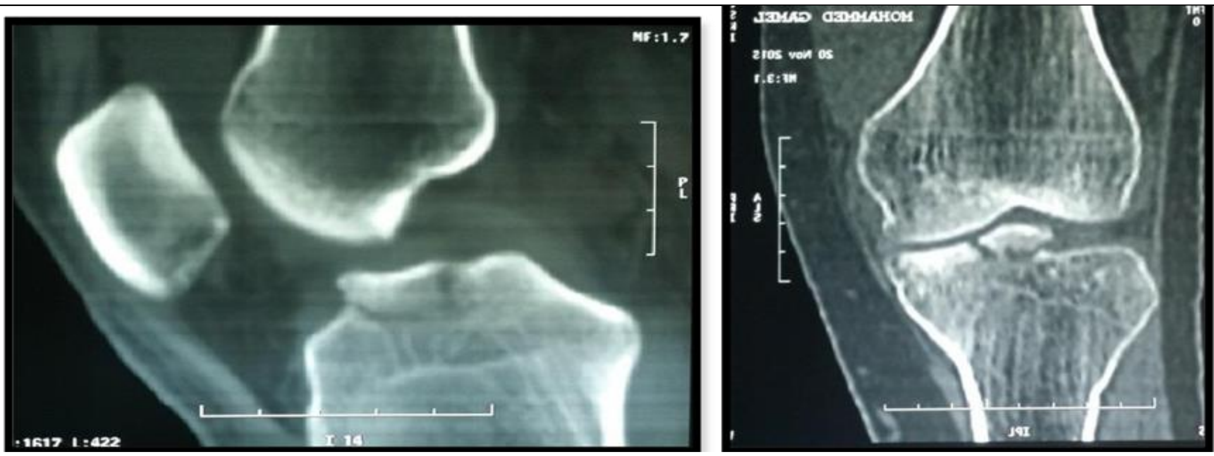
Before surgery, the mean score of Lysholm was 11.86 with a standard deviation of 3.55. The mean score increased to 55.57 with a standard deviation of 13.37 following 6 weeks of operation. After 3 months of operation, the mean score further improved to 85.68 with a standard deviation of 15.50. After 6 months of operation, the mean score was 93.54 with a standard deviation of 7.84. The P value was statistically significant in all post-operative periods. (Table 6)

4. Case presentation

Case One: A 19-year-old male sustained a twisting injury to the right knee during sports. X-rays revealed an isolated avulsed tibial spine fracture, confirmed and classified as type III by CT scan. Surgery was performed four days later. The Lachman and pivot shift tests were positive, with a preoperative Lysholm score of 13, which improved to 96 postoperatively.

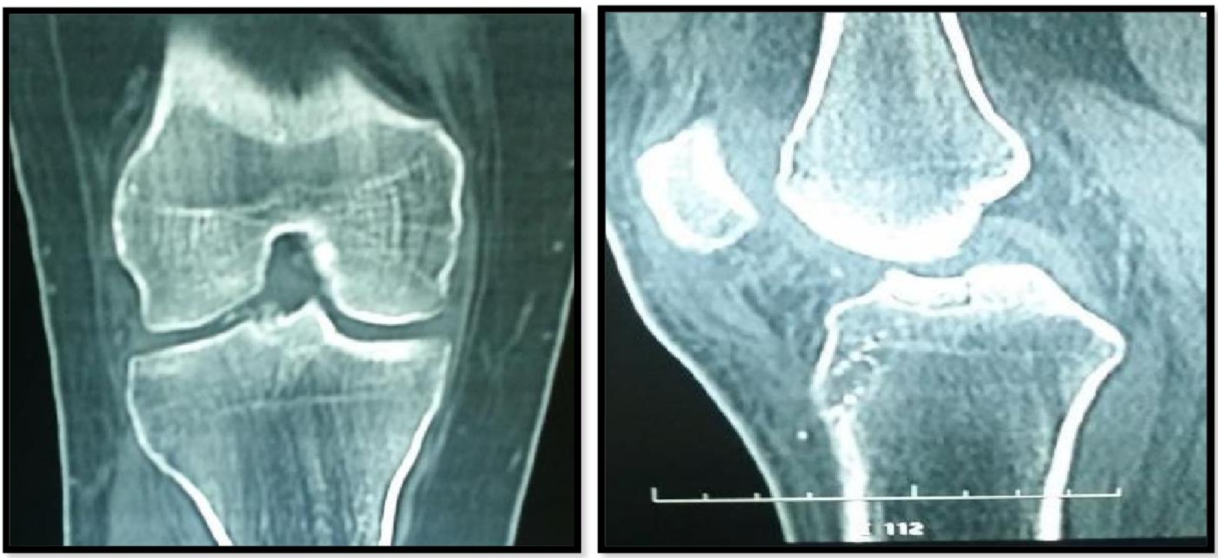


Preoperative x-ray shows AP and lateral views



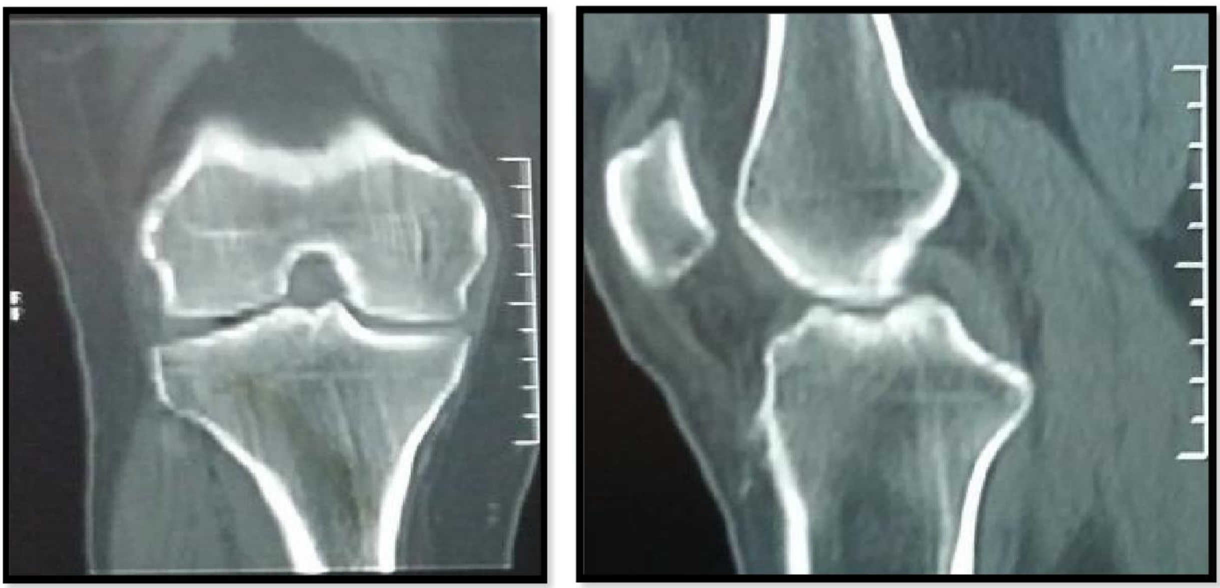
Preoperative   CT coronal cand sagittal views

Immediate postoperative x-ray

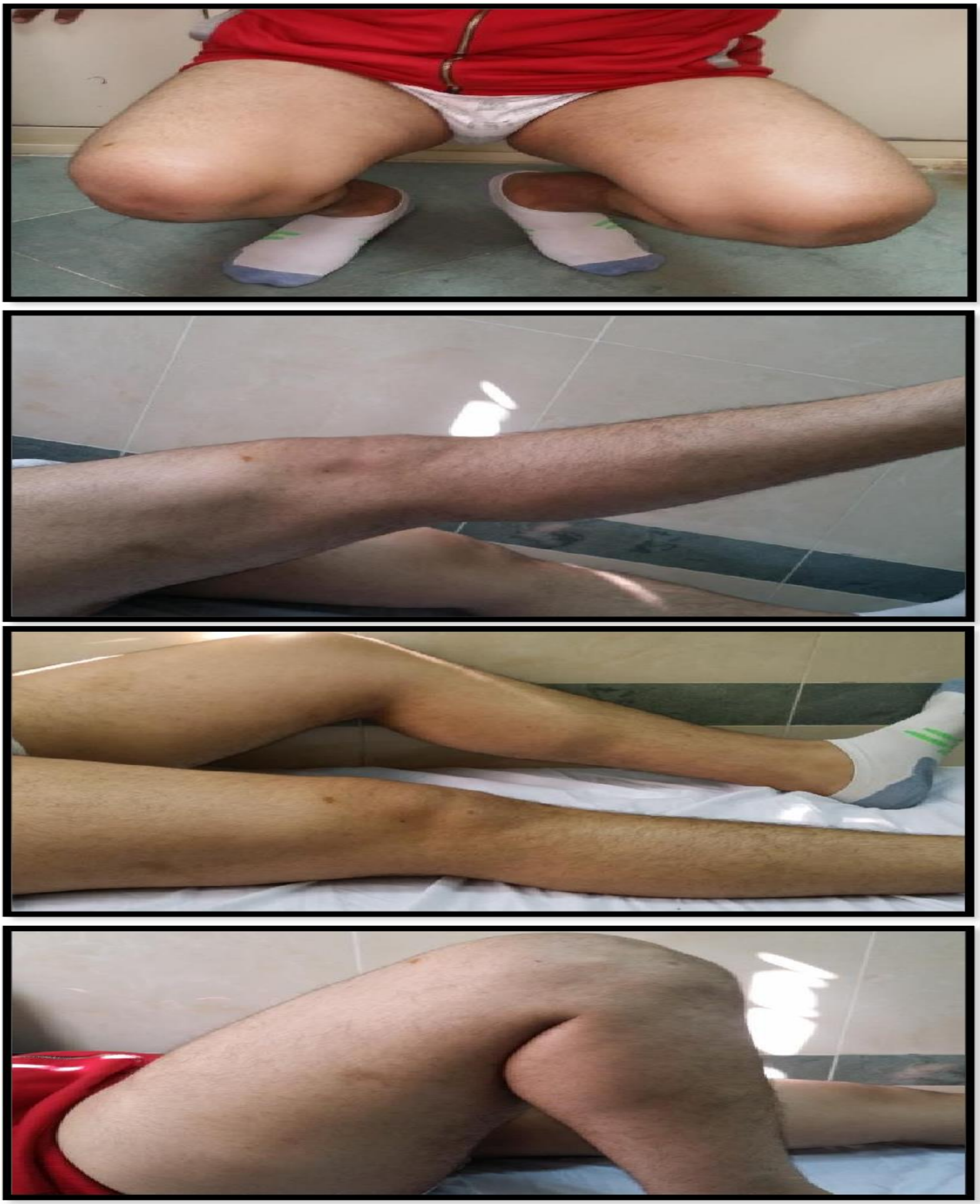


Immediate post-operative coronal and sagittal CT.

Six months' postoperative x-ray



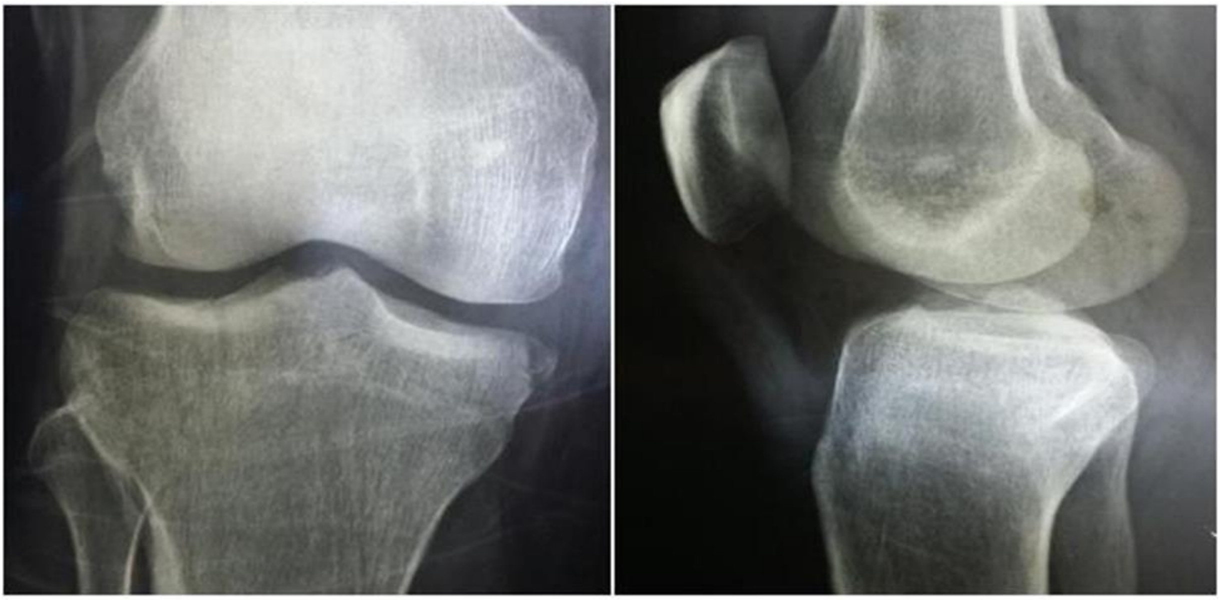
Six months' post-operative follow up coronal and sagittal CT



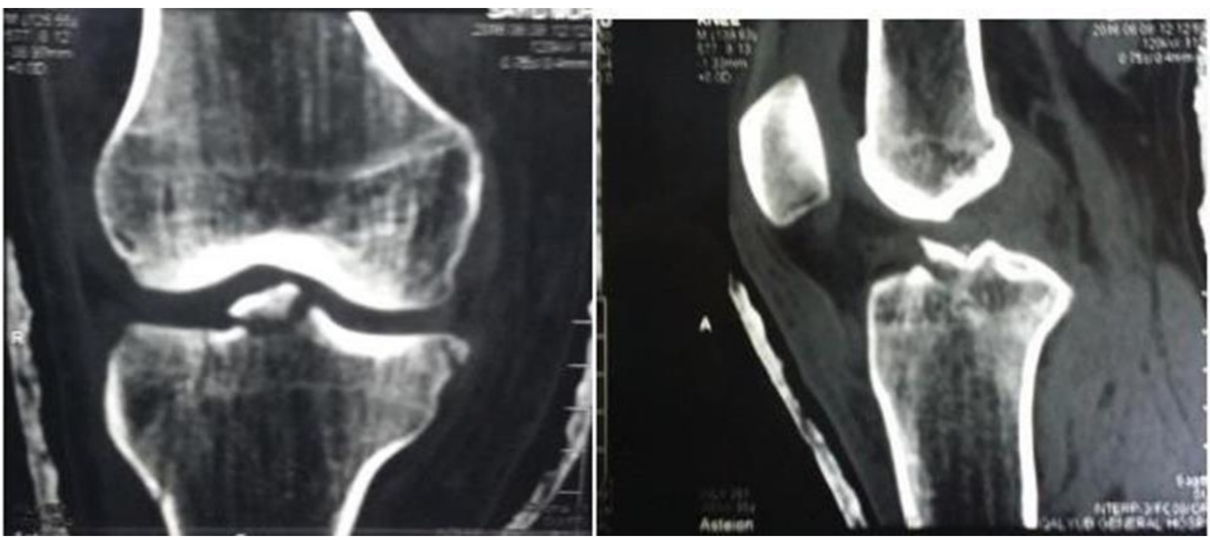
Six months' follow up ROM

Figure (1): Shows case One

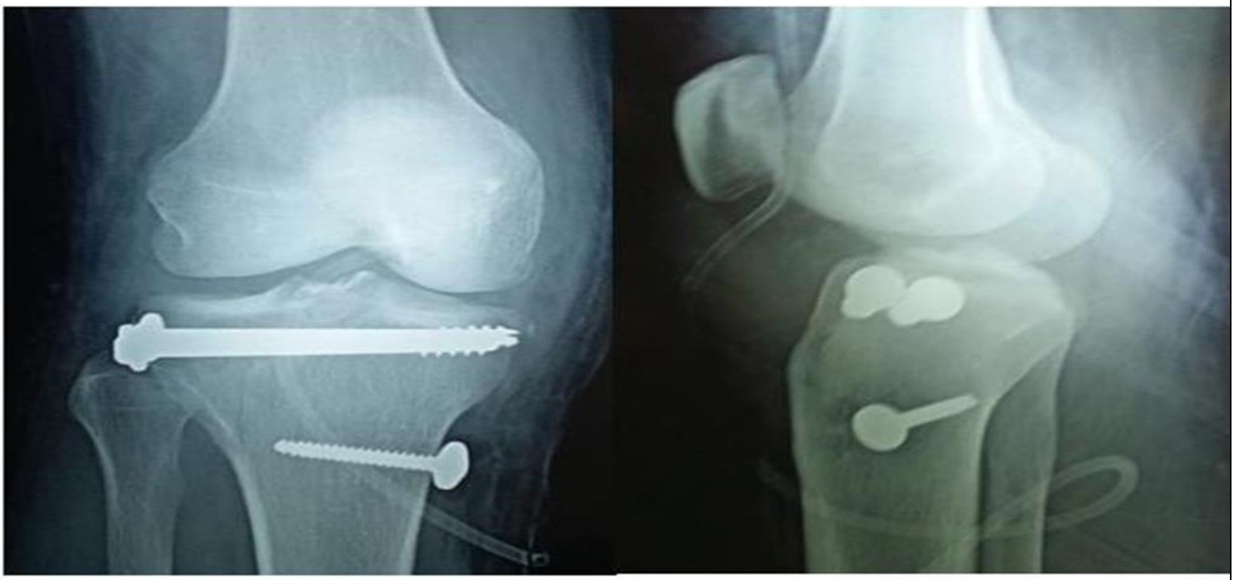
Case Two: A 35-year-old male case has been admitted following a motorbike accident (MBA). After completing a trauma survey, the patient was diagnosed with a type IV avulsed tibial spine fracture in the right knee, associated with an ipsilateral tibial plateau type I fracture. Surgery was performed six days later. The Lachman test was positive, with a preoperative Lysholm score of 10, improving to 93 postoperatively. Postoperatively, a posterior slab was applied for six weeks with no weight-bearing, followed by a knee immobilizer for an additional two weeks, allowing only range of motion exercises with flexion limited to 90°. Partial weight-bearing was permitted after eight weeks.



Preoperative x-ray



Preoperative CT



Immediate postoperative x-ray

Immediate postoperative CT

Six months' postoperative x-ray

Six months postoperative CT

Figure (2): Shows case Two

5. Discussion

This investigation assesses the clinical and functional outcomes following arthroscopic-assisted reinsertion of an avulsed tibial spine using the pull-out suture method tied over the tibial cortex.

Our hypothesis that method leads to good clinical and functional outcomes had been confirmed. Arthroscopic treatment of ACL avulsion provides several benefits over open surgery, such as reduced morbidity in comparison to arthrotomy, easier debridement of intra-articular hematoma, and the possibility of fracture inspection and interposed tissue removal.

In this technique, we used a 90-degree' suture lasso to pass the ethibond through the ACL substance, unlike Masato (8), who used a 45 suture lasso. We believe that this allowed easier retrieval of the proloene and less risk of chondral damage.

In this case series, we used Ethibond 5 or FiberWire 2, unlike Masato, who used Ethibond 2. The Ethibond 5 is stronger, thus providing more stable fixation. that tied over the anterior tibial cortex, leaving a bone bridge at least 1 .5 cm. This fixation allows early motion. Masato used DSP (double spike plate) for fixation, which needed removal in 5 patients (62 .5%) (8).

Masato (8) described arthroscopic suture fixation in cases with a tibial intercondylar eminence fracture utilizing pull-out sutures tied over the Double Spike Plate Fixation Device, maintaining a tension of forty lb.

The outcomes of this investigation indicated a statistically significant increase in the mean Lysholm score following operation at the final follow-up assessment in comparison to the assessment before operation (p-value less than 0.001).

The mean age group in this study was close to all other five studies. Patients who underwent arthroscopic reinsertion of avulsed tibial spines were males (84%) and females (16%), due to more frequency of injuries in males, who show greater participation in vigorous sports as compared to females, particularly in our Middle Eastern communities. Bruno (9) suggested that women sustain significant knee injuries at a higher rate than their male counterparts when the frequency of participation is taken into account.

In this study, the most common mechanism is motorbike accidents (36%), followed by sports injuries (24%). In contrast with the other five studies, the most common mechanism was sports injuries.

The mean time to surgery in this study (5.6 days) was shorter than Vladimir (10) (7.5 days). It was recommended to delay surgery at least four days in order to avoid developing compartment syndrome.

The mean follow-up time (12 months) was shorter than Masato (8), Vladimir (10) (31 .8 months), and Bruno (9) (22 .2 months) and longer than J. Dowdal (11) (12 .3 months). Longer follow-up time allows more accurate future judgment of functional outcomes of the different methods of reinsertion of the avulsed tibial spine.

Egger (12) reported in a biomechanical study that suture fixation in the repair of tibial eminence fracture is superior to that of screw fixation.

Ki-Mo Jang (13), in addition to this study, compared preoperative with postoperative Lysholm scores and showed a statistically significant improvement. It is important to score and know the preoperative functional level of the patients for comparison with postoperative results. This helps to tell how much improvement this treatment modality offers.

In this investigation, all patients achieved a full range of motion at final follow-up; Masato (8) reported one patient with a flexion deficit of 10° and maximum flexion of 110°. Vladimir (10) reported one patient with a flexion deficit of 17° and an extension deficit of 20°. Bruno (9) reported one patient with a flexion deficit of 10° and an extension deficit of 5°.

The type of suture used in this study was Ethicon No. 5. or fiber wire 2 Masato (8) and Ki-Mo Jang (13) used Ethicon No. 2. and fiber wire used by Bruno (9); it is supposed that this adds more fragment stability and ensures rigid fixation, then early mobilization could be allowed.

One patient in this study has significant laxity and was poor on the Lysholm score and is a candidate for ACL reconstruction.

6. Conclusion

Arthroscopic reinsertion of avulsed tibial spine fractures using pull-out sutures tied over the tibial cortex yields excellent clinical and functional outcomes, with significant Lysholm score improvements. Ethibond No. 5 or Fiberwire 2 ensures strong fixation, permitting early mobilization and a full range of motion in nearly all patients. This method offers advantages like reduced morbidity, easier debridement, and stable fixation without implant removal. One patient with notable laxity may need ACL reconstruction, highlighting the need for tailored follow-up.

References

1. Melugin HP, Desai VS, Camp CL, Milbrandt TA, Dahm DL, Levy BA, Stuart MJ, Krych AJ. Do tibial eminence fractures and anterior cruciate ligament tears have similar outcomes?. Orthopaedic Journal of Sports Medicine. 2018 Dec 3;6(12):2325967118811854.
2. MEYERS MH, McKEEVER FM. Fracture of the intercondylar eminence of the tibia. JBJS. 1970 Dec 1;52(8):1677-84.
3. Delzell PB, Schils JP, Recht MP. Subtle fractures about the knee: innocuous-appearing yet indicative of significant internal derangement. AJR. American journal of roentgenology. 1996 Sep;167(3):699-703.
4. Parikh SN, Wells L, Mehlman CT, Scherl SA. Management of fractures in adolescents. JBJS. 2010 Dec 15;92(18):2947-58.
5. Wiley JJ, BAXTER AP. Tibial spine fractures in children. Clinical Orthopaedics and Related Research®. 1990 Jun 1;255:54-60.
6. Rajanish R, Jaseel M, Murugan C, Kumaran CM. Arthroscopic tibial spine fracture fixation: Novel techniques. Journal of Orthopaedics. 2018 Jun 1;15(2):372-4.
7. Leeberg V, Lekdorf J, Wong C, Sonne-Holm S. Tibial eminentia avulsion fracture in children-a systematic review of the current literature. Dan Med J. 2014 Mar 1;61(3):A4792.
8. Aratake M, Akamatsu Y, Mitsugi N, Taki N, Ota H, Shinohara K, Kobayashi H, Saito T. Arthroscopic suture fixation in patients with a tibial intercondylar eminence fracture using a simple device to penetrate the anterior cruciate ligament. Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology. 2014 Apr 1;1(2):67-71.

9. Faivre B, Benea H, Klouche S, Lespagnol F, Bauer T, Hardy P. An original arthroscopic fixation of adult's tibial eminence fractures using the Tightrope® device: a report of 8 cases and review of literature. The Knee. 2014 Aug 1;21(4):833-9.
10. Senekovič V, Veselko M. Anterograde arthroscopic fixation of avulsion fractures of the tibial eminence with a cannulated screw. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2003 Jan 1;19(1):54-61.
11. Mulhall KJ, Dowdall J, Grannell M, McCabe JP. Tibial spine fractures: an analysis of outcome in surgically treated type III injuries. Injury. 1999 May 1;30(4):289-92.
12. Eggers AK, Becker C, Weimann A, Herbort M, Zantop T, Raschke MJ, Petersen W. Biomechanical evaluation of different fixation methods for tibial eminence fractures. The American journal of sports medicine. 2007 Mar;35(3):404-10.
13. Jang KM, Bae JH, Kim JG, Wang JH. Novel arthroscopic fixation method for anterior cruciate ligament tibial avulsion fracture with accompanying detachment of the anterior horn of the lateral meniscus: three-point suture fixation. Injury. 2013 Aug 1;44(8):1028-32.