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Clinical Outcome of Arthroscopic Fixation of Anterior Cruciate Ligament Avulsion Fractures with Pull-Out Suture Technique: A Cross-sectional Study

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Abstract: ***Arthroscopic ACL avulsion fracture fixation has gained popularity in recent years, but there is no consensus on which method of fixation works best. The aim of this study is to evaluate the clinical outcome of the arthroscopic reduction and pull-out suture technique in displaced ACL avulsion fractures. This was a cross-sectional study conducted in two institutions from March 2015 to January 2019. A total number of 13 patients who met the inclusion criteria were enrolled in the study. From our study, all patients achieved overall good postoperative functional outcomes. Hence, ACL avulsion fractures can be effectively treated with arthroscopic pull-out suture fixation.***

Keywords: Arthroscopic fixation, ACL, Avulsion fracture, Functional outcome, Pull-out suture

1. Introduction

Anterior cruciate ligament (ACL) avulsion fracture is a common injury in children aged between 8 and 14 years [1], but the recent literature suggests that the incidence in adults is more than previously thought [2, 3]. Meyers and McKeever [4] classified this injury based on the amount of displacement of the ACL tibial fragment: type I–no displacement; type II–partially displaced, the anterior fragment avulsed, and posterior hinge attached to tibia; type III–complete displacement.Type III was subdivided into types IIIA and IIIB: Subtype IIIA fracture was merely displacement; Subtype IIIB fracture was completely displaced and rotated. Zaricznyj [5] added type IV in which the displaced fragment was comminuted.

Non-operative treatment in the form of immobilization is indicated for type 1 fracture. Type 2 fracture treatment continues to be controversial. Conservative management in type 2 fracture has limited role and requires close monitoring as it commonly results in loss of reduction and ligament laxity [6]. Hence, surgical intervention is usually recommended for type 2, type 3 and type 4 fractures.

The goal of the operative treatment is to restore full range of motion and knee stability. Arthroscopic technique has the advantage of minimal invasive, better visualization, allow us to address associated intra-articular pathologies and decreased morbidity if compared to open surgery.Arthroscopic fixation may be accomplished with either sutures or hardware like metal screws, Kirschner wires and suture anchors. The optimum method of reduction and fixation is still unknown [7, 8]. The purpose of this study is to evaluate the clinical outcome of the arthroscopic reduction and pull-out suture technique in ACL avulsion fractures.

2. Materials and Methods

Between March 2015 and January 2019, a total number of 22 patients with ACL avulsion fractures were treated operatively at both institutions. The surgical procedure was performed by two senior surgeons using the same surgical technique and post-operative protocol. The inclusion criterion was ACL avulsion fractures of type II, III and IV based on modified Meyers-McKeever classification. Chronic injury, concomitant tibial plateau fractures and other severe injuries which will influence knee joint stability were excluded, such as osteochondral lesion, meniscal injury andknee ligament injury. Total number of 13 patients who met the inclusion criteria, and completed a postoperative follow-up for a minimum of 1 year could be contacted and agreed to come for follow-up examination and interview were enrolled in the study. A written consent from the patients and institute ethical committee approval was taken for the study.The patients were clinically examined by the same observer (orthopedic surgeon) who was not involved in the initial surgery.

Data including demographics, injury data and complications were collected from the medical records. Outcome was evaluated radiologically and clinically. Anteroposterior laxity and knee range of motion were assessed. Knee function was evaluated by the Lysholm and International Knee Documentation Committee (IKDC) subjective scores. Knee radiographs were examined for union.

2.1 Surgical Technique

Under anesthesia, diagnostic knee arthroscopy was performed through anterolateral and anteromedial portals. Haematoma was thoroughly drained. The fracture bed was debrided and trial reduction was performed with a probe

(Figure 1). Interposition of soft-tissue structures at fracture site that hindering reduction should be disengaged or removed.

A Spectrum suture hook (Linvatec, Largo, FL) loaded with No. 2-0 polydioxanone suture (PDS; Ethicon, Somerville, NJ) was introduced through the anteromedial portal and pierced full thickness of the ACL fibers anteriorly and at the insertion as close to the bony fragment as possible. The PDS was used to shuttle a No. 5-0 Ethibond suture (Ethicon) or fibrewire 2-0 (Arthrex). The second suture was passed in the same fashion through the ACL slightly posterior to the initial suture.

A 2cm longitudinal incision was made over the proximal anteromedial tibia. Two 2.4 mm bone tunnels were drilled obliquely from proximal anteromedial tibia leaving a minimum of 1cm bony bridge in between 2 tunnels on external cortex of the tibia toward the fracture site with the guidance of ACL tibial aiming guide. The exit of the tunnels in the joint were positioned at the anteromedial and anterolateral margins of the crater of fracture site respectively. The medial and lateral limbs of the sutures were passed acrossthe ACL fibers and then shuttled through the medial and lateral bone tunnels respectively using Prolene suture loop. The fragment was held reduced with a probe and the sutures were kept under constant tension until all sutures were tiedover the endobutton or bony bridge with the knee in 30° flexion. The reduced fragment was re-examined with a probe, checking the stability of the fragment, impingement and tension of the ACL throughout knee flexion and extension. Wound was closed and backslab was applied.

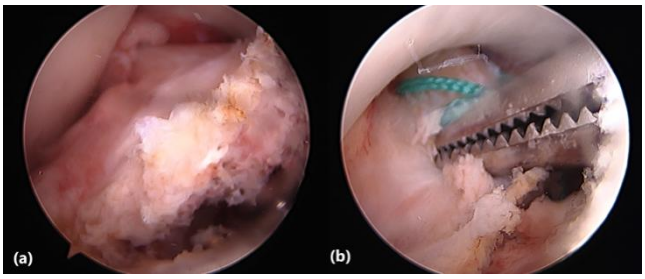

Figure 1: Intraoperative arthroscopic view of the avulsion fracture fragment (a) and the reduction was maintained with kocher forceps (b)

2.2 Post-operative protocol and follow up

The post-operative program was standardized in all cases. A cylinder backslab was applied for the first 2 weeks. The knee was then placed in a hinged knee brace which allows 0-60 degrees range of motion (ROM) for another 2 weeks. The brace was then adjusted to allow increased knee range of motion. The hinged knee brace was discontinued when the patient was able to achieve full extension, typically at 6 weeks. Patients were initially allowed partial weight-bearing with crutches, and at 6 weeks post operation, full weight-bearing and full ROM were allowed. Patellar mobilization, isometric quadriceps, and hamstrings exercises were performed throughout the immobilization period to minimize disuse atrophy and arthrofibrosis. Return to full activity or sports was permitted after confirmed bony healing, restoration of knee stability, range of motion and proprioception.

2.3 Statistical analyses

All the statistical analyses were performed with IBM SPSS Statistics software (version 26). Descriptive statistics were presented for all continuous variables. Frequencies were used to describe all categorical variables.

3. Results

The study population consisted of 9 male (69.2%) and 4 female (30.8%) patientswith age ranging from 7 to 31 years (mean 17.5 years). The cause of injury was related to sports in 2 patients, motorcycle accident in 9 patients, and fall from stairs in 2 patients. Out of 13 patients, 3 (23.1%) patients were of type II, 8 (61.5%) patients were of type III and the remaining 2 (15.4%) patients were of type IV injury. The time interval from injury to surgery was in the range of 1-21 days with a mean of 10.9 days. The demographic and injury data of the patients were presented in Table 1.

The mean follow-up period was 30.9 months (range 12 to 60 months). The Lysholm knee score was on average 97.3 (range, 91–100) and the mean IKDC subjective score was 96.0 (range, 92–98.9). Preoperative Lysholm and IKDC subjective scoring were not taken and no range of motion measurements because all injuries were acute.

A total of 7 patients had clinical signs of ACL deficiency (anterior drawer test grade 1 laxity in 5 patients, grade 2 laxity in 2 patients who also had positive pivot shift test). Out of the 7 patients, 5 patients with grade 1 laxity denied having any symptom of instability whereas the other 2 patients had mild instability only during vigorous activity.

Three patients (patient 1, 3, 13) who initially failed to comply to rehabilitationregimen developed arthrofibrosis of the knee and showed range of motion of 30° to 60°, 15° to 100° and 10° to 90° respectively at 2 months post-operation. Three of them underwent manipulation under anesthesia (MUA) at third month after failed intensive physiotherapy. MUA along with physiotherapy resulted in satisfactory results for 2 patients with the range of motion of 0° to 140° and 0° to 135°. Only one patient had residual fixed flexion deformity of 10°.

Radiologically, all cases achieved union at mean 8.5 weeks postoperatively and all could return to their previous level of activity. The descriptive data for knee evaluation results were summarized in Table 2.

Table 1: Demographic and Injury Data

Patient	*Gender*	*Age (year)*	*Cause of injury*	*Type of fracture*	*Time to surgery (day)*
1	F	23	MVA	III	15
2	M	17	MVA	III	12
3	F	15	MVA	III	6
4	M	16	MVA	III	3
5	M	23	MVA	II	20
6	M	31	Fall from stairs	II	12
7	M	15	Sports injury	III	21

8	M	14	Fall from stairs	III	10
9	F	7	MVA	II	1
10	M	13	MVA	III	11
11	M	14	Sports injury	IV	18
12	M	19	MVA	III	6
13	F	21	MVA	IV	6

Abbreviations: F, female; M, male; MVA, motor vehicle accident

Table 2: Summary of knee evaluation results

Patient	*F/U (month)*	*ADT (grade)*	*Pivot shift (grade)*	*ROM (°)*	*Lysholm score*	*IKDC score*	*Union duration (week)*	*Others*
1	37	-	-	0-140	100	96.55	10	MUA
2	12	1	-	0-130	95	94.25	8	-
3	50	1	-	0-135	91	96.55	7	MUA
4	12	1	-	0-135	100	94.25	8	-
5	12	-	-	0-145	100	98.85	10	-
6	12	-	-	0-140	100	96.55	9	-
7	60	-	-	0-140	91	94.25	7	-
8	15	-	-	0-145	94	95.40	8	-
9	34	-	-	0-130	100	98.85	5	-
10	29	1	-	0-140	100	97.70	6	-
11	48	2	1	0-140	95	95.40	12	-
12	50	1	-	0-130	100	97.70	8	-
13	31	2	1	10-135	99	91.95	12	MUA

Abbreviations: F/U, follow-up; ADT, anterior drawer test; ROM, range of motion;
IKDC, International Knee Documentation Committee; MUA, manipulation under anaesthesia

4. Discussion

ACL avulsion fracture is a rare injury and there has been only a few reported literatures of arthroscopic suture fixation with mixed populations [9, 10]. We prefer the arthroscopic suture to screw fixation technique because suture fixation can eliminate the risk of fracture fragment comminution during screw insertion and possible impingement of screw head during knee extension and the need for secondary surgery for hardware removal. Moreover, suture fixations have been found to have a higher load to failure and survival rate during cyclic loading which allows more aggressive rehabilitation, potentially reduces complications such as stiffness and pullout failure.

Residual laxity is the most common complication. It has been reported in 10% of skeletally mature patients treated surgically and in 22% managed nonsurgically [11]. Kocher *et al.* [12] concluded that arthroscopic fixation of type III tibial spine fractures in skeletally immature patients resulted in persistent laxity but excellent functional outcomes. Osti *et al*. [13] reported 30% of laxity but no extension deficit with fair or poor results. It is believed that the ACL intrasubstance damage and stretching during injury lead to permanent deformation and laxity, independent of the treatment method. Although we observed a higher rate of residual laxity in type III and IV fractures, no functional instability was reported. Therefore, the patient's subjective perception of stability must be taken into consideration in decisions to perform secondary surgery.

Stiffness may occur in 60% of knees that were treated surgically for tibial eminence fracture [11]. Berg et al. [14] reported 2 cases of arthrofibrosis, whereas Montgomery et al. [15] found that 9 of 17 patients (53%) treated with arthroscopic suture fixation had difficulty in regaining motion postoperatively. Three of ourpatients developed knee stiffness in which two regained full range of motion after MUA, leaving only one patient with residual 10 degrees extension limitation.

The good results in our study were related to surgical technique used. We recommend the placement of two or more sutures to resist forces during early rehabilitation. It is crucial to make drilled holes more anterior than the mid-transverse axis of the crater and lie just outside the crater to minimize any anterior tilt or displacement after suture tightening.

5. Conclusion

Our study shows good post-operative functional outcome, excellent union rate without functional instabilityin all the cases regardless of age and fracture type. Thus, we recommend this simple and reproducible technique.

6. Future Scope

The main limitation of this study is the relatively small sample size. The physical examinations were dependent on one examiner; no inter- or intra-observer reliability/ variability was reported in this study. Further study is required with larger sample and longer follow up.

7. Ethical Approval

Ethical approval for this study was obtained from the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia. We conducted our study in compliance with ethical principles outlined in the Declaration of Helsinki and Malaysian Good Clinical Practice Guideline.

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