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Contents

Review Article

Demystifying Partial Tears of the Anterior Cruciate Ligament: A Review of Current Diagnostic and Management Strategies

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Abstract

Partial tears of anterior cruciate ligament (ACL) are a diagnostic and management challenge. There is ongoing discussion and debate about the ideal management of a partial tear with "ala carte" options available in the current literature. Findings can remain occult on imaging studies, necessitating more efficient clinical examination and acumen to identify patients requiring surgical intervention. The authors through this literature review provide an overview on partial tears of ACL including the background anatomy, pathology, clinical diagnosis, imaging finding, and surgical techniques. The literature is critically probed and tabulated for effortless assessment. The objective is to help the orthopedic surgeon decide the optimal course for a suspected partial ACL tear. The authors do not aim to provide a guideline but rather present an inventory of available options and approaches for managing partial ACL tear. This review is a comprehensive amalgamation of the heterogeneity in the present literature.

Keywords: Imaging, partial anterior cruciate ligament tear, surgical steps

Introduction

The anterior cruciate ligament (ACL) is one of the most crucial knee ligaments and the one to be frequently torn. A complete tear of the ACL necessitates surgical reconstruction; meanwhile, the management of a partial tear of the ACL warrants discussion. Diagnosing and thereby deciding the optimal course of management for a partial ACL tear is challenging.

The ACL is essential for stability and proprioception. It consists of two bundles – the anteromedial and anterolateral – named according to their tibial insertion. The anteromedial bundle (AMB) has its footprint more anterior and medial on the tibial side as compared to the posterolateral bundle (PLB).[1] This bundle is mainly isometric, while the PLB is anisometric. When the knee is in extension, both bundles run in a parallel manner, with the PLB being taut. Meanwhile, in flexion, the AMB spirals around the posteromedial bundle and becomes tauter compared to the posteromedial bundle. Each bundle has its own specific function in various angles of knee flexion with the AMB providing stability in the sagittal plane during knee flexion and the PLB providing rotatory stability on extension.[2]

A partial ACL tear can be observed in 10%–27% of isolated knee injuries.[3] Most patients are unable to comprehend the true nature of their knee morbidity as partial tears lack typical instability, presenting only with quadriceps atrophy on general examination and failure to return to do sports activities. No clinical test is sensitive enough to accurately diagnose a partial ACL tear. Various clinical tests have been advised, but all lack good sensitivity to fathom final diagnosis. The combination of more than one clinical examination helps in the identification of the bundle involved.

The use of magnetic resonance imaging (MRI) is necessary for diagnosis and helps in the detection of other associated injuries. However, arthroscopic evaluation is a gold standard for proper assessment of damaged fiber and which surgical intervention should be pursued.

The ideal treatment of partial ACL tear is lacking in the existing literature. Before the 2000s, conservative management was preferred which resulted in varied outcomes. Presently, biological healing components, partial bundle augmentation,

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or repair techniques have come in vogue, and the decision is based on clinical instability and the duration of the injury. Partial bundle reconstruction is preferred over single-bundle conventional ACL reconstruction due to better restoration of proprioception, less re-rupture rate, better graft healing, and better stability to the knee. More recently, the repair technique for acute proximal partial tears has been advocated with favorable results with short-term follow-up.[4,5]

Discussion

Anatomy

ACL is the main structure responsible for resisting anterior tibial translation and rotatory load. The ACL consists of 2 bundles, AMB and PLB.[6] The PLB is tight during extension, while the AMB is lax. The reverse occurs during flexion. During extension of the knee, both bundles run parallel to each other, while during flexion, the AMB spirals around the rest of the bundle in an arcuate manner. This is due to the different orientations of the bony attachment of ACL.[7] ACL attachment toward the femoral side is in a vertical fashion, while the tibial attachment is in an anteroposterior direction. This leads to the typical orientation of both bundles during knee movement [Figure 1]. The terminology of the AMB and PLB has been described according to the tibial attachment.

Blood supply

The main blood supply of the ACL is from the middle geniculate artery (MGA), which originates at right angle from the anterior aspect of the popliteal artery. It then pierces the posterior capsule and runs almost vertically downward. Apart from this nutrient artery, ACL also receives a posterior descending branch of MGA which supplies the posterior part of the upper tibia.[7,8]

The blood supply of the ACL is not homogeneous – its proximal part is gifted with a rich blood supply as compared to the distal part. The distal part of the ACL is supplied by infrapatellar branches of inferior genicular arteries. The blood supply is scanty in a zone 5–10 mm proximal to the tibial attachment[9] [Figure 2]. This unique pattern of blood supply is exploited while repairing proximal ACL avulsion injuries.

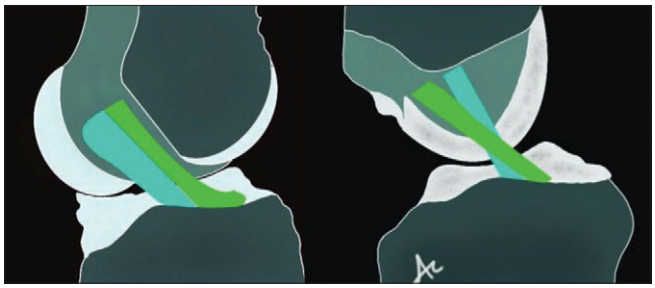

Figure 1: Graphical representation of the normal orientation of the blue AM and green PLB of ACL relative to each other with knee extension (left) and flexion (right). AM: Anteromedial, PLB: Posterolateral bundle, ACL: Anterior cruciate ligament

Nerve supply

The posterior articular branch of the tibial nerve is the main nerve supply of ACL.[10] Various mechanoreceptors such as Ruffini, Vater-Pacini, and Golgi tension nerve-ending receptors are important for proprioception in the knee joint and are essential for knee stability.[11,12]

Function

ACL is primarily responsible for resisting anterior tibial translation with respect to the femur, providing 87% restraining force at 30° of knee flexion and 85% at 90° of flexion,[13] and acts as a major knee stabilizer. It is also a major secondary restraint to the internal rotation of the tibia during full extension of the knee. Some studies describe that both the AMB and anterolateral bundle have an independent function in knee stability and the integrity of both is essential for the proper function of the knee.[14-16]

Arthroscopic Examination

During an arthroscopic examination, each bundle should be properly identified to rule out partial and hidden tears. Since most knee surgeries are performed with 90° of knee flexion, it is difficult to identify the PLB, bearing in mind that the majority of its fibers are usually covered by the AMB which spirals around it. Identification of this bundle requires a figure-of-4 position (Cabot's position).[17]

Incidence

Partial ACL tear accounts for 10%–26% of isolated ACL injuries.[3] It most commonly occurs in young patients with a male predominance (70% of cases).[18]

Clinical diagnosis

Diagnosing a partial tear based on clinical examination is always a dilemma for clinicians. No single test is specific and sensitive enough to clinch the diagnosis with 100% accuracy.

Figure 2: Graphical representation of the blood supply to the ACL fibers depicting richer supply in the proximal (femoral) part as compared to the distal (tibial). ACL: Anterior cruciate ligament

The classical Lachman test presents with moderate laxity as compared to the normal contralateral knee and often presents with a firm endpoint.[19] A pivot shift test is rarely present with grade 3 in case of an isolated partial ACL tear. Sonnery-Cottet *et al*. in their study mentioned that some patients presented with subtle pivot glide in spite of an overt pivot shift test in a patient with a partial ACL tear.[20]

The most commonly performed test, the Lachman test, has a sensitivity of 42% while the anterior drawer test is only 19% sensitive.[21] Although Lelli *et al.* described the "lever test" claiming 100% sensitivity for partial ACL tears, some others refute this finding with an overall accuracy of 77%.[21,22] Siebold and Fu in their study concluded that isolated posterolateral tears result in positive pivot shift, while the positive anterior drawer and Lachman test have been more suggestive of AMB injury.[23]

In a recent article, the authors of a retrospective case–control study for clinical examination of partial ACL tears gave a comprehensive idea regarding its diagnosis based on clinical examination.[24] They concluded that collectively using both Lachman and pivot shift tests can distinguish between partial and complete tears. It also helps in relegating between partial PL tears, and complete tear with pivot shift test is more important than Lachman test for diagnosis. On the other hand, the anterior drawer test was more likely to be positive in the case of partial AM tears [Table 1].

Imaging of partial anterior cruciate ligament tear

Diagnosing a complete ACL tear is straightforward particularly when accompanied by contemporaneous clinical findings. A partial ACL tear, however, is challenging to identify confidently on imaging. Certain direct signs which suggest a partial tear on MRI include focal angulation of the ACL fibers and intrasubstance high-signal intensity which needs to be differentiated from a sprain or ACL cyst.[25] Subtle angulation and only marginal reduction in the transverse diameter of the ACL fibers in the axial plane may point toward a "stable" or "low-grade" partial tear.[26] ACL tears with a disrupted single bundle, associated ligamentous injuries, and bone bruises represent "high-grade" partial tears and are at risk of progression to complete tears. Chronic partial tears may demonstrate normal signal with only attenuation in caliber with anterior tibial translation serving as an indirect sign of ACL laxity. The nonweight-bearing nature of the MRI study further limits the accurate assessment of anterior tibial translation.

For an isolated tear of PLB, two signs were described by Volokhina *et al*.: "gap sign" and "footprint sign."[27] The gap sign is a tear of PLB from its femoral attachment, which was described as the increased signal intensity between the lateral femoral condyle and proximal aspect of ACL. The footprint sign was described for the avulsion of this fiber from PLB from the tibial site, which can be appreciated in the coronal section.

Routine MRI sequences which are orthogonal to the femoral and tibial axis are sufficient to diagnose complete ACL tears and high-grade injuries. Sagittal and coronal imaging orthogonal to the ACL axis, that is oblique sagittal and oblique coronal imaging, is considered to be beneficial in identifying subtle and partial ACL tears for optimal patient management.[28-30] Studies support using either the oblique coronal or oblique sagittal imaging for better accuracy in routine MRI for identifying partial ACL tears[31] [Figure 3].

Management

Deciding the ideal management for a partial ACL tear is a daunting task. This is because the management options are like an "ala carte" menu for the patient, with a unique treatment strategy for every case. Those patients who have returned to their normal sports activities without any symptomatic instability can be managed conservatively by proper rehabilitation and proprioception training. Surgical intervention should be considered for those patients who continue to have symptomatic instability and those who have failed to return to normal sports activity. Fayard *et al*. in their study concluded that patients with the age <20 years and those who have active participation in pivoting sports have an increased chance for progression to complete tears.[32] In the authors' experience, PLB tears in patients engaged in pivoting sports are more symptomatic.

Conservative management

Majority of the studies in the literature which support or advocate conservative management date before the 2000s. The collective proposition was to either immobilize the knee[33-36] or to perform a range of motion exercises with intensive rehabilitation protocols.[37-39] These studies had variable results of the return to sports and persistent instability in the participants with no single method being better than the other to support one of the management protocols [Table 2].

Table 1: Clinical examination of anterior cruciate ligament tear

Type of tear	Clinical examination
Isolated AM bundle tear	Low-grade Lachman with soft endpoint + low grade both anterior drawer and pivot test or high-grade anterior drawer + low-grade pivot + low/high-grade Lachman with firm endpoint
Isolated PL bundle tear	Low-grade Lachman test with firm endpoint + high-grade pivot-shift or high-grade Lachman with firm endpoint + high-grade pivot-shift or low-grade pivot and anterior drawer test + low/high-grade Lachman with a firm endpoint or low-grade anterior drawer + low-grade pivot shift + high/low-grade Lachman test with firm endpoint
Complete ACL tear	High-grade Lachman with soft endpoint + high/low-grade anterior drawer or pivot shift test or low-grade Lachman with soft endpoint + high-grade pivot + low/high-grade anterior drawer test

AM: Anteromedial, PL: Posterolateral, ACL: Anterior cruciate ligament

Biological agents in management of partial anterior cruciate ligament tears

The healing property of ACL tear is low, as synovial fluid limits by hampering the required environment for its self-healing.[42] Apart from this, the peculiar blood supply of ACL fiber has a good healing rate only for the proximal part of fiber.[43]

Various biologics have been mentioned in literature for partial ACL tears with variable results. Growth factor and PRP are most commonly used for enhancing the healing response for a partial ACL tear. In a retrospective study by Seijas *et al*.,[19] patients were evaluated following plasma-rich growth factor injection for a partial ACL tear, 15 patients returned to sports at an average of 16.2 weeks, while three patients did so in 12.33 weeks.[44] In another study by Matthias *et al*., trephination of ACL remnant with intraligament application of autologous conditioned plasma yielded promising results at mid-term follow-up with return to sports achieved at 4.8 months. However, the author reported failure in 3 patients out of 24.[45]

In another recent comparative study, 21 out of 40 patients were treated with PRP injection with a mean follow-up of 25 months. The overall failure rate was 32.0% (n = 13) in this study. No significant differences were observed between groups regarding subjective outcomes, return to sport, and failure rate.[46]

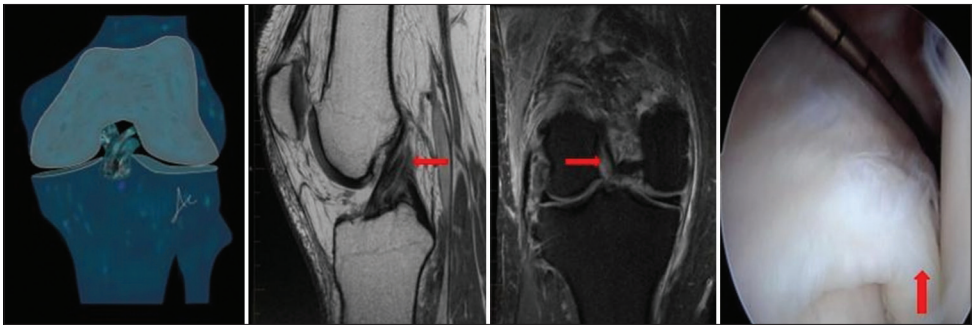

Figure 3: Image showing partial tear of the posterolateral bundle (red arrow) - graphical representation, sagittal oblique fluid-sensitive MRI sequence, coronal oblique fat-saturated fluid-sensitive MRI, and intraoperative arthroscopic image. MRI: Magnetic resonance imaging

Table 2: Studies on conservative management of partial anterior cruciate ligament tear

Author	Journal	Year	Number of patients	The average age of patients	Months of follow up	Mode of conservative management	Return to sports (%)	Persistent instability (%)
McDaniel[33]	CORR	1976	9	20	15 (3-37)	Debridement of the large fragment of tear, f/b knee immobilization in extension for 2-4 weeks	89	11
Odensten *et al*.[34]	AJSM	1985	21	28.3	70±22	Associated ligament injuries were repaired anatomically in 12 patients with knees immobilized in a long knee cast for 6 weeks. The isolated partial tear was managed by an intensive rehabilitation program	Not reported	14
Kannus and Järvinen[35]	JBJS	1987	41	32	96±28	By cylindrical cast application for 6±2 weeks for grade 3 and 3.7±2 weeks for grade 2 injuries	66	78
Noyes *et al*.[38]	JBJS (brit)	1989	32	21.4	67	4-4-4-4' program, first 4 weeks - partial weight-bearing with crutches. Second 4 weeks - increase weight-bearing with weaning of crutches. 3rd, 4th week - gradual straightening exercise. Last 4 weeks - gradual returns to sports activities	21	38
Buckley *et al*.[39]	AJSM	1989	25	25	49	Partial meniscectomy for meniscal tear followed by early ROM and hamstring strengthening	44	52
Barrack *et al*.[37]	JBJS	1990	35	25	41	Protected weight-bearing, early ROM, and hamstring strengthening	40	83
Sommerlath *et al*.[40]	CORR	1992	19	29	144	Associated ligamentous and meniscus injury was treated leaving behind partial ACL tear as such	32	9
Bak *et al*.[36]	KSSTA	1997	56	17-48	63	11 patients cast immobilization, 26 patients no bandaging, rest hinged cast for 6 weeks	30	23
Fruensgaard and Johannsen[41]	JBJS	1989	41	29	17	Plaster immobilizer for 6 weeks followed by rehabilitation	49	51

CORR: *Clinical Orthopaedics and Related Research*, JBJS: *Journal of Bone and Joint Surgery*, AJSM: *American Journal of Sports Medicine*, KSSTA: *Knee Surgery, Sports Traumatology*, Arthroscopy, ACL: Anterior cruciate ligament, ROM: Range of motion

Surgical Methods

Partial bundle reconstruction

It is always useful to preserve the remaining intact fiber during surgery, as it offers many advantages over conventional single-bundle ACL reconstruction such as:

a. Vascularity of reconstructed graft is enhanced[47]
b. Better proprioceptive function of the reconstructed graft[48]
c. The remaining fibers provide additional mechanical stability to the graft[49]
d. The intact bundle helps in the proper placement of the bone tunnels and serves as a guide for orientation.[23]

However, maintaining the integrity of the intact bundle is a challenging task for surgeons. Reconstruction of the selective single bundle may hamper visualization of footprint and can lead to nonanatomical tunnel placement[43] [Figure 4].

In a study by Sabat *et al*., which included 38 patients with single-bundle augmentation by hamstring graft followed up for 36 months, there was a significant improvement of objective laxity, International Knee Documentation Committee (IKDC), and Tegner knee score between the pre- and postoperative periods.[50] There was grade 1 laxity on the anterior drawer test (more in AM group), while pivot glide was positive in six patients with the majority in the PL group. No incidence of graft failure was observed.

In a study by Abet *et al*., 28 patients were followed up for 30 months with excellent clinical outcomes and normal returns to activity.[51] In another study on 36 patients with AMB tear with follow-up of 24 months, there was a significant improvement in instrumental laxity and IKDC score.[52] There was a significant improvement in instrumental laxity and IKDC score. One patient presented with graft failure at a 4-month postoperative period. Carulli *et al*. in their study of 36 patients with a mean follow-up of 64 months concluded that there was a good functional outcome and return to preinjury level after selective bindle reconstruction.[53] Various surgical techniques such as all inside, over the top, transtibial, and anteromedial have been described in the literature with success in all techniques[3,54-56] [Tables 3 and 4].

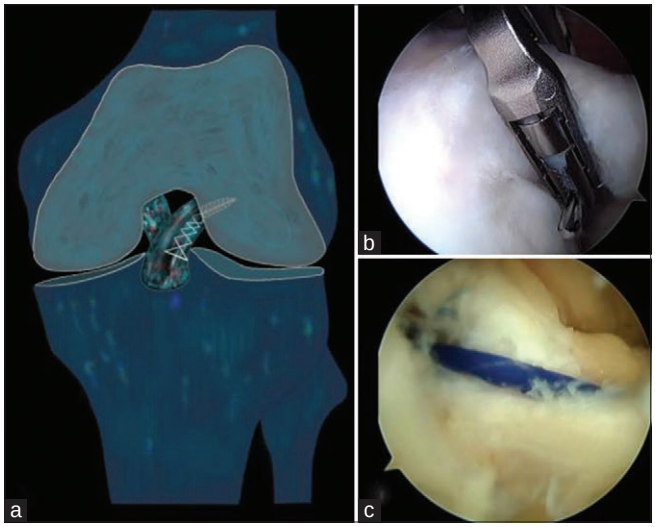

Figure 4: Graphical representation of repair of a partial ACL tear (a). The intraoperative arthroscopic picture shows the torn posterolateral bundle with fiber wire passing through it (b). Before the final repair. Image with final repair construct (c). Continuity of the bundle after knotless anchor placement with fiber tape augmentation. ACL: Anterior cruciate ligament

Standard complete anterior cruciate ligament reconstruction

There is limited literature on performing complete ACL reconstruction for partial tears. Pujol *et al*. in their randomized study, comparing selective AMB reconstruction and conventional single-bundle reconstruction for partial AMB tear, inferred that there was no difference in the functional outcome at 1-year follow-up. There was a significant improvement in clinical and subjective outcomes in the postoperative period from the preoperative period in both the groups.[64] Chia *et al*. compared the outcomes of double, single, and selective bundle techniques and found no differences in functional outcome scores and laxity in 2 years of follow-up. However, there was a slightly higher re-tear rate in the selective bundle reconstruction group.[65] In another study by Park *et al*., a comparison was made between remnant-preserving augmentation and double-bundle ACL groups, but the anterior drawer test was significantly better in the remnant-preserving group.[66]

Repair techniques

In the landmark paper of Vander list *et al*. on the systematic analysis of ACL repair techniques before 2000, he reviewed 29 studies and inferred that repair techniques are successful in cases with a proximal tear.[67] Apart from this, anatomical knowledge about the blood supply of the ACL says that there is better vascularization in the proximal part of the ACL. These perceptions have led to the re-emergence of ACL repair techniques in recent years for acute tears of the proximal ACL. There is abundant literature on the repair of complete proximal tears of ACL; however, there is an iota of literature for repair in a partial ACL tear. Repair techniques preserve the original fiber, which is important for proprioception and biomechanical function, thus having an inherent advantage over reconstruction [Figure 5].

Gobbi and Whyte in their article on the primary repair with biological healing in cases of partial ACL tears demonstrated good-to-excellent long-term results. In their study on 50 patients with 10.2 years of follow-up, the author reported 80% and 73% survival rates of repaired ACL graft at 5 and 10 years, respectively. Twelve patients noted ACL insufficiency and residual laxity.[68]

In the recent study by Liao and Zhang, the author evaluated the short-term outcome of repair methods in partial ACL tears in 18 military personnel with a mean delay of 11.9 ± 1.8 days from the date of injury.[4] Out of 18 patients, 17 had no laxity in the sagittal plane, while 1 had a grade 1 anterior drawer test.

Table 3: Existing literature on surgical management of partial anterior cruciate ligament tear

Author	Total sample size	PL bundle	AM bundle	Associated injury	Delay in surgery	Graft used*	Average graft size in AM	Average. graft size in PL group (mm)	Postoperative laxity	Graft failure
Sabat and Kumar 2015[50]	36	12	26	14 patients - meniscus injury	2-26 months	4ST			Grade 1 laxity in 5 patients (more in AM group), pivot glide in 6 patients (more in PL group)	None
Abat *et al*.[51]	28	10	18	8 - meniscus injury	0.5-9 months	3ST/4ST-G	7.4 mm	6.5	No laxity in any patients	None
Carulli *et al*.[53]	36	1	35	15 - meniscus tear	0.2-5 months	2ST	-	-	No laxity in any patients	None
Sonnery-Cottet *et al*.[57]	39	39	0	12 - meniscus tears	5.7±6.8 months	2/3ST	-	7-9	Grade 1 pivot in 4 patients	1 patient
Perelli *et al*.[58]	76	42	34	19 - meniscus tears	-	3ST	7.4 mm	7.6	-	2 patients
Sonnery-Cottet *et al*.[59]	168	0	168	44 - meniscus tears	3 months	HT (108), PT (55) and QT (5)	-	-	Grade 1 in 4 patients, grade 2 in 1 patient	5 patients
Buda *et al*.[60]	42	42	0	23 - meniscus tears		ST/G	-	-	No laxity	None
Ochi *et al*.[61]	45	8	37		-	-	-	-	Pivot glide in 2 cases	-
Buda *et al*.[62]	47	35	12	4 - meniscus tears	12-36 weeks	-	-	-		None
Matsushita *et al*.[56]	68	43	25	19		ST±G			No laxity	-
Yadav and Singh[63]	40				4.2 months	ST±G	8 mm in 65% and 9 mm in 35%	-	-	-
Yazdi *et al*.[54]	56	56		15 - medial meniscus tear, 7 - lateral meniscus tear	10.2 weeks	ST±G	-	-	No laxity	-

Numerical value depicts turns - double/triple/quadruple. *ST: Semitendinosus, G: Gracilis, HT: Hamstring tendon, PT: Patellar tendon, QT: quadriceps tendon, AM: Anteromedial, PL: Posterolateral

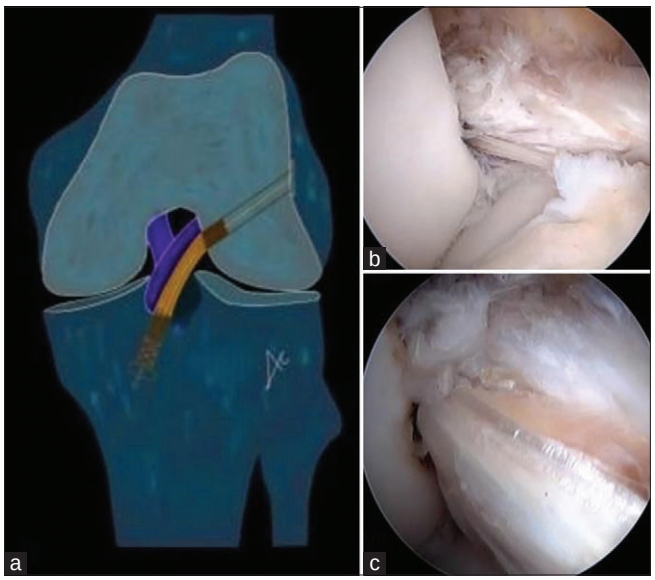

Figure 5: Graphical representation of reconstruction of a partial ACL tear (a). The intraoperative arthroscopic picture shows the passage of endo-button loop toward the femoral tunnel (b) with final construct showing the reconstructed posterolateral bundle (c). ACL: Anterior cruciate ligament

There was significant improvement of Lysholm, IKDC, and Cincinnati scores at the final follow-up for 2 years.

In another study by Wei *et al*., partial ACL repair under local anesthesia in 18 patients was followed up for 19.1 months. There was a significant improvement in IKDC and Tegner scores at 6- and 12-month follow-up. The total satisfaction rate was found to be 94.4%.[5]

Conclusions

Wayward presentation of partial ACL tears makes diagnosis and management challenging. This comprehensive review provides an insight on approaching a case of suspected partial tear of ACL and choosing from the diverse management options to best complement the clinical profile [Figure 6].

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Conflicts of interest

There are no conflicts of interest.

Table 4: Existing literature on outcome of surgical management of partial anterior cruciate ligament tear

Author	Follow-up (months)	Sample size	Running (months)	Return to full activities (months)	High-level sports (months)	Clinical improvement	Complications
Sabat and Kumar[50]	36	38	After 3	6	12	29 patients return to normal activities	4 patients had flexion deficit of >15 degree
Abat *et al*.[51]	30	28	3	6	6	All patients return to normal preinjury activity	2 patients had extension deficit in AM group, 1 had septic arthritis
Sonnery-Cottet *et al*.[52]	24	36	3	6	6	33 patients returned to their preinjury level at 12 months follow up	2 patients developed extension deficit (due to cyclops lesion) (larger size graft was used >8 mm)
Carulli *et al*.[53]	48	36	-	5	12	33 patients returned to their preinjury level, 3 changed their activities	1 patient had persistent instability
Sonnery-Cottet *et al*.[57]	24.2	44	3	-	6	Significant clinical improvement in terms of various objective score	No complication
Perelli *et al*.[58]	85	76	3	-	6	Significant improvement in terms of various objective score	-
Sonnery-Cottet *et al*.[59]	26	168	3	-	6	Significant clinical improvement in terms of various objective scores	Residual pain in 13% of patients, cyclops syndrome in 9 patients
Buda *et al*.[60]	60	42	3	-	6.7	Significant improvement in terms of various objective scores	No complication
Ochi *et al*.[61]	24	45	-	-	-	-	-
Buda *et al*.[62]	60	47	-	-	3	38 patients returned to sports	No complication
Yadav and Singh[63]	12	40	3	6	9-12	-	Ant knee pain in 1 and stiff knee in 2 patients
Yazdi *et al*.[54]	19.3	56	-	3	6	-	Donor site infection in one patient

AM: Anteromedial

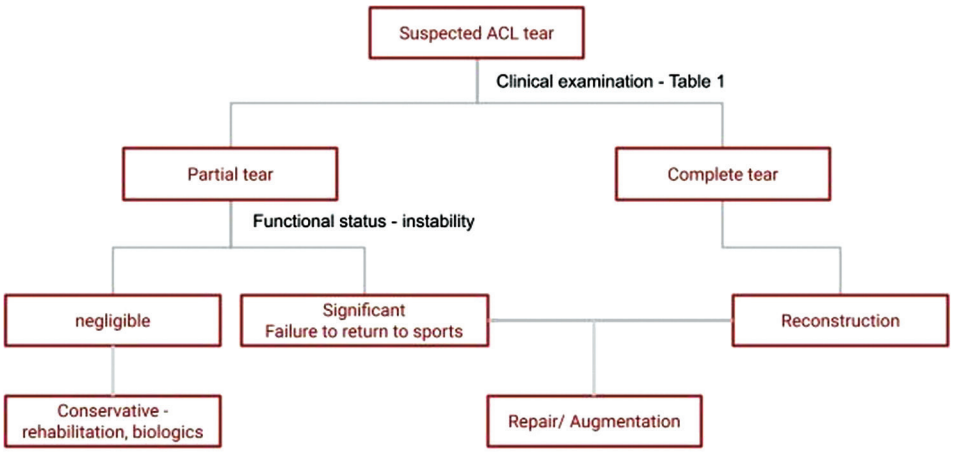

Figure 6: Algorithm for approaching a suspected case of partial ACL tear. ACL: Anterior cruciate ligament

References

1. Amis AA, Dawkins GP. Functional anatomy of the anterior cruciate ligament. Fibre bundle actions related to ligament replacements and injuries. J Bone Joint Surg Br 1991;73:260-7.
2. Petersen W, Zantop T. Anatomy of the anterior cruciate ligament with regard to its two bundles. Clin Orthop Relat Res 2007;454:35-47.
3. Colombet P, Dejour D, Panisset JC, Siebold R, French Arthroscopy Society. Current concept of partial anterior cruciate ligament ruptures. Orthop Traumatol Surg Res 2010;96:S109-18.
4. Liao W, Zhang Q. Arthroscopic primary repair for partial proximal anterior cruciate ligament tear in military personnel. Clin J Sport Med 2021;31:e258-64.
5. Wei Y, Yun X, Liu Y, Wei M. [Effectiveness of partial anterior cruciate ligament suture repair with wide awake local anesthesia no tourniquet technique]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2021;35:337-42. Chinese. doi: 10.7507/1002-1892.202008127.
6. Girgis FG, Marshall JL, Monajem A. The cruciate ligaments of the knee joint. Anatomical, functional and experimental analysis. Clin Orthop Relat Res 1975;(106):216-31. doi: 10.1097/00003086-197501000-00033.
7. Arnoczky SP. Anatomy of the anterior cruciate ligament. Clin Orthop Relat Res. 1983;(172):19-25.
8. Scapinelli R. Vascular anatomy of the human cruciate ligaments and

surrounding structures. Clin Anat 1997;10:151-62.
9. Petersen W, Tillmann B. Structure and vascularization of the cruciate ligaments of the human knee joint. Anat Embryol (Berl) 1999;200:325-34.
10. Kennedy JC, Weinberg HW, Wilson AS. The anatomy and function of the anterior cruciate ligament. As determined by clinical and morphological studies. J Bone Joint Surg Am 1974;56:223-35.
11. Haus J, Halata Z. Innervation of the anterior cruciate ligament. Int Orthop 1990;14:293-6.
12. Zimny ML, Schutte M, Dabezies E. Mechanoreceptors in the human anterior cruciate ligament. Anat Rec 1986;214:204-9.
13. Butler DL, Noyes FR, Grood ES. Ligamentous restraints to anterior-posterior drawer in the human knee. A biomechanical study. J Bone Joint Surg Am 1980;62:259-70.
14. Gabriel MT, Wong EK, Woo SL, Yagi M, Debski RE. Distribution of *in situ* forces in the anterior cruciate ligament in response to rotatory loads. J Orthop Res 2004;22:85-9.
15. Yagi M, Wong EK, Kanamori A, Debski RE, Fu FH, Woo SL. Biomechanical analysis of an anatomic anterior cruciate ligament reconstruction. Am J Sports Med 2002;30:660-6.
16. Zantop T, Petersen W, Sekiya JK, Musahl V, Fu FH. Anterior cruciate ligament anatomy and function relating to anatomical reconstruction. Knee Surg Sports Traumatol Arthrosc 2006;14:982-92.
17. Sonnery-Cottet B, Chambat P. Arthroscopic identification of the anterior cruciate ligament posterolateral bundle: The figure-of-four position. Arthroscopy 2007;23:**1128.e1-3**.
18. Panisset JC, Duraffour H, Vasconcelos W, Colombet P, Javois C, Potel JF, *et al*. Clinical, radiological and arthroscopic analysis of the ACL tear. A prospective study of 418 cases. Rev Chir Orthop Reparatrice Appar Mot 2008;94:362-8.
19. Dejour D, Ntagiopoulos PG, Saggin PR, Panisset JC. The diagnostic value of clinical tests, magnetic resonance imaging, and instrumented laxity in the differentiation of complete versus partial anterior cruciate ligament tears. Arthroscopy 2013;29:491-9.
20. Sonnery-Cottet B, Barth J, Graveleau N, Fournier Y, Hager JP, Chambat P. Arthroscopic identification of isolated tear of the posterolateral bundle of the anterior cruciate ligament. Arthroscopy 2009;25:728-32.
21. Lelli A, Di Turi RP, Spenciner DB, Dòmini M. The "Lever Sign": A new clinical test for the diagnosis of anterior cruciate ligament rupture. Knee Surg Sports Traumatol Arthrosc 2016;24:2794-7.
22. Jarbo KA, Hartigan DE, Scott KL, Patel KA, Chhabra A. Accuracy of the lever sign test in the diagnosis of anterior cruciate ligament injuries. Orthop J Sports Med 2017;5:2325967117729809.
23. Siebold R, Fu FH. Assessment and augmentation of symptomatic anteromedial or posterolateral bundle tears of the anterior cruciate ligament. Arthroscopy 2008;24:1289-98.
24. Guenther D, Zhang C, Ferlin F, Vernacchia C, Musahl V, Irrgang JJ, *et al*. Clinical examination of partial ruptures of the anterior cruciate ligament: A retrospective case-control study. Knee 2020;27:1866-73.
25. Vincken PW, ter Braak BP, van Erkell AR, de Rooy TP, Mallens WM, Post W, *et al*. Effectiveness of MR imaging in selection of patients for arthroscopy of the knee. Radiology 2002;223:739-46.
26. Roychowdhury S, Fitzgerald SW, Sonin AH, Peduto AJ, Miller FH, Hoff FL. Using MR imaging to diagnose partial tears of the anterior cruciate ligament: Value of axial images. AJR Am J Roentgenol 1997;168:1487-91.
27. Volokhina YV, Syed HM, Pham PH, Blackburn AK. Two helpful MRI signs for evaluation of posterolateral bundle tears of the anterior cruciate ligament: A pilot study. Orthop J Sports Med 2015;3:2325967115597641.
28. Nenezic D, Kocijancic I. The value of the sagittal-oblique MRI technique for injuries of the anterior cruciate ligament in the knee. Radiol Oncol 2013;47:19-25.
29. Kosaka M, Nakase J, Toratani T, Ohashi Y, Kitaoka K, Yamada H, *et al*. Oblique coronal and oblique sagittal MRI for diagnosis of anterior cruciate ligament tears and evaluation of anterior cruciate ligament remnant tissue. Knee 2014;21:54-7.
30. Ghasem Hanafi M, Momen Gharibvand M, Jaffari Gharibvand R, Sadoni H. Diagnostic value of oblique coronal and oblique sagittal magnetic resonance imaging (MRI) in diagnosis of anterior cruciate ligament (ACL) tears. J Med Life 2018;11:281-5.
31. Kwon JW, Yoon YC, Kim YN, Ahn JH, Choe BK. Which oblique plane is more helpful in diagnosing an anterior cruciate ligament tear? Clin Radiol 2009;64:291-7.
32. Fayard JM, Sonnery-Cottet B, Vrgoc G, O'Loughlin P, de Mont Marin GD, Freychet B, *et al*. Incidence and risk factors for a partial anterior cruciate ligament tear progressing to a complete tear after nonoperative treatment in patients younger than 30 years. Orthop J Sports Med 2019;7:2325967119856624.
33. McDaniel WJ. Isolated partial tear of the anterior cruciate ligament. Clin Orthop Relat Res. 1976;(115):209-12.
34. Odensten M, Lysholm J, Gillquist J. The course of partial anterior cruciate ligament ruptures. Am J Sports Med 1985;13:183-6.
35. Kannus P, Järvinen M. Conservatively treated tears of the anterior cruciate ligament. Long-term results. J Bone Joint Surg Am 1987;69:1007-12.
36. Bak K, Scavenius M, Hansen S, Nørring K, Jensen KH, Jørgensen U. Isolated partial rupture of the anterior cruciate ligament. Long-term follow-up of 56 cases. Knee Surg Sports Traumatol Arthrosc 1997;5:66-71.
37. Barrack RL, Buckley SL, Bruckner JD, Kneisl JS, Alexander AH. Partial versus complete acute anterior cruciate ligament tears. The results of nonoperative treatment. J Bone Joint Surg Br 1990;72:622-4.
38. Noyes FR, Mooar LA, Moorman CT 3rd, McGinniss GH. Partial tears of the anterior cruciate ligament. Progression to complete ligament deficiency. J Bone Joint Surg Br 1989;71:825-33.
39. Buckley SL, Barrack RL, Alexander AH. The natural history of conservatively treated partial anterior cruciate ligament tears. Am J Sports Med 1989;17:221-5.
40. Sommerlath K, Odensten M, Lysholm J. The late course of acute partial anterior cruciate ligament tears. A nine to 15-year follow-up evaluation. Clin Orthop Relat Res. 1992;(281):152-8.
41. Fruensgaard S, Johannsen HV. Incomplete ruptures of the anterior cruciate ligament. J Bone Joint Surg Br 1989;71:526-30.
42. Kennedy JC, Alexander IJ, Hayes KC. Nerve supply of the human knee and its functional importance. Am J Sports Med 1982;10:329-35.
43. Rao AJ, Cvetanovich GL, Zuke WA, Go B, Forsythe B. Single-bundle augmentation for a partial tear of the anterior cruciate ligament. Arthrosc Tech 2017;6:e853-7.
44. Seijas R, Ares O, Cuscó X, Alvarez P, Steinbacher G, Cugat R. Partial anterior cruciate ligament tears treated with intraligamentary plasma rich in growth factors. World J Orthop 2014;5:373-8.
45. Koch M, Matteo BD, Eichhorn J, Zellner J, Mayr F, Krutsch W, *et al*. Intra-ligamentary autologous conditioned plasma and healing response to treat partial ACL ruptures. Arch Orthop Trauma Surg 2018;138:675-83.
46. Zicaro JP, Garcia-Mansilla I, Zuain A, Yacuzzi C, Costa-Paz M. Has platelet-rich plasma any role in partial tears of the anterior cruciate ligament? Prospective comparative study. World J Orthop 2021;12:423-32.
47. Dodds JA, Arnoczky SP. Anatomy of the anterior cruciate ligament: A blueprint for repair and reconstruction. Arthroscopy 1994;10:132-9.
48. Georgoulis AD, Pappa L, Moebius U, Malamou-Mitsi V, Pappa S, Papageorgiou CO, *et al*. The presence of proprioceptive mechanoreceptors in the remnants of the ruptured ACL as a possible source of re-innervation of the ACL autograft. Knee Surg Sports Traumatol Arthrosc 2001;9:364-8.
49. Crain EH, Fithian DC, Paxton EW, Luetzow WF. Variation in anterior cruciate ligament scar pattern: Does the scar pattern affect anterior laxity in anterior cruciate ligament-deficient knees? Arthroscopy 2005;21:19-24.
50. Sabat D, Kumar V. Partial tears of anterior cruciate ligament: Results of single bundle augmentation. Indian J Orthop 2015;49:129-35.
51. Abat F, Gelber PE, Erquicia JI, Pelfort X, Tey M, Monllau JC. Promising short-term results following selective bundle reconstruction in partial anterior cruciate ligament tears. Knee 2013;20:332-8.
52. Sonnery-Cottet B, Lavoie F, Ogassawara R, Scussiato RG, Kidder JF, Chambat P. Selective anteromedial bundle reconstruction in partial ACL tears: A series of 36 patients with mean 24 months follow-up. Knee Surg Sports Traumatol Arthrosc 2010;18:47-51.
53. Carulli C, Innocenti M, Roselli G, Sirleo L, Matassi F, Innocenti M. Partial rupture of anterior cruciate ligament: Preliminary experience of

selective reconstruction. J Orthop Traumatol 2020;21:5.
54. Yazdi H, Torkaman A, Ghahramani M, Moradi A, Nazarian A, Ghorbanhoseini M. Short term results of anterior cruciate ligament augmentation in professional and amateur athletes. J Orthop Traumatol 2017;18:171-6.
55. Ochi M, Adachi N, Deie M, Kanaya A. Anterior cruciate ligament augmentation procedure with a 1-incision technique: Anteromedial bundle or posterolateral bundle reconstruction. Arthroscopy 2006;22:**463.e1-5**.
56. Matsushita T, Kuroda R, Nishizawa Y, Araki D, Hoshino Y, Nagai K, *et al.* Clinical outcomes and biomechanical analysis of posterolateral bundle augmentation in patients with partial anterior cruciate ligament tears. Knee Surg Sports Traumatol Arthrosc 2017;25:1279-89.
57. Sonnery-Cottet B, Zayni R, Conteduca J, Archbold P, Prost T, Carrillon Y, *et al.* Posterolateral bundle reconstruction with anteromedial bundle remnant preservation in ACL tears: Clinical and MRI evaluation of 39 patients with 24-month follow-up. Orthop J Sports Med 2013;1. doi: 10.1177/2325967113501624.
58. Perelli S, Ibañez F, Gelber PE, Erquicia JI, Pelfort X, Monllau JC. Selective bundle reconstruction in partial ACL tears leads to excellent long-term functional outcomes and a low percentage of failures. Knee 2019;26:1262-70.
59. Sonnery-Cottet B, Panisset JC, Colombet P, Cucurulo T, Graveleau N, Hulet C, *et al.* Partial ACL reconstruction with preservation of the posterolateral bundle. Orthop Traumatol Surg Res 2012;98:S165-70.
60. Buda R, Baldassarri M, Perazzo L, Ghinelli D, Faldini C. The biological respect of the posterolateral bundle in ACL partial injuries. Retrospective analysis of 2 different surgical management of ACL partial tear in a population of high-demanding sport patients. Eur J Orthop Surg Traumatol 2019;29:651-8.
61. Ochi M, Adachi N, Uchio Y, Deie M, Kumahashi N, Ishikawa M, *et al*. A minimum 2-year follow-up after selective anteromedial or posterolateral bundle anterior cruciate ligament reconstruction. Arthroscopy 2009;25:117-22.
62. Buda R, Ferruzzi A, Vannini F, Zambelli L, Di Caprio F. Augmentation technique with semitendinosus and gracilis tendons in chronic partial lesions of the ACL: Clinical and arthrometric analysis. Knee Surg Sports Traumatol Arthrosc 2006;14:1101-7.
63. Yadav S, Singh S. Analysis of partial bundle anterior cruciate ligament tears- diagnosis and management with ACL augmentation. J Clin Orthop Trauma 2020;11:S337-41.
64. Pujol N, Colombet P, Potel JF, Cucurulo T, Graveleau N, Hulet C, *et al.* Anterior cruciate ligament reconstruction in partial tear: Selective anteromedial bundle reconstruction conserving the posterolateral remnant versus single-bundle anatomic ACL reconstruction: Preliminary 1-year results of a prospective randomized study. Orthop Traumatol Surg Res 2012;98:S171-7.
65. Chia ZY, Chee JN, Bin-Abd-Razak HR, Lie DT, Chang PC. A comparative study of anterior cruciate ligament reconstruction with double, single, or selective bundle techniques. J Orthop Surg (Hong Kong) 2018;26:2309499018773124.
66. Park SY, Oh H, Park SW, Lee JH, Lee SH, Yoon KH. Clinical outcomes of remnant-preserving augmentation versus double-bundle reconstruction in the anterior cruciate ligament reconstruction. Arthroscopy 2012;28:1833-41.
67. van der List JP, DiFelice GS. Role of tear location on outcomes of open primary repair of the anterior cruciate ligament: A systematic review of historical studies. Knee 2017;24:898-908.
68. Gobbi A, Whyte GP. Long-term outcomes of primary repair of the anterior cruciate ligament combined with biologic healing augmentation to treat incomplete tears. Am J Sports Med 2018;46:3368-77.

Original Article

Transphyseal Anterior Cruciate Ligament Reconstruction in Adolescent Athletes Provides Good Functional Outcomes

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Abstract

Background: In adolescent athletes, the treatment of anterior cruciate ligament (ACL) tear is still a topic of debate. The present study aimed to evaluate the functional outcomes and complications of transphyseal ACL reconstruction (ACLR) in adolescent athletes. **Materials and Methods:** Thirty-four athletes who underwent transphyseal ACLR using a hamstring tendon graft participated in this study. Functional outcomes (Lysholm and Tegner activity score) and potential complications (graft rupture, angular deformity [AD], or limb length discrepancy) after transphyseal ACLR were assessed at the final follow-up. **Results:** The average age at the time of the surgery was 13.1 ± 0.8 years. Lysholm and Tegner activity score was 96.5 ± 5 and 8.1 ± 1.4, respectively, at a mean follow-up of 64.9 ± 23.9 months. 27/34 (79%) of patients returned to the same level of sports. The mean time to return to sports was 8.3 ± 1.5 months. Three patients had graft tears, and none of the patients had any deformity. **Conclusion:** Transphyseal ACLR is a safe procedure with good functional outcomes.

Level of Study: Level III.

Keywords: Graft rupture, growth disturbance, pediatric anterior cruciate ligament tear, return to sports, skeletally immature, transphyseal

Introduction

There is a surge in the incidence of sports injuries in the last two decades[1] due to the promotion of sports participation at school levels and awareness among parents regarding the importance of sports in the overall development of children. Anterior cruciate ligament (ACL) tear is a common sports injury among children. The incidence of pediatric ACL tear varies from 0.7 to 3.2 per 10,000 person-years.[1] Nearly 3% of overall ACL injuries occur in the pediatric age group.[2]

The ideal treatment of choice for a pediatric ACL tear is still a topic of debate as drilling through an open growth plate can cause growth disturbances.[3,4] Due to this concern, many authors advocate nonoperative treatment for pediatric ACL tears.[5,6] However, the reported results of nonoperative treatment in previous studies are variable with most of the studies reporting inferior results with the nonoperative treatment.[7-9]

Pediatric ACL injuries remain a major concern for parents also, number of questions arises in parents' mind after ACL tear-will child be able to grow normally after surgery? Will he/she be able to play sports again? Do they need to wait for child to attain full height before surgery? Therefore, a treating clinician needs to have answers to all these questions. The present study is an attempt to answer these questions by analyzing the functional outcomes and complications after surgical treatment of ACL tears. It was hypothesized that transphyseal ACL reconstruction (ACLR) with hamstring tendon graft (HT) results in satisfactory functional outcomes with minimal growth disturbance.

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Materials and Methods

This was a retrospective study conducted in the sports injury department of a tertiary hospital. Athletes of age 11–15 years having ACL tears were included in the study. Transphyseal ACLR was done using an HT graft in all the patients. A total of 38 athletes were operated from 2008 to 2017, out of these, we were not able to contact 4 patients and thus were excluded from the study. Skeletally mature patients or having multi-ligament injury (medial collateral ligament, lateral collateral ligament, or posterior cruciate ligament/posterolateral corner) were excluded from the study. Explained written consent was received from all the patient's parents. Data related to demographic details, Tanner staging, intraoperative findings (meniscal tear/chondral damage), type of graft, tunnel diameter, and type of sports were retrieved from the departmental medical reports. Chondral damage was graded according to Outerbridge classification. The Lysholm score and Tegner Activity Scale were used for the evaluation of functional outcomes at the final follow-up of a minimum of 3 years.

Patients-reported questionnaires, limb length measurement, and gait analysis were used to clinically assess the growth disturbances after ACLR. All patients were evaluated by two different observers for any deviation in the operated leg and limp while walking. Second, all patients were asked a series of questions in their vernacular language regarding functional outcomes and the deformity in the operated leg as compared to the normal leg [Table 1]. Outcomes were assessed by the senior research fellow.

In the present study, some modification of conventional arthroscopic ACLR was done to minimize the risk of growth damage. ACLR was done using preserved insertion technique, and no implant was used in the tibial tunnel.[10] To prevent thermal damage, the tunnel was drilled slowly and intermittently. To minimize the risk of growth plate damage, maximum graft diameter of 7.5 mm was used, and tunnels were reamed of the same size as of graft. Tibial zig was set at 65° instead of the conventional 55°.

Rehabilitation: Patients were made full-weight bearing in an unhinged knee brace on postoperative day (POD)-1. Meniscal repair patients were kept nonweight bearing for 6 weeks. From POD-1, active knee bending and closed-chain quadriceps strengthening exercises were initiated. Activities were advanced to include cycling and half squats at 6 weeks. Game-specific exercises were started at 3 months. From 5 months onward, friendly practice games were permitted. Limb symmetrical index (LSI) was calculated from 6 months onwards; return to sports (RTS) is only if LSI was more than 85%. If LSI was <85%, athletes were advised to continue physiotherapy. KT-1000, single hop test, and thigh circumference were used to calculate the LSI.

Statistical analysis

Discrete categorical data were presented as percentages (%), and continuous data were presented as mean ± standard deviation. Comparisons of continuous data (Tegner Activity Scale) were made using a student *t*-test. $P \leq 0.05$ was considered significant.

Results

Demographic details of patients are given in Table 2. The mean follow-up was 64.9 ± 23.9 (range = 38–144) months. 11/34 (32%) patients had no meniscal tear, 12/34 (35%) patients had lateral meniscus tear, 9/34 (26%) patients had medial meniscus tear, and 2/34 (6%) patients had both menisci tear. 13 patients underwent meniscal repair. 20/34 (59%) patients had normal condyle or grade 1 chondral damage, 11/34 (32%) had grade 2 chondral damage, and 3/34 (9%) patients had grade 3 chondral damage. The average tibial tunnel and femoral tunnel drilled were 7.2 ± 0.6 mm and 7.1 ± 0.6 mm (range: 6–8 mm). The average time interval between injury and surgery was 3.9 ± 2.4 months.

Most of the patients in this study were football players, followed by basketball players. Details of patients involved in various games and their incidence of RTS after surgery are given in Table 3. 27/34 (79%) patients returned to the same level of sports. The most common cause of not returning to sports was the prioritization of studies over sports, three patients did not RTS because of this reason [Table 4]. There was a significant improvement in mean KT-1000 at 12 months from preoperative value of 6.2 ± 1.6 mm to 0.9 ± 0.9 mm at 12-month follow-up ($P = 0.0001$).

The mean Lysholm score at the final follow-up was 96.5 [Table 5]. There was also no significant difference in mean Tegner activity score (range) at final follow-up as compared

Table 1: Performa of clinical evaluation of functional outcome and any growth disturbances

Questions	Response
Return to same level or higher level of sports	
If not, what is the cause of not returning to sports	Yes/no
If yes, at what time (months)	
Presence of any angular or cosmetic deformity in operated leg	Yes/no
Presence of any LLD	Yes/no
Development of any AD after surgery in operated leg	Yes/no
Presence of any limp	Yes/no

AD: Angular deformity, LLD: Limb length discrepancy

Table 2: Demographic and concomitant injuries details of the patients

Mean age±SD (range)	13.1±0.8 (11-15)
Gender (male: female)	25:9
Dominant: Nondominant	15:19
Median Tegner activity at the time of surgery	4 (3-5)
Meantime from injury to surgery (months)	3.9±2.4
Meniscus tear (%)	23/34 (67)
Chondral damage (Grade 2 or more) (%)	14/34 (41)

SD: Standard deviation

Table 3: Incidence of return to sports after anterior cruciate ligament reconstruction in different sports

Type of sports	Number of patients having ACL tear	RTS	Did not return to same level of sports	Did not RTS
Athletics	4	3	-	1
Basketball	6	5	-	1
Boxing	2	2	-	-
Football/soccer	11	9	1	1
Kabaddi	4	2	1	1
Combat sports	3	3	-	-
Tennis	2	2	-	-
Wrestling	2	1	-	1
Total	34	27	2	5

ACL: Anterior cruciate ligament, RTS: Return to sports

Table 4: Details of reasons why athletes did not return to sports

Unable to play the at same level	2
Financial issues	1
Left sports for higher studies	3
Fear of reinjury	1
Total unable to RTS	7

RTS: Return to sports

Table 5: Details of functional outcomes and complications at the final follow-up

Lysholm score (range)	96.5±5 (85-100)
Tegner activity (range)	8.1±1.4 (6-10)
RTS (%)	27/34 (79.4)
Meantime to RTS (months) (range)	8.3±1.5 (6-11)
AD	0
LLD	0
Graft rupture	3

AD: Angular deformity, LLD: Limb length discrepancy, RTS: Return to sports

to preinjury (preoperative 8.4 [6–10] vs. final follow-up 8.1 [6–10]; *P* = n. s). Three patients had graft rupture and one patient had an injury to the contralateral knee. All patients had attained skeletally maturity (X-rays) at the final follow-up. In the patient-reported questionnaire and clinical evaluation, no patient reported any angular deformity (AD) or limp in walking or running.

Discussion

In the present study, satisfactory results were observed with transphyseal ACLR in the pediatric age group with no AD or limb length discrepancy (LLD). Results are similar to previously published literature where satisfactory results were reported with transphyseal ACLR.[11-14] McCarthy and Harty[11] and Courvoisier *et al*.[12] reported excellent results with transphyseal ACLR without any AD or LLD.

A recent meta-analysis recommended early ACLR for better chances of RTS.[13] Early ACLR is recommended in children with ACL tears as the incidence of meniscal injuries was increased with delay in surgery[15] and with conservative treatment.[16] Fabricant *et al*. suggested early ACLR surgery in children, as the incidence of meniscal and chondral lesions was significantly high in patients who underwent delayed ACLR.[15]

Return to sports

In the present study, 79% (27/34) of patients returned to the same or higher level of sports. The average time to RTS was 8.3 months. Return to the same level of activity in children and adolescents varies from 41% to 100%.[17-19] Cohen *et al*. in their study reported that 89% of children were able to return to RTS after ACLR.[18] Previous studies reported that younger athletes have higher chances of RTS as compared to relatively senior athletes.[20] Fabricant *et al*. observed RTS was significantly higher with surgery as compared to conservative treatment in children and adolescents.[21]

In the present study, none of the patients had any LLD or AD. Most of the previous studies also suggested that transphyseal ACLR does not cause growth disturbances,[11,12,22] however, some studies reported AD in few patients.[14,23] Kocher *et al*. observed that none of the patients had any AD after transphyseal ACLR.[22] Kohl *et al*. observed that 1/15 of patients had AD although none of the patients had any LLD.[14] Yoo *et al*. in their magnetic resonance imaging-based study reported that nearly 11% of children who underwent transphyseal ACLR had focal physeal disruption without any clinical AD.[24]

In the present study, the mean tunnel diameter was 7.2 ± 0.6 mm. Previous animal experimental studies showed that a minimum of 7%–9% of growth plate damage by drilling causes growth disturbances.[25,26] Janarv *et al*. reported that transphyseal ACL tunnel takes up only 3%–4% of the total cross-sectional growth area.[25] Pananwala *et al*. observed that the use of 7 mm and 8 mm drill bits for the tibia caused 1.45% and 1.84% defects in the physeal area, respectively.[27] Beasley and Chudik and Stadelmaier *et al*. reported that the presence of soft-tissue grafts in the tunnel leads to fewer chances of growth disturbances.[28,29] In the present study, HT graft was used for ACLR in all the patients.

Graft rupture

Nine percentage (3/34) of patients reported graft failure in this study. The reported incidence of graft failure rate was 0%–24.5%.[22,30,31] Frosch *et al*. in their meta-analysis reported that the graft failure rate in children and adolescents was 4.8%.[31] Astur *et al*. observed that the incidence of graft rupture rate was significantly higher in patients aged <16 years (24.6%) as compared to patients aged >18 years (9.2%).[30]

This study had some limitations

(1) At the time of surgery, the remaining growth potential was not documented. (2) In this study, there is a lack of data on very young patients (<11 years), therefore, the results of

this study may not be validated for them. (3) Radiological investigation to detect AD or LLD is lacking. (4) the present study is a retrospective study.

Conclusion

Transphyseal ACLR shows satisfactory results in adolescent athletes.

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Conflicts of interest

There are no conflicts of interest.

References

1. Weitz FK, Sillanpää PJ, Mattila VM. The incidence of paediatric ACL injury is increasing in Finland. Knee Surg Sports Traumatol Arthrosc 2020;28:363-8.
2. Souryal TO, Freeman TR. Intercondylar notch size and anterior cruciate ligament injuries in athletes. A prospective study. Am J Sports Med 1993;21:535-9.
3. Kocher MS, Saxon HS, Hovis WD, Hawkins RJ. Management and complications of anterior cruciate ligament injuries in skeletally immature patients: Survey of the Herodicus Society and The ACL Study Group. J Pediatr Orthop 2002;22:452-7.
4. Shifflett GD, Green DW, Widmann RF, Marx RG. Growth arrest following ACL reconstruction with hamstring autograft in skeletally immature patients: A review of 4 cases. J Pediatr Orthop 2016;36:355-61.
5. Madelaine A, Fournier G, Sappey-Marinier E, Madelaine T, Seil R, Lefevre N, *et al.* Conservative management of anterior cruciate ligament injury in paediatric population: About 53 patients. Orthop Traumatol Surg Res 2018;104:S169-73.
6. Engebretsen L, Moksnes H. Conservative treatment of pediatric ACL injury. In: Controversies in the Technical Aspects of ACL Reconstruction. Springer; 2017. p. 55-60.
7. Pressman AE, Letts RM, Jarvis JG. Anterior cruciate ligament tears in children: An analysis of operative versus nonoperative treatment. J Pediatr Orthop 1997;17:505-11.
8. Henry J, Chotel F, Chouteau J, Fessy MH, Bérard J, Moyen B. Rupture of the anterior cruciate ligament in children: Early reconstruction with open physes or delayed reconstruction to skeletal maturity? Knee Surg Sports Traumatol Arthrosc 2009;17:748-55.
9. Vavken P, Murray MM. Treating anterior cruciate ligament tears in skeletally immature patients. Arthroscopy 2011;27:704-16.
10. Gupta R, Kapoor A, Soni A, Khatri S, Masih GD, Raghav M. No difference in outcome of anterior cruciate ligament reconstruction with "bone-patellar tendon-bone versus semitendinosus-gracilis graft with preserved insertion": A randomized clinical trial. Indian J Orthop 2020;54:665-71.
11. McCarthy CJ, Harty JA. Follow-up study on transphyseal ACL reconstruction in Irish adolescents with no cases of leg length discrepancy or angular deformity. Ir J Med Sci 2020;189:1323-9.
12. Courvoisier A, Grimaldi M, Plaweski S. Good surgical outcome of transphyseal ACL reconstruction in skeletally immature patients using four-strand hamstring graft. Knee Surg Sports Traumatol Arthrosc 2011;19:588-91.
13. Smith ID, Irfan A, Huntley JS, Spencer SJ. What is the best treatment for a child with an acute tear of the anterior cruciate ligament? J Paediatr Child Health 2018;54:1037-41.
14. Kohl S, Stutz C, Decker S, Ziebarth K, Slongo T, Ahmad SS, *et al.* Mid-term results of transphyseal anterior cruciate ligament reconstruction in children and adolescents. Knee 2014;21:80-5.
15. Fabricant PD, Lakomkin N, Cruz AI Jr., Spitzer E, Lawrence JT, Marx RG. Early ACL reconstruction in children leads to less meniscal and articular cartilage damage when compared with conservative or delayed treatment. J ISAKOS 2016;1:10-5.
16. Raad M, Thevenin Lemoine C, Bérard E, Laumonerie P, Sales de Gauzy J, Accadbled F. Delayed reconstruction and high BMI z score increase the risk of meniscal tear in paediatric and adolescent anterior cruciate ligament injury. Knee Surg Sports Traumatol Arthrosc 2019;27:905-11.
17. Hui C, Roe J, Ferguson D, Waller A, Salmon L, Pinczewski L. Outcome of anatomic transphyseal anterior cruciate ligament reconstruction in Tanner stage 1 and 2 patients with open physes. Am J Sports Med 2012;40:1093-8.
18. Cohen M, Ferretti M, Quarteiro M, Marcondes FB, de Hollanda JP, Amaro JT, *et al.* Transphyseal anterior cruciate ligament reconstruction in patients with open physes. Arthroscopy 2009;25:831-8.
19. Schmale GA, Kweon C, Larson RV, Bompadre V. High satisfaction yet decreased activity 4 years after transphyseal ACL reconstruction. Clin Orthop Relat Res 2014;472:2168-74.
20. Gupta R, Kapoor A, Soni A, Khatri S, Masih GD. Anterior cruciate ligament reconstruction with bone-patellar tendon-bone graft is associated with higher and earlier return to sports as compared to hamstring tendon graft. Knee Surg Sports Traumatol Arthrosc 2020;28:3659-65.
21. Fabricant PD, Lakomkin N, Cruz AI Jr., Spitzer E, Marx RG. ACL reconstruction in youth athletes results in an improved rate of return to athletic activity when compared with non-operative treatment: A systematic review of the literature. J ISAKOS 2016;1:62-9.
22. Kocher MS, Smith JT, Zoric BJ, Lee B, Micheli LJ. Transphyseal anterior cruciate ligament reconstruction in skeletally immature pubescent adolescents. J Bone Joint Surg Am 2007;89:2632-9.
23. Kumar S, Ahearne D, Hunt DM. Transphyseal anterior cruciate ligament reconstruction in the skeletally immature: Follow-up to a minimum of sixteen years of age. J Bone Joint Surg Am 2013;95:e1.
24. Yoo WJ, Kocher MS, Micheli LJ. Growth plate disturbance after transphyseal reconstruction of the anterior cruciate ligament in skeletally immature adolescent patients: An MR imaging study. J Pediatr Orthop 2011;31:691-6.
25. Janarv PM, Nyström A, Werner S, Hirsch G. Anterior cruciate ligament injuries in skeletally immature patients. J Pediatr Orthop 1996;16:673-7.
26. Mäkelä EA, Vainionpää S, Vihtonen K, Mero M, Rokkanen P. The effect of trauma to the lower femoral epiphyseal plate. An experimental study in rabbits. J Bone Joint Surg Br 1988;70:187-91.
27. Pananwala H, Jabbar Y, Mills L, Symes M, Nandapalan H, Sefton A, *et al.* Tibial tunnel defect size as a risk factor in growth arrest following paediatric transphyseal anterior cruciate ligament reconstruction: An anatomical study. ANZ J Surg 2016;86:691-5.
28. Beasley LS, Chudik SC. Anterior cruciate ligament injury in children: Update of current treatment options. Curr Opin Pediatr 2003;15:45-52.
29. Stadelmaier DM, Arnoczky SP, Dodds J, Ross H. The effect of drilling and soft tissue grafting across open growth plates. A histologic study. Am J Sports Med 1995;23:431-5.
30. Astur DC, Cachoeira CM, da Silva Vieira T, Debieux P, Kaleka CC, Cohen M. Increased incidence of anterior cruciate ligament revision surgery in paediatric verses adult population. Knee Surg Sports Traumatol Arthrosc 2018;26:1362-6.
31. Frosch KH, Stengel D, Brodhun T, Stietencron I, Holsten D, Jung C, *et al.* Outcomes and risks of operative treatment of rupture of the anterior cruciate ligament in children and adolescents. Arthroscopy 2010;26:1539-50.

Original Article

Complications of the Open Latarjet Procedure are not Related to the Learning Curve: Analysis after 11 Years of Experience

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Abstract

Introduction: The purpose of this study is to determine a relationship between complications of the open Latarjet procedure with the surgeon's learning curve during an 11-year experience in shoulder surgery. **Methods:** We conducted a retrospective descriptive observational case series of all open Latarjet procedures performed by a single shoulder surgeon between June 2011 and September 2021. Latarjet procedure was indicated in patients with glenoid bone defects of more than 15% or revision after a failed Bankart repair. Complications were recorded as well as patients' demographic data. We described the time between surgery and complication and correlated complication presentation with the surgeon's surgical curve. **Results:** Sixty-two consecutive patients were included (96, 8% male patients with an average age of 30 years). Eight patients presented with a complication (12, 5% of all patients). These complications were classified as graft related (n = 3), hardware related (n = 3), wound related (n = 1), and other (n = 1). There were no instability recurrences and no neurologic injuries. Complications were present in all periods of the surgeon's learning curve. **Conclusions:** The Latarjet procedure is technically demanding and complications can be present regardless of the surgeon's learning curve. Nevertheless, it is a successful procedure in most patients, with a low recurrence rate of instability.

Keywords: Complications, coracoid transfer, Latarjet procedure, learning curve, shoulder instability

Introduction

The Latarjet procedure is a surgical alternative in patients with anterior glenohumeral instability and risk factors for failure of soft-tissue procedures. The technique consists of a bone transfer of the coracoid process that aims to achieve 3 main effects. These are the conjoint tendon "sling" effect, the bone block effect, and the Bankart effect.[1,2] Although it has demonstrated satisfactory outcomes and low recurrence rates, it is a technically demanding procedure and complications are not uncommon.[3,4]

The "learning curve" is a concept that was initially described in the manufacturing industry and the last 30 years has been applied to the field of surgery.[5] It states the time or number of cases necessary for a surgeon to perform a procedure independently. The learning curve can be measured in terms of task efficiency (such as operative time) or patient outcomes.[5] Understanding surgical curves for a specific procedure can improve both mentoring processes for trainees and improve patient safety.

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Currently, the evidence regarding learning curves in the Latarjet procedure is focused mainly on the arthroscopic Latarjet, nevertheless, open Latarjet procedure is still performed frequently by shoulder surgeons around the world.[6,7] To the best of our knowledge to date, only one study has described the learning curve of open Latarjet, but the main outcome was surgical time, which might not necessarily correlate with patient outcomes.[3] To date, there is no study that describes outcomes and complications of the Latarjet procedure in Latin America.

The purpose of this study was to describe the main complications of the open Latarjet procedure by a single

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surgeon and their relationship to the surgeon's learning curve. We hypothesized that graft and hardware-related complications tend to decrease while other types of complications remain unchanged.

Methods

We conducted a retrospective descriptive observational case series, reviewing medical records of all consecutive open Latarjet procedures performed by a single shoulder fellowship-trained surgeon (senior author). The study was carried out in a private institution and was approved by the institutional review board. The open Latarjet procedure was indicated in the setting of anterior glenohumeral instability with glenoid of bone loss of more than 15%, revision of a previous failed Bankart repair, and patient risk factors such as the practice of collision sports. Patients with neuromuscular pathologies were excluded. Informed consent was obtained from all enrolled patients. The main objective of this study was to determine the frequency of complications of open Latarjet procedure performed by the same shoulder surgeon and characterize the type of complications throughout the surgeon's surgical curve.

Surgical technique

The Latarjet procedure was performed in all patients by the senior author, by a technique that has been previously described.[2,8] With the patient under general anesthesia and regional block, using a pad under the scapula, a 5 cm incision is made starting at the tip of the coracoid distally. The deltopectoral interval is developed and the coracoid process is exposed, freeing the coracoacromial ligament laterally, leaving a 5 mm stump for capsular repair, and the pectoralis minor medially. Protecting with retractors the neurovascular structures, the osteotomy is performed with a 90° oscillating saw blade anterior to the coracoclavicular ligaments, measuring a graft length with a sterile ruler to be from 22 to 27 mm from the tip. The coracoid graft is then prepared by decorticating the inferior aspect of the coracoid using the saw blade and a high-speed burr. Two bicortical pilot holes are drilled in the long axis of the graft using a 3.75 mm parallel drill guide. Then, the subscapularis is split horizontally at the junction between the middle and inferior thirds. In the initial cases (first 8 years of the surgeon's curve) a vertical capsulotomy was performed. The surgeon modified the technique in 2018 to perform a horizontal capsulotomy, as described by Landreau, to allow a simpler capsular shift without overtightening the capsule during closure.[9] Glenoid exposure is completed using Hohmann retractors and a Steinmann pin superiorly. The anterior surface of the glenoid is prepared with a burr to optimize graft healing. The graft if then retrieved and placed flush with the glenoid surface, and secured with two 4.0 mm cannulated screws, using a washer only in the inferior screw. After verifying hemostasis the capsule is repaired with nonabsorbable sutures. An immobilized in a neutral position is used for 3 weeks. After the first 2 weeks, passive and scapular exercises are initiated under supervision by a shoulder-specialized physical therapist. Active range of motion is started at 6 weeks. Strengthening exercises begin after the patient has gained a full range of motion, usually by week 12. Return to sport is allowed at 6 months postoperatively, once the patient has gained full range of motion and strength.

Statistical analysis

For qualitative data, absolute and relative frequencies were described and for quantitative data median and range were used. The complications were classified as recurrence of instability, wound complications, neurologic complications, graft complications, hardware complications, and others such as venous thrombosis and hemorrhagic complications. We also described the time elapsed between surgery and complications. In addition, we correlated complication rates with the surgeon's surgical curve.

Results

Patients included underwent open Latarjet procedure between 2011 and 2021, performed by the same shoulder surgeon, with nine previous years of experience as a senior shoulder surgeon but no open Latarjet cases as an independent surgeon previously. A total of 62 patients were included in this case series. The majority of our patients were male with a median of 30 years of age. The majority of patients underwent open Latarjet during in the 4th year of the surgeon's learning curve and the patients were followed up till the first of March of 2022. Follow-up time was from 130 months to minimum of 7 months, with a mean follow-up time of 68.30 months [Table 1].

In the follow-up time of the whole cohort, a total of 8 patients presented a complication (12, 9% of all patients) [Table 2]. Of these, 3 (37, 5%) were graft-related, corresponding to graft fracture, and 3 (37, 5%) were hardware related. Graft-related complications occurred between 3 and 8 weeks postoperatory and in the 1st, 2nd and 10th year of the surgeon's learning curve. Two of these patients presented fractures during follow-up without having trauma or dislocations while the third patient presented graft fracture after a seizure [Figure 1]. In addition, all of these patients underwent fibrous nonunion of the fracture and none of them required a new surgical intervention or presented recurrent instability or dislocations. Hardware-related complications occurred between the second and the 6th year of the surgeon's learning curve. Two patients reported discomfort related to the screws, which underwent implant removal, with a complete improvement of the symptoms. The other patient had a high-energy motor vehicle accident 7 months after the

Table 1: Patient baseline characteristics

Variable	Results
Total patients	62
Male, *n* (%)	60 (96.8)
Median age, years (range)	30 (16–59)
Median follow-up, months (SD)	68.30 (±34.8)

SD: Standard deviation

procedure; presenting with bending of the screws, but without symptoms to require reoperation [Figure 2]. Complications occurred 22, 18, and 7 months after the surgery, respectively. There was one superficial wound infection (12.5% of total complications), that occurred in the last year of the surgeon's curve, that resolved with oral antibiotics. Finally, during the 7th year of the surgeon's learning curve, one patient had a hematoma that required immediate reintervention for cauterization and drainage on the same day of the open Latarjet procedure [Figure 3]. Overall, there were no recurrences or instability episodes, and no neurologic complications in any patient.

Regarding the relationship of surgical complications with the surgeon's learning curve, we found that the complications did not become less frequent as the surgeon gained experience. Regardless of the moment of the learning curve, all types of complications are presented. During the 1st year of the surgeon's curve 100% of the procedures presented complications, in the 2nd and 4th years 16.7% of the procedures presented complications, in the 6th year 33.3% of the procedures presented complications, in the 8th year 11.1% presented complications, in the 10th year 25% of the procedures presented complications and in the 11th year 20% of the procedures presented complications [Figure 4].

Discussion

The main finding of our study is when performing an open Latarjet procedure complications may occur regardless of the surgeon's learning curve period or overall experience. Nevertheless, these occur in 12% of cases, with most of the patients presenting a satisfactory outcome and no recurrence of instability. To be noted, in our setting the Latarjet procedure is indicated in the setting of a critical glenoid bone defect of a revision of a previous failed Bankart repair. Although graft problems are the most frequent complication, they do not imply subsequent instability or require revision surgeries.

Table 2: Total complications by type

Type of complication	*n* (%)
Total complications	8 (100)
Graft-related complications	3 (37.5)
Graft fracture	3 (37.5)
Graft resorption	0
Hardware-related complications	3 (37.5)
Discomfort	2 (25)
Screw bending	1 (12.5)
Wound related complications	1 (12.5)
Superficial infection	1 (12.5)
Deep infection	0
Wound dehiscence	0
Neurologic complications	0
Recurrence of instability	0
Other	1 (12.5)
Hematoma	1 (12.5)
Stiffness	0
Venous thrombus	0

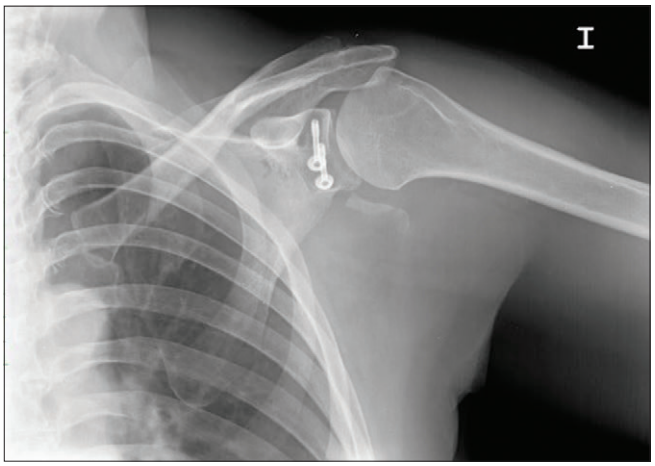


Figure 1: Coracoid bone graft fracture after a seizure in a patient with epilepsy 8 months after surgery

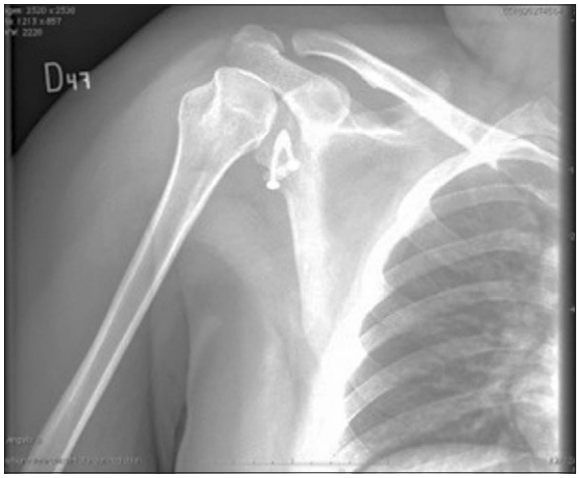
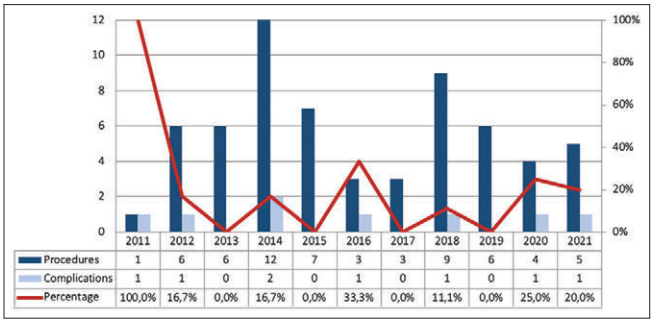


Figure 2: Screw breakage in one of the patients, 7 months after the Latarjet procedure during a motor vehicle accident

Figure 3: Progressively enlarging hematoma after open Latarjet procedure due to a small arterial bleeding from a vessel adjacent to the medial capsule



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Procedures	1	6	6	12	7	3	3	9	6	4	5
Complications	1	1	0	2	0	1	0	1	0	1	1
Percentage	100,0%	16,7%	0,0%	16,7%	0,0%	33,3%	0,0%	11,1%	0,0%	25,0%	20,0%

Figure 4: Eleven years of the surgeon's curve in open Latarjet procedure. Number of procedures per year, quantity of complications per year and percentage of complications related to quantity of procedures per year

Complications that require reoperations are frequently due to hardware-related discomfort, usually presenting in the 2nd year postoperatively, and symptoms resolve with screw removal. Although neurologic injuries are reported as a potential complication of the Latarjet procedure, there were no nerve injuries in our series.

Our study finds that the open Latarjet procedure, which is still considered the gold standard in patients with critical bone defects and risk factors for instability recurrence, is overall a safe procedure. Although in Shah *et al*., initial series of 45 patients complications reach up to 30%,[10] subsequent studies have shown that this rate may be lower.[11] Recently in the systematic review by Gilat *et al*., which analyzed outcomes of 1052 Latarjet surgeries in 15 studies, medium and long-term complications were 4%–3%, respectively.[12] Among these, the most frequent are hardware failure or removal, graft complications, and to a lesser extent, nerve injury. These results are similar to those reported in our study. Likewise, regarding early complications up to 90 days, Gartsman *et al*. and Frank *et al*. have found that these range from 5% to 7.5%, being the most frequent recurrence of instability, infection, and transient neurological injury.[13,14] Recently, Hendy *et al*. reported on early complications of 190 Latarjet procedures, with a rate of 9%, the most frequent being graft failure, which required either revision Latarjet, distal tibia allograft, or iliac crest autograft revisions.[15] The authors found that graft failure was associated with fixation using only 1 screw and an increased screw divergence angle.

Bone-block fracture was the most frequent complication in our patients. In all cases, they presented as a delayed complication. In line with previous studies, graft fractures or resorption did not require surgical intervention and were not associated with poor clinical outcomes or recurrence. According to the review by Domos and Walch, this can be minimized by preparing the graft with appropriately sized drills, drilling wide apart in the graft and tightening the screws with the "two finger" technique.[16] The only major complication in our series was a progressively enlarging hematoma which presented before patient discharge and required immediate revision for drainage and hemostasis of a small arterial vessel adjacent to the capsule. This ocurred in one of the first cases of the curve when the surgeon decided to modify his technique to perform the capsulotomy horizontaly to allow a more thurough and secure capsular plication, as described by Landreau.[9] Hematoma is an infrequent complication of the Latarjet procedure (1%–2%) which can be usually treated with cold packs and oral analgesia.[16]

Interestingly, there were not any nerve injuries in our series. Nerve injuries are the second most frequent complication of the Latarjet procedure in most series. Although they can be potentially devastating, in most studies usually neurologic deficit is transient and does not require surgical intervention.[9,10,12,13,15] Delaney *et al*. using intraoperative neuromonitoring found that the axillary and musculocutaneous nerves are most at risk during the procedure, particularly during glenoid exposure and graft insertion.[4] All patients with clinically detectable deficit resolved completely after 28–165 days postoperatively.

Recently, in the systematic review published by Ekhtiari *et al*., the authors found that after 22 open Latarjet and 20–40 arthroscopic procedures, surgeons achieve an adequate level of proficiency, measured in surgical time.[17] The authors emphasize that in most of these studies, the learning curve analysis takes surgical time as the outcome of interest. Although it is a relevant outcome measure, it does not necessarily represent patient outcomes or the success of the intervention. Moreover, the studies that address the arthroscopic Latarjet curve have been performed by surgeons with extensive experience in arthroscopic surgery, which limits the generalizability of these results to other shoulder surgeons. A total of 5 studies have described the learning curve of the Latarjet procedure. Of these only 1 has analyzed the learning curve of the open Latarjet procedure before. This is the study by Dauzère *et al*., which examines the results of the learning curve in 68 patients, a sample similar to the one of our studies.[3] They find that there is a negative correlation between the surgeon's experience and surgical complications, operative time, and length of hospital stay of the patients. However, the authors do not specify the number of cases necessary to demonstrate a reduction in such complications.

The limitations of the present study are inherent to its retrospective design, and all complications may not be noted and reported. We did not measure other variables which might relate to the learning curve such as operative time, hence the approach was focused only on clinical outcomes. On the other hand, the exposed surgical curve is limited to the experience of a single surgeon which may reduce the generalizability of the results. Patient-reported outcome measures and range of motion were not available in this retrospective review for analysis. Nerve injuries were not searched for specifically and may be unreported. This case series has a limited number of patients and more complications might be reported in higher volume settings. Statistical analysis was not possible given the homogeneity in the presentation of complications across the years on the surgeon's learning curve of Future studies

may compare complications and outcomes of arthroscopic and open approaches to the Latarjet procedure, assessing not only operative time but patient outcomes and complications. The strengths of the study are a long-term follow-up in a homogeneous cohort of patients, and to the best of our knowledge, it is the first study in Latin America to analyze the outcomes and learning curve of the open Latarjet.

Conclusions

The open Latarjet procedure is technically demanding and complications can be present regardless of the surgeon's learning curve. Nevertheless, it is an effective intervention to manage glenohumeral instability, with more than 87% of the patients presenting no complications. Graft-related complications usually do not require revision surgeries and hardware-related discomfort was the most frequent cause of reintervention in our cohort.

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Conflicts of interest

There are no conflicts of interest.

References

1. Yamamoto N, Muraki T, An KN, Sperling JW, Cofield RH, Itoi E, *et al.* The stabilizing mechanism of the Latarjet procedure: A cadaveric study. J Bone Joint Surg Am 2013;95:1390-7.
2. Bradley Edwards T, Walch G. The Latarjet procedure for recurrent anterior shoulder instability: Rationale and technique. Oper Tech Sports Med 2002;10:25-32.
3. Dauzère F, Faraud A, Lebon J, Faruch M, Mansat P, Bonnevialle N. Is the Latarjet procedure risky? Analysis of complications and learning curve. Knee Surg Sports Traumatol Arthrosc 2016;24:557-63.
4. Delaney RA, Freehill MT, Janfaza DR, Vlassakov KV, Higgins LD, Warner JJ. 2014 neer award paper: Neuromonitoring the Latarjet procedure. J Shoulder Elbow Surg 2014;23:1473-80.
5. Hopper AN, Jamison MH, Lewis WG. Learning curves in surgical practice. Postgrad Med J 2007;83:777-9.
6. Valsamis EM, Kany J, Bonnevialle N, Castricini R, Lädermann A, Cunningham G, *et al.* The arthroscopic Latarjet: A multisurgeon learning curve analysis. J Shoulder Elbow Surg 2020;29:681-8.
7. Leuzinger J, Brzoska R, Métais P, Clavert P, Nourissat G, Walch G, *et al.* Learning Curves in the arthroscopic latarjet procedure: A multicenter analysis of the first 25 cases of 5 international surgeons. Arthroscopy 2019;35:2304-11.
8. Bhatia S, Frank RM, Ghodadra NS, Hsu AR, Romeo AA, Bach BR Jr, *et al.* The outcomes and surgical techniques of the Latarjet procedure. Arthroscopy 2014;30:227-35.
9. Dines J, Dines D, Gulotta L. Shoulder Surgery: Tricks of the Trade. New York, NY: Thieme; 2019.
10. Shah AA, Butler RB, Romanowski J, Goel D, Karadagli D, Warner JJ. Short-term complications of the Latarjet procedure. J Bone Joint Surg Am 2012;94:495-501.
11. Hurley ET, Jamal MS, Ali ZS, Montgomery C, Pauzenberger L, Mullett H. Long-term outcomes of the Latarjet procedure for anterior shoulder instability: A systematic review of studies at 10-year follow-up. J Shoulder Elbow Surg 2019;28:e33-9.
12. Gilat R, Lavoie-Gagne O, Haunschild ED, Knapik DM, Parvaresh KC, Fu MC, *et al.* Outcomes of the Latarjet procedure with minimum 5– and 10-year follow-up: A systematic review. Shoulder Elbow 2020;12:315-29.
13. Gartsman GM, Waggenspack WN Jr, O'Connor DP, Elkousy HA, Edwards TB. Immediate and early complications of the open Latarjet procedure: A retrospective review of a large consecutive case series. J Shoulder Elbow Surg 2017;26:68-72.
14. Frank RM, Gregory B, O'Brien M, Bernardoni E, Verma NN, Cole BJ, *et al.* Ninety-day complications following the Latarjet procedure. J Shoulder Elbow Surg 2019;28:88-94.
15. Hendy BA, Padegimas EM, Kane L, Harper T, Abboud JA, Lazarus MD, *et al.* Early postoperative complications after Latarjet procedure: A single-institution experience over 10 years. J Shoulder Elbow Surg 2021;30:e300-8.
16. Domos P, Lunini E, Walch G. Contraindications and complications of the Latarjet procedure. Shoulder Elbow 2018;10:15-24.
17. Ekhtiari S, Horner NS, Bedi A, Ayeni OR, Khan M. The Learning Curve for the Latarjet Procedure: A Systematic Review. Orthop J Sports Med. 2018;6:2325967118786930. doi: 10.1177/2325967118786930.

Original Article

Does Acromioclavicular Joint Tenderness Affect the Outcome of Rotator Cuff Repair? A Prospective Cohort Study

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Abstract

Purpose: The purpose of this study was to assess the functional outcome of rotator cuff repair (RCR) without distal clavicle excision (DCE) in patients with degenerative rotator cuff tear and acromio-clavicular joint (ACJ) tenderness. **Methods:** A cohort of 70 patients undergoing arthroscopic RCR without DCE were prospectively evaluated. Parameters such as the presence of ACJ arthritis on imaging and long head of biceps tendon (LHBT) pathology (intra-operative) were recorded. The ACJ tenderness and clinical outcome scores including Oxford shoulder score and quick-disability of arm, and shoulder and hand score were evaluated preoperatively and at 1-year postoperatively. **Results:** Four patients were lost to follow up. Of remaining 66 patients, ACJ tenderness was found in 50% of the total study population. ACJ tenderness showed significant positive correlation with biceps tendinopathy ($R = 0.37$, $P = 0.002$). Postoperatively, there was significant improvement in clinical outcome scores which were comparable in patients with or without ACJ tenderness. Among patients with tender ACJ, the tenderness resolved completely in 78.7% of patients. **Conclusions:** ACJ tenderness did not adversely affect the outcome following RCR. Furthermore, the patients with ACJ tenderness have higher incidence of LHBT tendinopathy.

Keywords: Acromioclavicular joint arthritis, acromioclavicular joint tenderness, distal clavicle excision, re-tear, rotator cuff repair

Introduction

Distal clavicle excision (DCE) in the setting of rotator cuff repair (RCR) has been debated extensively in the literature. A number of studies have shown that DCE in patients undergoing RCR does not improve clinical outcomes following surgery.[1,2] A recent study suggested that routine DCE is not necessary even in patients with symptomatic acromioclavicular joint (ACJ) arthritis, with no statistically significant improvement in patient reported outcome measures.[3] In contrast, other studies have shown that DCE in addition to RCR leads to better clinical outcomes.[4-7] While these studies had small numbers with heterogeneous group of patients, a larger study of 184 patients found that not having DCE during RCR resulted in poor postoperative outcome measures in patients with rotator cuff tear (RCT) and ACJ arthritis.[8] However, DCE in conjunction with RCR has the disadvantages of higher surgical cost, lower postoperative outcome scores, pain, refractory symptomatic instability, and revision surgery.[9-11]

Clinically, the symptomatic ACJ is evaluated with tenderness on palpation and cross body adduction test. The ACJ tenderness is more sensitive (96%) indicator of symptomatic ACJ, but it has poor specificity.[12] In patients with RCT, it is used by the clinicians to explain the superior pain as well.[2,13] The DCE is performed during RCR as an adjunctive procedure for either radiological ACJ arthritis or clinical ACJ tenderness.[14]

The ACJ can be clinically asymptomatic despite exhibiting all the signs of arthritis. Choo *et al*.[15] found that over 50% of patients with radiological arthritis on magnetic resonance imaging (MRI) scan did not have pain or tenderness related to ACJ. Similarly, Shubin Stein *et al*.[16] found that 93% of asymptomatic individuals had radiological ACJ arthritis signs on MRI. However, the patients with degenerative RCT frequently have symptomatic ACJ irrespective of presence or

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absence of ACJ arthritis.[17] The cause of symptomatic ACJ in the absence of ACJ arthritis is not investigated yet. We believe that this tenderness may be attributed to long head of biceps tendon (LHBT) pathology where the compression or direct palpation of the ACJ can result in the pain in LHBT mimicking ACJ pain. Previous studies have shown that isolated LHBT tenotomy or tenodesis may improve clinical outcomes significantly in massive irreparable RCT.[18,19] In our practice, we do not perform DCE during RCR irrespective of presence of ACJ tenderness or ACJ arthritis.

The purpose of this study was to assess the functional outcome of RCR without DCE in patients with ACJ tenderness. We also aimed to evaluate the relationship of LHBT pathology with ACJ tenderness. The hypothesis of the study was that the patients with ACJ tenderness would have comparable clinical outcome to the patients without ACJ tenderness following RCR.

Methods

This was a prospective study conducted at a single institution between December 2018 and July 2019. All consecutive patients undergoing arthroscopic RCR were recruited. The inclusion criteria were symptomatic RCT having failed conservative treatment including physical therapy, nonsteroidal anti-inflammatory drugs, and/or steroid injections. The exclusion criteria were co-existing osteoarthritis or rotator cuff arthropathy, partial RCR, revision RCR, previous shoulder surgery or fractures, irreparable tears, inflammatory disease of the ipsilateral shoulder or ongoing insurance/compensation claims.

All the surgeries were performed arthroscopically in a lateral decubitus position by the senior author or his fellows with supervision. The RCR was performed using single or double row knotted suture anchors (4.5 mm Healicoil, Smith and Nephew, Andover, MA). Long head of biceps pathology (tendinopathy with tenosynovitis/increased vascularity/hypertrophy/fissures/partial tear; or instability due to ruptured pulley) was dealt with tenotomy or tenodesis (in young patients involved in manual work). Subscapularis tendon was repaired if a tear was noted. The subacromial decompression was performed routinely in all the patients. The ACJ was not excised in any of the patient.

Postoperatively, all the patients underwent uniform rehabilitation as per the established departmental protocols, which included 3 weeks of immobilization, with strengthening commencing at 3 months. The patients were reviewed in the clinic at 3, 6, and 12 months after surgery.

The ACJ tenderness by direct palpation over the ACJ was recorded preoperatively by a senior fellow. Based on ACJ tenderness, patients were divided into two groups: tender ACJ and nontender ACJ groups. The ACJ tenderness was assessed again at 12 months postsurgery by same observer.

The preoperative radiographs were reviewed for the signs of ACJ arthritis (joint space narrowing, osteophytes, and subchondral cyst). Based on radiological diagnosis of ACJ arthritis, patients were divided into two groups as well: arthritic and nonarthritic ACJ groups.

The intra-operative findings such as long head of biceps pathology (tendinopathy with tenosynovitis/increased vascularity/hypertrophy/fissures/partial tear; or instability due to ruptured pulley), subacromial impingement grades according to Copeland and Levy classification[20] and number of suture anchors used were recorded. The type of RCT was classified as per the Copeland and Levy classification.[20]

All patients were assessed using the Oxford shoulder score (OSS)[21] and Quick-Disability of arm, shoulder, and hand (qDASH) score[22] preoperatively and at 1 year postoperatively. Minimum clinically important difference (MCID) was defined as 6.0 for OSS and 16.3 for qDASH score.[23] The patients with improvement of less than MCID in any of the outcome scores were considered to have an unsatisfactory outcome.

All the surgeries were performed in a public health system; hence, routine postoperative evaluation with imaging was not obtained in all the patients. The ultrasound was offered to the patients postoperatively only if there was a concern regarding the integrity of the repair. The ultrasound was performed by a fellowship trained radiologist who was blinded to the study. The complications such as re-tear and revision surgery were also recorded. The outcome scores were measured before revision RCR in those patients who had developed re-tear following primary repair.

Statistical analysis

The statistical analysis was carried out using SPSS 22.0 (IBM Corp, Armonk, NY, USA). The continuous variables were presented as mean ± standard deviation and categorical values were presented as number or percentages. The two groups (tender and nontender ACJ) were compared using two-tailed paired/unpaired *t*-test for numerical variables and Chi-square/Fisher's exact test for categorical variables. The strength of association of the ACJ tenderness with biceps pathology and ACJ arthritis was evaluated using Spearman correlation test. The binary logistic regression analysis was undertaken to assess the predictive value of individual preoperative variables with the unsatisfactory outcome. Similarly, the statistical tests were used to compare the outcome between arthritic and nonarthritic groups. $P < 0.05$ was considered statistically significant.

Results

A total of 70 patients met the inclusion criteria and were recruited in the study. Four patients were lost to follow up, and therefore, excluded. A total of 66 patients were available for final analysis. The ACJ was found tender in 50% of the study population; hence, the two groups (tender and nontender ACJ groups) comprised of 33 patients in each group. The descriptive statistics are presented in Table 1. The two

groups were significantly different in terms of age, biceps tendinopathy, and impingement grades. The patients in tender ACJ group were significantly older than those in nontender ACJ group ($P < 0.05$).

The biceps tendinopathy was found more commonly in patients with tender ACJ than nontender ACJ (57.6% vs. 21.2%). The ACJ tenderness showed significant positive correlation with biceps tendinopathy ($P = 0.002$). There was no correlation between ACJ tenderness and biceps instability [Table 2].

In the study population, the radiographs were available in 55 patients for the evaluation of signs of ACJ arthritis. A total of 20 patients were noted to have ACJ arthritis. A greater proportion of patients in tender ACJ group were found to have ACJ arthritis in comparison to nontender ACJ group; however, the difference was not significant (48.1% vs. 25%, $P = 0.074$). In other words, while the ACJ tenderness was found in 13 out of 20 patients with ACJ arthritis, it was also noted in 14 out of 35 patients without ACJ arthritis. The correlation between ACJ tenderness and ACJ arthritis was not statistically significant [$P = 0.074$, Table 2].

The preoperative clinical outcome scores were inferior in tender ACJ group than in nontender ACJ group ($P = 0.003$ and 0.039 for OSS and qDASH, respectively). However, postoperatively, there was no statistically significant difference in the clinical outcome scores between the two groups. Both the groups had significant improvement in the outcome scores following surgery ($P < 0.001$). Based on MCID, satisfactory outcome was obtained in 81.8% and 78.8% of patients in tender and nontender ACJ groups; however, this difference was not statistically significant ($P = 0.756$). One patient in each group underwent revision RCR [Table 3].

The binary logistic regression analysis did not reveal a significant relationship of any of the preoperative variables with unsatisfactory outcome including ACJ tenderness (odd ratio 1.687, 95% confidence interval 0.263–10.828, $P = 0.582$) [Table 4].

The ultrasound was obtained to assess the integrity of the RCR in 10 patients who failed to show early improvement in symptoms following surgery. Three patients in each group were diagnosed to have developed re-tear. One patient in each group (3%) underwent revision RCR. One patient in nontender ACJ group underwent an arthroscopic capsular release for postoperative stiffness. There were no other complications.

In tender ACJ group, the tenderness resolved completely in 26 (78.7%) patients. However, seven (21.2%) patients reported residual tenderness at the final follow-up, of which none of the patients required revision surgery for ACJ tenderness. The ACJ remained nontender in all patients in nontender ACJ group.

On comparing the patients with arthritic and nonarthritic ACJ, the outcome scores improved significantly in both the groups. The improvement in outcome scores and revision surgery, however, was comparable in both the groups [Table 5].

Table 1: Descriptive statistics of the tender and nontender acromio-clavicular joint groups ($n=33$)

Parameters	Tender ACJ, *n* (%)	Nontender ACJ, *n* (%)	*P*
Age	65.54±10.24	58.12±11.06	0.006
Side right	20 (60.6)	24 (72.7)	0.224
Biceps tendinopathy	19 (57.6)	7 (21.2)	0.002
Biceps instability	4 (12.1)	10 (30.3)	0.141
ACJ arthritis[#]	13 (48.1)	7 (25)	0.074
Impingement grade			
A1	5 (15.1)	0	0.02
A2	28 (84.9)	33 (100)	
Cuff tear grade			
B1	0	0	0.403
B2	9 (27.3)	8 (24.2)	
B3	14 (42.4)	19 (57.6)	
B4	10 (30.3)	6 (18.2)	
Biceps procedure			
Biceps tenotomy	23 (69.7)	12 (36.4)	0.07
Biceps tenodesis	1 (3.03)	5 (15.2)	
Subscapularis repair	10 (30.3)	5 (15.2)	0.141
Number of anchors			
1	18 (54.5)	22 (66.7)	0.133
2	9 (27.3)	10 (30.3)	
3	6 (18.2)	1 (3.03)	

[#]Number of patients for acromioclavicular joint arthritis were 27 and 28 in tender and nontender acromio-clavicular joint group respectively.
ACJ: Acromio-clavicular joint, *n*: Number of patients

Table 2: Correlation of acromioclavicular arthritis tenderness with biceps pathology and acromioclavicular arthritis arthritis

Parameters	Correlation coefficient	*P*
Biceps tendinopathy	0.372	0.002
Biceps instability	−0.14	0.141
ACJ arthritis	0.24	0.074

ACJ: Acromioclavicular joint

Discussion

Various structural abnormalities have been thought to induce pain in degenerative RCT; hypertrophy and inflammation of rotator cuff tendon,[24,25] hypertrophy, inflammation, edema and necrosis of subacromial bursa,[24] and superior labral-biceps tendon pathology.[25,26] Patients with RCT frequently have symptomatic ACJ with overlying tenderness, as was found in 50% of our study population. The ACJ tenderness was found more commonly in slightly older population than the nontender group. However, the cause of superior pain and tenderness over ACJ specifically in the context of degenerative RCT is ambiguous. The current study has shown no correlation between ACJ tenderness and ACJ arthritis, as arthritis was found in less than half of patients with tender ACJ. Moreover, patients with RCT can have symptomatic ACJ without an obvious ACJ arthritis, as was seen in 25% of our study population (14 of 56 patients).

Table 3: Difference in clinical outcome scores between tender and nontender acromioclavicular arthritis groups (*n*=33)

Outcome measures	Tender ACJ, *n* (%)	Nontender ACJ, *n* (%)	*P*
OSS			
Preoperative	33.64±7.54	39.64±8.3	0.003
1 year	51.24±11.7	55.69±6.6	0.062
Improvement	17.12±12.2	16.06±9.4	0.744
*P**	<0.001	<0.001	
qDASH			
Preoperative	56.05±19.1	46.13±19.4	0.039
1 year	19.42±23.6	10.72±13.9	0.073
Improvement	36.9±20.04	35.41±19.69	0.76
*P**	<0.001	<0.001	
Outcome			
Satisfactory	27 (81.8)	26 (78.8)	0.756
Unsatisfactory	6 (18.2)	7 (21.2)	
Revision RCR	1 (3.03)	1 (3.03)	1

**P*-value for the difference between pre-and post-operative outcome scores in each group. ACJ: Acromio-clavicular joint, OSS: Oxford shoulder score, qDASH: Quick-disability of arm shoulder and hand, RCR: Rotator cuff repair

Table 4: Binary logistic regression analysis of various preoperative parameters for predicting unsatisfactory outcome following surgery

Parameters	OR	95% CI	*P*
Age	0.970	0.902-1.043	0.413
Side	1.246	0.265-5.861	0.781
ACJ tenderness	1.687	0.263-10.828	0.582
ACJ arthritis	1.09	0.253-4.747	0.908
Preoperative OSS	1.089	0.985-1.203	0.096
Preoperative qDASH	0.992	0.953-1.032	0.678
Cuff tear grades	0.785	0.098-6.315	0.820
Biceps tendinopathy	1.402	0.207-9.505	0.729
Biceps instability	1.535	0.220-10.724	0.666
Subscapularis repair	3.457	0.400-29.855	0.259

ACJ: Acromio-clavicular joint, OSS: Oxford shoulder score, qDASH: Quick-disability of arm shoulder and hand, OR: Oddis ratio, CI: Confidence intervel

LHBT is known to be an important pain inducer in the shoulder. Biceps pathology (fraying/erythema/partial tear/subluxation) has been implicated with anterior pain and subpectoral tenderness in patients with RCT.[26] A molecular study has shown elevated vascular endothelial growth factor in degenerate LHBT tissue which is an important inducer for neoangiogenesis.[10] In addition, in comparison to noninflamed LHBT, inflamed LHBT showed a significantly increased inflammatory marker gene expression which suggests that the LHBT acts as an important pain generator in the shoulder.[27] Previous studies have not looked at the correlation of biceps pathology and ACJ tenderness perioperatively in patients with RCT. We found that patients with ACJ tenderness have significantly higher rate of LHBT tendinopathy compared to nontender ACJ group (57.6% vs. 21.2%, P = 0.002). The RCR with addition of biceps procedure (tenotomy or tenodesis) resulted in improved outcome in patients with tender ACJ which was similar to patients with nontender ACJ (P = 0.744 and 0.76 for OSS and qDASH respectively). The reason for association of LHBT pathology with ACJ tenderness is not known, however, it may be assumed that the direct compression of the ACJ may reproduce pain due to biceps tendinopathy due to its close anatomic proximity with LHBT.

The role of DCE for symptomatic ACJ arthritis in setting of RCR continues to be debated. The recent evidence suggests that routine DCE in setting of RCR does not improve outcomes with no difference at 24 months between RCR with DCE and RCR alone.[14] Furthermore, our study did not find any difference in the outcome between arthritic and nonarthritic patients. Park *et al*.,[2] in a randomized controlled trial, compared RCR with DCE (21 patients) and isolated RCR (26 patients) in patients with RCT and symptomatic ACJ (radiological arthritis, tender ACJ, and positive ACJ injection test). They observed similar improvement in functional outcome, re-tear/re-operation rate, and disappearance of tenderness in both groups. They, subsequently, concluded that isolated RCR would be sufficient in patients having RCT and symptomatic ACJ. They, however, did not investigate the patients with symptomatic ACJ without arthritis, which forms around 25% of the RCT population as seen in our study.

In the current study, postoperatively, both the groups (tender and nontender ACJ) reported significant and clinically important improvement in both the outcome scores which were at least twice the MCID for both OSS and qDASH scores. The clinical outcome scores following surgery were comparable in both the groups (P = 0.744 and 0.76 for OSS and qDASH, respectively). Since the two groups were dissimilar in few of the preoperative variables including age and preoperative outcome scores, a binary logistic regression analysis was performed to independently assess the effect of ACJ tenderness over the outcome scores postsurgery. The regression analysis suggested that the ACJ tenderness does not affect the outcome following RCR without DCE.

Our results were similar to the findings from a recent prospective study by Yiannakopoulos *et al*.[3] who evaluated the effect of isolated RCR (without DCE) in a large group of patients with RCT and ACJ arthritis. They studied 185 patients with symptomatic ACJ arthritis and 312 patients with asymptomatic ACJ arthritis and reported similar functional outcome scores in both the groups. Although our results support their findings, recruitment of symptomatic ACJ patients based on ACJ tenderness (rather than ACJ arthritis) in our study represents wider inclusion of patients and is more reflective of current clinical practice. Furthermore, Yiannakopoulos *et al*.[3] reported that 1% of patients in both groups underwent revision surgery for recent or persistent ACJ pain. In contrary, none of our patients underwent revision surgery for ACJ pain,

Table 5: Difference in clinical outcome scores between arthritic and nonarthritic acromioclavicular joint groups

Parameters	Arthritic ACJ, *n* (%) (*n*=20)	Nonarthritic ACJ, *n* (%) (*n*=35)	*P*
OSS			
Preoperative	36.3±7.9	37.7±8.3	0.522
1 year	53.1±10.5	54.2±8.4	0.672
Improvement	16±10.7	16.4±10.4	0.884
*P**	<0.001	<0.001	
qDASH			
Preoperative	50.5±15.9	50.7±22.3	0.979
1 year	14.7±20.5	14.5±17.8	0.963
Improvement	35.8±20.4	36.4±19.6	0.907
*P**	<0.001	<0.001	
Revision surgery	1	1	1.000

**P*-value for the difference between pre-and post-operative outcome scores in each group. ACJ: Acromio-clavicular joint, *n*: Number of patients, OSS: Oxford shoulder score, qDASH: Quick-disability of arm shoulder and hand

but the revision rate for re-tears was same for both tender and nontender ACJ groups (3%).

Our result shows that isolated RCR without DCE improved the ACJ tenderness in 79% of the patients at 1-year postoperatively. This is consistent with the results of Park *et al*.[2] who reported the residual tenderness in 20% (5 of 26) of those undergoing isolated RCR and in 33% (7 of 21) of those undergoing RCR with DCE.

Furthermore, our study demonstrated that more than half of patients with tender ACJ in context of RCT did not have ACJ arthritis. Although ACJ arthritis was noted more commonly in tender ACJ group than nontender ACJ group (48.1% vs. 25%), it did not show a statistical difference ($P = 0.074$). On further analysis, the ACJ arthritis did not correlate significantly with the ACJ tenderness. The previous authors have noted ACJ arthritis in asymptomatic patients without pain or tenderness. Needell *et al*.[28] evaluated MRI scan of the shoulder joints of 100 asymptomatic volunteers and found ACJ arthritis in three fourth of the study population. Our study has shown that ACJ arthritis is less likely to cause superior pain in the context of RCT. Moreover, the postoperative outcome with isolated RCR without DCE in patients with arthritic ACJ was comparable to that in patients without ACJ arthritis.

While this study has the strength of being a prospective study involving a blinded observer, it also has few limitations. First, there were small number of patients in each group. Subsequently, the small number of events for different outcomes may have been a source of bias in our analysis. Second, the two groups were dissimilar in baseline characteristics such as age and preoperative outcome scores. However, despite having inferior preoperative outcome scores, the tender ACJ group demonstrated comparable improvement in outcome scores to that in the nontender ACJ groups. Third, due to the lack of routine postoperative ultrasound to evaluate RCR integrity for all the patients, the re-tear rates were not analyzed amongst the groups.

Conclusions

This study shows that the ACJ tenderness and ACJ arthritis have no effect on the outcome of RCR without DCE in the short-term follow-up. Furthermore, the patients with ACJ tenderness have higher incidence of LHBT tendinopathy in patients with degenerative RCT.

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Conflicts of interest

There are no conflicts of interest.

References

1. Oh JH, Kim JY, Choi JH, Park SM. Is arthroscopic distal clavicle resection necessary for patients with radiological acromioclavicular joint arthritis and rotator cuff tears? A prospective randomized comparative study. Am J Sports Med 2014;42:2567-73.
2. Park YB, Koh KH, Shon MS, Park YE, Yoo JC. Arthroscopic distal clavicle resection in symptomatic acromioclavicular joint arthritis combined with rotator cuff tear: A prospective randomized trial. Am J Sports Med 2015;43:985-90.
3. Yiannakopoulos CK, Vlastos I, Theotokatos G, Galanis N. Acromioclavicular joint arthritis is not an indication for routine distal clavicle excision in arthroscopic rotator cuff repair. Knee Surg Sports Traumatol Arthrosc 2021;29:2090-5.
4. Błasiak A, Mojżesz M, Brzóska R, Solecki W, Binkowska A. Results of arthroscopic treatment of rotator cuff tear with the resection of symptomatic acromioclavicular joint with degenerative changes. Pol Orthop Traumatol 2013;78:229-34.
5. Daluga DJ, Dobozi W. The influence of distal clavicle resection and rotator cuff repair on the effectiveness of anterior acromioplasty. Clin Orthop Relat Res 1989;247:117-23.
6. Levine WN, Soong M, Ahmad CS, Blaine TA, Bigliani LU. Arthroscopic distal clavicle resection: A comparison of bursal and direct approaches. Arthroscopy 2006;22:516-20.
7. Martin SD, Baumgarten TE, Andrews JR. Arthroscopic resection of the distal aspect of the clavicle with concomitant subacromial decompression. J Bone Joint Surg Am 2001;83:328-35.
8. Razmjou H, ElMaraghy A, Dwyer T, Fournier-Gosselin S, Devereaux M, Holtby R. Outcome of distal clavicle resection in patients with acromioclavicular joint osteoarthritis and full-thickness rotator cuff tear. Knee Surg Sports Traumatol Arthrosc 2015;23:585-90.
9. Kuster MS, Hales PF, Davis SJ. The effects of arthroscopic acromioplasty on the acromioclavicular joint. J Shoulder Elbow Surg 1998;7:140-3.
10. Lakemeier S, Reichelt JJ, Timmesfeld N, Fuchs-Winkelmann S, Paletta JR, Schofer MD. The relevance of long head biceps degeneration in the presence of rotator cuff tears. BMC Musculoskelet Disord 2010;11:191.
11. Wang J, Ma JX, Zhu SW, Jia HB, Ma XL. Does distal clavicle resection decrease pain or improve shoulder function in patients with acromioclavicular joint arthritis and rotator cuff tears? A meta-analysis. Clin Orthop Relat Res 2018;476:2402-14.
12. Walton J, Mahajan S, Paxinos A, Marshall J, Bryant C, Shnier R, *et al.* Diagnostic values of tests for acromioclavicular joint pain. J Bone Joint Surg Am 2004;86:807-12.
13. Li L, Bokshan SL, Mehta SR, Owens BD. Disparities in cost and access by caseload for arthroscopic rotator cuff repair: An analysis of 18,616 cases. Orthop J Sports Med 2019;7:2325967119850503.
14. Livingstone A, Asaid R, Moaveni AK. Is routine distal clavicle resection necessary in rotator cuff repair surgery? A systematic review and meta-analysis. Shoulder Elbow 2019;11:39-45.

15. Choo HJ, Lee SJ, Kim JH, Cha SS, Park YM, Park JS, *et al*. Can symptomatic acromioclavicular joints be differentiated from asymptomatic acromioclavicular joints on 3-T MR imaging? Eur J Radiol 2013;82:e184-91.
16. Shubin Stein BE, Wiater JM, Pfaff HC, Bigliani LU, Levine WN. Detection of acromioclavicular joint pathology in asymptomatic shoulders with magnetic resonance imaging. J Shoulder Elbow Surg 2001;10:204-8.
17. Brown JN, Roberts SN, Hayes MG, Sales AD. Shoulder pathology associated with symptomatic acromioclavicular joint degeneration. J Shoulder Elbow Surg 2000;9:173-6.
18. Boileau P, Baqué F, Valerio L, Ahrens P, Chuinard C, Trojani C. Isolated arthroscopic biceps tenotomy or tenodesis improves symptoms in patients with massive irreparable rotator cuff tears. J Bone Joint Surg Am 2007;89:747-57.
19. Walch G, Edwards TB, Boulahia A, Nové-Josserand L, Neyton L, Szabo I. Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears: Clinical and radiographic results of 307 cases. J Shoulder Elbow Surg 2005;14:238-46.
20. Levy O, Sforza G, Dodenhoff R, Copeland S. Arthroscopic evaluation of the impingement lesion: Pathoanatomy and classification. J Bone Joint Surg Br 2000;82B: 233.
21. Dawson J, Fitzpatrick R, Carr A. Questionnaire on the perceptions of patients about shoulder surgery. J Bone Joint Surg Br 1996;78:593-600.
22. Beaton DE, Wright JG, Katz JN, Upper Extremity Collaborative Group. Development of the QuickDASH: Comparison of three item-reduction approaches. J Bone Joint Surg Am 2005;87:1038-46.
23. van Kampen DA, Willems WJ, van Beers LW, Castelein RM, Scholtes VA, Terwee CB. Determination and comparison of the smallest detectable change (SDC) and the minimal important change (MIC) of four-shoulder patient-reported outcome measures (PROMs). J Orthop Surg Res 2013;8:40.
24. Chillemi C, Petrozza V, Franceschini V, Garro L, Pacchiarotti A, Porta N, *et al*. The role of tendon and subacromial bursa in rotator cuff tear pain: A clinical and histopathological study. Knee Surg Sports Traumatol Arthrosc 2016;24:3779-86.
25. Maher A, Leigh W, Brick M, Young S, Caughey M. Causes of pain and loss of function in rotator cuff disease: Analysis of 1383 cases. ANZ J Surg 2017;87:488-92.
26. Dwyer C, Kia C, Apostolakos JM, DiVenere J, Dyrna F, Cote M, *et al*. Clinical outcomes after biceps tenodesis or tenotomy using subpectoral pain to guide management in patients with rotator cuff tears. Arthroscopy 2019;35:1992-2000.
27. Schmalzl J, Plumhoff P, Gilbert F, Gohlke F, Konrads C, Brunner U, *et al*. The inflamed biceps tendon as a pain generator in the shoulder: A histological and biomolecular analysis. J Orthop Surg (Hong Kong) 2019;27:2309499018820349.
28. Needell SD, Zlatkin MB, Sher JS, Murphy BJ, Uribe JW. MR imaging of the rotator cuff: Peritendinous and bone abnormalities in an asymptomatic population. AJR Am J Roentgenol 1996;166:863-7.

Case Report

Management of Pipkin Type 3 Fracture-Dislocation in Young Adults: A Dilemma

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Abstract

Pipkin type 3 fracture-dislocation constitutes a rare subgroup of fractures involving the femoral neck and head fracture. The management is difficult and controversial, including osteosynthesis using Herbert or cancellous screws and hip replacement surgery. In this case report, a 26-year-old male suffered a road traffic accident leading to a hip fracture. Radiographs and computed tomography scan of the hip depicted three large fragments of the femur head, dislocated posteriorly along with the neck of femur fracture. Considering the needs of the patient, fracture morphology, and unpredictable results of the osteosynthesis, the patient was treated primarily with uncemented total hip replacement. The complexity of the fracture leads to more chances of malreduction and avascular necrosis of the femur head. The patient had an uneventful intra and postoperative period. At the 3-year follow-up, the patient was walking unaided, pain-free, and performing all the activities of daily living satisfactorily.

Keywords: Avascular necrosis, nonunion, osteosynthesis, Pipkin fracture, total hip replacement

Introduction

Pipkin fractures are caused by high-energy trauma, especially in polytrauma patients affecting younger people.[1] Only Pipkin type 3 injuries contain ipsilateral fractures of the femoral neck. They are the least common of Pipkin fractures representing 8.6% of femoral head fractures.[1] This not only increases the difficulty to reconstruct the femoral head but also adversely affects the vascular supply to the femoral head, leading to avascular necrosis (AVN) of the femoral head. All these factors lead to worse functional outcomes in Pipkin type 3 fracture.[2] The treatment option includes the replacement arthroplasty or reconstruction of the femoral head using Herbert and cancellous screws. The dilemma is still on regarding osteosynthesis and total hip replacement (THR) in young individuals with Pipkin type 3 fractures. The literature is still not clear, and no guidelines could be formulated regarding the standard of treatment in such cases. There are various advantages and disadvantages of osteosynthesis and replacement arthroplasty, which need to be weighed according to each patient. As of now, the surgery is based on the surgeon's and the patient's expectations. Many surgeons perform only osteosynthesis in this type of fracture, whereas others prefer replacement arthroplasty. We present a case of a 26-year-old male with Pipkin type 3 fracture treated with THR with good functional outcome in 3-year follow-up. The case will enrich the literature and philosophy of replacement arthroplasty in Pipkin type 3 fractures.

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Case Report

A 26-year-old male suffered a road traffic accident leading to head and right-side hip trauma. The mechanism of injury involves the fall of a motorcycle on the right lower limb of the patient after being hit by the car. The patient presented to the emergency in a conscious and hemodynamically stable condition. Radiographs of the pelvis and right hip revealed femoral head and neck fractures [Figure 1]. Computed tomography scan with a three-dimensional reconstruction of the right hip depicted Pipkin type 3 fracture-dislocation [Figure 2].

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Figure 1: A radiograph (AP view) of the right hip depicting fracture-dislocation of the femoral neck and head with a large posterior fragment. AP: Anteroposterior

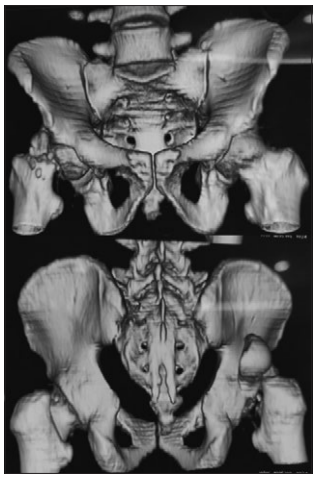

Figure 2: Noncontrast CT (3D reconstruction) of the pelvis with both hips showing anterior and posterior views. 3D: Three-dimensional, CT: Computed tomography

The femoral head was fractured into three large fragments with posterior hip dislocation. Because of the femoral neck fracture, reduction of the hip was not feasible and not attempted. After assessing the complexity of the fracture pattern, increased risk of AVN of the femoral head, and the needs and expectations of the patient, THR was considered the primary treatment modality. The patient was planned for operative intervention 3 days later. A posterolateral approach was used, and the femoral head was found to be fractured into three large fragments [Figure 3]. The head of the femur was split coronally, with the fragment dislocated posteriorly and a smaller fragment fractured from the superior-anterior aspect of the head. The coronally split anterior segment of the femoral head was further fractured into smaller fragments and was lying in the acetabular cavity, whereas the larger posterior fragment of the femoral head was lying out of the acetabulum in the posterosuperior aspect. The neck of the femur was fractured 5 mm from the upper border of the lesser trochanter. The fracture involved more than 30% of the femoral head. The neck cut was taken from the fractured site. The posterior capsule was avulsed from the acetabular margin with the contusion of the surrounding muscles. The acetabular articular cartilage on the posterior wall was avulsed at various places with many abrasions. Though there was no free acetabular cartilage fragment in the hip joint. Uncemented THR using 52 size acetabular cup and 12 size stem was used (Smith and Nephew: Reflexion cup and legend stem with 32 mm ceramic head). Posterior capsular repair and muscles (short external rotators and piriformis) were sutured to the bone to strengthen the posterior aspect. Postoperatively, radiograph was done depicting optimal implant positioning and alignment. The patient was mobilized on the 1st postoperative day with a walker. After 6 weeks, the patient was able to mobilize without any support and perform activities of daily living up to his satisfaction. The patient was pain-free and able to perform all the activities of daily living independently. At 36 months of follow-up, a radiograph [Figure 4] depicts the proper implant position, and the patient is able to walk pain-free without support performing occupational activities as well. The Harris Hip Score was 88 depicting a good functional outcome at the final follow-up.

Discussion

Femoral head fractures are mostly suffered by young adults, and the most common mechanism is dashboard injury suffered during road traffic accidents.[3] Femoral head fractures have a poor prognosis.[1,4] In Pipkin type 3 fracture, the force of impact is high enough to cause a fractured neck of the femur and transmission of forces further to cause injury to the femoral head. Such high-velocity trauma is associated with other injuries which may lead to life-threatening conditions.[5] It is widely accepted that the prognosis of these injuries is worse than the other types of Pipkin fractures.[2,6] The viability of the femoral head depends on the timely and successful reduction.

The hip dislocation, along with the femoral head and neck fracture, further compromises the blood supply and viability of the femoral head. These fractures increase intracapsular pressure, direct disruption, and kinking of the veins, subsequently decreasing femur head perfusion and vascularity. The delay in injury and management was more than 6–8 h, which is recommended for an optimized good outcome.[2,7] The first step in management involves the reduction of hip dislocation. This cannot be performed successfully in Pipkin type 3 fracture, as the neck of the femur is not in continuity with the shaft of the femur.[8] Moreover, the dislocated femoral head is fractured, and the fragments tend to resist the reduction. The overall injured condition of the patient also does not allow many attempts of reduction. Restoration of hip biomechanics and viability of the femoral head, in the long run, is the goal of Pipkin fracture management. Osteosynthesis of these fractures can lead to survival and sphericity of the native femur head, which is the best for the biomechanics and functioning of the hip. Open reduction and fixation of the femoral head have been the conventional management method for Pipkin fractures.

Figure 3: Fragments of the femur head with the neck

Figure 4: Postoperative radiograph at 3-year follow-up

The modified Smith-Petersen approach, and nowadays, safe surgical dislocation of the hip[3] are commonly used surgical approaches used to preserve the vascularity of the femoral head while fixing these fractures.

Stannard *et al*.[9] recommend osteosynthesis for such fractures with an emphasis on anatomic reduction and rigid fixation of the fracture. Such anatomic reduction and rigid fixation were not possible in every case. If possible, then osteosynthesis of Pipkin type 3 fracture can be an optimal option. Nonanatomic reduction of the femoral neck fracture leads to a poor prognosis,[10] and here, we were considering an anatomic reduction in a much more complex fracture. The case report by Zhao *et al*.[11] depicted osteosynthesis of Pipkin type 3 fracture with complicated acetabular fracture. The young age of the patient and the presence of transverse acetabular fracture negate hip replacement in that patient. There are higher complication rates (10%–40%), including the development of AVN within 2 years and a 20% risk of osteoarthritis within 5 years following conservative management.[12] The failure rates can be as high as 59% even after the internal fixation of a femoral neck fracture,[13] later requiring replacement arthroplasty. Keeping all the anatomic factors, patient requirements as well as the development in the hip arthroplasty implant, THR seems a good option to deal with the difficulties in the management of Pipkin type 3 fractures. It seems logical as THR is being used in young patients for the end-stage hip disease of nontraumatic etiology with a good outcome. Uncemented implants with highly crossed polyethylene liners increase the durability of the implant in young patients. In nonelderly patients with hip fractures undergoing osteosynthesis, only 25% recover fully[14] whereas 35% of such patients do not return to work.[15] One-third of such patients had fair-poor Oxford Hip Scores even after 12 months of the surgery.[16]

According to the review article by Polkowski *et al*,[17] the outcome of uncemented THR in very young patients (<30 years) with uncemented implants is excellent. The study by Clohisy *et al*.[18] included 102 hips with a mean age of 20 years. The revision rate was 7% in view of dislocation, polyethylene wear, and infection in this study over the mean follow-up of 4.2 years; no revision was done for the stem. Various bearing surfaces were used in this study. The study by Restrepo *et al*.[19] included 35 hips (mean age of 17.6 years) with a mean follow-up of 6.6 years. The revision rate was 2.9%, mainly due to polyethylene wear. THR in young adults is associated with higher revision rates due to loosening of the cup,[20] polyethylene wear, and dislocations. Tonetti *et al*.[6] reported only four Pipkin type 3 fractures of the total of 110 cases. All four were ultimately treated by THR, one was done primarily, and three Pipkin fractures were later converted to THR. In the study by Scolaro *et al*.,[21] there were 13 type 3 fractures of the total of 147 Pipkin injuries. Osteosynthesis was done in all the cases, and fixation failed in due course of time. Later on, THR was the only treatment option and was performed in all the cases. Similar conclusions and results were reported in a retrospective analysis by Yu *et al*.[22] in a case series of six type 3 fractures of 19 Pipkin fractures. Guimaraes *et al*.[23] treated two Pipkin type 3 patients (ages 30 and 32 years) with THR as primary surgery.

Moreover, salvage THR following internal fixation of the femoral neck fractures has a significantly increased complication rate (infection, dislocation, and periprosthetic fracture) compared to a primary THR for these fractures.[24] The complexity of salvage THR poses problems regarding the distortion of normal anatomical landmarks for THR, deformities at the hip joint, and implant-related problems, including removal of the implant, which can lead to poor bone stock and disuse osteoporosis. THR can save productive years for the young patient. Squatting and cross leg sitting is a concern in a few THR patients, especially in South-East Asia, but this patient could manage activities of daily living without squatting and cross leg sitting. Stem cells, vascularized bone grafts, muscle pedicle grafts, and bone grafts are used in the management of the early stages of AVN of the hip and nonunion neck femur fracture. All these techniques can be used to manage the complications arising from the osteosynthesis in Pipkin fractures, but none is used as *per se* in primary

management. Based on all this evidence in favor of THR in Pipkin type 3 fracture, we performed arthroplasty on this patient. The expectations of patient including early pain-free mobilization, one-time surgery and early return to work were considered. Even being a young patient, we resort to THR as the primary treatment modality keeping in mind the prime age of the patient for career and personal development, high chances of AVN of the femoral head, nonunion of fracture, surgical difficulty in osteosynthesis as well as later the need of salvage THR. At the 36-month follow-up, the patient could walk freely and perform daily activities with no pain and limp.

Conclusion

We conclude that the primary THR can be a good option in Pipkin type 3 fracture, even in young patients. This not only negates the consequences of malreduction of fracture, AVN of the femoral head, slow rehabilitation, and difficult surgery for osteosynthesis but also provides satisfactory and predictable results for the patients. THR gives a one-time solution to the problems and consequences faced in the treatment of Pipkin type 3 fracture-dislocation. It not only reduces the chances of resurgery but also gives a functional hip to a young patient during the productive years of his/her life. However, THR should be done at this young age, keeping in mind the need for revision later in life. Although there is longer survivorship of the implant now because of better design. There is a restriction on certain activities after THR, which should be discussed in detail with the patient beforehand. A well-done THR in such fracture patterns can be a great solution to various problems faced in the management of Pipkin type 3 fracture-dislocation, even in young adults.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

References

1. Giannoudis PV, Kontakis G, Christoforakis Z, Akula M, Tosounidis T, Koutras C. Management, complications and clinical results of femoral head fractures. Injury 2009;40:1245-51.
2. Chiron P, Lafontan V, Reina N. Fracture-dislocations of the femoral head. Orthop Traumatol Surg Res 2013;99:S53-66.
3. Henle P, Kloen P, Siebenrock KA. Femoral head injuries: Which treatment strategy can be recommended? Injury 2007;38:478-88.
4. McKee MD, Garay ME, Schemitsch EH, Kreder HJ, Stephen DJ. Irreducible fracture-dislocation of the hip: A severe injury with a poor prognosis. J Orthop Trauma 1998;12:223-9.
5. Lang-Stevenson A, Getty CJ. The Pipkin fracture-dislocation of the hip. Injury 1987;18:264-9.
6. Tonetti J, Ruatti S, Lafontan V, Loubignac F, Chiron P, Sari-Ali H, *et al.* Is femoral head fracture-dislocation management improvable: A retrospective study in 110 cases. Orthop Traumatol Surg Res 2010;96:623-31.
7. Mostafa MF, El-Adl W, El-Sayed MA. Operative treatment of displaced Pipkin type I and II femoral head fractures. Arch Orthop Trauma Surg 2014;134:637-44.
8. Tosounidis T, Aderinto J, Giannoudis PV. Pipkin Type-III fractures of the femoral head: Fix it or replace it? Injury 2017;48:2375-8.
9. Stannard JP, Harris HW, Volgas DA, Alonso JE. Functional outcome of patients with femoral head fractures associated with hip dislocations. Clin Orthop Relat Res 2000;(377):44-56. doi: 10.1097/00003086-200008000-00008.
10. Rogmark C, Kristensen MT, Viberg B, Rönnquist SS, Overgaard S, Palm H. Hip fractures in the non-elderly-Who, why and whither? Injury 2018;49:1445-50.
11. Zhao B, Li H, Yan J, Han LR, Yang XF. Pipkin type III femoral head fracture-dislocation combined with complicated acetabular fracture: A rare case report and literature review. Medicine (Baltimore) 2017;96:e9214.
12. Fernandez M, Williams T, Dubrana F, Di Francia R. A rare case of an irreducible Pipkin II fracture-dislocation of the femoral head in a young patient following low-energy trauma. Int J Surg Case Rep 2020;70:234-7.
13. Protzman RR, Burkhalter WE. Femoral-neck fractures in young adults. J Bone Joint Surg Am 1976;58:689-95.
14. Ekegren CL, Edwards ER, Page R, Hau R, de Steiger R, Bucknill A, *et al.* Twelve-month mortality and functional outcomes in hip fracture patients under 65 years of age. Injury 2016;47:2182-8.
15. Ekegren CL, Edwards ER, Oppy A, Liew S, Page R, de Steiger R, *et al.* Twelve-month work-related outcomes following hip fracture in patients under 65 years of age. Injury 2017;48:701-7.
16. Ramoutar DN, Kodumuri P, Rodrigues JN, Olewicz S, Moran CG, Ollivere BJ, *et al.* The epidemiology and functional outcomes of operative fixation of extracapsular proximal femoral fractures (AO 31-A) in young adults. Eur J Orthop Surg Traumatol 2017;27:267-72.
17. Polkowski GG, Callaghan JJ, Mont MA, Clohisy JC. Total hip arthroplasty in the very young patient. J Am Acad Orthop Surg 2012;20:487-97.
18. Clohisy JC, Oryhon JM, Seyler TM, Wells CW, Liu SS, Callaghan JJ, *et al.* Function and fixation of total hip arthroplasty in patients 25 years of age or younger. Clin Orthop Relat Res 2010;468:3207-13.
19. Restrepo C, Lettich T, Roberts N, Parvizi J, Hozack WJ. Uncemented total hip arthroplasty in patients less than twenty-years. Acta Orthop Belg 2008;74:615-22.
20. Adelani MA, Keeney JA, Palisch A, Fowler SA, Clohisy JC. Has total hip arthroplasty in patients 30 years or younger improved? A systematic review. Clin Orthop Relat Res 2013;471:2595-601.
21. Scolaro JA, Marecek G, Firoozabadi R, Krieg JC, Routt MLC. Management and radiographic outcomes of femoral head fractures. J Orthop Traumatol 2017;18:235-41.
22. Yu X, Pang QJ, Chen XJ. Clinical results of femoral head fracture-dislocation treated according to the Pipkin classification. Pak J Med Sci 2017;33:650-3.
23. Guimaraes RP, Saeki de Souza G, da Silva Reginaldo S, Ono NK, Honda EK, Polesello GC, *et al.* Study of the treatment of femoral head fractures. Rev Bras Ortop 2010;45:355-61.
24. Maceroli M, Nikkel LE, Mahmood B, Ketz JP, Qiu X, Ciminelli J, *et al.* Total hip arthroplasty for femoral neck fractures: Improved outcomes with higher hospital volumes. J Orthop Trauma 2016;30:597-604.

Case Report

Aspergillus Hip Arthritis in COVID-19 Era: Two Case Reports

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Abstract

Corticosteroids have been a mainstay in the treatment protocols and guidelines of COVID-19. However, its use in high dosage or for extended duration renders patients immunocompromised after COVID-19 recovery, and thus, susceptible to secondary opportunistic infections. We report the two cases of septic hip arthritis due to *Aspergillus* species in corticosteroid immunosuppressed post-COVID-19 patients. One patient recovered successfully from the arthritis and subsequently underwent total hip arthroplasty with good outcome. The second patient presented late to us in a critical condition and had two comorbid conditions along with, due to which, in spite of all measures, could not be revived and succumbed to death. We highlight the issue of the rare cause of fungal hip arthritis in immunosuppressed post-COVID-19 patients and stress the necessity to remain vigilant and identify the causative organisms correctly, especially fungal pathogens in such susceptible populations in the present COVID-19 era.

Keywords: Aspergillosis, *Aspergillus flavus*, *Aspergillus fumigatus*, *Aspergillus* infection, COVID-19, immunosuppression, infectious arthritis, post-COVID conditions, septic arthritis

Introduction

The rampant administration of high-dose systemic corticosteroids in COVID-19 patients in this pandemic roots from evidence that witnessed the benefits of glucocorticoids in severe COVID-19 requiring respiratory support, where its correct use may decrease fatal outcomes.[1,2] However, high corticosteroid dose or extended usage must be weighted with the risk and benefit of *primum non nocere*.[3] The overdrive of corticosteroids in the treatment of COVID-19 is largely accountable for the marked increase in opportunistic infections, especially patients with comorbidities and/or underlying disease conditions. Among the opportunistic infections, fungal infections account for the most case reports in COVID-19 patients.[4] Although COVID-19 associated pulmonary aspergillosis is widely reported and acknowledged as a complication,[4] osteo-articular manifestations of invasive aspergillosis are sparsely described in the literature.

Aspergillus septic arthritis is one such rare, severe, and in some cases, life-endangering variety of extrapulmonary invasive aspergillosis infection occurring mainly in immunocompromised patients.[5] No specific clinical manifestations can differentiate *Aspergillus* arthritis from septic arthritis due to bacteria or other pathogens. Early recognition plays a critical part in mortality and mortality, devolves on the identification of vulnerable immunosuppressed population with symptoms of fever, pain, joint tenderness, along with local signs of inflammation,[5] and warrants urgent further evaluation of septic etiology. We describe here two cases of *Aspergillus* septic arthritis of the hip occurring in immunosuppressed post-COVID-19 patients at a tertiary orthopedic center and review the relevant literature.

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Case Reports

Case 1

A 69-year-old male patient presented with complaints of severe pain, restriction of movements, and inability to bear weight on the left hip for the last 1.5 months. The symptoms were insidious in onset and progressive, with pain radiating to the ipsilateral

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knee. There was an associated history of low-grade fever and the presence of constitutional symptoms without any history of weight loss. There was no history of any preceding trauma or comorbidities. Past history of the patient elaborated on a history of repeated treatment with steroids due to severe COVID-19 infection 2.5 months and polymyositis 6 months before the onset of present complaints. The patient had been hospitalized for 10 days for severe COVID-19 infection when he had been administered intravenous (IV) steroids and subsequently discharged on the tapering dose of oral steroids. The patient had had a history of weakness of bilateral proximal thighs and arms when he was diagnosed with polymyositis and treated with tapering dose of oral steroids. Examination revealed body temperature 100.8°F, anterior hip point tenderness, mild joint swelling, and muscle spasm with global restriction of joint movement, without any erythema or local rise of temperature. X-ray showed features of septic arthritis [Figure 1]; laboratory results and synovial fluid analysis are shown in Table 1. As synovial fluid showed growth of *Aspergillus fumigatus*, urgent arthrotomy, debridement [Figure 2] with excision arthroplasty and gentamicin-loaded cement spacer for left hip was planned [Figure 3]. Tissue culture was also negative for any bacteria or *Mycobacterium tuberculosis* (MTB) and yielded growth of *A. fumigatus*. Computed tomography-scan chest did not show any foci of pulmonary invasive aspergillosis, and there was neither manifestation nor any history of cutaneous or any other source of primary Aspergillosis. The diagnosis was confirmed to be primary *Aspergillus* septic hip arthritis in a post-COVID-19 steroid immunosuppressed patient. After consultation with Infectious Disease Specialist Committee, the patient was started on oral posaconazole 300 mg twice daily on day 1, followed by 300 mg once daily. The patient was having uneventful and good recovery from *Aspergillus* arthritis when he suddenly developed acute decompensated heart failure 1.5 months thereafter. He was diagnosed with double-vessel coronary artery disease with severe left ventricular dysfunction; for which, coronary angiogram with percutaneous transluminal coronary angioplasty (PTCA) with stenting of proximal left coronary artery was done. The patient was continued on posaconazole prophylaxis for a total duration of 6 months. Left total hip arthroplasty (THA) was undertaken 6 months after PTCA after all clinical, radiological, and laboratory markers were normal. Intraoperative tissue cultures and biopsy did not yield any fungal organisms. The patient is doing well 1-year post-THA with painless free range of motion with no signs of recurrence. Follow-up X-rays are shown in Figure 4.

Case 2

A critically ill 74-year-old male patient was referred to our center with complaints of fever, pain in the left hip, inability to bear weight on affected hip and rapid deterioration of health condition for 15 days, when he was admitted at a primary center and diagnosed with *Pseudomonas aeruginosa* septic hip arthritis, and treated with antibiotics. The patient was a known case of chronic liver disease (CLD) with portal hypertension and chronic kidney disease (CKD). The patient suffered from COVID-19 infection 3 months before the onset of present complaints. The patient was hospitalized for 22 days for COVID-19 treatment with noninvasive mechanical ventilation, steroids and IV antibiotics, when his CLD and CKD stages deteriorated. On examination, patient was drowsy, with Glasgow coma score $E_4M_6V_3$, with heart rate of 110 beats/min, SpO_2 92% room air, respiratory rate 20/min, temperature 101.2°F, pitting pedal edema, flapping tremor, bilateral basal lung crepitation, and splenomegaly with abdominal free fluid. Left hip examination revealed anterior hip point tenderness, joint swelling, localized rise of temperature, and global restriction of joint movement, without erythema. X-ray showed features of septic arthritis [Figure 5]. Laboratory results and synovial fluid analysis are shown in Table 1. Patient was diagnosed with Grade II hepatic encephalopathy associated with

Figure 1: X-ray pelvis with both hips-Anteroposterior view showing gross destruction and resorption of the left femoral head with superior migration of the proximal femur. The supero-lateral weight bearing portion of the left acetabulum shows osteolysis with ill-defined acetabular margin. Juxta-articular osteoporosis is noted around the left hip joint

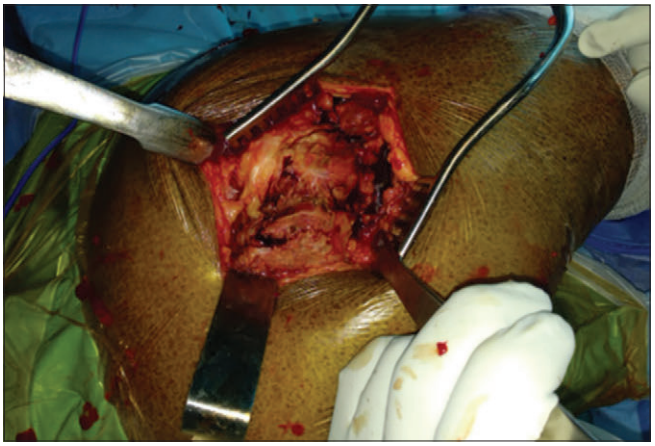

Figure 2: Intraoperative picture during debridement of the left hip. There was loss of soft-tissue planes. Capsule was adherent to the bone with surrounding unhealthy granulation tissue. There was no frank pus. Complete femoral head destruction and cavitary deformity with osseous destruction on weight-bearing surface in the acetabulum were observed

Table 1: Laboratory findings of two *Aspergillus* septic hip arthritis patients

Laboratory investigation (normal reference range)	Value	
	Case 1	Case 2
Hemoglobin: 13-16 (g/dL)	11.7	9.2
WBC: 4000-11,000 (/mm^3)	14,660	20,810
Differential leukocyte count (%)		
Neutrophil: 45-75	78.80	92.70
Lymphocyte: 25-45	12.90	4.60
Eosinophil: 1-8	2.50	0.00
Basophil: 0-1	0.10	0.00
Monocyte: 0-10	5.70	2.70
Platelet: 1.5-4.5 (lakhs/mm^3)	2.54	1.06
ESR: 0-15 (mm at end of 1 h)	60	85
C-reactive protein: 0-6 (g/L)	40.8	102.7
Procalcitonin: <0.5: Low risk of severe sepsis, >0.5-<2.0: Moderate risk of severe sepsis, >2.0-<10: High risk of severe sepsis, >10.0: Severe sepsis/septic shock (ng/mL)	-	4.37
PT: 11.2-14.8 (s)	12.8	20.2
INR: 0.8-1.13	1.10	2.3
aPTT: 25.9-39.3 (s)	28.2	53.4
Rheumatoid factor	Negative	Negative
Anti-cyclic citrullinated peptide	Negative	Negative
Anti-nuclear antibody	Negative	Negative
Anti streptolysin O titer: 0-200 (IU/mL)	<200	<200
Synovial fluid analysis		
WBC	42,700	94,300
Neutrophils (%)	85.2	94.7
Gram stain	Occasional pus cells, no organism	Plenty pus cells, gram negative bacilli
AFB smear	Negative	Negative
Aerobic culture	No growth	*P. aeruginosa*
Anaerobic culture	No growth	No growth
Fungal culture	*A. fumigatus*	*A. flavus*
Semi-nested real time PCR	MTB not detected	MTB not detected
Blood culture	No growth	No growth
Serum galactomannan	Negative	Negative
Urine analysis		
Routine examination	Normal study	Occasional pus cells and epithelial cells albumin 1+
Culture	No growth	No growth
Renal function test		
Urea: 11-43 (mg/dL)	25.60	154.90
Creatinine: 0.66-1.25 (mg/dL)	0.85	1.70
Sodium: 135-145 (mmol/L)	137.00	139.00
Potassium: 3.5-5.1 (mmol/L)	3.90	4.90
Liver function test		
Total bilirubin: 0.2-1.3 (mg/dL)	0.80	3.00
Direct bilirubin: 0-0.3 (mg/dL)	0.20	1.20
Total protein: 6.3-8.2 (g/dL)	7.80	6.10
Albumin: 3.5-5 (g/dL)	4.20	2.20
ALT: 5-50 (U/L)	35.0	75.0
AST: 17-59 (U/L)	37.0	89.0
ALKP: 38-126 (U/L)	108	151
GGT: 15-73 (U/L)	18	71
Serum HIV-1,2 antibody	Nonreactive	Nonreactive
Serum HbsAg	Nonreactive	Nonreactive
Serum anti-HCV	Nonreactive	Nonreactive

WBC: While blood cell count, INR: International Normalized Ratio, PT: Prothombin time, aPTT: Activated partial thromboplastin time, ESR: Erythrocyte sedimentation rate, HCV: Hepatitis C virus, HbsAg: Hepatitis B surface antigen, PCR: Polymerase chain reaction, ALT: Alanine transaminase, AST: Aspartate transaminase, GGT: Gammaglutamyltransferase, ALKP: Alkaline phosphatase, MTB: *Mycobacterium tuberculosis, A. fumigatus: Aspergillus fumigatus, A. flavus: Aspergillus flavus, P. aeruginosa: Pseudomonas aeruginosa*

Figure 3: Immediate postoperative X-ray after debridement and excision arthroplasty with gentamicin cement spacer insertion. The entire diseased femoral head and neck was excised, along with the diseased portions of the acetabulum

Figure 5: X-ray pelvis with both hips-Anteroposterior view showing gross destruction and resorption of the left femoral head with superior migration of the proximal femur. The supero-lateral weight bearing portion of the left acetabulum shows osteolysis with ill-defined acetabular margin. Juxta-articular osteoporosis is noted around the left hip joint

decompensated CLD, acute on CKD, and left hip septic arthritis. Urgent arthrotomy, debridement [Figure 6] with excision arthroplasty, and gentamicin spacer insertion were done for left hip [Figure 7]. Tissue culture analysis showed scanty growth of *P. aeruginosa*. In addition, fungal culture showed growth of *Aspergillus flavus*. Primary foci of Aspergillosis could not be ascertained; so it was diagnosed with a primary pseudomonas with *Aspergillus* septic hip arthritis. Infectious Disease Specialist Committee Consultation was taken and patient was started on sensitive drugs-IV Meropenem 1 g IV q8 h along with oral posaconazole 300 mg twice daily on day 1, followed by 300 mg once daily. However, the patient continued to deteriorate in spite of treatment and succumbed to death after 16 days due to deterioration of liver and kidney status.

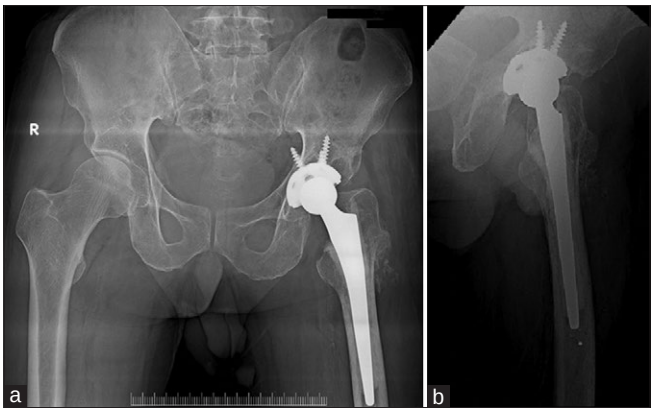

Figure 4: X-ray of the pelvis with both hips-Anteroposterior view (a) and X-ray left hip-lateral view (b) at 1 year follow-up after left total hip arthroplasty of the patient showing good alignment, positioning, and fixation of the components

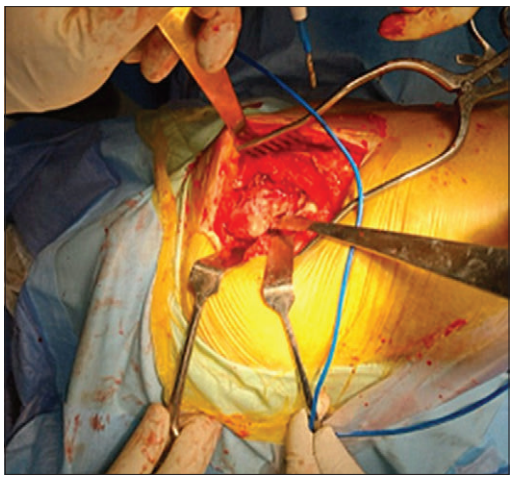

Figure 6: Intraoperative picture during debridement of the left hip. There was loss of soft-tissue planes. Capsule was adherent to the bone with lot of infected granulation tissue. There were the pockets of seropurulent pus. Complete femoral head destruction and cavitary deformity with osseous destruction on weight bearing surface in the acetabulum were observed. All the bones were osteoporotic

Discussion

Invasive fungal infection has been progressively attributed as a late sequelae of COVID-19.[6] High levels of pro-inflammatory (interleukin-1, 2, 6, and tumor necrosis factor-alpha) and anti-inflammatory (interleukin-4, 10) cytokines, less CD4 interferon-gamma expression, and fewer CD4 and CD8 cells which makes them vulnerable to opportunistic fungal infections.[7] An exponential increase in the incidence and mortality rates of invasive fungal infections is reported among COVID-19 survivors, especially whoever received immunosuppressive therapies or who had underlying conditions.[6,8-11] Although *Aspergillus* is the most common fungus isolated from COVID-19-infected patients,[10] there is no literature about COVID-19 associated *Aspergillus* septic hip arthritis till date. This is the first report of primary *Aspergillus* septic hip arthritis in immunosuppressed post-COVID-19 patients.

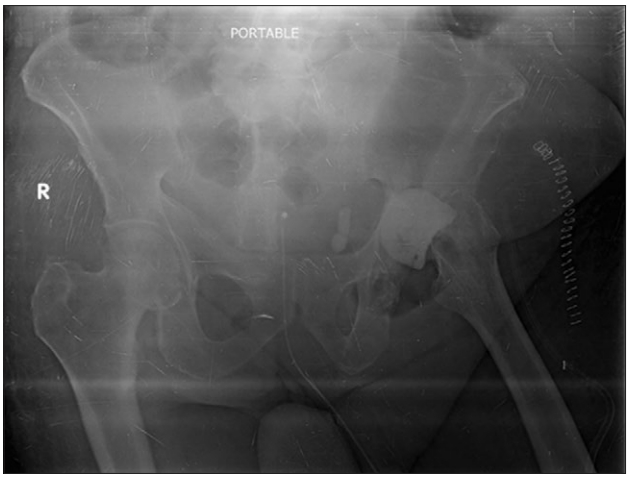

Figure 7: Immediate postoperative X-ray after debridement and excision arthroplasty with gentamicin cement spacer insertion. The entire diseased femoral head and neck was excised, along with the diseased portions of the acetabulum

Aspergillus species have ubiquitous distribution, affecting males predominantly and are commonly associated with immunosuppression, debilitating conditions such as chronic granulomatous disease, solid organ or bone marrow transplantation, chemotherapy, IV drug use, diabetes mellitus, or malnutrition.[12,13] It also occurs in patients undergoing surgical interventions,[12,13] immunocompetent individuals,[14] and also in co-infection with tuberculosis (TB).[15] *Aspergillus* infection spreads hematogenously, by contiguous infective foci, and by inoculation in the case of surgeries or trauma.[12,13] There has been a steady rise in Aspergillosis with >200,000 life-threatening infections due to invasive aspergillosis happening worldwide per year.[16] However, osteo-articular complications of invasive aspergillosis are still not well understood because of the scarcity of *Aspergillus* septic arthritis cases reported so far in the literature.[5,13,17] A total of 35 cases from 29 patients suffering from *Aspergillus* species arthritis of native joints were identified from PubMed and MEDLINE databases between the years 1976 and 2021.[5] *A. fumigatus* was the most common organism isolated, followed by *A. flavus*, *Aspergillus terreus* and not further specified.[5] Our literature search revealed only four cases of *Aspergillus* septic hip arthritis till date[14,15,18,19] [Table 2]. Diagnostic methods and technical and management guidelines are hence based on limited information.[5]

Swelling, pain, and tenderness of involved joint in *Aspergillus* arthritis are the most common clinical manifestations; fever, edema, erythema, and decreased range of motion are less common findings.[12,13] In septic arthritis where culture is negative for bacteria, substantial clinical acumen for fungal pathogens must be present, particularly for immunocompromised patients. Because of the rarity, orthopedicians must be trained to diagnose these infections through studies featuring their symptoms, severity, treatment, and outcome.[5]

Arthrocentesis and open biopsy are the most common tools for definite diagnosis of *Aspergillus* arthritis as fluid culture detects all cases; peri-articular culture of bone tissue is also highly sensitive.[13] Synovial fluid can be clear, turbid, or serosanguineous. Inflammatory markers may be elevated.[20] Even in positive fungal culture, TB must always be ruled out for TB-endemic countries.[15]

Treatment strategy is multidisciplinary based upon a combination of surgical drainage of joints, debridement of the necrotic bone and cartilage to reduce the fungal burden, and systemically active extended antifungal treatment.[21] Surgical irrigation and debridement is almost always mandatory.[12] We used local low-pressure pulsatile suction-irrigation using 4 l 0.9% normal saline, followed by 100 ml of 3% hydrogen peroxide, 100 ml of 10% povidone-iodine, and finally 2 l 0.9% normal saline after surgical debridement for both the cases because a combination of pulsatile lavage, hydrogen peroxide, and povidone-iodine is more effective in reducing the microbial count.

2016 practice guidelines for the diagnosis and management of Aspergillosis recommend voriconazole for the primary treatment of *Aspergillus* septic arthritis.[22] In a double-blind, double-dummy, Randomized Control Trial (RCT) in 2021, Maertens *et al*. concludes that posaconazole is noninferior to voriconazole for the treatment of invasive Aspergillosis and has significantly fewer treatment-related adverse events.[23] Posaconazole is a very potential drug for the treatment of *Aspergillus* arthritis and is even susceptible and suitable for *Aspergillus* species which demonstrate resistance to Amphotericin B, Itraconazole, and Voriconazole.[24,25] Posaconazole is generally well-tolerated, widely distributed in the body, undergoes liver metabolization with no significant renal effects. Adverse events are generally mild.[26] Posaconazole is even appropriate for patients unable to tolerate long-term therapy with other antifungals.[27] We also found very satisfactory results with the use of Posaconazole for the treatment of *Aspergillus* septic arthritis and propose further research for the validation of the same.

Literature about joint reconstruction after fungal septic arthritis is exceedingly sparse; and thus, no protocol has been developed for joint arthroplasty after fungal infections.[20] Two stage joint reconstruction with antibiotic-loaded cement spacer technique is a familiar and acclaimed protocol in periprosthetic joint infection management and is presently also acquiring evidence for the treatment of septic arthritis. It also benefits candidates with advanced joint degeneration before infection. Patients treated with a staged antibiotic-loaded cement spacer before joint arthroplasty report decreased re-infection rates, lesser contractures due to head and neck resection, and superior leg length maintenance and functional scores.[28,29] The final stage of joint arthroplasty also becomes simpler with lesser intraoperative blood loss.[30] Most studies recommend proceeding with final arthroplasty when the wound is completely healed and C-reactive protein is normalized.[31]

Table 2: Case reports of *Aspergillus* septic hip arthritis described in English literature

Year	Authors	Gender/age (years)	*Aspergillus* species	Joint affected	Immunosuppressive conditions/medications	Other site of *Aspergillosis*	Symptoms	Treatment
1990	Lagier[18] (Histological study)	Male/64	*Aspergillus* species	Right hip	Nil	Nil	Painful stiffness	Total hip replacement
2012	Figue`res *et al*.[19]	Male/43	*A. fumigatus*	Left hip	Pancreas-kidney transplantation for type 1 diabetic nephropathy Maintenance therapy: Tacrolimus (5 mg bid) and mycophenolate mofetil (500 mg bid)	Nil	-	Oral Voriconazole 200 mg bid, 50% reduction of tacrolimus dose Hip replacement after 6 months of initiation of Voriconazole
2015	Yoon *et al*.[14]	Female/49	*A. fumigatus*	Right hip	Nil	Undiagnosed recurrent pulmonary *Aspergillosis*	Pain, limited range of motion	Intravenous amphotericin B for 2 weeks, followed by Oral Voriconazole for 6 months THA after 9 months
2016	Kumar *et al*.[15]	Male/60	*A. flavus*, MTB	Right hip, right knee	Angioplasty, type 2 diabetes mellitus	Nil	Pain right hip and gluteal region, fever, low back pain	Intravenous Voriconazole 200 mg bid 2 weeks followed by Oral Voriconazole 200 mg bid Daily regimen anti-TB treatment

MTB: *Mycobacterium tuberculosis, A. fumigatus: Aspergillus fumigatus, A. flavus: Aspergillus flavus*, TB: Tuberculosis, THA: Total hip arthroplasty

In our opinion, modern two stage hip reconstruction with cement spacer is safe and effective in *Aspergillus* septic hip arthritis. Final stage THA can be carried out once the infection is cleared clinically, hematologic and biochemical marks are normal and if the patient has persistent pain and/or other symptoms of arthritis. We found a good outcome with THA in our patient, similar to the previous reports.[14,19] [Table 2] which report favorably for hip replacement in *Aspergillus* arthritis sequelae.

Conclusion

Immunosuppression is a very important clinical entity in the present post COVID-19 pandemic era, and it should be kept in mind while evaluating post COVID-19 patients in orthopedics. The use of corticosteroids and various other immunosuppressant drugs for COVID-19 treatment renders patients susceptible to various secondary invasive opportunistic infections. *Aspergillus* septic arthritis of the hip is a very rare condition that may develop *de novo* or as a superadded entity in immunosuppressed patients who had a prior history of COVID-19 infection. These cases emphasize the necessity of being vigilant about opportunistic fungal infections and stress upon performing fungal cultures routinely in septic arthritis in immunosuppressed patients. Prompt diagnosis and intensive management in the form of surgical debridement along with systemically active prolonged antifungal therapy with serial monitoring are prerequisite for a successful outcome. Posaconazole can be an alternative to voriconazole in the treatment of *Aspergillus* arthritis. Two-stage joint reconstruction with cement spacer is safe and effective in the treatment of *Aspergillus* septic hip arthritis. THA can be carried out in such patients after proper control of infection and carries good result.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. WHO Rapid Evidence Appraisal for COVID-19 Therapies (REACT) Working Group, Sterne JA, Murthy S, Diaz JV, Slutsky AS, Villar J, *et al*. Association between administration of systemic corticosteroids and mortality among critically Ill patients with COVID-19: A Meta-analysis. JAMA 2020;324:1330-41.
2. Recovery Collaborative Group, Horby P, Lim WS, Emberson JR, Mafham M, Bell JL, *et al*. Dexamethasone in hospitalized patients with Covid-19. N Engl J Med 2021;384:693-704.
3. Rodriguez-Morales AJ, Sah R, Millan-Oñate J, Gonzalez A, Montenegro-Idrogo JJ, Scherger S, *et al*. COVID-19 associated mucormycosis: the urgent need to reconsider the indiscriminate use of immunosuppressive drugs. Therapeutic Advances in Infectious Disease 2021;8:1-5.
4. Abdoli A, Falahi S, Kenarkoohi A. COVID-19-associated opportunistic infections: A snapshot on the current reports. Clin Exp Med 2022;22:327-46.
5. Koutserimpas C, Chamakioti I, Naoum S, Raptis K, Alpantaki K, Samonis G. Native joint infections by *Aspergillus* species. Diagnostics (Basel) 2021;11:2335.
6. Cafardi J, Haas D, Lamarre T, Feinberg J. Opportunistic fungal infection associated with COVID-19. Open Forum Infect Dis 2021;8:ofab016.
7. Pemán J, Ruiz-Gaitán A, García-Vidal C, Salavert M, Ramírez P, Puchades F, *et al*. Fungal co-infection in COVID-19 patients: Should

we be concerned? Rev Iberoam Micol 2020;37:41-6.
8. Heard KL, Hughes S, Mughal N, Moore LS. COVID-19 and fungal superinfection. Lancet Microbe 2020;1:e107.
9. Bhatt K, Agolli A, Patel MH, Garimella R, Devi M, Garcia E, *et al*. High mortality co-infections of COVID-19 patients: Mucormycosis and other fungal infections. Discoveries (Craiova) 2021;9:e126.
10. Silva LN, de Mello TP, de Souza Ramos L, Branquinha MH, Roudbary M, Dos Santos AL. Fungal infections in COVID-19-positive patients: A lack of optimal treatment options. Curr Top Med Chem 2020;20:1951-7.
11. Kula BE, Clancy CJ, Hong Nguyen M, Schwartz IS. Invasive mould disease in fatal COVID-19: A systematic review of autopsies. Lancet Microbe 2021;2:e405-14.
12. Koehler P, Tacke D, Cornely OA. Aspergillosis of bones and joints – A review from 2002 until today. Mycoses 2014;57:323-35.
13. Gamaletsou MN, Rammaert B, Bueno MA, Sipsas NV, Moriyama B, Kontoyiannis DP, *et al*. *Aspergillus* arthritis: Analysis of clinical manifestations, diagnosis, and treatment of 31 reported cases. Med Mycol 2017;55:246-54.
14. Yoon PW, Song JH, Yoon KS, Chang JS, Kim HJ, Rhyu KH. *Aspergillus* septic arthritis of the hip in an immunocompetent middle-aged female with undiagnosed recurrent pulmonary aspergillosis. Hip Pelvis 2015;27:196-200.
15. Kumar M, Thilak J, Zahoor A, Jyothi A. Septic arthritis due to tubercular and *Aspergillus* co-infection. Indian J Orthop 2016;50:327-30.
16. Brown GD, Denning DW, Gow NA, Levitz SM, Netea MG, White TC. Hidden killers: Human fungal infections. Sci Transl Med 2012;4:165rv13.
17. Pérez-Cantero A, López-Fernández L, Guarro J, Capilla J. Azole resistance mechanisms in *Aspergillus*: Update and recent advances. Int J Antimicrob Agents 2020;55:105807.
18. Lagier R. A case of hip osteoarthrosis contaminated by fungi. A histological study. Arch Orthop Trauma Surg 1990;109:113-6.
19. Figuères ML, Cantarovich D, Tattevin P, Le Pogamp P, Polard JL, Stock N, *et al*. *Aspergillus* arthritis and organ transplantation. Clin Kidney J 2012;5:237-9.
20. Bariteau JT, Waryasz GR, McDonnell M, Fischer SA, Hayda RA, Born CT. Fungal osteomyelitis and septic arthritis. J Am Acad Orthop Surg 2014;22:390-401.
21. Al-Abdely HM, Alothman AF, Salman JA, Al-Musawi T, Almaslamani M, Butt AA, *et al*. Clinical practice guidelines for the treatment of invasive *Aspergillus* infections in adults in the Middle East region: Expert panel recommendations. J Infect Public Health 2014;7:20-31.
22. Patterson TF, Thompson GR 3rd, Denning DW, Fishman JA, Hadley S, Herbrecht R, *et al*. Practice guidelines for the diagnosis and management of aspergillosis: 2016 update by the infectious diseases society of America. Clin Infect Dis 2016;63:e1-60.
23. Maertens JA, Rahav G, Lee DG, Ponce-de-León A, Ramírez Sánchez IC, Klimko N, *et al*. Posaconazole versus voriconazole for primary treatment of invasive aspergillosis: A phase 3, randomised, controlled, non-inferiority trial. Lancet 2021;397:499-509.
24. Manavathu EK, Cutright JL, Loebenberg D, Chandrasekar PH. A comparative study of the *in vitro* susceptibilities of clinical and laboratory-selected resistant isolates of *Aspergillus* spp. to amphotericin B, itraconazole, voriconazole and posaconazole (SCH 56592). J Antimicrob Chemother 2000;46:229-34.
25. Lodge BA, Ashley ED, Steele MP, Perfect JR. *Aspergillus fumigatus* empyema, arthritis, and calcaneal osteomyelitis in a lung transplant patient successfully treated with posaconazole. J Clin Microbiol 2004;42:1376-8.
26. Torres HA, Hachem RY, Chemaly RF, Kontoyiannis DP, Raad II. Posaconazole: A broad-spectrum triazole antifungal. Lancet Infect Dis 2005;5:775-85.
27. Schiller DS, Fung HB. Posaconazole: An extended-spectrum triazole antifungal agent. Clin Ther 2007;29:1862-86.
28. Fleck EE, Spangehl MJ, Rapuri VR, Beauchamp CP. An articulating antibiotic spacer controls infection and improves pain and function in a degenerative septic hip. Clin Orthop Relat Res 2011;469:3055-64.
29. Diwanji SR, Kong IK, Park YH, Cho SG, Song EK, Yoon TR. Two-stage reconstruction of infected hip joints. J Arthroplasty 2008;23:656-61.
30. Li W, Fang X, Zhang C, Xu Y, Huang Z, Yu Z, *et al*. Comparison of efficacy and complications between two types of staging arthroplasty in treating chronic septic hip arthritis: A retrospective clinical study. Exp Ther Med 2019;17:4123-31.
31. Davis CM, Zamora RA. Surgical options and approaches for septic arthritis of the native hip and knee joint. J Arthroplasty 2020;35:S14-8.

Case Report

Primary Arthroscopic Bicruciate Repair in Multiligamentous Knee Injury with Ipsilateral Long Bone Fracture

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Abstract

Long bone fractures and multiligamentous knee injury (MLKI) have a firm relationship. Primary arthroscopic bicruciate repair along with long bone fixation has not been reported hitherto. Here, we report two cases of long bone fracture with MLKI treated with long bone fixation and primary arthroscopic bicruciate repair with open lateral collateral ligament repair for one patient. Both patients had good clinical outcomes at 1-year follow-up. With the present-day advancements in the field of arthroscopy, there is a place for primary arthroscopic ligament repair in specific tears along with long bone fixation.

Keywords: Long bone fracture, multiligamentous knee injury, primary arthroscopic bicruciate repair

Introduction

The majority of long bone fractures of the lower limb are typically due to high-energy trauma and are inadvertently associated with intra- and extraarticular knee injuries.[1] Identification and intervention of these injuries are of prime importance due to their direct correlation with clinical outcomes. Although plenty of research is available on the incidence of knee ligament injury following long bone fractures,[1,2] less is talked about their primary management.

Multiligamentous knee injury (MLKI) leads to persistent pain and instability on the failure of appropriate early treatment. A long bone fracture with supplemented MLKI delays rehabilitation and escalates patient morbidity. Although the incidence is <0.02% of orthopedic injuries, surgical treatment is highly recommended. The gold standard treatment of MLKI whether to repair or to reconstruct still remains debatable. In MLKI early reconstruction procedures have higher odds of arthrofibrosis and donor-site morbidity. Although the primary fixation of bony avulsions of cruciates is well established in the literature, primary treatment of soft tissue avulsions still remains a controversy. In the early 1970s, open repair was performed followed by the usage of synthetic graft materials, all having abysmal outcomes with high rerupture rates. In modern days, we see a resurgence of interest in primary anterior cruciate ligament (ACL) repair owing to advances in arthroscopic techniques, orthobiologics, rehabilitation protocols, and advantages such as preservation of native ligament, proprioception, and decreased donor morbidity.[3] After institutional ethics clearance, we discuss two cases of long bone fracture with ipsilateral MLKI treated with long bone fixation and primary bicruciate repair.

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Case Reports

Case 1

A 22-year-old male sustained an injury to the right thigh and knee following an Road Traffic Accident (RTA). Radiology revealed shaft of femur fracture and avulsion fracture of the fibular head with reverse Segond fracture. On day 1, he was taken up for femur closed reduction and fixation rotation

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with Intramedullary interlocking nail (IMIL) nail. Following fixation of femur, he had gross anterior, posterior, and varus instability [Video 1]. Magnetic resonance imaging (MRI) of knee joint revealed femoral soft tissue avulsion of posterior cruciate ligament (PCL) with tibial avulsion of ACL (Modified Sherman's Type V) and fibular head avulsion. On day 4, he was taken up for stage two procedure. Diagnostic arthroscopy revealed ACL and PCL avulsion tears [Figure 1]. Using No. 2 fiber wire, two suture lasso stitches were taken on the ACL with the help of a knee scorpion needle and pulled out through 2-mm tibia tunnels on either side of the tibial footprint of ACL and secured on the tibial side by suture bridge technique [Video 2]. Similar stitches were taken on the PCL with No. 2 fiber wire and pulled out through the femoral side through a 4-mm tunnel at the femoral footprint of the PCL and secured with 4-mm cancellous screw as post. Through lateral approach to the knee, the fibula head was exposed and common peroneal nerve neurolysis was done. The fibular head avulsion fracture was fixed with 4-mm cancellous screw and lateral retinaculum was repaired. Postoperative stability was found to be good [Video 3]. Standard rehabilitation protocol with knee ROM from day 1 was executed [Table 1]. Regular follow-up at the 4-week interval was done up to 1 year. Fracture healed well and stability was good with Lysholm score of 92 [Figure 2].

Case 2

A 19-year-old male presented with shaft of tibia fracture and knee X-ray showed an avulsion fracture of the PCL confirmed with computed tomography of the knee [Figure 3]. On day 1, the patient was planned for tibia nailing with arthroscopic PCL fixation. Through the transpatellar approach, tibia nailing was done. Evaluation after fixation showed gross anterior and posterior instability [Video 4]. Diagnostic arthroscopy showed complete avulsion of the ACL from the tibial attachment site and a lax PCL [Video 5]. ACL repair was done using a similar technique to the first case using No. 2 fiber wire and secured to the tibial side over a bony bridge. Bites taken on the PCL were advanced through the PCL tibial tunnel buttressing the avulsed fragments and secured with the help of an endobutton. Postoperative stability was found to be good [Video 6]. One-year follow-up showed good stability with Lysholm score of 88.

Discussion

Long bone fractures of the lower limb are more prone for concomitant MLKI. This is well established in the literature.[1] Although clinical examination and MRI have been adequately stressed, primary management of such injuries has not been reported. Diagnostic pitfalls include failure to primarily scrutinize such injuries as proper assessment of instability is possible only after fracture fixation.

There always remains a question whether to repair or to reconstruct in soft tissue ligamentous avulsions. The orthopedic dogma that ACL cannot heal was based on rather a historic surgical technique and rehabilitation protocol.[4] In the past, ACL repair was experimented in all types of tears using open arthrotomy approach with high failure rates. With the present-day advancements in MRI, better understanding of tear morphology, optimal patient selection, and early mobilization ligament repair yield excellent outcomes. Difelice *et al*.[5] in 2018 advocated ACL repair and inferred that revision of a primary ACL repair is technically more like a primary ACL reconstruction.

Reports have shown promising outcomes of primary repair with early implementation of rehabilitation. Frosch *et al*.

Table 1: Postoperative rehabilitation

Phase	Time period	Plan
Phase 1	0-1 week	Swelling/pain management (analgesics, ice compression, and elevation)
		Nonweight bearing walking with walker
		Rom knee brace locked in extension (with PCL support)
		Patella mobilization
		Static quadriceps
		SLR with knee brace
		Hip abduction and adduction exercises
		ankle pumps
	1-4 weeks	In addition to week 1
		Continue nonweight bearing walking
		Passive knee ROM to tolerance
		Hamstring and calf stretching
Phase 2	4-8 weeks	In addition to phase 1
		Continue brace (unlock for exercise only)
		Active and active-assisted knee ROM
		Maintain full extension and progressive flexion
		Toe touch weight bearing from 4 weeks (gradually discontinue crutches)
		quadriceps and hamstring strengthening exercises
	8-12 weeks	Weight bearing as tolerated
		Full knee ROM
		Prone stretches
		Gradually discontinue ROM knee brace after 8 weeks
		Gait training
		Stair climbing
		Balance and proprioceptive activities
Phase 3	12 weeks-9 months	In addition to phase 2
		Full weight bearing with a normalized gait pattern
		Achieve pain-free full knee ROM
		Progressive proprioception and balance activities
		Closed chain strengthening
		Walking to jog progression
Phase 4	9 months and beyond	In addition to phase 3
		Full weight-bearing walking
		Maintain strength, flexibility, and function
		Begin sport-specific functional progression

PCL: Posterior cruciate ligament, ROM: Range of motion, SLR: Straight leg raise

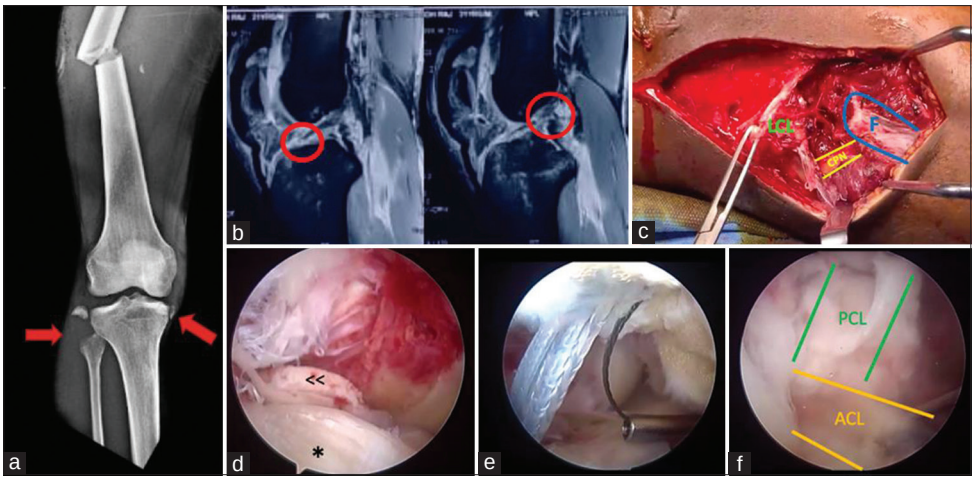

Figure 1: Case 1 (a) X-ray showing LCL avulsion fracture (red arrow over fibular head) with reverse segonds fracture (red arrow over medial proximal tibia). (b) MRI showing tibial avulsion of ACL (left MRI image) and femoral avulsion of PCL (right MRI image) indicated by red round. (c) Clinical image showing LCL avulsion fracture. (d) Arthroscopic image showing torne ACL and PCL. (e) Shuttling of the sutures through the bony tunnels. (f) Repaired ACL and PCL. *-ACL, <<-PCL, F-Fibula head, CPN: Common peroneal nerve, LCL: Lateral collateral ligament, ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament, MRI: Magnetic resonance imaging

Figure 2: Postoperative X-rays (1-year follow-up). (a) Case 1 – Femur x-ray. (b) Case 1 – Knee X-rays. (c) Case 2 – Knee X-rays

in their meta-analysis compared nonoperative, repair, and reconstruction groups in MLKI and showed 77.5% good and excellent clinical outcomes with suture repair in Grades 3 and 4 knee dislocations (Schenk).[6] Heitmann *et al*. in his multicenter prospective study showed excellent clinical outcomes in primary ACL and PCL repair with suture augmentation.[7] Inferior outcomes were seen in patient with low-velocity dislocations and those with common peroneal nerve injuries. Vermeijden *et al*. in 2020 did a retrospective analysis of MLKI and inferred PCL and PLC repair groups had high failure rates (17% and 18%) with excellent outcomes in MCL and ACL repair groups (0% and 9%).[8] Murakami *et al*. showed good long-term outcomes (2 years) with primary ACL and PCL repair with open MCL repair and early mobilization.[9]

Not all ligaments are amenable to repair, modified Sherman's types I and V are ideal for repair provided the stump is adequate. Ateschrang *et al*. inferred that ACL with intact synovial membrane had the lowest failure rate (4%) with good outcomes when compared with two part or lacerated ruptures.[10]

A plethora of repair techniques have been described in the literature, Difelice *et al*. described the suture augmentation technique along with repair.[11] Liao *et al*. showed good outcomes in partial tears repaired using suture anchors (Pulley technique).[12] Vermeijden explained the single bundle graft augmentation with repair in selected types of tears.[13] Other techniques include internal brace ligament augmentation, dynamic intraligamentary stabilization, and bridge-enhanced ACL repair. All described techniques have their own perils and pitfalls and a steep learning curve. Our suture bridge technique with No. 2 fiber wire is easily reproducible, cost-effective, and gives good clinical outcomes. Biological supplementation to repair using platelet-rich plasma, bio-scaffolds, and stem cells has proven to improve healing and we use marrow stimulation technique.

Conclusion

Long bone fractures with MLKI are not uncommon but often missed. Look for telltale signs of MLKI (abrasions, avulsion fractures, and effusion). Long bone fixation and primary arthroscopic bicruciate repair with open collateral repair is a technically challenging surgery and has excellent outcomes in appropriate patients.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other

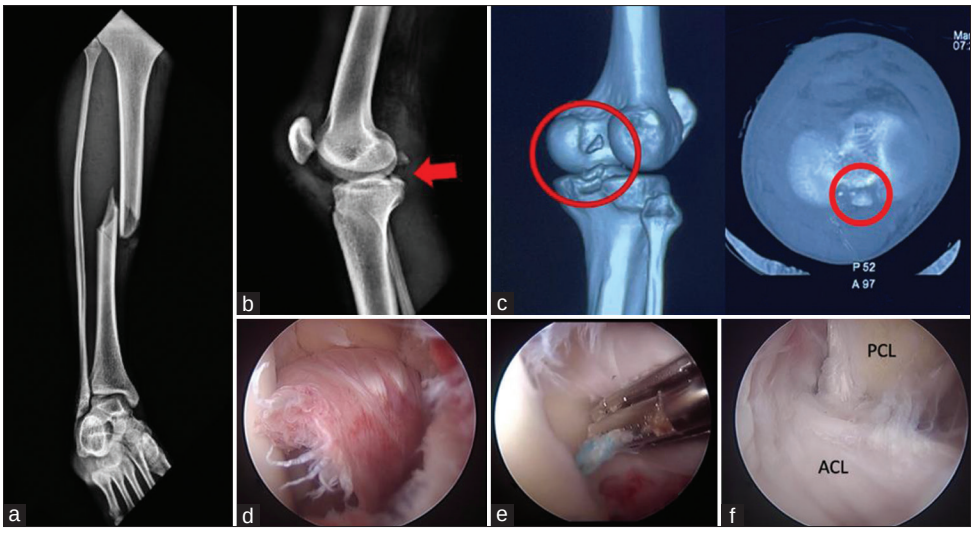

Figure 3: Case 2 (a) X-ray showing shaft of tibia fracture. (b) X-ray of knee showing PCL avulsion fracture indicated by red arrow. (c) CT images of PCL avulsion fracture indicated by red rounds. (d) Arthroscopic image of ACL soft tissue tibial avulsion. (e) Sutures taken on the ACL with knee scorpion. (f) Repaired ACL and PCL. ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament, CT: Computed tomography

clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Guler F, Kose O, Erol B, Turan A, Koroglu M, Akalin S. The prevalence of knee injuries ipsilateral to tibial shaft fractures and their impact on clinical outcome. Eur J Orthop Surg Traumatol 2015;25:141-8.
2. Caldas MT, Malheiros DS, Lazzaroni AP, Avelino EA, Santos AJ. Injury of the knee ligaments associated with ipsilateral femoral shaft fractures. Rev Bras Ortop 2013;48:438-40.
3. van der List JP, DiFelice GS. Range of motion and complications following primary repair versus reconstruction of the anterior cruciate ligament. Knee 2017;24:798-807.
4. van der List JP, DiFelice GS. Primary repair of the anterior cruciate ligament: A paradigm shift. Surgeon 2017;15:161-8.
5. Ahmad SS, Difelice GS, van der List JP, et al. Primary repair of the anterior cruciate ligament: Real innovation or reinvention of the wheel?. Knee Surg Sports Traumatol Arthrosc 2019;27:1-2.
6. Frosch KH, Preiss A, Heider S, Stengel D, Wohlmuth P, Hoffmann MF, *et al.* Primary ligament sutures as a treatment option of knee dislocations: A meta-analysis. Knee Surg Sports Traumatol Arthrosc 2013;21:1502-9.
7. Heitmann M, Akoto R, Krause M, Hepp P, Schöpp C, Gensior TJ, *et al.* Management of acute knee dislocations: Anatomic repair and ligament bracing as a new treatment option-results of a multicentre study. Knee Surg Sports Traumatol Arthrosc 2019;27:2710-8.
8. Vermeijden HD, Jonkergouw A, van der List JP, DiFelice GS. The multiple ligament-injured knee: When is primary repair an option? Knee 2020;27:173-82.
9. Murakami R, Honda E, Fukai A, Yoshitomi H, Sanada T, Iwaso H. Single-Stage Arthroscopic Anterior and Posterior Cruciate Ligament Repairs and Open Medial Collateral Ligament Repair for Acute Knee Dislocation. Case Rep Orthop 2020;2020:7348201. doi: 10.1155/2020/7348201. PMID: 32158579; PMCID: PMC7060436.
10. Ateschrang A, Schreiner AJ, Ahmad SS, Schröter S, Hirschmann MT, Körner D, *et al.* Improved results of ACL primary repair in one-part tears with intact synovial coverage. Knee Surg Sports Traumatol Arthrosc 2019;27:37-43.
11. Jonkergouw A, van der List JP, DiFelice GS. Multiligament repair with suture augmentation in a knee dislocation with medial-sided injury. Arthrosc Tech 2018;7:e839-43.
12. Liao W, Zhang Q. Is Primary Arthroscopic Repair Using the Pulley Technique an Effective Treatment for Partial Proximal ACL Tears? Clin Orthop Relat Res. 2020;478:1031-45. doi: 10.1097/CORR.0000000000001118. PMID: 31876551; PMCID: PMC7170704.
13. Vermeijden HD, van der List JP, DiFelice GS. Arthroscopic primary repair of the anterior cruciate ligament with single-bundle graft augmentation. Arthrosc Tech 2020;9:e367-73.

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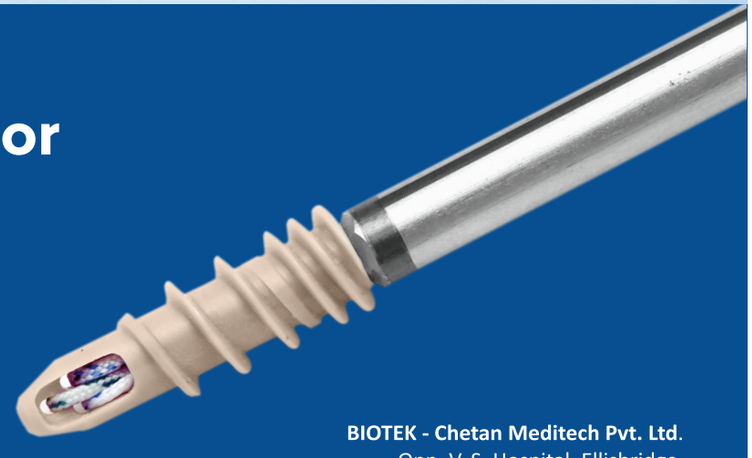

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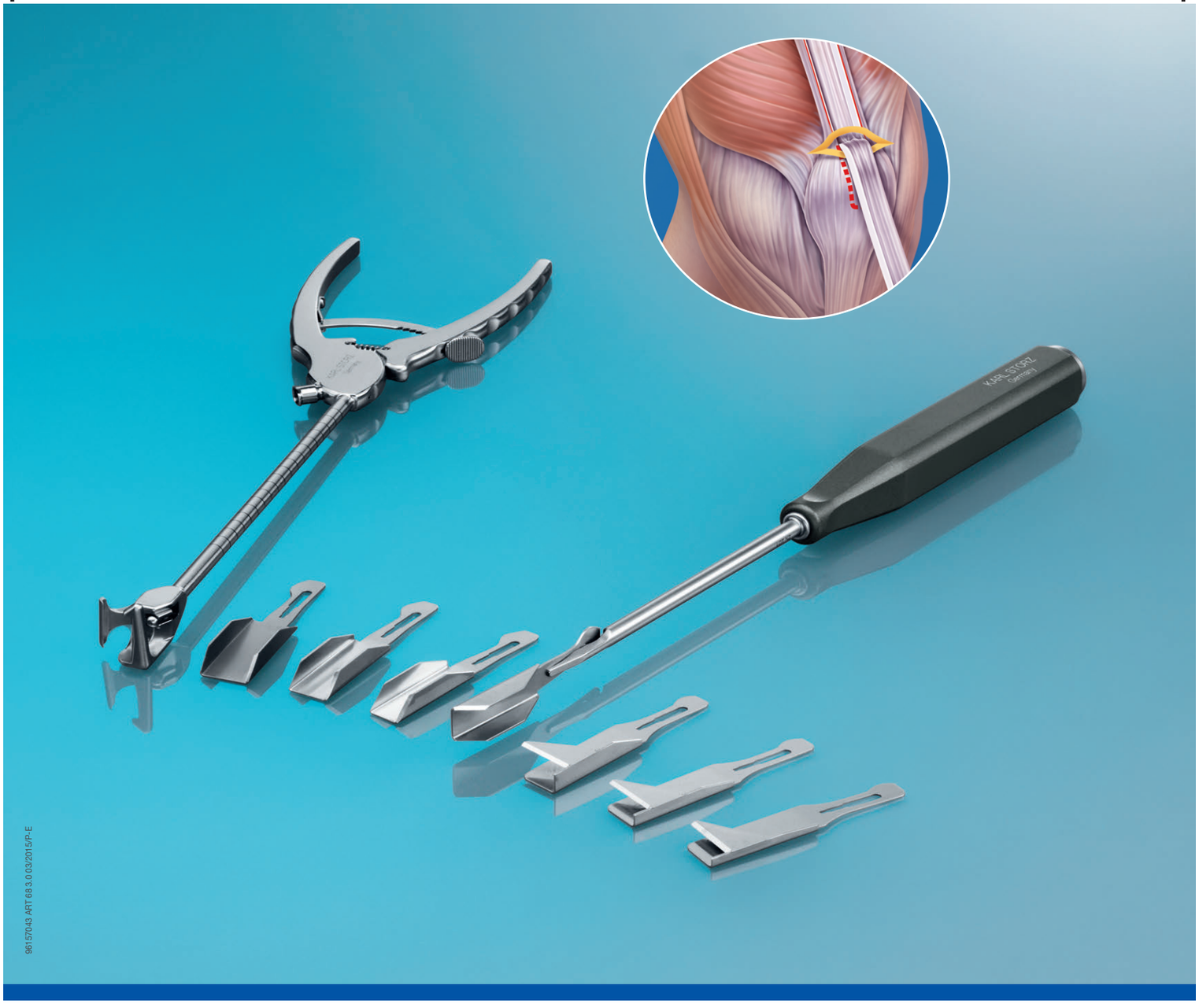

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