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ISKSAA International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

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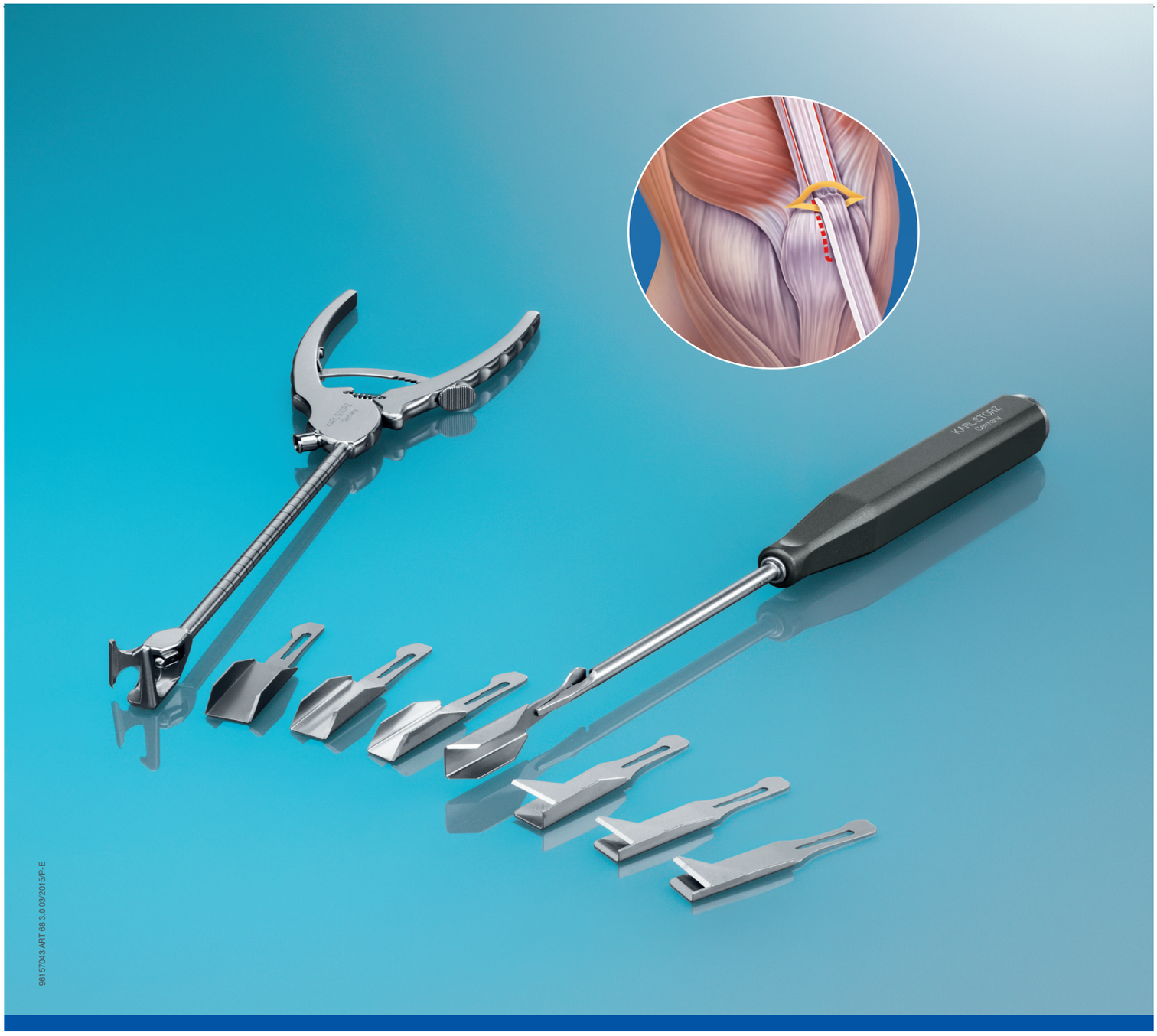

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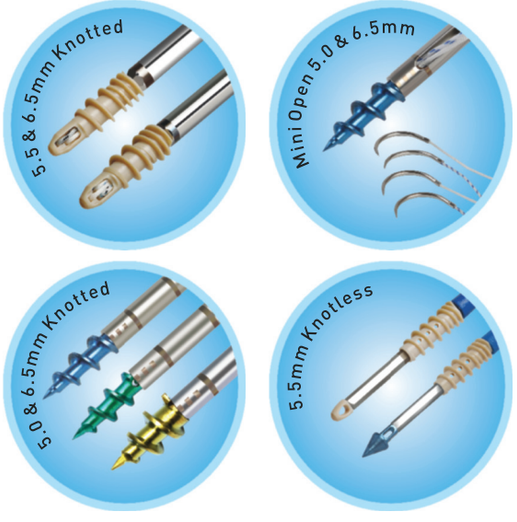

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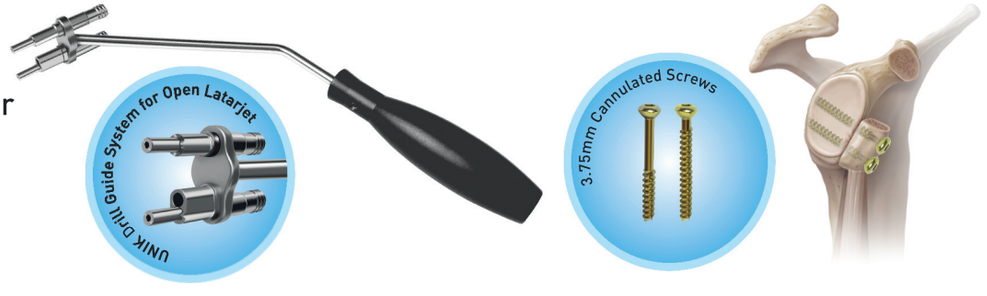

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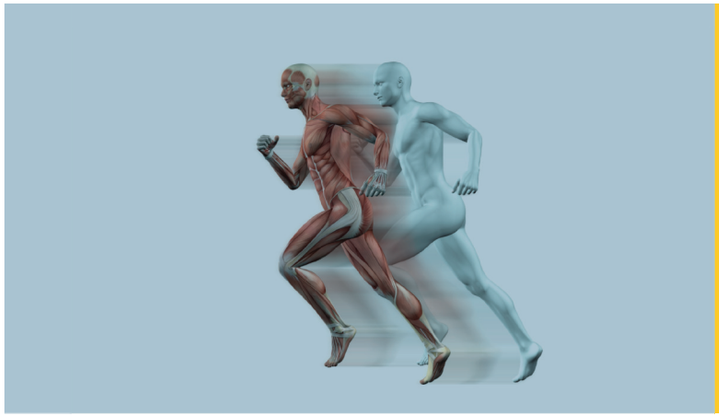

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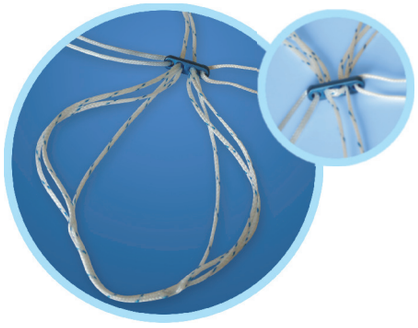

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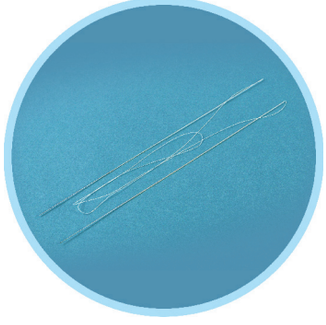

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Aims and Scope

Journal of Arthroscopy and Joint Surgery (JAJS) is committed to bring forth scientific manuscripts in the form of original research articles, current concept reviews, meta-analyses, case reports and letters to the editor. The focus of the Journal is to present wide-ranging, multi-disciplinary perspectives on the problems of the joints that are amenable with Arthroscopy and Arthroplasty. Though Arthroscopy and Arthroplasty entail surgical procedures, the Journal shall not restrict itself to these purely surgical procedures and will also encompass pharmacological, rehabilitative and physical measures that can prevent or postpone the execution of a surgical procedure. The Journal will also publish scientific research related to tissues other than joints that would ultimately have an effect on the joint function.

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Review article

Acute Achilles tendon rupture treatment: Where are we now?

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ABSTRACT

Objective: Our objective was to review the current literature regarding acute Achilles tendon ruptures and provide a succinct summary of the use of clinicians treating Achilles tendon ruptures. We aim to provide guidance for treatment based upon current literature.
Methods: We reviewed current literature and subjectively assessed for quality and influence of studies in current practice.
Review: The Achilles Tendon Rupture Score (ATRS) has become a vital tool in assessing functional outcome following interventions as re-rupture rates have balanced out for all treatment modalities. There remains continued debate between surgical and non-surgical treatment options. Both patterns have evolved over the past decade. Percutaneous fixation techniques are superseding traditional open surgery. Functional dynamic non-surgical regimes are also being developed to create the optimum environment for the Achilles tendon to heal and provide high functional outcomes. There even remains limited evidence that platelet-rich plasma aids healing, the significance of gap between tendon ends or of thromboprophylaxis lowering the incidence of symptomatic venous thromboembolism.
Conclusions: Acute Achilles tendon ruptures should either be managed in a functional rehabilitation regime or by percutaneous surgical repair. The decision depends upon both patient and clinician factors.

Contents

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1. Background

The Achilles tendon is the most frequently ruptured tendon in the body.[1] The incidence of Achilles tendon ruptures (ATR) is rising.[1–4] Table 1 highlights the demographics of ATR across multiple communities, the majority of these studies taking place in Scandinavia.[3,5–7] Incidences ranging from 6 to 37.3 per 100,000 have been quoted.[1,3] Five studies demonstrate an increased incidence over their studied periods. Most of these studies attribute the increased incidence with a higher population participation in sporting activities. However, there is a trend away from surgical treatment.[7–9] Males are far greater affected than females with a male-to-female ratio ranging between 0.9–7.7:1, with only one study finding a female predominance.[10]

1.1. Achilles Tendon Rupture Score (ATRS)

Outcome measures for patients with AT ruptures are based on a mixture of subjective parameters. The Achilles Tendon Rupture Score (ATRS) was first developed in 2007 after a need for a validated patient-relevant evaluation tool was identified.[17] The ATRS has been proved to have a high level of reliability, validity, sensitivity and internal consistency.[18,19] The ATRS gives surgeons the best tool to assess the functional outcomes post-Achilles tendon ruptures.

Ability to single-heel raise does correlate with PROMs however this outcome is not widely reported.[20]

2. Currents treatment modalities

2.1. Plaster cast regime

Plaster cast regimes have been the traditional method to non-operatively treat acute ATR. Equinus casts are still utilised acute from Accident and Emergency Departments but regimes progressing to sequential plantigrade positions were common.[21] Plaster cast allows the treating surgeon control over the amount of plantaflexion to apply at the ankle and assurances about patient compliance. There is however the risk of plaster sores, poor skin management/hygiene and stiffness.

2.2. Orthosis

Management of acute ATR within an orthosis is commonplace now. The benefits include flexibility of ankle position, ability to take care of any skin problems, improved weight bearing ability, earlier return of function and improved patient satisfaction.[22,23] Disadvantages of the orthosis is that they do not full immobilise all patients due their off-the-shelf design although air filled liners improve the fit (Fig. 1). There is also the issue to possible patient removal of the orthosis. This lack of compliance could potentially impair tendon healing.

2.3. Open surgery

Open surgery involves exposure and debridement of the ends of the ruptured tendon. Following this suture repair is conducted and repair of the dissected paratenon. Usually equinus plaster cast is applied before the initiation of the surgeons chosen rehabilitation regime.

2.4. Percutaneous surgery

More recently percutaneous repair systems have been launched to reduce the morbidity associated with Achilles tendon repairs. These systems allow reduced impact upon soft tissues and obviate the need for breaching the paratenon. However there is an association with nerve injury. Strength is comparable to open Kessler formation repairs (Fig. 2).[24]

3. Comparison of treatments

3.1. Any surgery vs. any non-surgical regime

A recent meta-analysis looked to compare all surgical versus all non-surgically managed acute ATR.[25] The primary outcome measure was re-rupture. A small benefit was found in the surgical group, but with so many variables involved in each management regime, this is an inaccurate representation to counsel patients. Also, functional outcomes must become of higher importance following ATR as this is what we must provide for patients. We shall attempt to break down comparisons of treatment regimes to

Table 1
A table to show critical demographics from multiple studies assessing acute Achilles tendon ruptures.

Study	Community	Population Size	Study Period	Incidence per 100,000	Mean Age	M:F ratio	Trend
Erickson et al.[10]	USA	25.6 million	2005–2011	10.8		0.9	Increasing (6.7–10.8)
Huttunen et al.[7]	Sweden	9.5 million	2001–2012	55.3 (male)/14.7 (female)		3.8	
Maffulli et al.[1]	Scotland	5.1 million	1980–1995	6.0	30	1.7	Increasing (4.7–6)
Suchak et al.[2]	Alberta, Canada	950,000	1998–2002	9.9	41.4	4.0	Increasing (5.5–9.9)
Moller et al.[11]	Malmo, Sweden	230,000	1987–1991	±30	37	6.3	
Houshian et al.[3]	Multiple cities, Denmark	220,000	1984–1996	37.3	42.1	3.1	Increasing (18.2–37.3)
Lantto et al.[6]	Oulu, Finland	140,000	1979–2011	21.5	43 (SD 13)	7.7	Increasing (2.1–21.5)
Levi et al.[5]	Copenhagen, Denmark	89,000	1978–1995	13.4	41	2.9	

Risk factors for ATR include the use of steroids[12,13] and fluoroquinolone antibiotic therapy.[14–16]

Fig. 1. An example of an orthosis that can be used (VACOPed®).

Fig. 2. The Achillon® system used for percutaneous repair.

include similar studies to gain stronger conclusions when comparing surgical and non-surgical regimes.

3.2. Open surgery vs traditional non-surgical

Trends in treating AT ruptures have been traditionally based on re-rupture rate as the primary outcome measure. The re-rupture rate has been notoriously quoted as being lower in surgical treatment based on an early meta-analysis.[26] However, this result was based on four studies all pre-dating 2001, with one from 1981, which compared open surgery and traditional non-surgical regimes using plaster cast with non-weight bearing immobilisation.[21,27–29] A defining study was performed by Keating et al. in 2011. Their RCT compared standard open surgery against a traditional casting immobilisation regime.[30] Re-rupture rates were 5% and 10% respectively, both which would be considered high rates for the latest treatment methods. Limited functional outcome scores were included, and both treatment methods are relatively historical despite being published in 2011. Based on this evidence there was an era of functional dynamic regimes and modern surgical methods.

3.3. Plaster cast versus walking boot

As orthopaedics moves forward, there is a constant drive away from the use of plaster of Paris to more patient-friendly methods including synthetic casts, orthosis and splints. This pressure has made its way into acute ATR management also. Many centres initially treated with a plaster cast immobilisation from the Accident and Emergency department. This allows easy, cheap and immediate immobilisation of the injured limb. A group from Sheffield in the UK compared cast immobilisation versus controlled early mobilisation in an orthosis.[22] The splint led to early regain mobility and increased satisfaction. A systematic review reviewed plaster cast immobilisation versus dynamic functional rehabilitation following surgical repair of the ATR. The concluded that functional regimes were safe with high satisfaction rates.[31]

There has been no study directly comparing plaster cast and orthosis in similar cohorts. The UK STAR study is aiming to assess the effect on functional outcomes following treatment in either functional bracing or plaster cast immobilisation. This multi-centre randomised controlled trial (RCT) will aim to recruit 330 patients over the future three years. This study is likely to lay to rest the argument between plaster cast and functional bracing.

3.4. Functional regimes

Recent studies had supported non-surgical treatment using functional/dynamic rehabilitation for acute ATR with comparable re-ruptures rates between surgical and non-surgical regimes when these methods were utilised.[23] Early weight-bearing with a dynamic range of motion has been shown to achieve favourable outcomes regarding the range of motion, strength, and return to activities while minimising the possibility of healing in a lengthened position, or re-rupture.[32] These results were summarised by McCormack et al. Meta-analysis of RCTs comparing post-surgical dynamic regimes versus immobilisation in a cast.[31] They pooled data from 10 studies (570 patients) to show that there was no increase in complication rates and a higher patient satisfaction after using dynamic regimes.

An RCT performed by Valkering et al. compared early full-weight bearing and non-weight bearing following open surgical repair. Interestingly they found raised levels of biological markers of tendon repair (procollagen type 1, glutamate, lactate and pyruvate) in the full-weight bearing cohort with an improved early ankle range of motion.[33] In a similar study, Barfod et al. demonstrated an increased stiffness in the plantar flexor muscle-tendon complex in the non-weight bearing group.[34] These results add some clinical evidence that early stressing of the healing tendon tissue can lead to an improved outcome, likely due to collagen fibre orientation. However, these regimes were all instituted after surgical repair.

Hutchison et al. implemented a hospital-wide (Swansea Morriston Achilles Rupture Treatment; SMART) programme between 2008 and 2014, reporting on 211 non-operatively managed ATR.[35] The regime involved two weeks in an equinus cast followed by eight weeks in a VACOped boot. They allowed immediate full-weight bearing. Mean ATRS at nine months was 72.4 (SD 14) with a re-rupture rate of 1.1%. However, this final functional level was only available for 20% of patients included in the study. A similar study from Northern Ireland presented 949 ATR seen between 1996 and 2008.[36] This study used different methods to immobilise the limb but included all patients. Initially, they used a custom-made rigid polypropylene double shell patellar tendon bearing orthosis before an aircast pneumatic walking boot was introduced in 1999. A re-rupture rate of 2.8% with good to excellent subjective assessments in 99.4% was found.

Currently, there is no consensus as to the most superior functional regime.[37] Immediate full-weight bearing regimes have been implemented, in both non-surgical and post-surgical regimes, without compromise to outcomes or re-rupture rates.[38–41] Aujla et al has demonstrated that a functional regime of 8 weeks duration, compared to 10 weeks, lead to no detriment in functional outcome scores following ATR.[42]

3.5. Open surgery vs. functional non-surgical regime

Three RCTs have compared traditional open surgery and non-surgical functional rehabilitation.[19,43,32] Willits et al. showed no difference in re-rupture rate, calf strength, the range of motion, calf circumference or Leppilahti score.[32] They advised non-surgical treatment to avoid surgical complications. Nilsson-Helander et al. found no difference in re-rupture rates, Achilles Tendon Rupture Score (ATRS) at 6 and 12 months. The only statistically significant difference in outcome was noted in the 12-month heel-rise work test in favour of surgical treatment.[19] Olsson et al. demonstrated no difference in symptoms, physical activity level or quality of life. Statistical superiority was only shown in drop counter-drop jump and hopping in favour of surgery.[43] These results suggest that open surgical repair may lead to superior functional in loading activities over functional non-surgical regimes with no discernable difference in functional scores or re-rupture rate. This would support the use of dynamic functional non-operative regimes for the majority of patients. It provides fewer risks with equivocal re-rupture rates.

3.6. Open surgery vs. minimally invasive surgery

As surgical techniques improved the desire for minimally invasive surgery (MIS) has to lead to multiple systems being developed. Laboratory studies have demonstrated no difference in ultimate tensile strength of repair between percutaneous MIS and open techniques.[44] A meta-analysis of six RCTs compared traditional open surgery versus MIS techniques.[45] This showed no difference in re-rupture rate, nerve injury, deep infection, tissue adhesions or deep vein thrombosis. However, MIS was shown to provide three times greater good to excellent subjective outcomes and a significantly lower superficial infection rate.[45] Hsu et al. showed in their retrospective series that their percutaneous technique had a significantly improved rate of return to baseline physical activities over open repair with no difference in complication rates.[46]

3.7. Minimally invasive surgery vs. functional non-surgical regime

No RCT has yet been conducted directly comparing modern MIS versus a non-surgical functional dynamic regime with the primary outcome measure being a patient function. Metz et al. did conduct an MIS versus functional non-surgical regime in a VACOped boot, but they did not include the ATRS as part of their outcomes.[40] They did include Leppilahti scores as functional outcome assessment, which showed no statistical difference, but this was not the primary outcome being assessed.

4. Adjuncts to treatment

4.1. Platelet Rich Plasma (PRP)

There have been multiple studies assessing the use of biological augmentation following surgical repair of ATR.[47–49] These cohort studies suggest an earlier return to work with no adverse outcomes. De Carli et al. went on step further and evaluated all patients with MRI imaging. They found no clinical difference between the PRP and non-PRP cohorts but did find increased signal enhancement, to gadolinium, in the PRP cohort suggesting better tendon remodelling.[50]

Kaniki et al. injected PRP twice within the first two weeks following acute ATR treated in a non-surgical regime. They compared this to a previous historical cohort that underwent the same non-surgical regime but with no PRP. No measurable difference was found in strength at 1 or 2 years following injury.[51]

No RCT using biological augmentation has been performed as of yet, but the Platelet Rich Plasma in Achilles Tendon Healing (PATH-2) trial is on-going at the moment in the United Kingdom. This pragmatic multi-centre RCT is comparing the use of PRP in non-surgically managed ATR. The primary outcome measure is heel-rise endurance test at 24 weeks.

4.2. Stem cell therapy

A small cohort, level 4 study in patients with sport-related Achilles tendon ruptures showed excellent results with no re-ruptures when open Achilles tendon repair was augmented with bone marrow aspirate concentrate (BMAC).[49]

Kadakia et al. showed promising results of use of bone marrow-derived stem cells in animal models.[52]

In another animal model, Yuksel et al showed the efficacy of local bone marrow mesenchymal stem cell therapy, and platelet-rich plasma positively affected the recovery of the tendon histopathologically, immunohistochemically, and biomechanically and increase the structural strength.[53]

Mesenchymal stem cells were used to treat rabbits with surgically Achilles tendon rupture and were divided into three groups looking at tendon healing at 14 and 28 days. The three groups were, cross-section of the Achilles tendon (CSAT); CSAT + Suture; and CSAT + MSC (mesenchymal stem cell). A comparison showed a statistically significant decrease in the inflammatory process and an increase in the structural organisation of collagen in the CSAT and CSAT + MSC groups.[54]

In an animal study, rats were divided into three groups: the BMC group (bone marrow cells injected around the tendon), the MSC group (mesenchymal stem cells injected around the tendon), and the non-treated control group (incision only). The researchers looked at outcome measures which included mechanical testing, collagen immunohistochemistry, histological analysis, and reverse transcription-polymerase chain reaction to detect expression of transforming growth factor-β (TGF-β) and vascular endothelial growth factor (VEGF). They reported the ultimate failure load in the BMC group was significantly higher than that in the non-treated or the MSC group at seven days after incision (3.8 N vs. 0.9 N or 2.1 N, $p < 0.016$) and at fourteen days after incision (10.2 N vs. 6.1 N or 8.2 N, $p < 0.016$). Hence they concluded transplantation of whole bone marrow cells might be a better option than cultured mesenchymal stem cells.[55]

5. Controveries

5.1. Does Achilles tendon rupture gap matter?

It was Kotnis et al. in 2006 that highlighted the need to assess ATR gap to aid decision making for surgical treatment.[56] They assessed 125 ATR patients and surgically managed those with a residual gap of >5 mm in full equinus. As a result of this protocol, they treat 54% of ATR surgically with either open or percutaneous repair, but they did not employ a dynamic functional rehabilitation regime in either arm. There was no significant difference in complications, but no functional results were recorded. Two earlier studies employed a similar 5 mm gap protocol.[57,58] Other studies have utilised a 10 mm gap to drive surgical treatment.[35] However, this was based on tendon lengthening showing poor function in a cadaveric study.[59] A more recent study found no difference in function when comparing acute ATR with gaps less than or greater than 10 mm using a functional dynamic regime.[60] Roberts et al. assessed 69 ATR using MRI and found no significant correlation between gap size and one-year functional outcome in non-surgically managed ATR.[61] Westin et al. demonstrated that a gap of >10 mm led to an increased re-rupture rate and lowered functional outcome, but this was based on a cohort of just 45 patients.[62]

Ultrasound is a dynamic assessment but is inherently user-dependent. Those that criticise this protocol would discuss how ATR rarely occurs as a clean-ended rupture and often depicts a horses-tail appearance. This makes precise identification of rupture ends confusing and inaccurate. Overall there is no clear evidence that gap size affects functional outcome.

5.2. Venous-thromboembolism in Achilles tendon rupture

There remains an unexplained high rate of VTE in patients after acute ATR when compared to other lower limb injuries requiring immobilisation.[63] The incidence is said to vary between 0.8% and 23.5%.[64,65] The true incidence, of symptomatic VTE, likely to be between 3 and 7% depending on an individual institutes treatment algorithm and thresholds to investigate. Lapidus et al. showed an asymptomatic deep vein thrombosis rate of 34–36% after ATR with or without chemical thromboprophylaxis.[66] Studies have failed to show any benefit of using low-molecular-weight heparin (LMWH) or aspirin in patients after ATR to reduce symptomatic VTE rate.[66–68] Nevertheless, the majority of hospital recognise ATR as a high-risk patient and treat with thromboprophylaxis after risk assessment.

5.3. Predictors of outcome

Domeij-Arverud et al. used data from a prospective RCT comparing post-operative regimes in surgically treated ATR.[69] They found improved outcomes in patients aged under 40, females and in patients that did not suffer from a VTE during treatment. Conversely, two studies have shown superior results in males.[70,71] In our unpublished data across 236 ATR treated in a functional regime found that age had an inverse correlation with outcome and that males had superior functional outcomes at final follow-up.

6. Conclusion

We propose that a two-tier treatment protocol is required for the acute ACT. The vast majority of patients will achieve good functional outcomes using a dynamic functional regime of 8–10 weeks duration. Three randomised controlled trials have shown no differences in functional outcomes between dynamic functional regimes and open surgery. There are minimal risks to the patients along with Achilles Tendon Rupture Scores of 75–85 out of 100. For patients with higher demands, a minimally invasive technique can be used to repair the Achilles tendon surgically. This provides superior, yet not statistically proven, higher Achilles Tendon Rupture Scores of 85–90 out of 100 that may provide this cohort with improved results. A randomised controlled trial comparing these two methods, utilising functional outcomes, could be undertaken to quantify the functional difference between the two.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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Review article

Isolated popliteal tendon avulsions: Current understanding and approach to management

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ABSTRACT

Isolated popliteal tendon avulsions are rare injuries with less than 20 cases reported in the literature. Clinical suspicion of injury is aided by MRI findings. Due to the paucity of literature there is a lack of consensus as to the best management for such injuries. Both non-operative and operative treatment options have been reported to be successful. We proposed a treatment algorithm based on our findings of the literature with a trial of 3 months of non-operative treatment followed by delayed surgical repair in refractory cases.

Contents

1. Introduction

An isolated popliteus tendon avulsion is a rare and uncommon injury, with less than 20 cases reported in the literature. Avulsion of the popliteus tendon may occur as a result of knee hyperextension, with the combination of either tibial external rotation or a varus force to the knee. Due to the lack of literature, both operative and non-operative treatments have been reported to be successful. We review the current literature and provide a treatment algorithm based on our findings.

2. Anatomy

The posterolateral corner (PLC) complex of the knee consists of the popliteus tendon, lateral collateral ligament, biceps femoris tendon, popliteal meniscal ligament, popliteal fibular ligament, lateral gastrocnemius muscle, arcuate ligament, oblique popliteal ligament and the fabellofibular ligament.

The popliteal muscle originates from the posteromedial aspect of the proximal tibial metaphysis above the soleal line[1] and forms the floor of the popliteal fossa.[2] The popliteal tendon then passes through the popliteal hiatus, entering the knee joint and inserting into the lateral femoral condyle at the edge of the popliteal sulcus, with a curved footprint. The popliteus tendon is intracapsular, but extra-articular and extrasynovial.[3] There are various aponeurotic attachments described to the posterior horn of the lateral

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meniscus and the fibular head.[4] The insertion into the lateral meniscus retracts and protects the meniscus in flexion.[5]

3. Function

The PLC functions to resist genu varum, external tibial rotation and posterior tibial translation. The role of the popliteus within the PLC is less clearly described. It has been proposed to assist in unlocking the knee,[6] initiate and assist internal rotation of the tibia on the femur[2] and prevent forward dislocation of the femur on the tibia in low flexion.[7]

Within the PLC it is an important static stabilizer. It acts as a secondary restraint to posterior displacement of the tibia in posterior cruciate ligament deficient knees.[8]

The popliteal tendon has been described recently as the static 'fifth ligament' of the knee.[9] Sectioning of the tendon in cadavers leads to significant increases in external rotation and smaller increases in internal rotation, varus angulation and anterior translation. Further, an anatomic popliteal tendon reconstruction in the same cadaveric knees significantly reduced the increase in external rotation seen with sectioning but not the smaller differences in internal rotation, varus angulation and anterior translation.[9]

It appears thus that the main role of the popliteus tendon may be in assisting internal rotation of the tibia on the femur and as a restraint to external rotation.

4. Mechanism of Injury

It has been suggested that popliteal injuries occur due to blows to the anteromedial aspect of the proximal tibia with the knee hyperextended or due to non-contact related hyperextension with external rotation.[10] Nakhostine et al reported four cases in which the isolated avulsion of the popliteal tendon was due to external rotation with the tibia in low flexion.[11] Brown could not identify a clear mechanism of injury in their radiological study.[1] It appears that an external rotation force with the knee in hyperextension or near hyperextension is the most likely mechanism of injury.

5. Clinical signs and symptoms

Due to the lack of literature surrounding such injuries it is hard to elucidate a constant pattern of signs and symptoms. The typical injury appears to result from an external rotation force in a hyperextended or near hyperextended knee, with subsequent stop of play and pain towards the lateral and posterolateral aspect of the knee with effusion. There is usually tenderness laterally and posterolateral and the dial test is usually negative. The range of motion tends to be preserved other than in the acute phase where pain may limit movements. There are no specific tests described in the literature to isolate the popliteus from the PLC.

It is important however to test for concomitant injuries to the cruciates and collaterals. Isolated injuries to the popliteus occur in less than 10% of cases with over half of cases having associated meniscal injuries or bone bruises.[1,12] One quarter of cases have concomitant injury to the cruciates and a small number have injury to the collaterals also.[1,13]

6. Imaging

Plain radiographs may show small avulsion of fragment from the lateral femoral condyle at the insertion point of the popliteal tendon[14] however this is non-specific and not a consistent finding. The presence of such an osseous fragment though is important for pre-operative planning.

On MR imaging, the popliteus tendon is seen as a T2 hypointense cord-like structure attaching to the popliteal sulcus on the lateral aspect of the lateral femoral condyle (Fig. 1a and b). On coronal images, the insertion is below the origin of the lateral head of the gastrocnemius and the femoral attachment of the LCL. On the saggital images, the tendon can then be seen passing posteroinferiorly behind the posterior horn of the lateral meniscus.[3]

The classical MR findings of injury related to degree of strain[15] also apply to the popliteus tendon[3] (Fig. 2a and b) – first degree (stretch injury): minor degree of fiber disruption with interstitial edema and haemorrhage producing a feathery appearance on MR; second degree (partial tear): fluid signal without retraction along

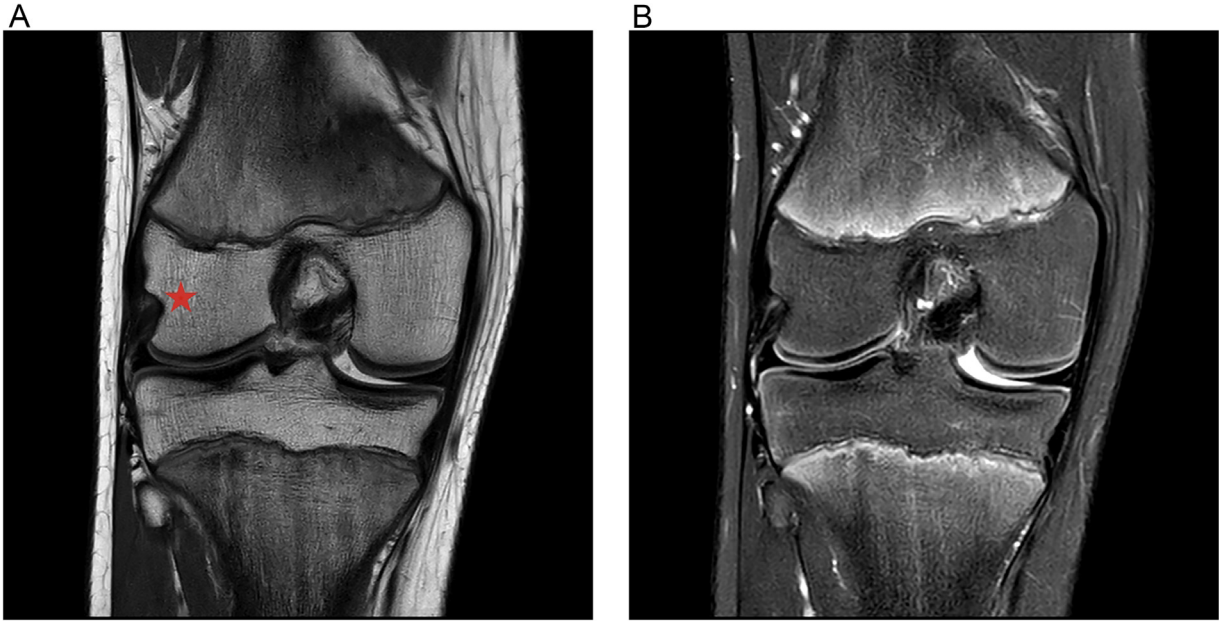

Fig. 1. a and b – Coronal proton density (a) and fast spin echo T2 (b) images of a normal popliteal tendon showing insertion into the footprint along the popliteal sulcus.

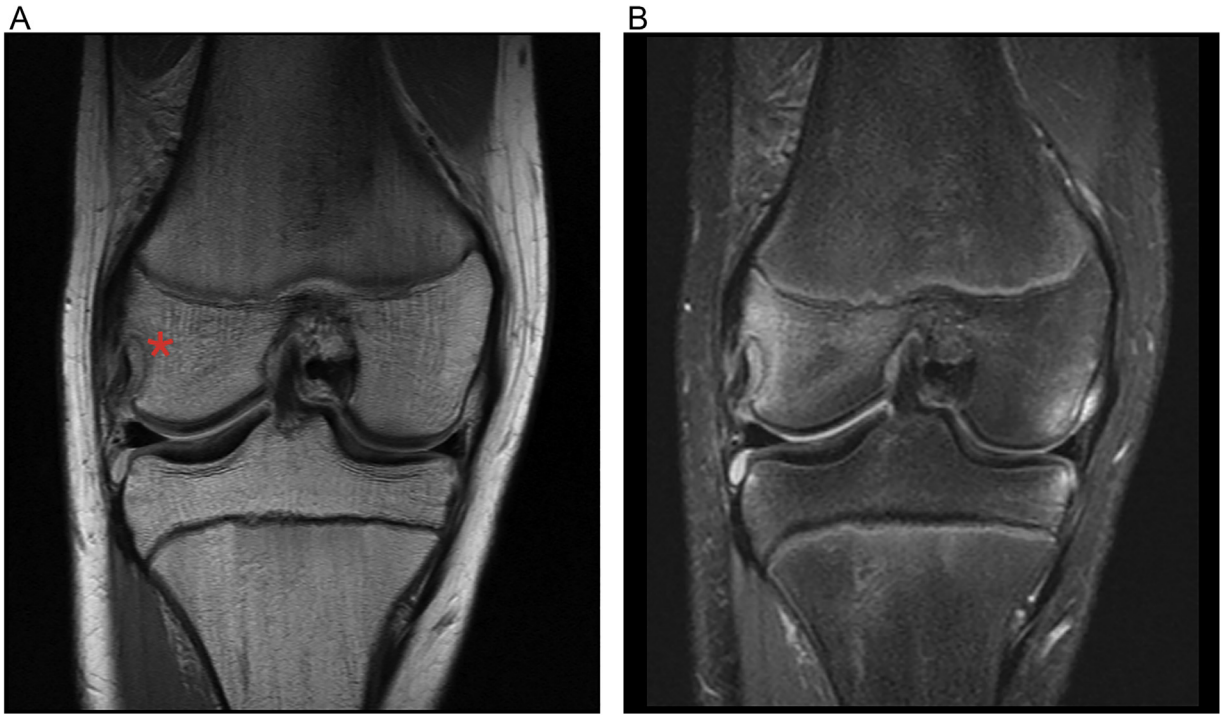

Fig. 2. a and b – Coronal proton density (a) and fast spin echo T2 (b) images of a Grade 3 (complete) popliteal tendon avulsion of the anatomical footprint.

with haematoma and perifascial fluid collection; and third degree (complete rupture): complete separation of the tendon from the footprint with fluid signal intervening and various degrees of retraction. In cases of complete rupture it is important to note the presence of an osseous fragment attached to the tendon. Further, complete ruptures may benignly appear as a periarticular soft tissue swelling surrounded by fluid.[16]

In a study of the MRI scans of 24 consecutive patients, Brown et al (1995) found that 96% of tears of the popliteus involved the muscular portion and 15% of patients had tears to both the muscular and tendinous portion with only one case of tendon tear alone.[1] This emphasizes both the rarity of the lesion and the need to look for, not just tendon avulsion and injury, but injury to the muscle belly itself, which may take the form of fluid signal and oedema within the muscle belly or perimuscular soft tissues.

7. Treatment

Due to paucity of literature surrounding popliteal tendon avulsions, there is a lack of consensus as to the most effective treatment. Both non-operative[14,17–19] and operative treatment[6–8,11,20,21] regimens have been described as successful.

Non-operative treatment protocols usually consist of a long leg hinge knee brace with no motion or weight bearing restrictions and an early physical therapy program starting with gentle range of motion exercises which are progressively increased as tolerated. Usually there is return to most activities and some sports by 6 months. There was one case[22] of a popliteal tendon avulsion with a posterior tibial nerve compression due to the haematoma of the injury, where the tendon had adequately recovered by 3 months however the nerve took another 3 months for recovery.

Operative options usually centre on reducing the fragment to bone and fixing with either screws or suture anchors. Intra-operatively, an arthroscopic 'lateral gutter drive-through' sign[23] has been described where the arthroscope can be pushed into the interval between the politeus tendon and the lateral femoral condyle. A positive sign indicates the presence of a femoral avulsion of either the popliteus tendon or concomitant LCL.[23] There has been one case described where the fragment was simply excised in an elderly patient[21] who had adequate function postoperatively and was able to return to all daily activities.

Based on the available literature we propose a treatment algorithm for isolated popliteal tendon avulsions (Fig. 3).

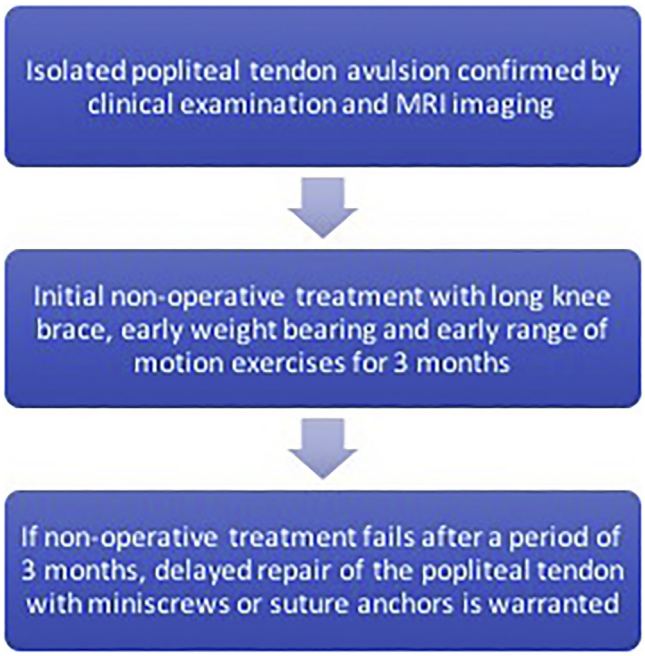

Fig. 3. Treatment algorithm for approach to popliteal tendon avulsions based on the literature.

Conflict of interest

None.

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Research paper

Multiligamentous knee injury – A Level III study to describe systematic approach, management and rehabilitation protocol with review of literature

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ABSTRACT

Introduction: Multiligamentous knee injury (MLKI) is a complex and difficult entity in terms of management and rehabilitation programme due to lack of consensus in literature over optimal treatment guidelines. Thus this case series was intended to describe our surgical technique, sequence of fixation of ligaments with functional & clinical outcomes following reconstruction of ligaments and rehabilitation protocol.

Material and methods: 20 consecutive patients diagnosed with MLKI between 2015 and 2017 were enrolled and underwent surgical reconstruction/repair of torn ligaments. A prospective collected data of all patients were analysed retrospectively in terms of clinical and functional outcome by assessing the patients with their range of motion (ROM), lysholm and tegner activity scores.

Results: A total of 20 MLKI patients who were operated from 2015 to 2017 were recruited and followed up for a mean period of 1.8 years (range 6 months to 2 years). Mean range of motion among the KD groups (I-V) was from 5° to 111.67°. Mean Lysholm score among the KD groups (I-V) was 84.53. Mean Tegner activity level of KD groups (I-V) before injury was 4.6 and mean current level at the time of follow up was 3.6. No significant medial laxity was observed at final follow up period.

Conclusion: We found good functional outcome in most cases treated by our systematic approach and management protocol. Better functional outcomes in MLKIs needs thorough clinico-radiological evaluation and proper surgical planning in terms of repair/reconstruction. Early intervention (<3 weeks), multistage reconstruction and individualized rehabilitation are key factors for early return to activities.

1. Introduction

Multiligamentous knee injury (MLKI) is a complex and difficult entity in terms of management and rehabilitation programme due to lack of consensus in literature over optimal treatment guidelines.[1] It constitute less than 0.02% of all orthopaedic injuries and may be associated with neurovascular injury that can threaten the affected extremity.[1] Heterogeneity in injury mechanism and pattern necessitates comprehensive clinical and detailed radiological examination to identify and planning for management of all injured structures.[2] A multiligamentous knee injury (MLKI) is defined as one complete cruciate ligament tear (grade III) with either partial or complete collateral or other cruciate ligament tear (grade II or III).[3] Knee dislocations usually result in multiligament knee injuries and are characterised by disruption of both cruciate ligaments with or without associated collateral ligament injury.[2]

With recent advances in surgical technique and devices, multiligament knee injuries are now being managed surgically with superior outcomes compared to non operative in terms of return to work and sports activities. Early surgical intervention (<3 weeks from the injury) with reconstruction of cruciate ligaments along with PLC associated with less revision rates and yielded superior functional and clinical outcomes as measured by Lysholm and Tegner activity score[4,5] compared to repair of these structures.[6]

There is paucity of literature addressing the management options and their outcomes in MLKI patients because of low incidence of these injuries and higher rates of associated trauma, complexity

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and heterogeneity in both pattern and mechanism of injury.[1] Thus this case series was intended to describe our surgical technique, sequence of fixation of ligaments with functional & clinical outcomes following reconstruction of ligaments and rehabilitation protocol.

1.1. Objectives of study

The objectives of our study are 1) to describe the surgical technique of repair, reconstruction and sequence of fixation of ligaments in combined cruciate and collateral ligaments injuries 2) to describe rehabilitation protocol following reconstruction/repair of ligaments 3) to analyze the functional and clinical outcomes of patients with multiligamentous knee injuries (MLKI) using Lysholm, Tegner activity scoring methods and range of motion of the injured knee.

2. Material and methods

20 consecutive patients diagnosed with MLKI between 2015 and 2017 were enrolled and underwent surgical reconstruction/repair of torn ligaments. A prospective collected data of all patients were analysed retrospectively in terms of clinical and functional outcome by assessing the patients with their range of motion (ROM), lysholm and tegner activity scores. Schenck[7] classification was used to classify the pattern of multiligament knee injuries.

2.1. Preoperative evaluation

All patients were first examined clinically including neurovascular examination. USG Color Doppler and CT Angiography were done for patients with feeble or diminished distal pulses in cases of knee dislocation resulting from high velocity injury. In case of neurological deficit EMG (Electromyography) and NCV (Nerve Conduction Velocity) were done for diagnosing the type of neural injury. After addressing the neurovascular emergencies a thorough clinical assessment was done to determine the cruciates and collaterals injury. Various clinical tests were used to diagnose the ligament injuries as shown in Table 1.

2.2. Radiographic evaluation

All patients underwent plain radiographic assessment for joint congruency and to rule out periarticular/avulsion fractures. In cases of Tibial spine/PCL/Medial collateral ligament (MCL) bony avulsion injuries CT scan was advised for precise evaluation. MRI evaluation was done in all MLKI patients to confirm the ligamentous injuries and to identify any associated intraarticular damage and concomitant meniscal injuries. Fig. 1A showing ACL, MCL tear with meniscal injury and Fig. 1B showing bicruciate injury (ACL + PCL).

2.3. General surgical management of MLKI

After clinico-radiological examination preoperative planning was done regarding repair vs reconstruction of ligaments, autograft selection and mode of fixation in cases of MLKI as shown in Table 2. Surgery was performed within 3 weeks of injury in acute cases so that repair of the torn collateral ligaments could be performed easily. In chronic cases patients were operated when near normal range of motion and good quadriceps control achieved to prevent post-operative arthrofibrosis and loss of joint motion. Both legs were prepared and draped at the same time to harvest the Semitendinous-gracilis (STG) graft from contralateral normal leg if required. Diagnostic arthroscopy was performed to begin with using standard anterolateral and anteromedial portals. Associated meniscal injuries were addressed at the same time. In cases of grade II/III MCL tear repair was always being augmented by STG graft to prevent the post-operative valgus instability/laxity due to poor result of repair procedure done alone. In cases of LCL/PLC injuries reconstruction was always being attempted using autograft to yield better functional outcomes.

2.4. Surgical management of cruciate ligament tears

In patients with bicruciate injuries with intact collateral ligaments, PCL reconstruction was indicated in all grade 3 injuries. Reconstruction started first with PCL tunnels formation using STG graft harvested from contralateral side. For ACL reconstruction, STG graft harvested from ipsilateral leg was used. Then graft was prepared in 5 strands manner with standard whipstitch technique using ethibond and vicryl thread. Both femoral and tibial tunnels were drilled using the standard technique of anatomical PCL reconstruction. Then ACL tunnels were drilled in tibial and femoral side using standard anatomical ACL reconstruction technique. PCL graft was passed and secured with biointerference screw on femoral side while tibial tunnel aperture was left unsecured. Then ACL graft was passed and secured with adjustable/fixed loop on femoral side. Now both grafts on tibial sites were secured with biointerference screws. PCL graft was secured first with knee in 90° flexion followed by ACL graft fixation in knee extension. In cases with associated collateral injuries, PCL reconstruction was done using Quadriceps tendon graft which was harvested from ipsilateral side by giving 5 cm long incision over anterior aspect of distal thigh starting from superior pole of patella as shown in Fig. 2 and prepared in same manner using standard whipstitch technique.

2.5. Surgical management of medial structure injuries

In cases of cruciate tear with avulsion from tibial site or intrasubstance MCL tears, repair was done with suture anchors or with non-absorbable sutures (Ethicon) along with capsule imbrication. In cases with severe rupture of MCL and the capsule, repair with augmentation was employed. Medial longitudinal incision given over anteromedial surface of proximal tibia, ipsilateral STG tendon graft prepared in double strands fashion without detachment from tibial surface. Then graft was passed through the medial retinaculum and inserted at medial epicondyle level (5 mm posterior and 3 mm proximal) through the coronal tunnel (graft size) formed in the femur and secured with biointerference screw with knee in 30 degree flexion. The graft was reflected back over the tibial surface

Table 1
Showing clinical assessment of MLKIs.

Ligament	Clinical tests
ACL	Anterior drawer, Lachman & pivot shift
PCL	Posterior drawer, Posterior sag & loss of tibial step off
MCL/LCL	Valgus/Varus stress test done in 0 and 30° of flexion
Posteromedial structures	Anteromedial drawer test/Slocum test done in 90° flexion & external rotation
Posterolateral structures	Dial test performed in prone position with knee in 30 & 90° flexion

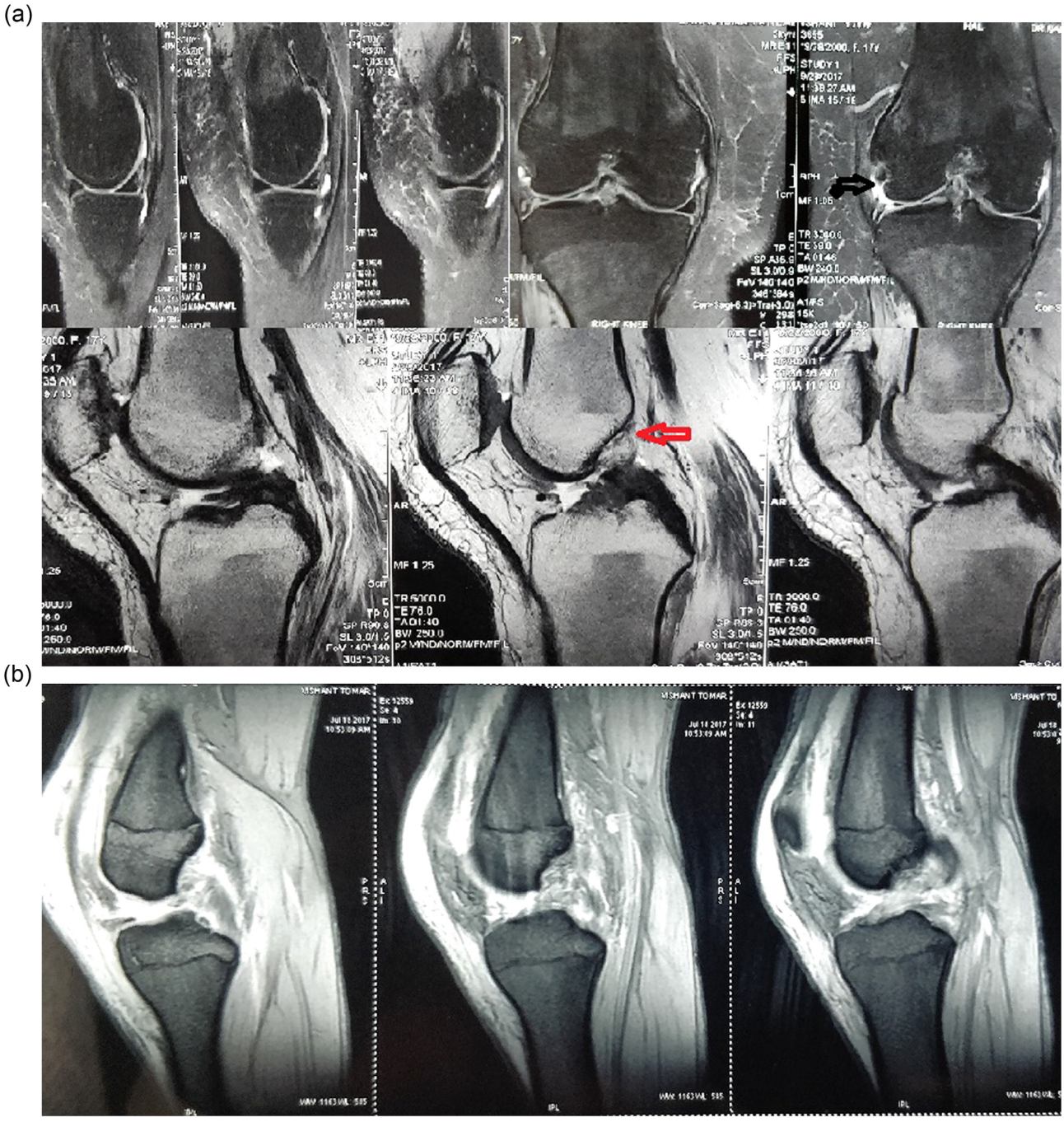

Fig. 1. A: showing ACL, MCL and medial meniscal injury.

Table 2
Preferred graft selection, technique and mode of fixation of ligaments in MLKIs.

Ligament	Graft	Technique	Mode of fixation
ACL	Ipsilateral/contralateral STG	Single bundle reconstruction	Adjustable/fixed loop-femur side, biointerference screw-tibial side
PCL	Ipsilateral/contralateral STG/Quadricep tendon	Single bundle reconstruction	biointerference screw- femur & tibial side
MCL/ PMC	Ipsilateral STG	Repair with augmentation	biointerference screw- femur side, Ligament staple – tibial side
LCL/PLC	Ipsilateral/contralateral STG	Repair + Larson figure of 8 reconstruction	Biointerference screws-femur & fibular side

and attached posterior to pesanserinus insertion to secure a two point fixation on tibia. Spiked metallic ligament staple (Arthrex) was used to fix the posterior limb as shown in Fig. 3.

2.6. Surgical management of lateral structure injuries

In cases of cruciate tear with lateral side injuries, reconstruction

Fig. 2. B: showing combined ACL + PCL injury.

was preferred. Using the lateral curved incision, extended proximally between iliotibial band and biceps femoris, distally between gerdy's tubercle and the fibular head. Long head of biceps femoris was identified & act as landmark for common peroneal nerve which was traced posterior and medial to it. STG tendon autograft was used to reconstruct the LCL by using standard modified Larson (figure of 8) technique. Biointerference screw was used to secure the graft in the lateral aspect of distal femur with knee in 20–30° flexion and slight internal rotation.

2.7. Surgical management of anterior structure injuries

Concomitant anterior structure viz patellar tendon avulsion injury was addressed after ACL + MCL fixation. A transosseous repair of patellar tendon was done by forming two vertical tunnels in patella from inferior to superior pole direction and fixed with knee in complete extension using ethibond/fibre wire.

2.8. Rehabilitation protocol

All MLKI patients were given knee brace for 6–8 weeks. Protected active assisted ROM was started in the immediate postoperative period except in cases of concomitant patellar tendon injuries where ROM started after delay of 3 weeks. All patients were kept non weight bearing with toe touch till 4 weeks followed by partial weight bearing for another 4 weeks. Full weight bearing without brace was begun at 8 weeks.

2.9. Statistical/data analysis

Data was analysed and compiled in mean values and ranges for relevant variables. Functional outcomes of all MLKI patients were evaluated by Lysholm score and Tegner activity score. Comparison was done between pre-operative and postoperative values using paired Wilcoxon test. P value was considered significant when it was less than 0.05.

3. Results

A total of 20 MLKI patients who were operated from 2015 to 2017 were recruited and followed up for a mean period of 1.8 years (range 6 months to 2 years). There were 15 males (75%) and 5 females (25%). The mean age of the patients was 29 years (range 15–43 years).10 patients had MLKI due to motor vehicle accident (MVA-50%), 5 patients had injury during sports activities (25%) and rest 5 fell in other mechanisms of injury that include fall from stairs, twisting of knee during dancing (25%). Out of 4 major ligaments of the knee, 13 patients of MLKI (65%) had 2 injured ligaments&7 patients (35%) had 3 injured ligaments. No patient had all 4 ligaments injured in our study. 1 patient (5%) had associated vascular injury who underwent popliteal arterial repair with saphenous graft taken from contralateral side along with multiligament reconstruction with uneventful recovery whereas no patient (0%) had neural injury (Table 3).

We classified various pattern of MLKIs according to Schneck RJ[7] classification of knee dislocations (KD) as shown in Fig. 4. 13

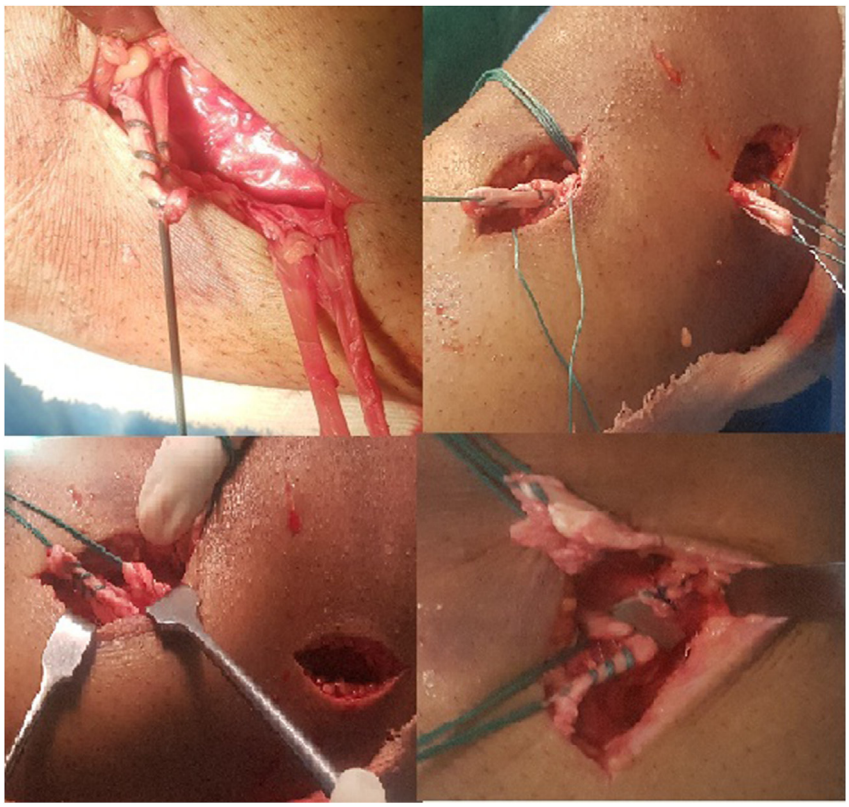

Fig. 3. Showing medial collateral ligament repair with augmentation using ipsilateral STG graft (2 point fixation technique).

Table 3
Showing demographic profile of MLKI patients (n = 20).

Demographic profile	(N = 20)
Age (years)	29(15–43)
Gender	
Male	15(75%)
Female	05(25%)
Mode of Injury	
MVA	10(50%)
Sports	05(25%)
Others	05(25%)
Numbers of Ligaments Involved	
2	13(65%)
3	07(35%)
4	0 (0%)
Vascular injury	1 (5%)
Neural injury	0 (0%)
Time from surgery to follow up (years)	1.8(6 months-2 yrs)

patients (65%) were KD-I, 2 patients(10%) were KD-II, 4 patients (20%) were KD-III involving the MCL, 1 patient (5%) was KD-III involving the LCL/PLC while no patient (0%) was of KD-IV and KD-V type of ligament injury pattern. 5 patients (25%)with KD-III type of injury pattern (ACL + PCL + MCL/LCL) were planned for stage reconstruction where ACL reconstruction was deferred and rest underwent single stage reconstruction. The most common injury pattern in our study was single cruciate with medial collateral ligament (MCL) followed by bicruciate with medial side injuries.

Table 4 describes the clinical and functional outcomes of all MLKI patients managed surgically. The mean follow up was 1.8 years (range 6 months –2 years). Mean range of motion among the KD groups (I-V) was from 5° to 111.67°. In KD I group ROM was near normal (0–120°) but as the severity of injury increased (from KD I to KD III) ROM showed a declining trend to 5–105°. KD I-II groups had equal performances in terms of range of motions ($p > 0.05$). Mean Lysholm score among the KD groups (I-V) was 84.53. KD I-II groups had the highest Lysholm scores while KD III group had lowest. Mean Tegner activity level of KD groups (I-V) before injury was 4.6 and mean current level at the time of follow up was 3.6. The difference in mean Tegner activity score was found to be statistically insignificant with p value = 1 ($p > 0.05$). Ligament laxity was evaluated in all MLKI patients pre and post operatively. Greater than 5 mm of movement was observed to be as positive laxity. At the final follow up, 2 patients (10%) had anterior translation/laxity and 1 patient of all MLKIs (5%) had lateral laxity on clinical assessment, however no subjective symptoms noticed by the patients to force them for any revision surgical intervention. No significant medial laxity was observed at final follow up period.

3.1. Postoperative complication

All the patients were observed and followed to detect early and late complications. 2 patients underwent arthroscopic lavage following their surgery due to postoperative knee effusion, fever and raised TLC count (that raises the suspicion of intraarticular infection). In both the patients symptoms resolved following the lavage, however no pathogenic organism was detected on culture of the joint fluid. 2 patients of KD–III group where stage reconstruction was planned (ACL reconstruction deferred) developed knee arthrofibrosis with range of flexion less than 70° but was having stable knee, arthroscopic adhesiolysis was done to resolve the knee stiffness. No patient underwent revision surgery (reconstruction) due to persistent instability/laxity of the reconstructed/repair ligaments or even in cases of stage reconstruction. No statistical relationship was found between complication and injury pattern.

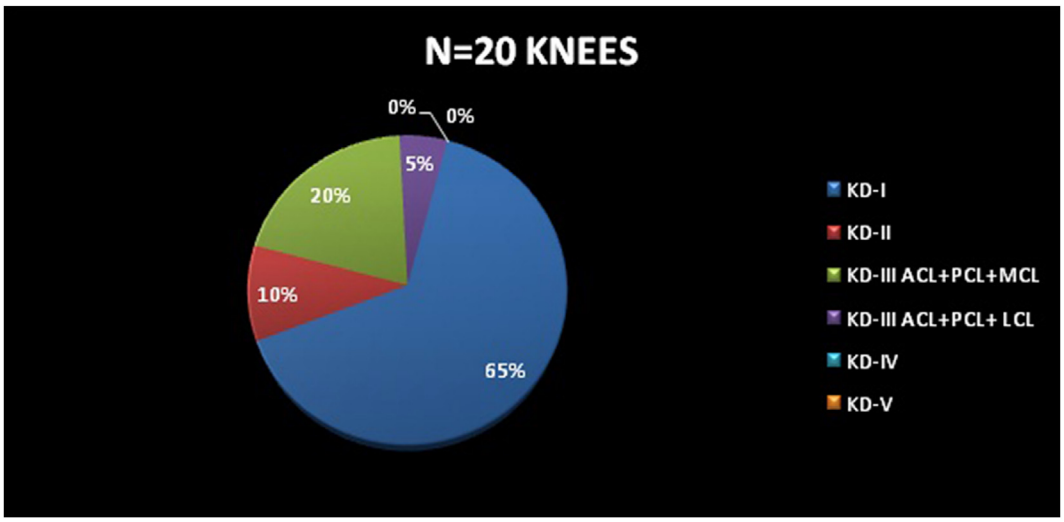

Fig. 4. Pie Graph showing Patterns of ligament injury, KD = knee dislocation, KD-I, single cruciate combined with either MCL or LCL injury; KD-II, central pivot injury(ACL + PCL); KD-III, bicruciate with either MCL or LCL/PLC; KD-IV, all 4 ligaments injury; KD-V, MLKI with associated fracture.

Table 4
Showing Functional and clinical outcomes of MLKI patients at final follow up.

Group	Lysholm Score (Mean) Range (78–95)	Tegner activity Level (Mean)		ROM In Degrees (Range 0–120)		Ligament laxity (Anterior & lateral)	
		Level before Injury (range 3–7)	Current Level (range 2–6)				
KD I	88	5	4	0	120	–	–
KD II	86	4	3	10	110	–	–
KD III	79.6	4.8	3.8	5	105	2(anterior)	1(lateral)
KD IV	–	–	–	–	–	–	–
KD V	–	–	–	–	–	–	–
Average among KD groups	84.53	4.6	3.6	5	111.67		

4. Discussion

A prospective collected data of all MLKI patients was analysed retrospectively to design a systematic approach and management protocol to yield better functional outcomes in all these patients. We observed that in our study, men in the age of 15–43 years were at high risk of MLKIs. The most common ligament injury pattern in our study was single cruciate with medial collateral ligament (MCL) followed by bicruciate with medial structure injuries (ACL + PCL + MCL). In our study, high velocity injury (MVA) accounted for 50% of cases whereas sports injuries accounted for 25% only. The demographic data including age, sex, ligament injury pattern showed similar reports as most of the literature on knee injuries. However, there is dramatic difference in terms of mode of injury from the results of western countries where Jenkins et al.[8] showed 45% high velocity and 40% low velocity injuries with mean age group of 21 years. This may be attributed to higher involvement in sports activities in western population. We have found 2 patients with concomitant anterior structure injuries (ACL + MCL + PT avulsion/tear along with meniscal injury) over which no published literature is available concerning the mechanism and management of this type of injury pattern. In the literature it has been shown that one of the important factor behind the failure of surgical management of MLKIs was unrecognized posteromedial or posterolateral injuries occurred due to poor clinical and radiographic assessment of the injury.[9–11] Thus a thorough clinical assessment (examination under anaesthesia in acute cases) and radiographic evaluation including X-rays, CT, MRI are needed in all MLKIs for appropriate surgical planning in terms of graft choice and mode of fixation of reconstructed ligaments. In the literature, it has shown that surgical management of MLKIs yields better outcomes than conservative treatment.[4,5] Early (<3 weeks) vs late surgical intervention in MLKIs is also a debatable issue in the literature in terms of return to sports activity, however in terms of functional outcomes no difference was found between the two groups as shown in the study of Levy BA et al.[6] In our study, we addressed all MLKIs surgically within 3 weeks so that repair of the injured structures could be attempted easily. Decision regarding repair vs reconstruction of ligaments was made according to the ligament injured, extent and site of its tear. We performed single bundle reconstruction of all cruciate injuries (ACL/PCL) in cases of MLKIs due to limitation of bone stock, fewer tunnels required and scarcity of grafts availability. However in terms of knee instability and OA rates no significant difference was found between single bundle and double bundle techniques at long term follow up as reported in a randomized controlled trial by Jarvela S et al.[12] In MCL injuries, repair or reconstruction depends upon site, extent of tear, quality of torn tissue and time since the injury as reported by Schein A et al.[13] We always performed repair along with augmentation with ipsilateral STG graft with 2 point fixation technique over tibia as described earlier. In our study no patient had significant medial laxity at final follow up. Lateral side injuries (LCL/PLC) were always being taken care by reconstruction at our institute using STG graft and it yielded better functional outcomes with no revision. This finding was found comparable with other author's results who have reported superior outcomes of reconstruction over repair.[6,14]

In cruciate combined with either medial or lateral collateral injuries, we performed single stage reconstruction. Bicruciate

injuries with either of the collateral ligament involvement, stage reconstruction was planned due to: (1) scarcity of graft (2) extensive soft tissue damage (3) to reduce the operating time (4) to decrease the chances of post operative arthrofibrosis and laxity. In staged reconstruction, ACL reconstruction was always being deferred. While PCL was always being reconstructed and secured first to restore the normal tibio-femoral alignment and to maintain central pillar of the joint followed by collateral ligament reconstruction.[15] On subsequent follow up patients did not find any subjective symptoms of ACL deficiency thus did not undergo second stage reconstruction. Bin SI et al.[16] reported two stage reconstruction of ligaments in acute injury cases produces good outcomes in terms of laxity, functional knee scores and ROM. However, Miller et al. in his study showed single stage reconstruction of all ligaments as index procedure in acute injury yields reliable functional outcomes and stability.[9] Outcomes in terms of symptomatic laxity and functional scores were equivalent to other KD group patients at final follow up. According to Lysholm scoring system (mean 84.53), we found fair to good functional outcome in all MLKIs patients with this approach and management protocol. This favourably correspond to findings of other studies who reported satisfactory results with functional score between 68–79.[17,18] We found that injury pattern and anatomical lesions were possible indicators of prognosis of MLKIs.

Sequences of graft tensioning is also a debatable topic in literature. We prefer PCL graft fixation and tensioning first with knee in 90° position. This restores the normal anatomy, tibial step off and central pivot of the joint. PLC graft is fixed next in 70° knee flexion and LCL at 20–30° with slight valgus force. Prepassed ACL graft is fixed next on tibial site with knee in near full extension and finally the MCL in 30° knee flexion. This sequence has also been supported by many publications in the literature.[19,20]

The most common complication associated with surgically intervened MLKIs are postoperative knee arthrofibrosis and persistent instability/laxity. Medial side injuries tend to provide more stiffness while with lateral side injuries, persistent laxity is more of an issue.[1] We started immediate brace protected active assisted ROM exercises with non-weight bearing toe touch till 4–6 weeks. After that physiotherapy was started with continuous passive motion which was helpful in restoring the ROM. After 8 weeks of rehabilitation full weight bearing was started and patients were trained to develop good quadriceps and hamstring control to achieve stable and functional knee.

5. Conclusion

We found good functional outcome in most cases. Mean Lysholm score was 84.53 (84–95 good) in MLKIs treated by our systematic approach and management protocol. The difference in scores among KD groups suggestive of possible impact of injury pattern over functional recovery and prognosis. Better functional outcomes in MLKIs needs thorough clinico-radiological evaluation and proper surgical planning in terms of repair/reconstruction. However, heterogeneity in injury pattern and small population size made the comparison & conclusion difficult. Early intervention (<3 weeks), multistage reconstruction and individualized rehabilitation are key factors for early return to activities.

Level of evidence

Level III study.

Conflict of interest

The authors of the study have no conflict of interest.

Funding

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Ethical approval

This study does not contain any study with animals and all patients were included in the study only after their written consent.

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Research paper

MPFL reconstruction using autologous semitendinosus tendon and transpatellar technique

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ABSTRACT

Background: Several authors have recommended many different MPFL surgical reconstruction or repair techniques and use of various types of grafts.
Purpose: Is use of autologous semitendinosus tendon and transpatella tunnel technique good choice for MPFL reconstruction?
Study design: Retrospective case series study.
Method: Patients attending orthopaedic opd with traumatic dislocation of patella without bony deformity between the age group of 20–55 years over the last 10 year period 2006–2015 were included in the study. 23 patients could be followed up for 2–6 years. In all the patients ipsilateral semi tendinosus free graft harvested and looped through two parallel tunnels made horizontally in the patella while holding both the ends of the tendon near the attachment site which is equidistance between adductor tuberosity and medial epicondyle and temporarily fixed. After fixation, range of motion of knee, patella femoral tracking and lateral tightness checked. Then permanent fixation done accordingly at that point. Patients were allowed to bear weight from second post op day.
Results: Out of 23 patients, 4 patients had arthrofibrosis which required arthroscopic fibrolysis. Three patients had underwent lateral retinacular release earlier. There were no recurrent dislocations.
Conclusion: Semitendinosus autograft and transpatella tunnel technique are one of the good choices in MPFL reconstruction.

What is known about the subject?

MPFL is a band like tissue extending from midpoint between adductor tubercle and medial epicondyle of femur to medial border of patella. It is ruptured in traumatic dislocation of patella. There are many suggested soft tissue procedures for prevention of recurrent dislocation of patella like lateral release, medial imbrications, vastus medialis advancement over patella and MPFL reconstruction. Among these it has been found that MPFL reconstruction is superior to others and has least reoccurrences. For MPFL reconstruction various tendon can be used like semitendinosus, gracilis, quadriceps and patellar tendon. Different authors have claimed superiority of one over the other. Similarly, different fixation techniques at patellar and femoral site have been described in literature along with fixation at various degree of knee flexion.

What this study adds to the existing knowledge?

MPFL reconstruction prevents recurrent dislocation of patella in traumatic dislocation of patella. Using Autologous semitendinosus graft has good results with trans- tunnel technique of patellar fixation.

1. Introduction

Patello- femoral dislocations are common and occur as a result of rotational injuries at knee joint. In recent biomechanical studies, MPFL (Medial Patello-Femoral Ligament) has been recognised as a major stabiliser of the patella on the medial aspect, and contributes to proper patello femoral tracking.[1] It is injured in almost all lateral patellar dislocations and is commonly seen in young active individuals with incidence being more in females.[37]

Radiographs taken in patello-femoral view (with knee in 30° flexion) show opening of medial patella-femoral joint, lateral sublaxation of patella and MRI studies (Axial sections) prove

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rupture of the MPFL after patellar dislocation.[28] It has also been shown that the reconstruction of this ligament can restore stability. If not repaired this leads to chronic recurrent dislocation and patello-femoral osteoarthritic changes.[30]

Since it is known that soft tissue procedures previously described with or without lateral retinacular release alone cannot consistently restore patello femoral stability, more focus has been given to stabilization by MPFL reconstruction.[8]

Deie M et al.[14] noted that after Reconstruction of the medial patellofemoral ligament no recurrence of patellar instability was found with normalization of the congruence angle, tilt angle, and lateral shift ratio in all of their patients.

Drez D et al.[13], Noted in their series of 15 patients; a 93% good to excellent results of medial patello-femoral ligament reconstruction using autologous Hamstring or Fascia Lata graft in the treatment of patellar dislocation. Mean follow-up was 31.5 months.

Now, the role of the MPFL has been almost established in the Management of Dislocations of patella.

For reconstructing MPFL, various kinds of grafts can be used including Semitendinosus [31], Quadriceps[41], Gracilis[12] or Fascia Lata[13] or allografts.[2]

For proper patellaofemoral tracking it is essential to reconstruct MPFL in anatomic fashion. Non anatomical reconstruction can lead to non physiologic loading in patellofemoral joint.[16]

2. Anatomy and biomechanics

Kaplan[21] first described in 1957, MPFL as a transverse reinforcement between base of patella and the tendon of medial head of gastronemius. MPFL was first described and named by Warren and Marshell.[42]

MPFL is condensation of tissue from medial border of patella to a point between adductor tubercle and medial epicondyle in the second layer of antero medial region of the knee.[42] Average length of MPFL is 56.9 mm ± 4.69 mm (range 46.0 to 75.0 mm) .[34] Towards the femoral attachment MPFL passes beyond the limit of joint capsule and then overlays the periosteum of femoral condyle.[42] Patellar attachment is usually wider than the femoral attachment and is at the most prominent medial edge of the patella.[1] The patellar end of the MPFL passes deep to the distal vastusmedialisobliquus (VMO), which overlays the MPFL at the patellar attachment and also attaches to the proximal part of the medial border of the patella.[1] When the vastus medialis contracts, the MPFL may be pulled proximally and become tighter. It is suggested that the VMO pulls the patella medially via the MPFL and acts not only as a direct dynamic stabiliser of the patella but also as an indirect dynamic stabiliser through the MPFL.[32]

The MPFL provides approximately 60% of the total medial restraining force against lateral patellar displacement, at 20° of knee flexion.[15] MPFL experiences maximal loads at full knee extension or during early flexion as quadriceps femoris neuromuscular activation pulls the patella toward the femoral trochlea.[5,17] After 30° of knee flexion, the femoral trochlea contributes more to patellar stability.[19] Nomura et al.[29] reported that the MPFL was very taut at 0° of knee flexion, slightly relaxed at 15°–30° of knee flexion, and relatively taut at 45°–150° of knee flexion when a 1-kg force was applied to the quadriceps tendon. Amis et al.[1] reported that the patella could be subluxated laterally most easily at 20° flexion in the intact knee. The contribution of the MPFL to resisting patellar lateral subluxation was greatest in the extended knee.

Nomura et al.[29] reported that the length change pattern was affected greatly if the femoral fixation point moved only 5 mm from the normal femoral attachment. Thus, the natural MPFL is clearly not isometric. Amis et al.[1] reported that the length change pattern of a reconstructed MPFL depends critically on the site of femoral attachment, with a more proximal attachment increasing distance to the patellar attachment as the knee flexes; the converse is true for a distal attachment.

The mean failure load was 208 ± 90 N at 26 ± 7 mm of displacement for specimens with a mean age of 72 years.[27] Burks et al.[9] noted a mean force of 209 ± 55 N (range, 125 to 308 N) at 25 mm of displacement for MPFL failure during lateral patellar dislocation.

2.1. Material and methods

Patients who attended our department with lateral dislocation of patella due to trauma from 2009 to 2016 (23 patients) formed the material of our study. Out of these 23 patients 11 were male and 12 females with age group between 20 and 55 years of age.

2.1.1. Exclusion criteria

Patients having excessive genu valgum, torsional deformities of femur/tibia, trochlear dysplasia and fractures of condyles of femur and tibia and neuromuscular disorders. Patients who had existing osteoarthritis, congenital dislocation of patella, and collagen disorders (habitual dislocation of patella) were excluded

2.1.2. Inclusion criteria

Post traumatic isolated MPFL rupture with recurrent dislocation of patella.

2.2. Method

Clinical assessment-History of type of trauma, general examination, other joint laxities to exclude existing collagen disorder.

Local examination- examination of knee joint for other ligamentous instabilities, attitude of limb (varus/valgus), position of patella, ROM, Tracking of patella.

- Q Angle
- Apprehension test
- Patellar glide test and patella tilt test
- Sideways movement of the patella (SAGE Test)

Fig. 1. Clinical evaluation.

Fig. 2. Clinical evaluation.

Fig. 3. Radiograph image showing medial patellar damage.

After clinical examination and imaging studies, surgical blood profile and Pre Anaesthetic Check up were done (Figs.1–5).

Patients were given Spinal/General anaesthesia. Post anaesthesia again local examination was done. Under all aseptic precautions painting and draping was done.

Ipsilateral autologous semitendinosus tedon is harvested and prepared and non absorbable sutures are applied at either end to serve as leading and trailing suture material (Figs. 6 and 7).

Two patellar tunnels are created, one just proximal to center of patella and one distal using two K wires. Tunnel diameters are increased using appropriate size cannulated drill bit to 4 mm taking care not to breach articular or anterior surface of patella (Figs. 8 and 9).

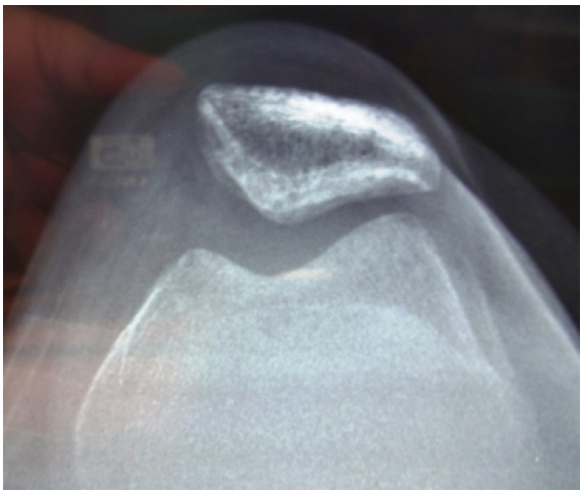

Fig. 4. Radiograph image showing opening of patella- femoral joint space.

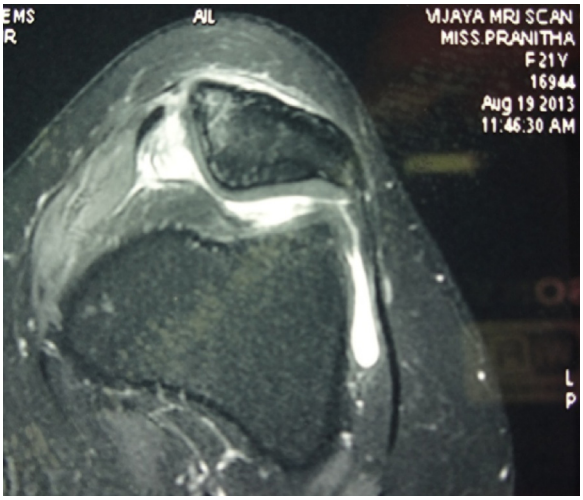

Fig. 5. MRI image showing torn MPFL.

Fig. 6. Autologous semitendinosus graft harvested.

The prepared graft is pulled from medial to lateral side through one tunnel of patella and looped and pulled lateral to medial through second tunnel of patella and both ends presenting in the medial patellar margin incision (Figs. 10 and 11).

These threads are tightly held at appropriate femoral fixation site (posteromedial margin equidistant between adductor tubercle and medial epicondyle in 30° flexion of knee) and ROM as well as patellar tracking checked (Figs. 12 and 13).

Fig. 7. Graft preparation with ethibond.

Fig. 8. Transpatellar tunnel drilling.

The fixation site could be manipulated as per the intra op observation. Final fixation was done using non absorbable suture material, fibre wire or screw. If required, arthroscopic lateral release was done at the same time (Fig. 14).

After giving proper wash, closure was done in layers and sterile dressing applied. Compression was applied.

POST-OP PROTOCOL –

- Immobilization was done using either brace or plaster slab.
- Quadriceps- strengthening exercises and full weight bearing walker walking from 2nd p.o.day
- Suture removal done after ten days.
- After that, Immobilization in hinged brace allowing ROM 0–30° FOR 1 week, 0–60° for second week and 0–90° from third week, unrestricted ROM from six weeks.

Fig. 9. Increasing size of tunnel with cannulated drill bit.

Fig. 10. Passing graft from medial to lateral.

- Proprioceptive protocol from 9 weeks to six months.

3. Results

We followed 23 patients for a minimum of 2 years and maximum of 6 years.

For all 23 patients, MPFL tear could be recognised in MRI.

Number of male and female patients was 11 and 12 respectively.

Fig. 11. Looping of graft on patella with both the free ends on medial side.

Fig. 12. Determining femoral fixation site.

All the patients were in the age group of 20 to 55 years. We excluded patients in whom growth plate was not fused and patients above 55 years as they had osteoarthritis requiring total knee replacement as a treatment.

Fig. 13. Checking range of motion.

Fig. 14. Arthroscopic evaluation and lateral release if required.

Among these 23 cases, 14 had isolated MPFL rupture. Six patients had associated ACL injury and three were part of multi ligamentous injury.

We found Weiberg type 3 patella in 18 cases.

There were no reoccurrences in our patients. Patellar apprehension was relieved in all patients.

In four patients post op arthrofibrosis was encountered and required Arthroscopic fibrolysis. These patients were in the age group of 50–55 or with multi ligamentous injury.

Three patients underwent lateral retinacular release.

4. Discussion

Patellar dislocation is defined as complete loss of contact between the articular surfaces of the patella and femoral trochlea. This is an objective instability: at least one true dislocation episode

has occurred. The instability is considered subjective in cases of patellar subluxation.[20] First episode of patellar dislocation is treated conservatively with immobilisation and quadriceps (vastus medialis) strengthening exercises.[7] If the dislocation recurs after a trial of rehabilitation, operative intervention is considered with the aim restoring soft tissue anatomy to normal.[11]

Patellofemoral instability can be attributed to both primary and secondary factors. Trochlear dysplasia, excessive tibial tubercle–trochlear groove (TT–TG) distance, and patella alta has been identified as primary instability factors. Excessive femoral anteversion, excessive lateral tibial torsion, recurvatum and genu valgum are known secondary instability factors.[20] Weiberg type 3 patella is also a predisposing factor.[43] Soft tissue injury like MPFL rupture after post traumatic dislocation leads to recurrent dislocations.

Various treatments for patellofemoral instability have been proposed including bony and soft tissue procedures, such as lowering or medialization of the tibial tubercle, division of the lateral retinaculum, plication of the medial retinaculum, MPFL reconstruction, lowering of the vastus medialis, and trochleoplasty.

Role of MPFL in patellar stabilization is well established and its reconstruction is considered as one of the most important soft tissue procedures to prevent recurrent dislocations of patella.

In our study we included patients with post traumatic recurrent patellar dislocation without any bony defects who required only soft tissue procedures. We excluded the patients with bony abnormality requiring bony procedures. Out of many soft tissue procedures available like patellar tendon grafting by Camanho et al.[10], quadriceps tendon grafting by Fink et al.[18] We chose MPFL reconstruction using semitendinosus over others, as role of MPFL as patellar stabiliser is well established and published studies have shown good outcome after MPFL reconstruction using semitendinosus.[13,14] Other soft tissue procedures like repairing MPFL for mid substance tear and medial retinacular imbrication with or without lateral release[6,23,25,44] do not provide consistent good results because it is difficult to identify thinned out MPFL, difficult to provide adequate tension and it fails due to stretching.[22]

There are various graft options available including Semitendinosus[31], Gracilis[12], Fascia Lata[13], Quadriceps[41] and allografts.[2] The semitendinosus and gracilis are commonly harvested as grafts for MPFL reconstruction.[26] We chose autologous Semitendinosus tendon because of its easy accessibility, strength and length is appropriate. Allografts are not that readily available.

Common methods of patellar fixation described include tunnels[11,24] and suture anchors.[13] We chose tunnels over suture anchor. Anatomical studies have shown the graft to be 5–12 mm wide. Single strand technique utilise hamstrings of about 3.5 mm wide. This can be doubled over to give a thickened ligament, but may cause difficulty with the placement of a large single tunnel within the patella. A larger patellar tunnel may increase the risk of joint penetration or patellar fracture.[24] Our two tunnel technique allows a wide tendon graft but uses small tunnels, thus minimising these potential complications. Also as tunnel transverse the entire width of patella it influences the patellar tilting.[11]

Most important part of this procedure, as other authors have also mentioned is the femoral attachment point. More proximally placed graft will result in a reconstructed MPFL that is lax in extension and tight in flexion that might cause loss of knee flexion and creates excessive pressure on the medial patella.[16] Conversely, distally placed graft will result in an over tight MPFL in extension and a lax ligament in flexion. We did not use image intensifiers for this purpose. Many authors suggest use of image intensifier for the exact location of the femoral attachment site.[36] We palpated medial epicondyle and identified a point posterior and proximal to it, just below the adductor tubercle.[4,32,38] Here, graft was held temporarily and range of motion was checked along with patellar tracking. If not satisfied femoral attachment site was manipulated. For femoral fixation any one out of many methods like suture fixation.[39] or screw fixation.[12] can be chosen. In our cases we did suture fixation with fibre wire (Arthrex).

One of the important aspects of any ligament reconstruction is the tension of the graft.[11] Computational analysis has shown that small alterations in length and position of the graft can dramatically increase the force and pressure applied to the medial patellofemoral cartilage.[5,16] To try to optimise graft tension, we, with other authors, recommend cycling the knee through its range of motion prior to fixation with the knee flexed at 30°. To optimise graft tension, we did cycling the knee through its range of motion prior to fixation. This aims to remove “give” from the graft prior to fixation.[11] Over tensioning could be avoided by applying low loads (2n) to reconstructed MPFL graft during fixation to medial femoral condyle, so that normal translation and patellofemoral contact is re-established.[3] Excessive graft tension can lead to flexion contracture.

Complications mentioned by previous authors are patellar fracture, graft impingement, graft failure either due to pull out or graft rupture, mal tracking of patella and recurrent dislocations.[20] We did not find any of these complications in our patients throughout the follow up. We faced arthrofibrosis in 4 patients which is the most common complication according to other authors also.[20] These patients were of higher age group or with multi ligamentous injury. These were treated with arthroscopic arthrofibrolysis. Three patients required lateral release at the time of primary reconstruction. None of the patients had recurrent dislocations. Reported recurrence rate is 0% to 4% in published studies.[13,33,35,40]

5. Summary

MPFL reconstruction done using autologous ipsilateral Semitendinosus tendon by looping the graft in two patellar tunnels and determining the femoral fixation point by intra op checking of ROM and patellar tracking for 23 patients having recurrent patellar dislocation without any bony abnormality after clinical and radiological examination who were followed up for a period of 2–6 years has given good results with no reoccurrence of dislocation in any case and with minimal complication rate.

6. Conclusion

Autologous Semitendinosus tendon as a graft and transverse patellar tunnel technique for patellar side fixation are good choice for MPFL reconstruction.

Conflict of interest

None.

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Research paper

A longitudinal analysis of functional outcome between all-polyethylene and metal-backed tibial components in total knee arthroplasty

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1. Introduction

Osteoarthritis of knee is a most common form of arthritis due to degeneration of articular cartilage and subchondral bone. Arthroplasty is reserved for patient with advanced osteoarthritis despite appropriate conservative management such as exercise, weight loss, physiotherapy, analgesics, anti-inflammatory drugs, intra-articular steroids and have an unacceptable level of pain or physical function or both. There are mainly two types of tibial component implants used which are metal-backed and all-polyethylene.[1–10]

Due to manufacturing and packaging of All-Polyethylene tibial components, particularly sterilization techniques, causing components were prone to rapid oxidation, leading to wear debris, osteolysis, loosening and failure.[11] Then, Metal-Backed was favoured and predominant design due to improved load transmission, greater heat-sink capacity, improved locking mechanisms and intraoperative flexibility with the use of stems and augments which led to better results.[12–15]

With the introduction of Ultra-High-Molecular-Weight Polyethylene (UHMWPE) and improvement of crosslinking, sterilization with gamma radiation in oxygen-free environment, and packaging techniques, polyethylene becomes the gold standard bearing surface in modern arthroplasty.[16–18]

Hospital economic challenges especially developing countries are associated with decreasing reimbursement and increasing costs causing knee arthroplasty surgeons to examine the cost of joint implants and their effects on procedure profitability. In response to cost pressures, the interest in the use of All-Polyethylene implants in low physical demands patients are increasing which could offer economic benefits by reducing cost and potential clinical benefits if long-term survivorship of total knee arthroplasty is improved.[19–21]

2. Materials and methods

This prospective study of 68 patients with advanced osteoarthritis operated for cemented posterior stabilised total knee arthroplasty (TKA) for comparison of All-Polyethylene and Metal-Backed tibial components using Fixed Bearing PFC Sigma Tibial Tray PS and AllPoly PS.

The decision of patients recieving either type of implants were decided by the hospital policy. Due to cost saving, All-Polyethylene was decided by hospital policy to be used as the type of implant for all patients who would undergo total knee arthroplasty procedure. Transition of the implant changes policy was the timing of this study to collect 34 patients for each group by consecutive sampling method. Patients with neurologic deficits, pathologic process, other injury causing gait imbalance and bone loss or intraoperative complications were excluded in this study.

The operations were performed by two trained arthroplasty surgeons with considerable experience. Patient underwent standard cemented total knee arthoplasty with appropriate balancing. Postoperative regimens consisted of early mobilisation with immediate full weight-bearing and physiotherapy.

Clinically, patients were assessed for deformity, range of motion, pain, satisfaction, expectations and functional activities according

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Table 1
Details of the patients in both groups.

	Metal-Backed	All-Polyethylene	*p value*
Male: Female	18: 16	16: 18	
Mean Age in years (range)	63,1 (54–73)	64,4 (53–74)	0,628
Mean BMI in kg/m^2 (range)	27,7 (25–33)	27,8 (25–35)	0,945

*Mann-Whitney test.

to Knee Society Score (KSS) list and Western Ontario & Macmaster University Osteoarthritis Index Score (WOMAC) list which were validated with specific cut-off points for total knee arthroplasty.[22–24] The data were collected preoperative and post-operatively at 1st, 3rd and 6th months and final follow up of 1 year assessing clinical and functional paramaters. Data were then analyzed using SPSS for windows version 22. Non-parametric statistical methods were used since data is not distributed normally with Mann-Whitney *U* test. We constructed in graphs and tables for the data interpretation.

3. Results

With the duration of one year follow-up of all total knee arthoplasties, 34 were in men and 34 were in women. The mean age at the time of the index of the surgery was 63,8 years (range, 53 years–74 years). The distribution in various age groups is given in Table 1. The mean Body Mass Index (BMI) was 27,8 kg/m^2 (range, 25 kg/m^2 to 35 kg/m^2). There was no significant difference in distribution between the age, gender and body mass index (BMI) of two groups (Table 1).

3.1. Knee society score

After the operation, the anatomical alignment of the knees were restored to normal. The Score of objective knee indicators increased significantly after operation with minor improvement was seen between 3 months and 1 year. The mean range of motion of all the patients improved from 76° to 106° with mean improvement of 30°. There was no statistical difference (p value > 0.05) between two groups in terms of objective knee indicators and range of motion (Table 2).

From the symptoms score evaluating pain with level walking and stairs, significant improvements were seen from preoperative period to one-year post-operative follow-up. Significant difference of symptom score was seen at 3-month and 6-month follow-up in which Metal-Backed group was better with p value 0.024 and 0.039 consecutively. In patient satisfaction, the mean scores were increasing after operation and statiscally there were no difference between groups. While in evaluation of the patient's expectations, we found a decrease in the score at one-year post operation and no statiscal difference between both groups was found (Table 3).

In functional activities, improvement was seen before operation and one year follow-up after operation. No significant difference was found between two groups (Table 4).

Table 2
Comparison of Objective Knee Indicators and Range of Motion before operative and 1, 3, 6 months and 1 year after operation.

	Metal-Backed (Mean ± SD)	All-Polyethylene (Mean ± SD)	*p value*[a]
Objective Knee Indicators			
Preoperative	36.9 ± 17.5	38.3 ± 22.5	0.863
1 month	69.8 ± 2.7	68.9 ± 3.3	0.468
3 month	70.1 ± 2.7	69.5 ± 3.1	0.584
6 month	70.4 ± 2.4	69.8 ± 2.6	0.524
1 year	70.4 ± 2.4	69.8 ± 2.6	0.524
Range of Motion			
Preoperative	76.2°±18.8°	75.9°±17.7°	0.986
Postoperative	107.1°±6.4°	105.9°±5.9°	0.538
Improvement	30.8°±13.4°	30.8°±15.1°	0.838

SD: Standard Deviation.
[a] Mann-Whitney test.

Table 3
Comparison of Symptoms, Patient Satisfaction and Patient Expectation Score before operative and 1, 3, 6 months and 1 year after operation.

	Metal-Backed (Mean ± SD)	All-Polyethylene (Mean ± SD)	*p value*[a]
Symptoms			
Preoperative	13.5 ± 1.9	13.5 ± 2.4	0.861
1 month	16.4 ± 1.5	15.8 ± 1.8	0.332
3 month	19.2 ± 1.1	18.1 ± 1.5	***0.024***
6 month	21.6 ± 0.9	20.8 ± 1.2	***0.039***
1 year	23.5 ± 0.9	23.5 ± 0.8	0.955
Patient Satisfaction			
Preoperative	9.6 ± 2.1	10.6 ± 3.4	0.508
1 month	13.5 ± 1.8	14.2 ± 3.1	0.623
3 month	16.7 ± 1.6	17.3 ± 2.6	0.768
6 month	19.5 ± 1.5	19.9 ± 3.2	0.728
1 year	22.6 ± 1.7	23.1 ± 2.7	0.851
Patient Expectations			
Preoperative	11.2 ± 2.3	10.9 ± 2.3	0.676
1 month	12.2 ± 2.0	11.9 ± 2.1	0.774
3 month	12.9 ± 1.1	12.6 ± 1.4	0.641
6 month	12.9 ± 1.0	12.9 ± 1.1	0.914
1 year	12.4 ± 0.7	12.5 ± 0.9	0.564

SD: Standard Deviation.
[a] Mann-Whitney test.

Table 4
Comparison of Functional Activities Score before operative and 1, 3, 6 months and 1 year after operation.

	Metal-Backed (Mean ± SD)	All-Polyethylene (Mean ± SD)	*p value*[a]
Functional Activities			
Preoperative	7.3 ± 4.0	7.2 ± 5.3	0.863
1 month	11.1 ± 3.3	11.4 ± 3.6	0.848
3 month	15.6 ± 2.6	15.4 ± 3.0	0.821
6 month	18.5 ± 2.3	18.4 ± 2.6	0.903
1 year	21.6 ± 2.4	21.2 ± 2.7	0.570

SD: Standard Deviation.
[a] Mann-Whitney test.

3.2. Western Ontario & Macmaster University Osteoarthritis Index Score

From this score list, pain, stiffness and physical function were accessed and it showed improvement after operation. there were no statistically significant difference between two groups with regard to the pain, stiffness, physical function or in cummulative score(Table 5).

4. Discussion

Despite the advantages that metal-backed design provides, it also has several disadvantages. The metal component will reduce the thickness of polyethylene by 2–5 mm with a potential for increased wear.[25–27] additional bone resection is necessary to increase the thickness of polyethylene. Due to the interface between the insert and metal component, it may serve as a source of wear debris.[28] In addition, metal backing increases the cost burden.[16] Consequently, all-polyethylene emerges because of the desire to reduce costs.[19]

This prospective study involving 34 patients consists of metal-backed and all-polyethylene groups which showed significant improvement after the operation. Improvement in pain, range of motion and daily activity performance were seen starting from one month to one year post operation. We found no significant difference between all-polyethylene and metal-backed implants in terms of functional outcome.

In our study, Knee Society Score (KSS) list showed significant improvement of objective score, symptoms, patient satisfaction and expectation, and functional activities after the operation. No difference in functional outcome were found between two groups. The result was similar to previous studies[1,12,13] due to advancement technology in cross-linking and gamma radiation in an oxygen-free environment enhancing tensile strength, ductility, modulus, toughness, crack propagation resistance and the packaging.[29–31]

Metal-backed component was initially introduced to improve the longevity of fixation particularly in deficient bone. Recent studies concluded that there were no differences in clinical function, radiographic evaluation or durability of fixation till 8–10 years of follow-up. Surpisingly, some studies showed higher incidence of osteolysis and backside wear in metal-backed components.[18]

The symptoms score showed a significant improvement in metal-backed components in 3-month and 6-month follow-up compared to All-Polyethylene although the both scores were equal in one year follow-up. The result could be influenced by multiple factors. Brihault et al.[32] showed a higher and less uniform stress distribution, especially in cancellous bone, in deformability of all-polyethylene components resulting in higher micromotion compared to metal-backed due to higher strain. Since the stiffness of metal components is higher, the loads for the condyle to the polyethylene insert will be transmitted to the metal, which carry the bulk of load and generate low peak stress beneath the tibial component. On the other hand, load transmitting to the polyethylene component will concentrate on certain areas of cancellous bone beneath the polyethylene. Although exact correlation with clinical outcomes are not well established, these effects on tibial bone could lead to pain.[33]

Another possible explanation would be the potential difficulty of with removing posterior extruded cement as stated as one of the disadvantages.[34,35] Repeated stress due to impingement or scratch at the polyethyelene surface is the suspected cause of reactive synovitis which will eventually detach and subsequently become loose body hence forming hypertrophic fibrous tissue. Other proposed explanation is that the extruded cement mantle irritates the surrounding synovial tissue or fibrous scar tissue.[36] Athough In this study, pain was not intense and prolonged until 20 months post operation as stated by Katargalis et al.[37]

Pain itself is influenced by various factors including individual difference in pain threshold, previous expectations, physiological and psychological aspect. In this study, expectation somehow decreased after one year follow-up and this finding could correlate with pain perception as mentioned by Coghill et al.[38]

The evaluation with *The Western Ontario and McMaster Universities Osteoarthritis Index* (WOMAC) *score list* concluded a significant improvement after operation despite deference between all-polyethylene and metal-backed group regarding pain, stiffness, and functional activity. The significant pain finding in Knee Society Score (KSS) List was not found in this score list. Difference evaluation was used, in which KSS determined the level of pain by using Numerical Rating Score (NRS), while WOMAC used a range of 0–4. Wider range by using NRS will increase the sensitivity of the measurement.

Table 5
Comparison Western Ontario & Macmaster University Osteoarthritis Index Score (WOMAC) list of before operative and 1, 3, 6 months and 1 year after operation.

	Metal-Backed (Mean ± SD)	All-Polyethylene (Mean ± SD)	*p value*[a]
Preoperative			
1 month	59.9 ± 14.8	60.1 ± 12.8	0.904
3 month	46.0 ± 9.2	45.9 ± 7.6	0.876
6 month	30.5 ± 6.1	31.9 ± 5.3	0.511
1 year	17.8 ± 4.6	18.8 ± 5.0	0.628
	7.9 ± 2.7	8.1 ± 2.6	0.862

SD: Standard Deviation.
[a] Mann-Whitney test.

5. Conclusion

The result of comparing the functional outcome between total knee arthroplasty using All-Polyethylene and Metal-Backed components resulted in no significant difference in one-year follow-up. In conclusion, our data showed that all-polyethyelene tibial component can be effectively and safely used in total knee arthroplasty as the alternative to metal backed component in terms of cost efficiency.

Disclosure

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Research paper

Role of drain in early clinical outcomes following primary total knee arthroplasty

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ABSTRACT

Purpose: To compare and study the short-term clinical outcome in patients with or without a drain usage in primary total knee arthroplasty (TKA).
Methods: A prospective cohort study in a consecutive series of 61 women and 39 men (mean age, 66 years) with primary osteoarthritis underwent unilateral TKA. In the first 50 patients a low suction pressure drain was used for six hours, and in the next 50 patients no drain was used following TKA.
Results: The 2 groups were comparable in terms of preoperative characteristics, age group, the proportion of patients with pharmacological prophylaxis for deep vein thrombosis, usage of anti fibrinolytics before surgery, the tourniquet time, mode of anaesthesia, operative approach and steps and type of implant used. The mean drain output in the drain group was 92 ml. The time to achieve straight-leg raising was earlier in the drain group (2.1 vs. 3.2 days, $p < 0.005$), and time to achieve knee flexion to 90° is earlier in patients with drain group (6.2 vs. 7.7 days, $p < 0.005$). In addition, patients of drain group had lesser postoperative wound soakage, need for dressing change and analgesics. The fall in haemoglobin rate was slightly more in drain group however there was no significant difference in the rate of blood transfusions in both groups and no significant difference in infection rate.
Conclusion: The use of a short duration (six hours), low suction pressure drain following total knee replacement enabled earlier return of quadriceps power, and range of motion, without increasing infection and blood transfusion rate. It also resulted in less pain and reduction in analgesic requirement in early postoperative period.

1. Introduction

In 1961, Waugh and Stinchfield were the first to advocate the use of drainage in orthopaedic surgery.[1] In particular, they observed that there was less pain, swelling and infection in patients whose wounds were drained, as well as better healing of the soft tissues and quicker mobilisation of the extremities. Since then, closed drainage has been used routinely for many years to prevent haematoma formation,[2] reduce the risk of infection and accelerate wound healing[3,4] and increase the range of movement and rehabilitation progress. It may also decrease wound dehiscence, infection, and persistent drainage.[5,6] In addition, not using the drain may cause blood to soak through the wound dressing and cause infection,[7–9] or seep into the subfascial plane and cause compartment syndrome or into the subcutaneous plane and cause ecchymosis,[8,9] limb oedema, skin blisters, and skin necrosis. Nonetheless, use of a drain following TKR may result in increased blood loss, need for transfusion[7,8] and retrograde infection.[9–11] To reduce such risks, the use of a clamping drain,[12,13] reduction in the drainage duration[9–11] and suction pressure,[14,15] and auto transfusion of drained blood[16,17] are suggested.

2. Materials and methods

Between July 2016 and November 2017, a prospective cohort of consecutive series of 61 women and 39 men (mean age, 66 years) with primary osteoarthritis of knee underwent unilateral TKA under spinal anaesthesia using Zimmer Natural Knee system II. We compared the early outcome in 100 patients with or without a drain following TKA in terms of straight leg raising, range of motion achieved, wound complications and rate of blood transfusion. In the first 50 patients a low suction pressure (200 mmHg) drain was used following TKA for 6 h, and the next 50 patients no drain was used. All the operations were carried out by the same team using standard medial parapatellar approach. Patients with inflammatory arthritis, thrombocytopenia, an abnormal clotting profile, or a

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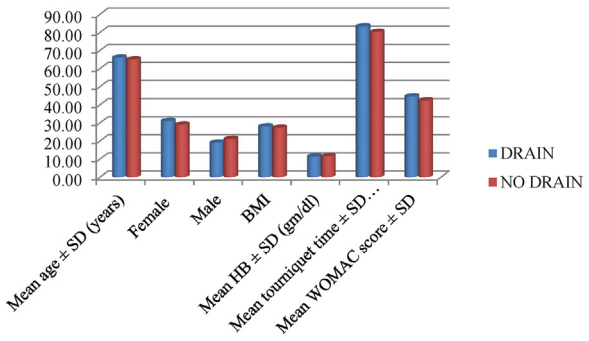

Chart 1. Preoperative Variables.

history of bleeding disorder, patients on antiplatelet therapy were excluded.

The 2 groups were matched in age, sex, body mass index (BMI), haemoglobin level, coronal alignment, range of motion and Western Ontario and McMaster Universities Arthritis Index (WOMAC) (Chart 1). The surgical protocol was standardised, including tourniquet use, medial para-patellar approach, usage of analgesics, surgery time, cementation, haemostasis without tourniquet release, closure of quadriceps and retinaculum with continuous suture, closure of skin, compression dressing with gauze, cotton wool, and crepe bandage, and mechanical prophylaxis for deep vein thrombosis (DVT) using a calf pump for 3–4 days until full ambulation. All patients received pharmacological prophylaxis of subcutaneous LMWH 40 mg daily from first postoperative day for a fortnight. All the operations were carried out and followed up by the same team.

The drain tube (3 mm in diameter with a 70-mm terminal section of multiple perforations at 5-mm intervals) was unclamped and placed at the lateral gutter and connected to an 800 ml plastic bottle (Romovac) with a suction pressure of 200 mmHg (Fig. 1). The drain was released immediately following application of compressive dressings and release of tourniquet.

Outcome measures were performed by an independent assessor (specialist nurse). The amount of blood seeping through the skin wound was assessed by the degree of soaking of the dressing (blood stain visible on the outermost layer of bandage). The amount of intra-articular haematoma was assessed by the size of knee swelling. The amount of blood seeping extra-articularly was assessed by the size of swelling and ecchymosis. Wound

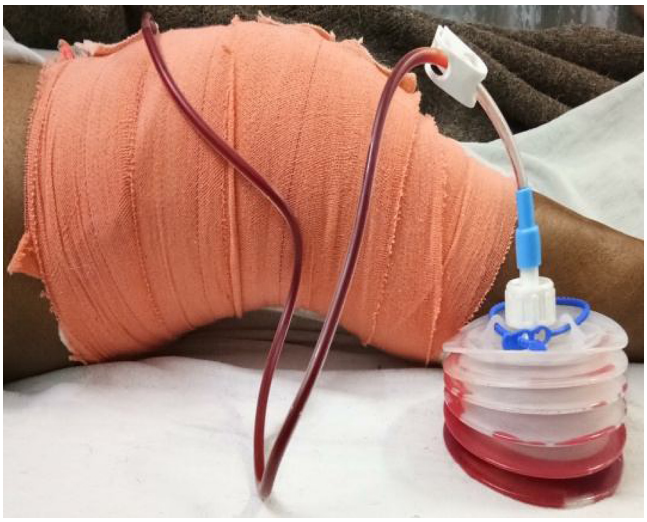

Fig. 1. Low suction pressure drain in TKA.

Table 1
Comparision of Pre Operative Variables.

Variable	Drain Group	No Drain Group	P-Value
Mean age ± SD (years)	66 ± 8.0	65 ± 8.5	0.546
Female: Male	31:19	30:20	0.491
BMI	28 ± 3.2	27.3 ± 3.9	0.328
Mean HB ± SD (gm/dl)	11.4 ± 1.3	11.5 ± 1.1	0.679
Mean tourniquet time ± SD (min)	83.3 ± 15.5	80.2 ± 17.2	0.346
Mean WOMAC score ± SD	44.6 ± 17.8	42.2 ± 18.2	0.543

complications (persistent wound discharge and infection) were measured, as were the visual analogue score for pain and duration of maximal score. The progress of rehabilitation was measured by the days needed to achieve straight-leg raising (quadriceps power $\geq$3) and the days needed to achieve knee flexion up to 90°. Knee range of motion and WOMAC were measured up to 6 weeks.

The 2 groups were compared using the 2-sample *t*-test, n-1 Chi-squared test, p value of <0.05 was considered statistically significant.

3. Results

The 2 groups were comparable in terms of preoperative characteristics, the proportion of patients with pharmacological prophylaxis for DVT, tourniquet time, and mode of anaesthesia (Table 1). The mean drain output in the drain group was 92 ml. The time to achieve straight-leg-raising was earlier in the drain group (2.1 vs. 3.2 days, $p < 0.005$), and time to achieve knee flexion to 90° is earlier in patients with drain group (6.2 vs. 7.7 days, $p < 0.005$), also patients of drain group had lesser post op wound soakage, lesser change of dressings and early debulking of dressings (on day 4). The fall in haemoglobin rate was slightly more in drain group however there was no significant difference in the rate of blood transfusions in both the groups and no significant difference in infection rate (Table 2).

4. Discussion

Advanced osteoarthritis of knee, affecting quality of life is the most common orthopaedic knee ailment in elderly individuals and total knee replacement has become a safe surgical procedure for treatment of these individuals. Postoperative pain management, early functional recovery, prevention of infection and reduction of mortality and morbidity arising out of comorbidities during total knee replacement continue to remain the modern challenges in carrying out TKA.

Amongst the controversial issues in TKA; use of a drain continues to be an important one, in view of a presumed increase in risk of infection and excessive blood loss. Most available evidence favouring TKA without drains are from surgeries done at high volume centres performed predominantly by experienced orthopaedic surgeons. The numbers of primary total knee arthroplasty carried out in peripheral centres and district hospitals manned by young surgeons are increasing in India. It is felt that the use of a drain will be a safe surgical practice in the initial evolving years of these young surgeons. We at a tertiary care Orthopaedic centre carrying out a large volume of primary arthroplasty of knee noticed a significant reduction in postoperative pain, analgesic requirement, soaked dressings warranting a change of dressings in early postoperative period and early return to straight leg raising and knee flexion in individuals undergoing TKA with a drain.

The time to achieve straight-leg-raising has been reported to be comparable following TKA with or without drain in few studies.[18] On the contrary, in our study the time to achieve straight-leg raising was earlier in patients with a drain (2.1 vs. 3.2 days,

Table 2
Comparision of Post Operative Variables.

Variable	Drain Group	No Drain Group	P-Value
% of patients with soakage	6.5%	15.3%	0.160
% of patients with erythema	5.2%	9.1%	0.450
% of patients with fever	11.7%	20.2%	0.248
% of patients with discharge	1.3%	5.2%	0.274
Mean HB drop ± SD (gm/dl)	2.4 ± 0.8	2.1 ± 0.8	0.064
% of patients with transfusion	5.2%	3.8%	0.737
Mean time for SLR ± SD (days)	2.1 ± 1.1	3.2 ± 1.9	0.0006
Mean time for 90^0 knee flexion ± SD (days)	6.2 ± 1.8	7.7 ± 2.1	0.0002
Mean max pain (VAS) score ± SD	5.1 ± 1.5	6.2 ± 1.2	0.0001
Mean WOMAC score ± SD (at 6 weeks post op)	78.0 ± 12.2	75.0 ± 11.4	0.207

$p < 0.005$), and time to achieve knee flexion to 90° was earlier, in patients with drain group (6.2 vs. 7.7 days, $p < 0.005$), probably owing to a smaller intra-articular haematoma that interfered less with the quadriceps mechanism[2] (Chart 2). Larger haematoma is more commonly found in knees without a drain. As haemarthrosis may induce an inflammatory response in the knee, the larger amount of undrained blood may require a longer time for reabsorption and may lead to a prolonged inflammatory response and worse pain and early functional outcome. In the patients with drain, early debulking of dressings was possible which would aid in early return of range of motion.

The use of drain is believed to be effective in decreasing hematoma formation[18,19] which has been theoretically thought to decrease postoperative pain, swelling, and the incidence of infection.[20] In our study, we analysed postoperative pain using VAS score and maximum pain score of each patient was noted. The patients without drain had statistically significant pain when compared to drain group and this might be one of the reasons for late return of quadriceps power and knee flexion in non drain group.

Patients with a drain following TKA have been reported to have a higher blood loss, haemoglobin drop, and transfusion rate.[7,8] Amongst the several RCTs done to study the blood loss and requirement of transfusions post operatively, two studies reported a haemoglobin decrease.[7] One of the studies, however, reported that the total blood loss and the blood transfusion rates were significantly higher in the closed drainage group.[7] Nonetheless in our study, patients with a short duration low suction pressure drain even though had a higher haemoglobin drop comparatively in drain group there was no significant difference in the transfusion rate. Lower suction pressure with shorter duration drain (125–200 mmHg) results in less blood loss.[14,15]

Some studies showed use of a drain following TKA may result in increased rate of retrograde infection.[9–11] the risk of drain tube contamination increases from 9% to 19% after 24 h,[11] Nonetheless, comparing patients with or without a drain, where a low suction shorter duration drain was used there was no difference in the infection rate and more over wound soakage, change of dressings, erythema around wound was less in patients with drain group.

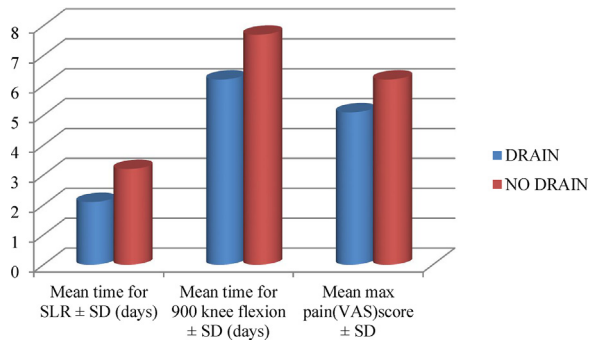

Chart 2. Post Operative Variables with Significant Difference.

Only one study has reported an association of drain use and knee scores.[21] In our study, there was a trend for better range of motion and WOMAC scores up to 6 weeks in patients with a drain. No patient required manipulation under anaesthesia as exhaustive inpatient physiotherapy was given till two weeks post surgery by a specialised physiotherapist. A larger prospective trial is needed to assess the worse short-term outcome in patients without a drain.

Conflict of interest

None.

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Research paper

Does intraarticular PRP injection improve function, pain and quality of life in patients with OA of knee? Case control study of 50 patients

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ABSTRACT

Knee osteoarthritis (OA) is a common debilitating chronic disease. Up to one in 5 people over the age of 45 suffer from knee OA and typical symptoms include significant pain, restricted mobility and difficulty to indulge in activities of daily living. Other than knee replacement, no other reliable treatment exists to manage symptomatic knee OA.

Platelet Rich Plasma (PRP) is a form of Prolotherapy and is increasingly used to manage OA patients, although the evidence is largely anecdotal. We conducted a case-control study to assess efficacy of PRP comparing it for pain relief in OA Knee.

We studied two groups of 25 patients each. One group of 25 patients was given therapeutic exercises and Acetaminophen for pain relief (control group). Second group of 25 patients (PRP group) was injected with two courses of intra-articular injection of Leucocyte rich PRP with interval of 6 weeks. WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) was recorded pre-intervention, at six months & one year post-intervention in both the groups. Change scores were assessed for statistical significance.

No compilations were noted in both groups and none of the cases needed further surgical intervention during the follow up period. Mean changes of total WOMAC, in PRP group showed significantly better improvement than control group ($P < 0.05$) at all time intervals.

This study showed that intra articular PRP knee injection combined with therapeutic exercise can be more effective in pain reduction and improvement of stiffness and quality of life, compared with therapeutic exercise alone.

1. Introduction

Osteoarthritis (OA) is a chronic disease defined by progressive degradation of the joint as well as loss of cartilage on joint surfaces. The degeneration that occurs in the joint leads to changes in the catabolic and anabolic activity of chondrocytes. As a result, other components of the joint get compromised which may lead to meniscus degeneration, bone deformity, sclerosis as well as subchondral tissue edema and intermittent synovial inflammation. This condition impairs functional capacity and decreases quality of life (QOL) in patients by producing pain, stiffness and limitation in range of motion of the joint.[1]

The weak potential of joint cartilage for repair which is related to its avascular nature has resulted in numerous researches focusing on cartilage repair processes during the last two decades. Common treatments for cartilage tissue repair procure relative satisfaction, but rarely achieve an ideal level of functional capacity for the patient.[2] Recently, innovative treatments for cartilage tissue repair have been introduced, including mesenchymal stem cell therapy, autologous chondrocyte implantation, use of matrix metalloproteinase inhibitors, gene therapy and growth factors.[3,4]

In 1970, various studies were performed on different platelet concentrations in plasma. This was followed by work on the higher amounts of growth factors present in platelets, and from those years the first clinical applications of platelet rich plasma (PRP) were investigated.[4] Classically, PRP is considered as a volume of plasma containing higher concentrations of platelets compared to blood base line level.[5] In fact, this definition includes plasma and platelets. Platelets contain different growth factors and cytokines,

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and plasma is a liquid without cells containing proteins and bioactive molecules which play an important role in the cellular repair process.[6] Today, the generic term PRP has progressed and includes various products. These products are categorized based on the PAW classification system (platelet concentration, white blood cells and activation method).[7] Because PRP contains growth factors and plasma proteins, it can regulate anti-inflammatory signals and equilibrate angiogenesis.[8,9] Based on this, its use in order to reduce the progression of OA has been suggested in some studies.[10,11]

The aim of this case-control study is to assess the efficacy of PRP in reducing pain and stiffness and improve function and quality of life in patients suffering from knee osteoarthritis (OA).

2. Materials & methods

Study Design: case-control study.
Study setting: Pain Clinic of India.
Study period: 2014–2017.

2.1. Inclusion criteria

Knee pain with minimum 3 months duration in adult patients presenting with evidence of Knee OA on plain x-rays (Kellgren-Lawrence Grade II or III).[12,13]

2.2. Exclusion criteria

- Age over 80 years
- Patients on immune suppressive therapy
- History of collagen vascular diseases,
- History of cancer or malignant disorders
- Presence of active infection or breach in the skin over the knee
- Recent history of severe trauma to knee (within the past 6 months)
- Auto immune platelet disorders
- Treatment with anti-coagulant and/or anti-platelet agents within ten days prior to injection
- Use of NSAIDS three days prior to injection
- History of intra articular cortisone within 3 weeks or use of systemic steroids within 2 weeks of proposed PRP injection
- Platelet count <150,000 per micro liter
- History of vasovagal shock
- Pregnancy or breast feeding

2.3. Methodology

All consecutive patients presenting to Pain Clinic of India with Knee OA were considered for inclusion in this study. All patients were offered standardized physiotherapy and adequate oral analgesia. In addition, patients were provided with information about PRP and if willing to participate in the study, they were recruited. The study-arm patients were offered PRP in addition to routine treatment of physiotherapy and oral analgesia whilst the control arm patients were offered physiotherapy and oral analgesia.

2.4. Intervention (for the study group)

For preparation of PRP sample all patients were referred to blood banks. 50–60 ml of blood was first collected from patient's upper limb cuboidal vein using 18 G needed in a pre-added 5 ml of ACD – A bulb. 1 ml of blood was sent for blood count. The rest sample passed two stages of centrifuge (first with 1600 rpm for 15 min for separation of erythrocytes and next with 2800 rpm for 7 min in order to concentrate platelets). The final product was 8–10 ml of PRP containing leukocytes. The PRP concentration was 4–6 times the average normal value. As it was stated in some resources that anesthetic agents could not only have toxic effects on chondrocytes but could also influence the activation of platelet by changing the pH of the environment, therefore no local anesthetic agent was injected.[14] The skin of injection site was prepped and draped and liquid PRP was injected in sterile condition using 24 G – 1.5 inch needle through classic approach for intra articular injection (supra patellar or medial). All injections were fluoroscopy guided to know exact location of intra articular needle placement. After 15–20 min of rest, patients were asked to actively flex and extend their knees so that the PRP could spread evenly across the joint space. Then patients were sent home with a written order regarding the following issues. They were recommended to have relative rest 24–48 h post-injection and limit weight bearing on the injected joint. Meanwhile for reducing pain and inflammation they were instructed to use cold therapy three times a day each time for 10 min. In the case of pain onset they had permission to use 650 mg of acetaminophen (up to 1.5 gm per day). However, they were strictly prohibited to take NSAIDs, Aspirin or any steroids. Generally patients were recommended to have mild to moderate levels of activity and increase it as tolerated. They could resume their usual activities of daily living (ADL) one week after injection. Exercises were started a week after injection with lower intensity in the first days and then it increased progressively to be continued on a normal level. PRP injection was repeated using the same precautions and technique at 6 weeks after the first injection.

2.5. Follow up

All patients were assessed at 3 months, 6 months and 12 months post initial consultation. Patients were requested to fill in WOMAC questionnaire and in addition joint swelling and range of movement were recorded at each visit.

3. Results

The mean age of patients was 60.2 ± 9 years. Characteristics of both the groups are shown in Table 1.

Platelet rich plasma preparations in this study contained leukocytes (LR-PRP). Table 2 demonstrates the mean platelet concentrations and white blood cell in PRP and the mean platelet concentrations at base (whole blood); PRP concentration had no significant relation to the response to treatment ($P > 0.05$).

Mean total WOMAC score from baseline to 6 months follow up improved significantly ($P = 0.005$) in both the groups. However the improvement in PRP group was significantly higher than in the control group at 6 months as well as at one year.

Table 1
The two treatment groups are homogenous for all the parameters evaluated.

Variables		PRP Group	Control Group
Age (Mean / SD)		60.12, +/− 8.75	60.36, +/− 9.30
Sex N,%	F	18(72)	19(76)
	M	7(28)	6(24)
KL Grade (%)	1	0(0)	9(36)
	2	12(48)	13(52)
	3	13(48)	3(12)
	4	0(0)	0(0)
Symptom Period	3–12 M	15(60)	13(52)
	>12 M	10(40)	12(48)

Table 2
Platelet rich plasma cytologic findings (mean ± SD).

Parameters	Platelets concentration in whole blood[a]	Platelets concentration in PRP[a]	Platelets concentration in whole blood/PRP[b]	WBC count in PRP[a]
First injection	218643.80 ± 85,715.72	1346060.00 ± 523,291.05	5.68 ± 1.17	240.00 ± 203.65
Second injection	241166.14 ± 51,168.98	1367833.33 ± 364,955.38	5.62 ± 1.65	388.89 ± 489.76

[a] Per mL.
[b] Fold increase in platelet concentration.

4. Discussion

In our study we found significant improvement in WOMAC score in group of patients who received two intra articular injections of PRP six weeks apart than control group. These improvements persisted at least for the first 12 months post-intervention.

There is no consensus about the standard regimen of PRP treatment in musculoskeletal disorders. In different study protocols, the average number of injections is two to three times at two to six week intervals.[15] We chose two injections six weeks apart as a pragmatic approach. Second injection was performed the same way after 6 weeks. All patients were followed up at predetermined regular intervals after the treatment. Meanwhile they were evaluated for Paracetamol consumption, Pain, Joint swelling and Stiffness. Six months and one year follow up, WOMAC questionnaire were filled with the help of project executor. In our study after 6 months and one year pain stiffness functional capacity improved in both PRP and Control group. Comparing with control group reduction in pain as well as total WOMAC score were significantly better in the PRP group.

Presently, various studies, including systematic reviews, have reported the effects of PRP on knee OA, and obtained results similar to our study.[1,5] Patel et al study, by comparing the effects of single injection or double injections of PRP and injection of normal saline (as a control group) in patients suffering from knee arthritis, showed that single injection was as effective as two times injections and both had better effects than normal saline injection. In their study, PRP obtained was lacking leukocytes with concentration of 2.5 million per micro litter with a single centrifuge turn.[16] In our study, PRP used contained leukocytes after 2 turns of centrifuge with a platelet concentration of 5.6 times.

Kon et al during a two year study investigating the short term (6 and 12 months) and long term (24 months) effects of PRP in knee osteoarthritis. In their studies using the IKDC questionnaire and VAS evaluation to assess patients' condition, results similar to our study were reported.[17–19]

Sanchez et al showed short term signs and symptoms improvement was correlated with severity of osteoarthritis (radiologic grading).[20] In our study also, PRP had better short term results compared to the control group even if in our study this finding didn't show any difference in various grades of OA. A reason for this difference may be related to fewer recruited patients in grades 1 and 4 compared to grades 2 and 3, exclusion of patients with severe genu varum and valgum and the small size of the sample.

The total amount of acetaminophen consumption during the 6 months follow up was higher in the PRP group than in the control group. By questioning patients, it appeared that in the PRP group due to prescription of before injection acetaminophen and because of intermittent pain 3–7 days after injection (because of the inflammatory process which is part of the PRP mechanisms), the highest amount of acetaminophen consumption occurred around the time of injection, but in the control group this amount was spread along the treatment period. Unfortunately, data regarding distribution of the time of acetaminophen consumption are unavailable to us. In further analysis, it appeared that there was no correlation between the amount of acetaminophen consumption and the amount of response to treatment. In the Patel et al study, it was stated that increase in amount of platelet concentration in PRP leads to an increase in patient's pain after injection which can explain the increased consumption of pain killers the first few days after injection.[16]

Cellularity is one of the main aspects of PRP evaluation in different clinical applications. In our study the mean platelet concentration obtained for PRP in the first and second injection was 3–7.8 and 3.2–8.6 times respectively. No relation was found between improvement of pain, stiffness, functional capacity and QOL of patients and the platelet concentration. Some studies have indicated a positive effect of PRP in musculoskeletal diseases subject to concentrations of 4–6 times and others believe that concentrations higher than 8 times can jeopardize the repair process and induce an inhibitory effect on cellular proliferation.[7,19] Up to now, we haven't been able to find a published study about the effect of PRP in knee OA based on platelet concentration.[1,5,21] Also, in our study, the obtained PRP contained WBCs with a mean of 10–20% of blood white cells. Some believe, in the process of PRP preparation not only platelet but also monocytes as well as white cell stem cells become present. Some studies only consider PRP to be appropriate when it is free of leukocytes. In their opinion, leukocyte secretion of proteases and reactive oxygen are unwanted.[7] But certain researches mention the secretion of substances such as cytokines and enzymes to be effective in the processes of repair, platelet activation, prolonging the duration of growth factor release and prevention of infection (Staphylococcus aureus and *Escherichia coli*).[7,22] Up to now very few human studies have been published which had mean WBC of PRP in mind.[1,5] In other studies it was also stated that presence of leukocytes increases pain after injection.

No significant complication (such as infection, atrophy, deep vein thrombosis, fever, hematoma and tissue hypertrophy) was observed except for transient increase in local pain and swelling. Other studies had the same reports. The most frequent patient complaint was injection site pain. In some cases pain lasted up to 10 min post injection, decreased gradually and continued as a dull pain at the injection site which lasted from 3 days to 2 weeks. Three patients complained of transient knee stiffness and feeling of swelling. These symptoms improved with oral analgesia and rest as needed.

This study has key strengths and some limitations. Use of a matched control group, assessment of functional outcome using validated scores and in depth evaluation of the PRP cytology are the strengths whilst relatively small sample size, predominance of female patients and limited follow up are potential weaknesses.

Overall, our study and other studies proposed the short term efficiency of PRP injection in comparison to control group in the treatment of patients suffering from OA. Details considered while choosing this treatment take into account age, gender, grade of arthritis and the duration of complaint from symptoms. These can affect the decision on the characteristics and best concentration of PRP, number of injection, their intervals as well as patient selection. The reduction of PRP effect with time indicates the lack of role of chondral remodeling alone. Therefore more studies are

suggested to determinate PRP treatment patients' eligibility conditions, assessment of PRP real effects in the short and long term, and PRP cost benefit nature in a comprehensive and unique protocol.

5. Conclusions

Results obtained from this study showed that intra articular PRP knee injection can be effective in reduction of pain, stiffness and QOL improvement of patients in comparison to the control group in the short term.

Conflict of interest

None.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jajs.2018.06.001.

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Research paper

Using google trends to assess for seasonal variation in knee injuries

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Mechanism of injury

ABSTRACT

Introduction: The Google Trends search engine provides an insight into the search habits of individuals using the Google search engine. Usage of such data can provide us with information about the incidence of medical condition that are otherwise hard to track as patients do not always seek medical attention. An example of this is injuries to the knee. This study aimed to assess the seasonality of patients with knee symptoms that may be suggestive of a knee injury using data from Google Trends.
Materials & methods: Data was downloaded for 'knee pain' and 'knee swelling' from the Google Trends search engine from 4th January 2004 to 2nd January 2016. Statistical analysis was conducted to assess for trends and seasonality for these search terms.
Results: The data demonstrated that there has been an overall increase in the volume of searches for both 'knee pain' and 'knee swelling' over time. The month of April demonstrated the highest number of searches. Statistical analysis demonstrated a statistically significant increase in searches in warmer months compared to colder months.
Conclusion: The Google Trends search engine represents a method of data collection and analysis that may complement more traditional methods Our study shows that internet searches for symptoms related to knee injuries demonstrated a seasonal trend that has also been shown to be present for knee injuries in professional athletes.

1. Introduction

The internet has become a medical resource not only for the clinician but also for the patient. The NHS choices website handles 48 million visits per month.[1] The Google search engine handles 2 trillion searches per year[2] with 1% of these being related to medicine.[3] Data associated with such searches is an opportunity for those involved in research to detect potential trends of disease and population behaviour.[4]

Google trends is a sample of the billions of searches that are conducted using the Google search engine.[5] The data is scaled on a range from 0 to 100 and can be broken down into time and geographical location. Its usage in medical research has gradually been gaining popularity with 70 studies having been published utilizing it since 2009.[6]

Currently there is no way to continuously monitor the health seeking habits of patients. Indeed a proportion of the population will not seek medical advice from a health professional immediately and as a result the true incidence of a given pathology at a given time may or may not be truly known or understood.

Reports of injury rates have been shown to be associated with weather conditions in professional athletes, but it is unclear if the same applies to the general population.[7] Monitoring such a problem would be difficult to do as patients may seek information from other resources such as the internet. The aim of this study is to establish any potential link between seasons and reporting of knee injury related symptoms using the Google Trends search engine.

2. Method

Ethical approval for this study was not sought as it was conducted using publically available data. The study was designed using the guidance from Nuti et al[6]. Search terms were identified by performing an initial comparative search using the Google Trends search engine of knee symptoms: 'knee giving way', 'knee pain', 'knee swelling', 'knee stiffness' and 'knee locking'. Due to the low frequency of searches of the other terms, 'knee pain' and 'knee swelling' were used for the purposes of this study.

A search was conducted on 23rd November 2016 using the Google Trends search engine to obtain search volume information using the composite search terms of 'knee pain' and 'knee swelling'. Data was

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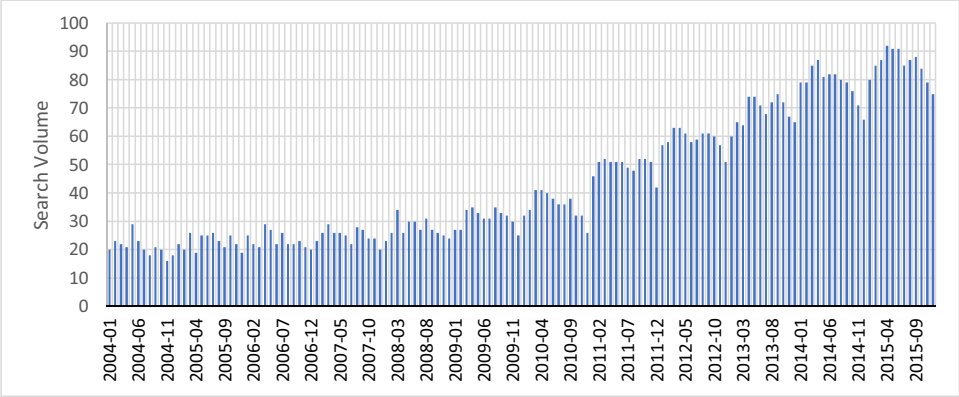

Fig. 1. Chart showing search volume over time.

obtained from 4th January 2004 to 2nd January 2016. The search was limited to the United Kingdom. Weekly search results were downloaded in the.csv format produced by Google Trends.

Data analysis was conducted using the Wilcoxon Signed Rank Test to assess for any seasonal variation and an analysis of variance (ANOVA) was conducted to assess the suitability of the seasonal model for this data set.

3. Results

Over time, as expected, we saw a year-on-year increase in the search volume for both these symptoms (Fig. 1). The average search volume by week of the year can be seen in Figs. 2 and 3. There is a gradual decrease in search volume from week 16 onwards. Search volumes were greatest in the month of April and lowest in December. This was found to be statistically significant using the student *t*-test.

When the search volumes are grouped by meteorological seasons, as defined by the Met Office[8], the greatest volume of searches were conducted in Spring and the lowest in Winter. The Wilcoxon Signed Rank Test was performed and demonstrated a statistically significant lower number of searches during the colder months ($p < .05$)

Regression analysis, conducted using an analysis of variance test (ANOVA), rejected the null hypothesis that there is an increase in search volume over time with no seasonality ($p = .82E\text{-}10$). The alternative hypothesis was, therefore, accepted that there has been an increase in search volume over time with associated seasonality.

4. Discussion

Identifying the mechanism by which an injury occurs and the factors associated has become paramount to injury prevention initiatives. Meeuwise[9] developed a model that considered the complex interactions that in the lead up to an inciting event may predispose an individual to an injury. Meeuwise[9] divided these risk factors into those that are intrinsic and those that are extrinsic. Bahr[10] progressed this model further by developing a comprehensive injury causation model which incorporated a biomechanical perspective and focuses on the characteristic of the sport in question. In both of these models, weather would be regarded as an extrinsic risk factor.

We set out in this study to see if there is a link between weather and reported knee symptoms. We have shown that searches for 'knee pain' and 'knee swelling' peaks in April and is lowest in December. We hypothesise that this may be related to increased levels of activity during warmer months. This is in keeping with other studies published that have shown an increased incidence of injuries in warmer months. A study of American football players in the National Football League found that knee and ankle sprains were less common when the temperature was cooler outside.[7] Furthermore, Orchard reported an increased incidence of ACL injuries in Australian football players in dryer conditions.[11] A further two studies demonstrated that moving rugby league games from autumn and winter months to the spring and summer resulted in a higher risk of injuries.[12,13] The reason that this is thought to happen is that ground is harder during the warmer and drier months.[14]

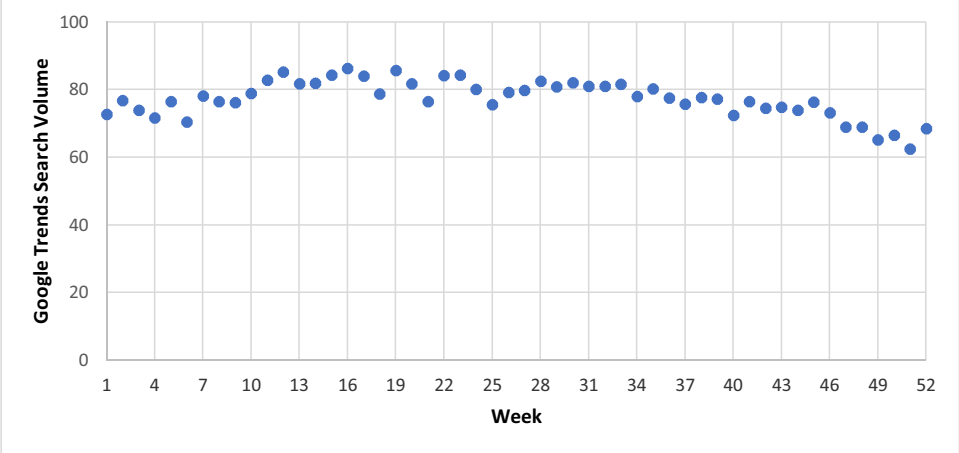

Fig. 2. Chart showing the average search volume per week.

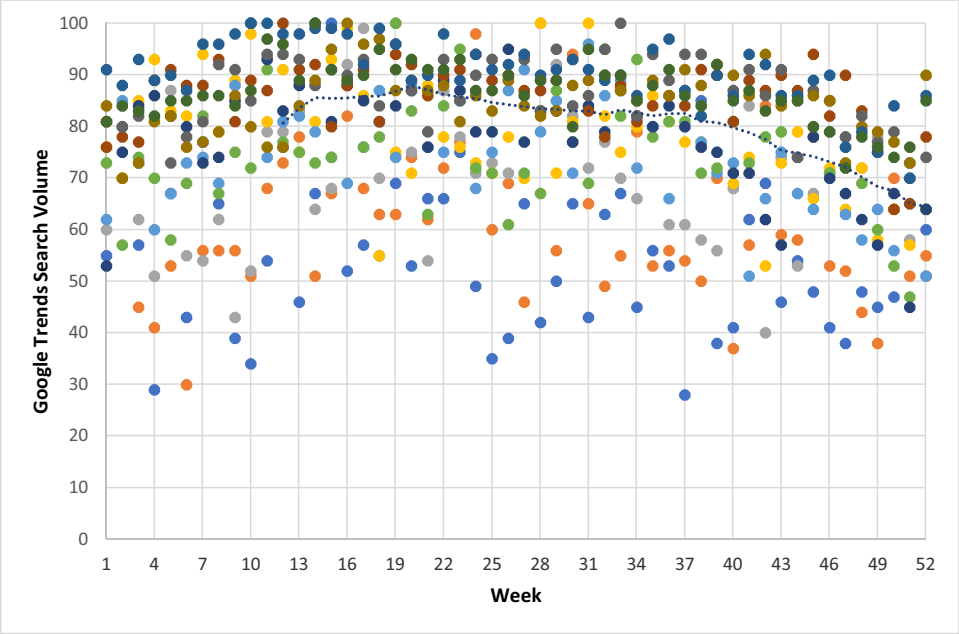

Fig. 3. Chart showing the volume of searches by week of the year for study period.

Whilst these studies have been conducted on professional athletes, this environmental factor is also likely to be true for the amateur or 'fair-weather' athlete. These people are more likely to participate in activities that subsequently expose them to injury risk during the spring and summer months.[15] They are not likely to have participated in any injury prevention programs, have the type of equipment that is available to the professional athletes nor the appropriate training. A further factor that has been noted, is that activities may be conducted at a slower pace when weather conditions are thought to be more adverse during the autumn and winter months. The faster pace during the warmer months may be a further risk factor.[16] Types of activities that occur in the warmer months also differs from those the rest of the year and again this may increase the number of injuries.[17] It may have been expected that the injury rates would be higher during the summer months when the weather is at its warmest and the ground at its hardest. However, it is believed that there would likely be decreased levels of activity as the higher temperatures at this time of year causes fatigue.[14]

Other studies have previously used Google Trends to demonstrate seasonality in the reporting of ankle symptoms,[18,19] mental health searches[20] and restless leg syndrome[21] by comparing searches within one or several Northern Hemisphere countries with that of Australia due to their seasons being at different times of year. This was a way to add validity to their results. We did not feel comparing the results of the United Kingdom with those of Australia represented an appropriate comparison owing to the differing climates of the two countries with their milder winter and warmer summer.

Google Trends data allows an interesting opportunity for research into 'real time' public interest in particular topics. It has been utilized in various areas of medical research such as multiple sclerosis[22], cancer screening[23] and most notably in the tracking of influenza.[24] However, the subsequent failure of the Google Flu Trends[25] project has cast doubt on the usefulness of Big Data. Some commentators regard Big Data sets as essentially being 'found data'. This data cannot be verified independently, does not allow for further subgroup analysis, we do not know the purpose for the search being conducted and we are not completely aware of the biases that may be present.

We do know, however, that data from Google Trends does suffer from sampling bias as the results are limited only to users of the Google search engine. From the point of healthcare, it is also more likely to be used by younger generations who are perhaps more 'tech savvy' and more embracing of alternative avenues of medical advice. Therefore, this only allows us to gain an insight into a further subset of this population. The Office of National Statistics reported that only 38.7% of adults over the age of 75 used the internet in 2015 compared with 99.2% of those aged between 16 and 24.[26] As a result, we are not be able to comment on the group of patients most likely to suffer from osteoarthritis, who often report knee pain associated with colder weather.

The aim of Google Flu Trends was to predict the immediate prevalence of flu and provide a 'nowcast' with the aim of attempting to identify where further resources may be required. We are not attempting to perform such a task with this paper. Instead we are hoping to identify a recurring pattern. We have shown in this paper that there is an increase in the search volume of knee-related symptoms during warmer environmental conditions. Whilst we are speculating that this may be a result of an increased incidence of knee injuries, the findings are in keeping with other injury studies.

Google Trends data represents an opportunity to gain an insight into the search habits of people. This study not only adds to the evidence regarding the possible association between seasonality and knee injuries but also shows that it can be used for purposes such as medical research. Guidelines have recently been published on how Google Trends may be used in medical research.[5] Adherence to such strict methodologies will aid us in the future as other Big Data sets become available and may play a role in the way we plan and deliver healthcare in the future. These systems are indeed fallible but that does not mean that they should be ignored. Instead an integrated approach should be used so that as much evidence is available to patients, clinicians and policy-makers.

Conflict of interest

None.

Contributorship

Varun Dewan: Study design and idea, data collection, statistical analysis and write-up.

Hartej Sur: Data collection, statistical analysis and write-up.

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Case Report

Spontaneous bilateral quadriceps tendon rupture in a patient with chronic kidney disease: A case report and review of literature

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1. Introduction

Spontaneous bilateral quadriceps rupture is a very rare phenomenon but is strongly associated in younger patients with chronic diseases such as gout, systemic lupus erythematosus, diabetes mellitus, corticosteroid therapy, corticosteroid injections, rheumatoid arthritis, hyperthyroidism or hyperparathyroidism secondary to chronic renal failure.

In patients with chronic renal failure, the metabolic mechanism causing the tendon rupture is the disturbances in the balance of calcium and phosphate and consequential secondary hyperparathyroidism which causes extraosseous periarticular and perivascular deposition of calcium–phosphate complexes.

Isolated or unilateral tendon rupture is frequently an associated complication but spontaneous bilateral rupture of the quadriceps tendons as a consequence of minor trauma is a very rare complication.[1,2] As the complication is very infrequently encountered, it may quite easily proceed unrecognized or be mistreated as pseudo gout or atypical rheumatoid arthritis[3]

2. Case report

A 34 year old gentleman presented to us with difficulty in walking and inability to stand from sitting position since past 1 month. The patient was apparently well since 1 month when he sustained a trivial jerk but no fall while climbing the stairs which lead to a feeling of giving away. He consulted a local practitioner where the rare possibility of a spontaneous quadriceps rupture was not considered and the patient was treated empirically with knee immobilizer on his right knee for ambulation following a period of rest. A few days later he felt another popping sound on the left knee while walking on level ground after which he developed similar complain in his left knee following which he was unable to walk or lift his legs. Patient was a known case of chronic kidney disease under medical management since the past 3 years pending haemodialysis and was a prospective candidate for renal transplant. The patient did not have any cycle of dialysis in the past.

On physical examination, patient was a thin, lean build man with local examination findings suggestive of suprapatellar swelling over both knees with tenderness on palpation. He was unable to perform a straight leg raise on both sides. On palpation, a defect in the continuity of both quadriceps tendons was found at its patellar insertion. Clinical suspicion of bilateral quadriceps tendon rupture was ascertained with X-rays of both knees suggestive of bilateral patella baja and calcium deposits in the quadriceps tendon. To further confirm the diagnosis and plan the surgical treatment, Magnetic resonance imaging was obtained which showed complete tear of the quadriceps tendon at the patellar insertion in both knees with proximal retraction of the tendon. (Fig. 1A, Fig. 1B).

On further biochemical evaluation in the line of secondary hyperparathyroidism following chronic kidney disease, it revealed elevated serum creatinine level of 6.9 mg/dl, urea 252 mg/dl, Glomerular filtration rate (GFR) of 14.7, Alkaline phosphatase value of 173U/L and Parathyroid Hormone (PTH) of 1691.6 IU/L.

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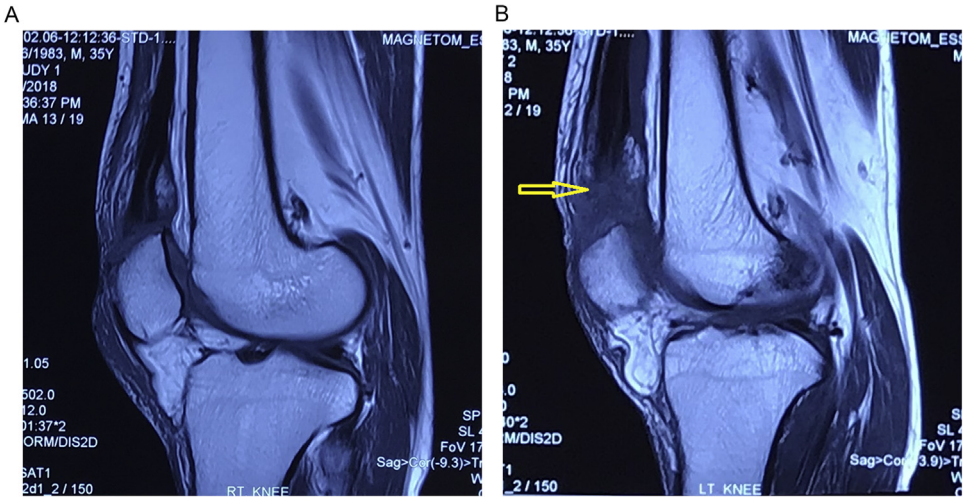

Fig. 1. A: Sagittal T2, MRI of left knee showing full-thickness tear of quadriceps tendon at patellar attachment site (yellow arrow). B: Sagittal T2, MRI of right knee showing full-thickness tear of quadriceps tendon at patellar attachment site.

Fig. 2. Quadriceps tendon repair using suture anchors in patella.

Fig. 3. Krakow's technique of tendon repair.

Fig. 4. Repair augmentation using stainless steel wire encirclage.

Patient was planned for bilateral quadriceps tendon repair. Nephrology consult was sought prior to the surgery. A cycle of dialysis was conducted and after optimization from nephrology team, he was taken up for surgery for bilateral quadriceps repair with suture anchors (Fig. 2), Krakow suture technique (Fig. 3) and 1.8 mm SS encirclage wiring for augmentation of the repair anchoring from patellar tendon distally and quadriceps tendon proximally following the repair. (Fig. 4). The immediate post-operative X-ray was obtained (Fig. 5A, Fig. 5B).

The patient was kept in knee immobilizer for a period of 3 weeks where patient was encouraged for static quadriceps exercises. At 3 weeks gentle range of motions exercises were initiated. Patient achieved 0–50 degrees of movements in both the knees at 6 weeks and 0–90 degrees of movements at 4 months of follow up (Fig. 6) with good quadriceps strength and no extension lag (Fig. 7).

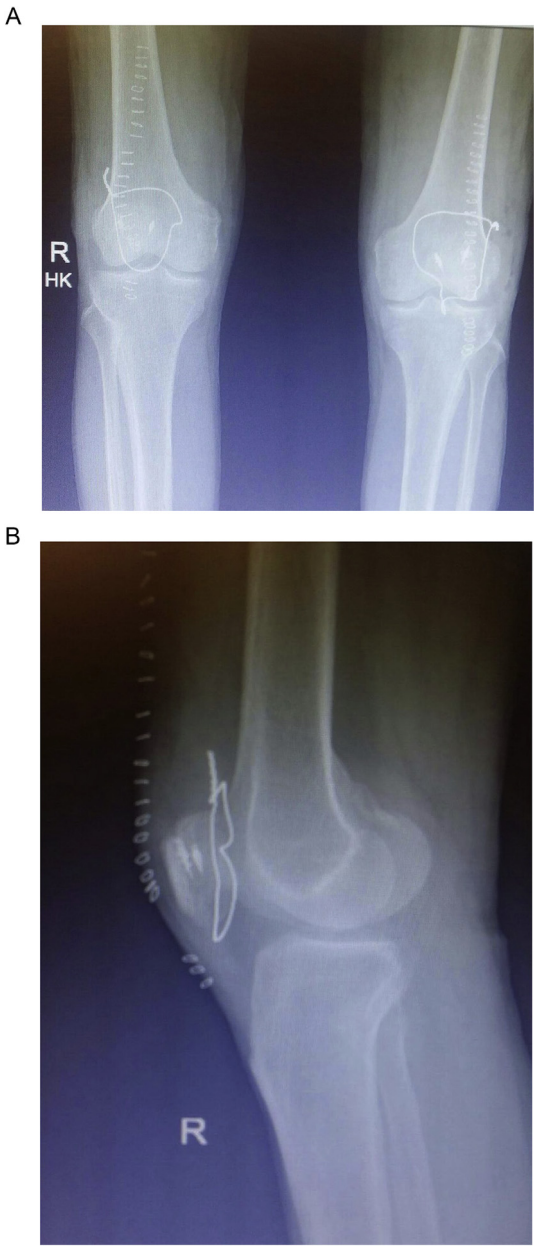

Fig. 5. A: Immediate post-operative Anteroposterior view. B: Immediate post-operative Lateral view.

Fig. 6. 90° range of motion at 4 months follow up.

3. Discussion

Bilateral quadriceps tendon tear is a very rare clinical entity. In 1949, Steiner and Palmer first reported a case of quadriceps tendon tear in a patient with renal failure. Trivial trauma can rupture bilateral quadriceps in patients with chronic renal failure, systemic lupus erythematosus, gout, diabetes, secondary hyperparathyroidism, pseudogout, alkaptonuria, severe osteomalacia and in patients with systemic steroid treatment.

The cause of tendon tear has not been well established and various causative factors have been proposed like diminished local circulation, disturbed collagen synthesis, repeated micro trauma and reduced tendon elasticity by calcification.[4]

The diagnosis of quadriceps tendon rupture is primarily based upon the history and meticulous clinical examination. Due to the rare incidence of this injury, early clinical diagnosis is essential, which is a challenging task to the physician. The consistent characteristic finding on clinical examination is a palpable suprapatellar gap where insinuation of finger is possible between the tendon and the superior pole of the patella. Radiographs are not sufficient to make an accurate diagnosis whereas USG (Ultrasound) is the screening investigation. MRI remains the gold standard imaging to assess the extent of rupture, site of rupture, associated osteotendinous injury and preoperative planning.

In view of chronic renal disease, the clinician should have high index of suspicion of this entity and early imaging, especially MRI, is essential. Partial tendon ruptures are managed conservatively with physiotherapy, whereas complete ruptures warrant surgical intervention.[5]

In the described case scenario, the tendon rupture was complete on both the sides and hence warranted a repair. An important rarity of presentation which requires special mention in this case is that there have been multiple case reports in English literature describing the similar pathology in patients with chronic kidney disease undergoing short or long term haemodialysis, but to the best of our literature search, this is probably the first reported case of bilateral spontaneous quadriceps rupture with chronic kidney disease with secondary hyperparathyroidism with no haemodialysis received till the time of presentation.

The association of tendon rupture with the duration of renal failure and period of dialysis have been studied and discussed in literature with a direct relation between the both.[6,7]

Early surgical repair, control of secondary hyperparathyroidism, early use of vitamin D analogues and total parathyroidectomy can treat and prevent tendon rupture or re-rupture with satisfactory results.[8]

To conclude, bilateral spontaneous rupture of quadriceps tendon is a rare entity with the role of elevated parathyroid hormone in end-stage renal disease patients remaining crucial. Proper

Fig. 7. Full extension at 4 months follow up.

evaluation and management including surgical repair and medical treatment can result in satisfactory clinical and functional outcomes. Early surgical repair is the treatment of choice and is usually associated with good results.[9] Konrath et al.[10] reported that most patients can expect a good range of motion and may return to their preinjury level but may find difficulty in sporting activities due to persistent weakness. In their study they did not find any significant correlation between the length of time from rupture to repair with strength, function or activity scores.

Conflict of interest

There is no conflict of interest in the submitted research work.

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Case report

Concomitant multiligamentous knee injury and patellar tendon tear- A rare injury pattern

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ABSTRACT

Multiligamentous knee injury (MLKI) is a difficult and devastating injury of the knee. These injuries are not so common. Anterior cruciate ligament, medial collateral ligament concomitant with patellar tendon tear is even rarer combination. To best of our knowledge, only few such cases with similar injury pattern have been reported in the literature. We report two such cases & highlight the mechanism, treatment and modified rehabilitation protocol. In acute setting, diagnosis may be difficult due to gross soft tissue swelling. Magnetic resonance imaging is an important diagnostic tool to know the extent and site of ligament tears & to avoid misdiagnosis. Simultaneous repair or reconstruction of all the structures in the grossly unstable knee with modified rehabilitation protocol can be performed to obtain optimal functional outcomes.

1. Introduction

Multiligamentous knee injury (MLKI) is a difficult and devastating injury of the knee. MLKI is defined as tear/disruption (grade III) of at least 2 of the 4 major ligaments of the knee.[1] These complex injuries usually associated with knee dislocation that reduce spontaneously in more than 50% of the cases.[2] Most common injury pattern in a knee dislocation is anterior cruciate ligament (ACL) and medial collateral ligament (MCL).[2] These injuries are not so common. In the literature few case reports have been reported mentioning the combined ACL and patellar tendon (PT) ruptures.[3] However, ACL + MCL concomitant with PT tear is even rarer combination. To best of our knowledge, only few such cases with similar injury pattern have been reported in the literature.[2,4,5] Patellar tendon injury is easily missed due to other distracting injuries that take priority and a simultaneous injury may be overlooked. Tsarouhas et al. had reviewed 13 cases and found 1 patellar tendon tear and 5 ACL tear were missed during initial examination when these injuries occur simultaneously.[6] Patellar tendon tear usually seen in younger population due to eccentric quadriceps contraction. Most of the time tear occurs at inferior pole of patella as a bony avulsion injury. These injuries require surgical management for favorable functional outcomes[7,8].

We report two such cases with ACL, MCL & lateral meniscal injury with concomitant PT tear & highlight the mechanism, treatment and rehabilitation protocol.

2. Case reports

2.1. Patient 1

A 20 year old young boy, student by occupation, presented with history of motor vehicle accident (MVA), pedestrian hit by a car with a close injury to left knee. Initially he was treated with knee brace somewhere else in view of soft tissue injury. He reported to us after 2 weeks with pain and swelling over left knee & inability to extend the knee completely. On clinical examination anterior drawer, lachman and valgus stress tests were found to be positive with extensor lag sign with no neurovascular deficit. Radiographic evaluation was performed, revealing bony avulsion of patellar tendon from inferior pole of patella and soft tissue swelling as shown in Fig. 1. Magnetic resonance imaging (MRI) was done subsequently where ACL, MCL (tibial site avulsion), PT and lateral meniscus tear were noticed (Fig. 2).

After pre-anaesthetic clearance (PAC), patient underwent single stage surgical intervention of all the injured structures. First arthroscopic partial lateral menisectomy & ACL reconstruction was

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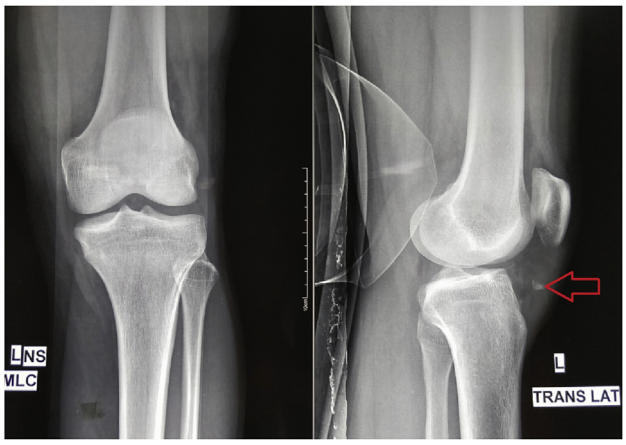

Fig. 1. X-ray of left knee AP & Lateral view (Arrow) showing bony avulsion fracture of inferior pole of patella: suggestive of patellar tendon avulsion.

performed by standard anatomical technique using Semitendinous gracilis (STG) graft harvested from contralateral side. After ACL reconstruction, MCL was repaired & augmented with ipsilateral STG graft. STG graft was prepared keeping its tibial site insertion intact and passed through the medial retinaculum. At medial epicondyle level, a coronal tunnel was drilled in femur and then graft was secured with biointerference screw at femur site with knee in 30° flexion. Graft was then reflected back over the medial surface of tibia and secured with spiked metallic ligament staple just posterior to pesanserinus insertion to achieve two point fixation over tibia. This technique allow us to replicate the natural wide insertion of MCL over tibia. In the end PT repair was done using anterior longitudinal incision given directly over the tendon. No.5 Ethibond suture was used in Krackow fashion to prepare the PT. Then suture was passed through osseous tunnels drilled from inferior to superior pole of patella and tied over the superior pole. Thus a transosseous repair of the PT was achieved with knee in full extension (Fig. 3A and B).

In the post-operative period patient was given knee brace with knee in full extension for a period of 3 weeks and was followed up in clinics at 3 weeks for suture removal then monthly till 3 months and then 6 monthly till complete rehabilitation. After 3 weeks, patient was allowed partial weight bearing with support and active assisted range of motion (ROM) upto 60°. At 6–8 weeks, patient was allowed full weight bearing with continue knee ROM exercises beyond 60°. At 3 months of rehabilitation, patient was trained to develop quadriceps and hamstring control to achieve functionally stable knee. At 18 months follow up, patient had returned to his pre-injury activity level with Tegner activity level of 5, lysholm knee score was 83 with ROM from 0 to 120° as compared to normal contralateral side with no laxity/instability.

2.2. Patient 2

A 34 year old gentleman, government clerk by occupation, presented to us with closed injury to right knee with complaining of pain, swelling & inability to do active extension. Mode of injury was high velocity injury in the form of fall from bike after hit by a car (MVA). Patient was treated with knee brace for 3 weeks somewhere else due to negative findings on plain radiographs. Upon clinical examination, multiligamentous knee injury was suspected due to positive lachman, valgus stress tests with terminal extension lag. MRI confirmed the clinical findings, revealing ACL, MCL, PT tear and lateral meniscal injury (Fig. 4).

3 weeks from the injury patient underwent single stage surgical repair/reconstruction of all the structures as described earlier. PT tear involving 50% of the tendon was found avulsed from inferior pole which was repaired with No.5 Ethibond suture by the previously described technique. Patient was followed at clinics in similar manner with same modified rehabilitation protocol as was the previous patient treated. At 12 months follow up, patient had reached his pre-injury status with Tegner activity level of 4, lysholm knee score of 79 & ROM from 5 to 125° as compared to normal other side with no significant laxity/instability.

In both the cases, due to scarcity of grafts, ACL reconstruction was performed using STG graft harvested from contralateral side. No donor side morbidity in terms of muscle weakness, neurological deficit were noticed.

3. Discussion

Combined ACL & PT injuries have been described in the literature largely as case reports as shown in the study of Malvasi S et al.[7] – a review of case reports. However, there is paucity of literature

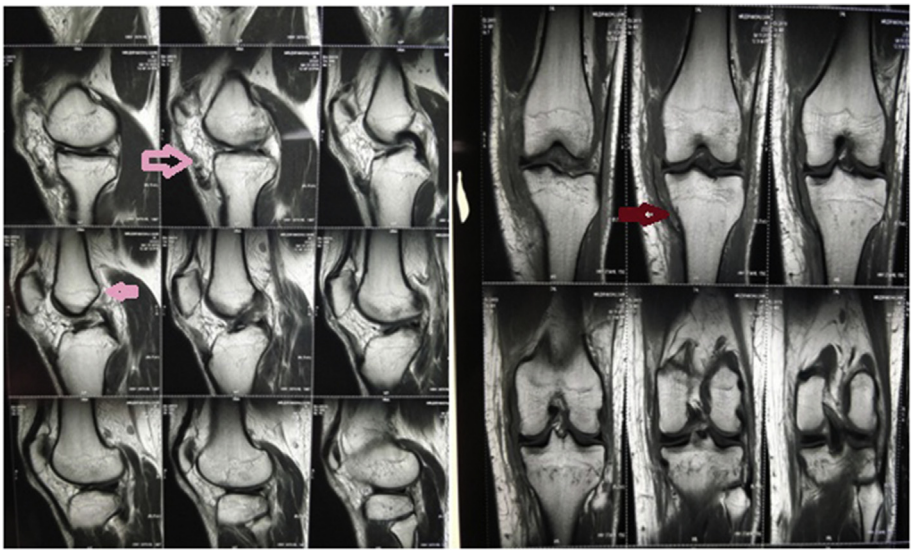

Fig. 2. MRI (Sagittal & Coronal) images of patient 1, Arrows denote Patellar Tendon tear, buckling of Posterior cruciate ligament suggestive of ACL injury & Medial collateral ligament avulsion from femur side.

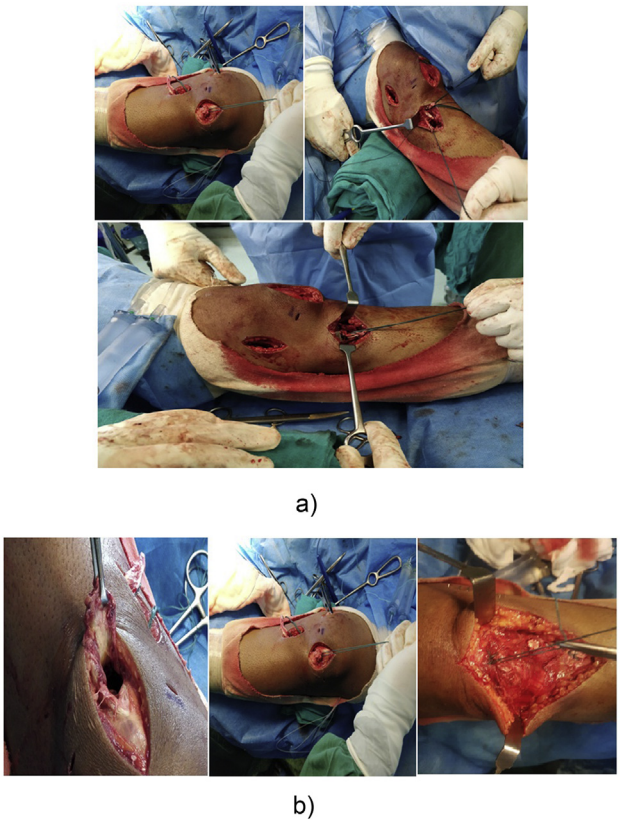

Fig. 3. (3A & 3B): showing Medial collateral ligament repair with augmentation by ipsilateral STG graft & transosseous repair of avulsed patellar tendon.

over MLKI (ACL + MCL) with PT injury in terms of mechanism of injury, definitive treatment and rehabilitation guidelines. Tsarouhas et al.[6] introduced a possible mechanism of injury in combined ACL + PT injury. A sudden anterior tibial translation followed by eccentric quadriceps contraction in a partially flexed knee seems to be a common injury pattern. Thus ACL tears first followed by PT.[6] While Wissman R et al.[9] reported a component of valgus stress is required for concomitant MCL tears in patients with ACL & PT tears. The major concern with these complex injuries is to achieve stability with full ROM of the knee post-operatively. Kovachevich et al.[10] had concluded poor healing capacity of full thickness tear of MCL in severely traumatized knees. Thus good results are obtained only with direct repair or reconstruction with STG autograft. PT repairs in acute setting is mandatory to yield good functional outcomes.[11] However, ACL reconstruction gives better results with full ROM prior to surgery.[12] There is also difference in postoperative rehabilitation protocol of PT repair which needs delay in range of motion exercises for healing. While ACL + MCL reconstruction requires early aggressive ROM exercises to prevent postoperative arthrofibrosis. Futch et al.[13] in his study addressed both ACL + PT injury simultaneously. Despite the early ROM rehabilitation protocol, patient developed knee arthrofibrosis and underwent for adhesiolysis. While Kim et al.[14] managed the similar case (ACL + MCL + PT tear) as a single stage procedure and found favorable outcomes in the follow up. Delay in addressing the PT injury results in quadriceps atrophy, extensor lag, patella alta with retraction of tendon thus makes the repair more difficult.[14] Brunkhorst J et al.[2] reported the two similar cases where he staged the surgical procedure. He repaired the PT and MCL tear in the acute setting while posterolateral corner (PLC) injury was addressed later on at the time of ACL reconstruction. According to Brunkhorst J et al.,[2] stage reconstruction decreases the operative time, postoperative knee stiffness & yields better functional outcomes. Our single stage repair/reconstruction approach with individualized rehabilitation protocol has also given better functional out comes in terms of ROM & stability with no revision surgical intervention. In both cases, MCL repair was always being augmented with STG graft with our two point anatomical fixation technique. Only 3 weeks immobilization with brace in full extension was enough for initial protection of the PT repair. This was followed by gradually increasing ROM exercises. Thus with this treatment and rehabilitation strategy, in both the cases we found no postoperative stiffness, extensor lag & ligament laxity. As there is paucity of literature over optimal treatment guidelines for these multiligamentous knee injury cases, we took consideration into simultaneous/single stage reconstruction on following grounds: 1) Complete tear of MCL was causing the severe joint instability 2) the patients were relatively young 3) stage repair would have

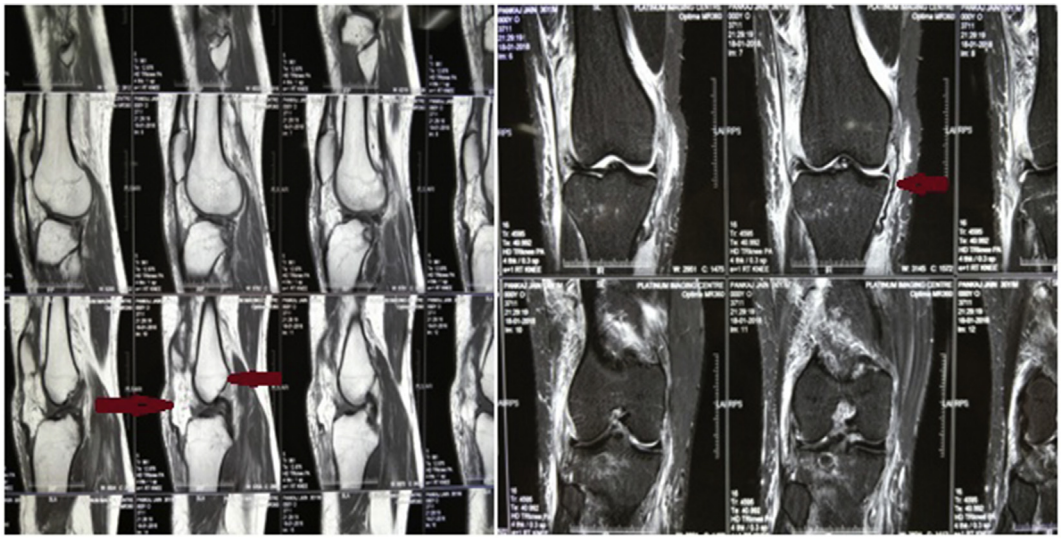

Fig. 4. MRI (Sagittal & Coronal) images of patient 2, Arrows showing Anterior cruciate ligament fibre discontinuity, Patellar Tendon tear & Medial collateral ligament avulsion from femur side with tortuosity due to laxity/tear of ligament.

Table 1
Reported cases of Concomitant multiligamentous knee injury and patellar tendon tear with surgical intervention performed.

Year	Sex	Age	Mode of Injury	Surgical Intervention
1991[5]	F	25	Sports injury	Not reported
1996[4](4 cases)	M	36	Sports injury	Single stage
	M	20	Sports injury	Not reported
	M	23	Motorcycle accident	Not reported
	M	23	Sports injury	Two stage
2011[6]	M	38	Martial arts	Not reported
2014[14]	M	32	Sports injury	Single stage
2015[2]	M	32	Bicycle accident	Two stage
	M	27	Sports injury	Two stage
*Current study (2018–2 cases)	M	20	Motor vehicle accident	Single stage
	M	34	Motor cycle accident	Single stage

prolonged the treatment 4) intraarticular concomitant lesions could have been undetected and to avoid second surgical procedure thus accelerating the rehabilitation program. Surgical planning also depends on soft tissue status, patient's activity level and surgeon's experience. These strategies were also supported by Kim et al.[14] in his study with favorable functional outcomes. Table 1 showing all the previously reported similar cases with their line of surgical intervention.

Misdiagnosis with delay in treatment is common entity with these complex injury pattern. Rae PJ et al.[5] found PT tear incidentally during surgical repair of acute ACL and MCL tears due to swelling masked the defect in PT and radiographs showed a normally positioned patella.

4. Conclusion

Concomitant MLKI (ACL + MCL) and PT tear is a rare injury pattern. In acute setting, diagnosis may be difficult due to gross soft tissue swelling. MRI is an important diagnostic tool to know the extent and site of ligament tears & to avoid misdiagnosis. Rapid deceleration in flexed and valgus knee followed by eccentric quadriceps contraction is most possible mechanism of this combined injury. Simultaneous repair or reconstruction of all the structures in the grossly unstable knee with modified rehabilitation protocol can be performed to obtain optimal functional outcomes. Although, there is no gold standard surgical treatment algorithm available in the literature. Future studies with large population size are needed to describe optimal treatment guidelines and rehabilitation strategy to achieve better functional outcomes in such complex injuries.

Conflict of interest

The authors of the study have no conflict of interest.

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Research paper

Midterm results of reconstruction of femoral defects with cementless femoral components in revision hip arthroplasty for aseptic loosening

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ABSTRACT

Objectives: To retrospectively review the mid-term outcomes of cementless femoral components used during revision arthroplasty.
Methods: Records of 52 hips with 28 women and 24 men (mean age 61.1 years) were reviewed in which cementless femoral revision was performed for aseptic loosening of the femoral component by a single senior surgeon. The clinical outcome was assessed using the Harris Hip Score. Radiological parameters followed were osseointegration, subsidence, remodelling and heterotropic ossification.
Results: Mean follow-up period was 8.1 years. The mean Harris hip score improved from 32 to 81.8. Subsidence >10 mm was noted in four hips within the first 6 months which was non-progressive. Osseointegration was noted in 42 hips; stable, fibrous integration was noted in the other 10 hips. Extended trochanteric osteotomy united in all cases (mean 5.2 months).
Conclusions: Both extensively porous-coated cylindrical stems and tapered, fluted long stems provide excellent outcomes and survival in reconstruction of femoral defects.

1. Introduction

The number of total hip arthroplasty (THA) procedures is consistently increasing due to the expanded indications, the ageing population and advances in surgical expertise and technology.[1–3] As a consequence, revision hip arthroplasty procedures have also increased and have become the focus of hip arthroplasty. By 2026, the number of revision hip arthroplasty procedures has been projected to increase twofold.[2]

Aseptic loosening of the femoral and acetabular components remains one of the major indications for revision hip arthroplasty.[4] The prevalence of aseptic loosening in most series beyond ten years is reported to be between 32% and 62% depending on the type of prosthesis used.[1,4,5] Obtaining a stable fixation of the femoral component in revision hip arthroplasty associated with femoral bone loss is technically demanding; poor bone stock and inherent difficulties of removing a well-fixed uncemented or cemented implant often complicates the procedure.[1,6,7] A variety of implants and surgical techniques are available to the surgeon to achieve stable fixation of the implant,[1,6]

The purpose of this retrospective study was to assess the clinico-radiological, mid-term outcomes associated with the use of uncemented femoral components (extensively porous-coated cylindrical stem and tapered, fluted long stems) in revision THA done for aseptic loosening of the femoral component with femoral bone defects/osteolysis.

2. Materials and methods

Between 2003 and 2012, 56 consecutive cases of revision hip arthroplasty were performed for aseptic loosening of the femoral component with femoral bone loss. Cases of septic loosening, periprosthetic fractures and cemented revision stems were excluded for the purpose of this study. Among these 56 cases, three patients died due to reasons unrelated to the arthroplasty and one patient was lost to follow-up; these four cases were excluded from the study. For the final analysis, we were left with 52 patients out of whom 28 were females and 24 were males. All surgeries were performed by a single senior surgeon (S.A). The mean age of the patients at the time of the revision surgery was 61.1 years (Range: 29–83 years). The mean duration of follow-up was 8.1 years (Range: 5–14 years; minimum follow-up 60 months).

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All the study operations were first revisions. The acetabular component was also revised in 33 (63.5%) cases. The femoral component used was either an extensively porous-coated cylindrical stem – VerSys® Beaded Full Coat Revision stem or a cylindrical, fluted, tapered long stem – Wagner Self-Locking (SL) Revision® hip stem (Zimmer, Inc, Warsaw, IN).

Demographic data, primary diagnosis, type of fixation used for the primary implant, interval between primary and revision surgery and details of revision surgery (surgical approach, details of osteotomy for implant removal if used, type of implant, intraoperative and postoperative complications) were noted on a pre-designed proforma. Leukocyte counts, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels were obtained for all patients; if any doubt for infection, a hip aspiration was performed to rule out infection.

Preoperative radiographs included anteroposterior (AP) and lateral views of the affected hip and femur and an AP view of the pelvis with both hips. Templating was performed to estimate the length and diameter of the stem so that a scratch-fit could be obtained in 4 to 6 cm of diaphyseal bone. The femoral bone loss was assessed both preoperatively (on plain radiographs) and intraoperatively after implant removal using the Paprosky classification.[8–10] The categories which include femoral osteolysis according to this classification are type 2 (metaphyseal damage), types 3A and 3B (metadiaphyseal bone deficiency with or without the reliability of a minimum 4 cm scratch-fit respectively) and type 4 (extensive metadiaphyseal precluding distal fixation). (Fig. 2).

All surgeries were performed in the lateral decubitus position; the posterolateral (Moore's) extensile approach was used in all cases. An Extended Trochanteric Osteotomy (ETO) was performed in 21 (40.4%) patients for removal of the cement mantle. Cerclage wires were used for the fixation of the osteotomy; supplementary bone grafting was not used for any osteotomy. In all cases a non-modular, distal diaphyseal-fixing, uncemented femoral component was used. In 29 cases, a Wagner Self-Locking (SL) Revision® hip stem (Zimmer, Inc, Warsaw, IN) was used (seven type II defects, eight type IIIA defects, nine type IIIB defects and five type IV defects). In 23 cases, an extensively porous coated, cylidrical stem-VerSys® Beaded Full Coat Revision stem (Zimmer, Inc, Warsaw, IN) was used (one type II defect, 14 type IIIA defects, four type IIIB defects and four type IV defects).

Follow-up visits were undertaken at 3 weeks, 12 weeks, 6 months, 12 months and annually thereafter. The Harris Hip Score (HHS) was calculated preoperatively and at every follow-up visit by the senior surgeon (SA).[15] Plain radiographs (AP view of the pelvis and AP, lateral views of affected femur) were obtained in the immediate postoperative period, at 6 months and annually thereafter; the immediate postoperative radiograph served as the baseline radiograph for all future radiological comparisons. All radiographs were reviewed by a single observer who was not involved in the clinical management of the patient (N.J). The ETO was considered to be healed if the patient had painless weight-bearing clinically with visible callus formation in both AP and lateral radiographs.

Osseointegration was assessed using the criteria of Engh et al.[10] The stem fixation was classified into three types: (i) stable implant with bony ingrowth (implant with no progressive migration plus minimal/absent radio-opaque line formation around the stem), (ii) stable with fibrous ingrowth (no progressive migration of the stem and extensive radio-opaque line formation) or (iii) unstable implant (progressive subsidence and divergent radiolucent lines around the stem).[11]

Subsidence of the implant was measured according to the method described by Callaghan et al.[12] The subsidence was considered significant only if it exceeded 10 mm.[13] The classification of Kolstad et al.[13] was utilised to classify remodelling in the proximal femur: A (increasing defects), B (stable defects) or C (osseous restoration). The cortical index proposed by Callaghan et al.[12] was also measured and documented. Intraoperative periprosthetic fractures were classified according to the modified Vancouver classification.[14,15] Any heterotropic ossification detected was graded according to the Brooker et al.[16] classification.

3. Results

The primary pathology of the hip for which a primary THA was performed has been summarised in Table 1. The mean time interval between the primary surgery and the revision surgery was 9.8 years (Range: 3–30 years). All the patients presented with groin pain and limp. Twenty-seven patients (51.9%) had progressive shortening with a short limb gait.

The old femoral component extracted was a cemented implant in 36 hips (69.2% of cases) and an uncemented implant in 16 hips. According to the Paprosky classification,[33,37] the osteolysis was classified as follows: eight patients had type II defect, 22 patients had type IIIA defect, 13 patients had type IIIB defect and nine patients had type IV defect (Fig. 1).

Clinical results

The mean HHS improved from a preoperative value of 32 (Range: 12–70) to a postoperative value of 81.8 (range 37–96; p-value < 0.001). The mean age at the last clinical follow-up was 69.1 years.

Radiological results

Evidence of bony ingrowth was noted in 42 patients (80.1% cases). Fibrous integration (periprosthetic radiolucent line) was noted in ten cases. At the time of the last follow-up none of the cases in this series had any evidence of a loose/unstable implant. The ETO united in all patients between 3 and 8 months post surgery (mean time to union: 5.2 months). Significant subsidence (>10 mm) was noted in four cases (maximum of 15 mm). In all

Table 1

Sl no.	Primary diagnosis	No. of Cases	Percentage of total cases
1	Fracture neck of the femur	18	34.5
2	Femoral head avascular necrosis (AVN)	7	13.4
3	Inflammatory arthritis (rheumatoid arthritis and ankylosing spondylitis)	4	7.7
4	Primary osteoarthritis of hip	4	7.7
5	Secondary osteoarthritis of hip (excluding AVN hip aetiology)	17	32.7
6	Developmental dysplasia of hip (DDH)	1	1.9
7	Intertrochanteric fracture with a failed DHS implant in-situ	1	1.9

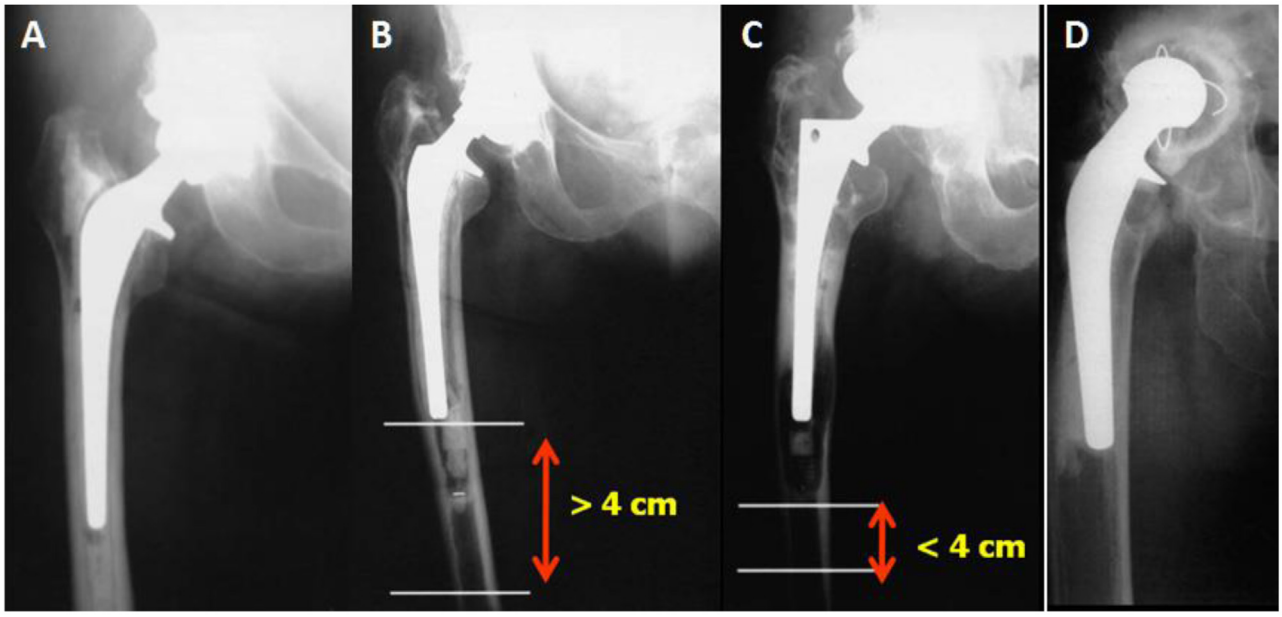

Fig 1. Radiographs showing aseptic loosening of femoral component arranged according to the Paprosky classification (A) Type II defect (B) Type IIIA defect (C) Type IIIB defect (D) Type IV defect.

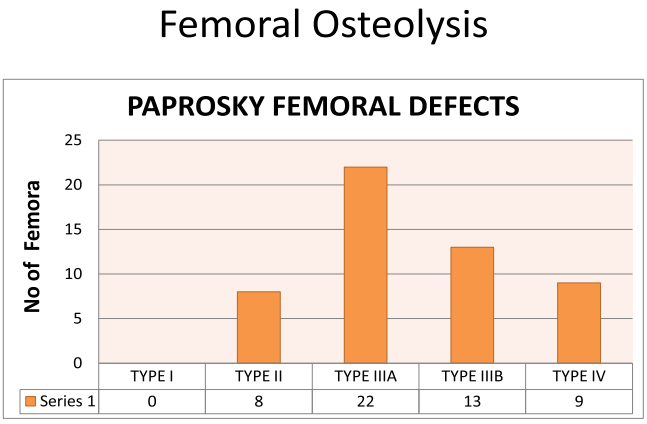

Fig. 2. Graph showing the distribution of our cases when classified according to the Paprosky classification[33],37.

these four cases, subsidence occurred in the first six months after surgery; no further subsidence was observed on further follow-up. Radiological signs of bone restoration were seen in 26 hips (81.3%).

Complications

One patient with a Paprosky type IIIA defect had an intraoperative fracture of the greater trochanter (Vancouver Classification-A_G) for which an encirclage was added; the fracture united in 8 weeks. One patient had a foot drop in the immediate postoperative period for which an ankle foot orthosis was applied and the patient was kept non-weight bearing for 12 weeks. The nerve deficit recovered completely within three months. Two patients had Brooker grade 1 heterotropic ossification which was not symptomatic. No cases of periprosthetic joint infection or postoperative hip dislocation were noted. One hip required re-revision after ten years due to loosening of the acetabular component. None of the femoral components needed revision at the last follow-up (Figs. 3–7).

4. Discussion

Obtaining a stable and durable fixation of the revision femoral component in an osteolytic femur is challenging even to the most experienced hip arthroplasty surgeons.[1] The key to a successful revision of the femoral stem in the face of bone loss is to ensure early stability and preservation of the normal biomechanics of the hip. Various implants and fixation strategies have been used over the course of time to achieve this objective. Despite improvements in cementing techniques, the re-revision rates of cemented femoral components have only increased with time and the radiologic loosening rates are still high.[17–19] Early review of cemented stems showed progressive failure over five to ten years, mainly secondary to aseptic loosening.[20]

The uncemented extensively porous coated, cylindrical, long-stem implant and fluted, tapered, long-stem implant (Wagner SL Revision system®) have both been the workhorse implants in the revision scenario.[1] Both these implants obtain purchase in the diaphysis, bypassing the metaphyseal and/or diaphyseal defects and provide initial stability to allow time for bony ingrowth.[6,21]

The long-term results for extensively porous-coated cementless implants have consistently been good and an excellent survivorship has been described in different series.[1,6,10,22] Hamilton et al.[22] described 905 femoral revisions with extensively porous-coated stems and observed a low incidence of aseptic loosening (1.3%) and re-revision rate (2.2%). The Kaplan-Meier survivorship, using stem re-revision as the end point, was 97.5% ± 1.3% (95% confidence intervals) at 5 years and 95.9% ± 1.9% at 10 years.[22]

Weeden and Paprosky[10] in their study of 170 patients (mean follow-up of 14.2 years and minimal follow-up of 11 years) reported radiographic evidence of bony ingrowth in 82% hips, stable fibrous fixation in 14% cases (i.e. >95% cases had stable, biologic fixation of the implant at 11 to 16 years after revision surgery) and unstable fixation only in 4% cases with an overall total mechanical failure rate of 4.1%. Almost half the cases in the series (48%) had a Paprosky type IIIA femoral defect. Though stress shielding and femoral osteolysis was observed in their series, it never went on to become a clinically significant issue nor did these factors compromise the stability of the implant.[10]However, results

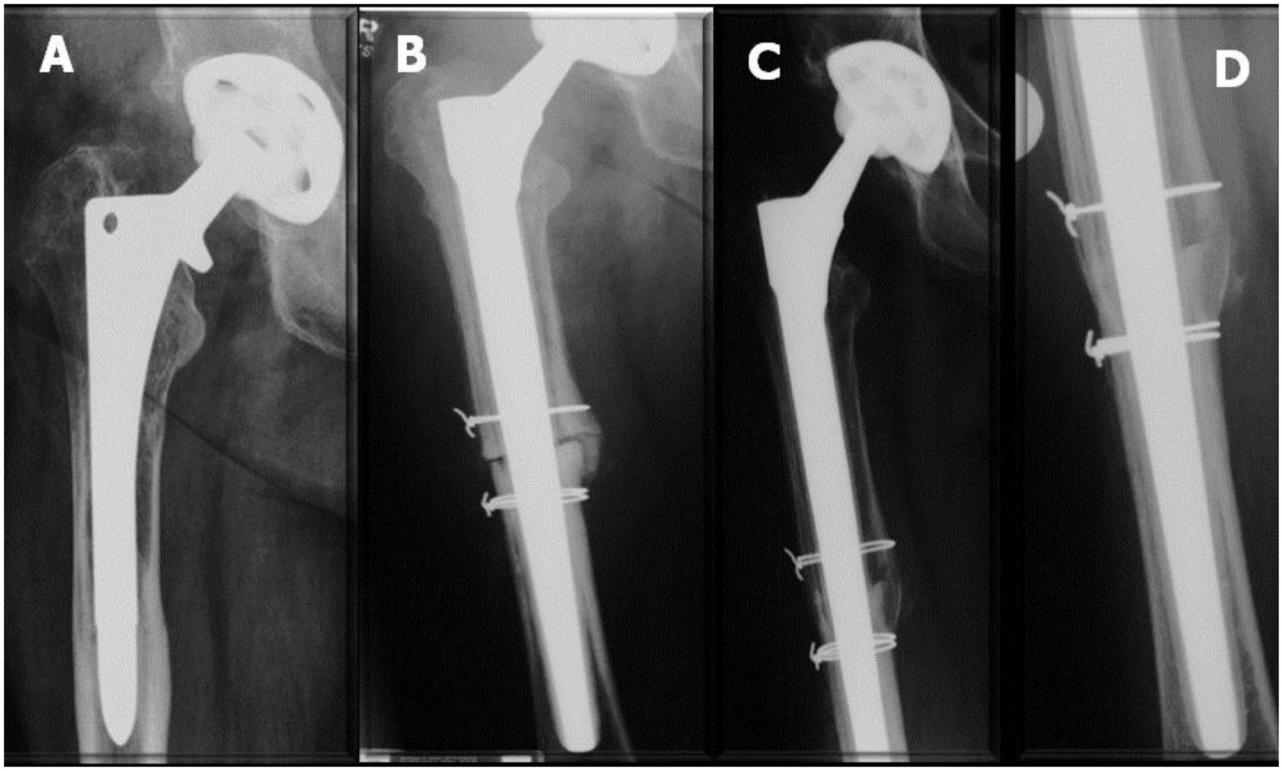

Fig. 3. (A) Pre-operative radiograph showing severe stress shielding and paper-thin cortex (B) One year post revision surgery with Wagner SL stem (C, D) Five years post-operative radiograph showing a well-fixed and osseointegrated implant and good consolidation of the osteotomy.

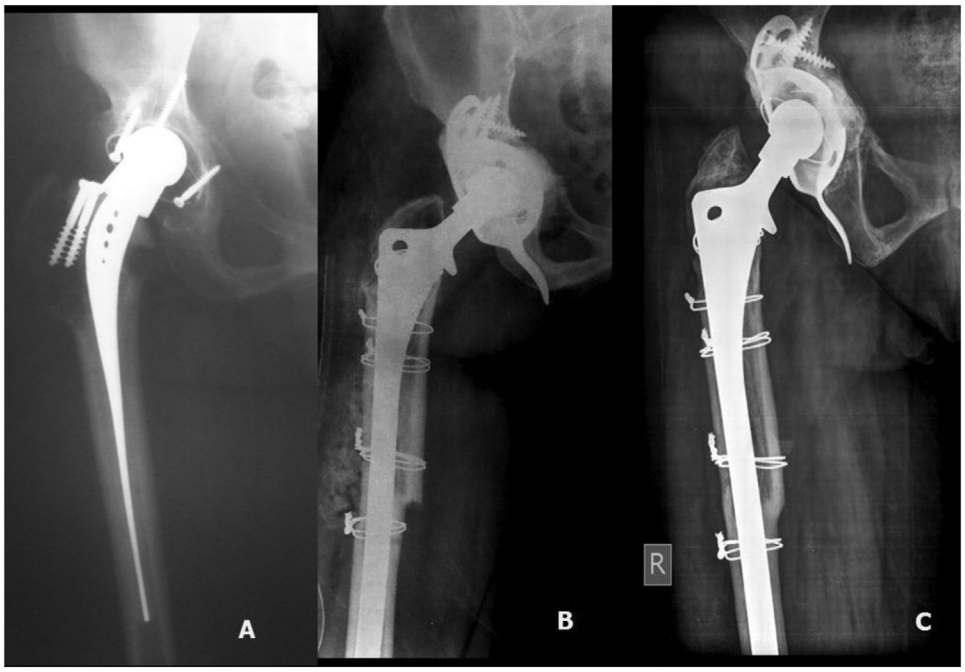

Fig. 4. (A) Radiograph of a loosened isoelastic stem 15 years after primary THA in a 51-year-old female with type II Paprosky defect (B) Revision of stem with an extensively porous coated long stem (C) Ten years post surgery showing stable, well-fixed implant and good consolidation of ETO.

of this stem are comparatively poorer in larger femoral defects (Paprosky type IIIB and IV).[1,6,10]

The Wagner stem, which was developed in 1987, is a straight, fluted, tapered, long stem with a grit-blasted surface used for cementless femoral revision. The longitudinal flutes and three point fixation principle provide rotational stability to the implant in the femoral canal whereas the tapered geometry contributes to the axial stability.[21,23,24] Multiple studies have reported >90% survival after five to ten years and it has been a very popular implant in the armoury of the revision arthroplasty

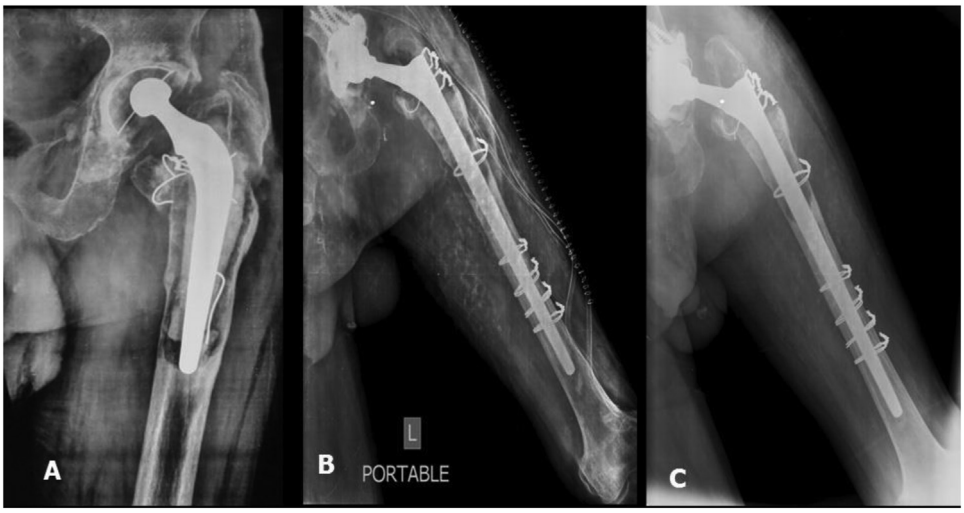

Fig. 5. (A) Radiograph of an 81 year old man with severe aseptic loosening of a Charnley stem with a Paprosky type IIIA defect (B) Immediate postoperative radiograph (C) Radiograph at 8-year follow-up showing a stable implant and healed osteotomy.

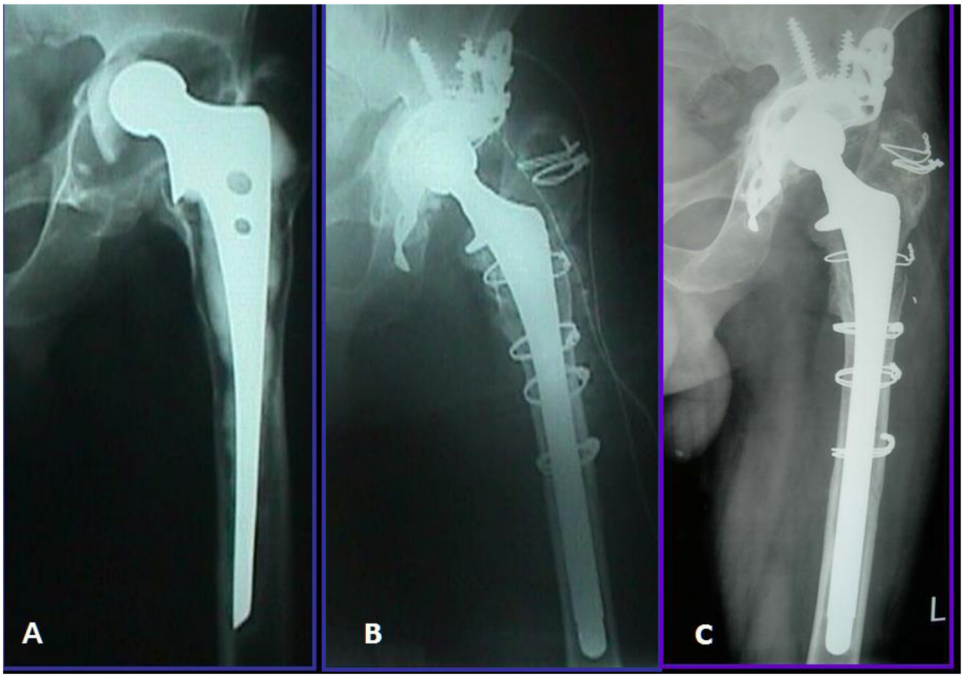

Fig. 6. (A)Aseptic loosening 16 years after primary THA with a grade IIIB Paprosky defect (B) Postoperative radiograph after revision with a Wagner stem (C) Radiograph at 10 years follow-up showing good osseointegration and a healed, consolidated osteotomy.

surgeon.[15],21,25–28 However, it is associated with complications like increased rates of subsidence and instability which has led to the development of modular, fluted, tapered stems.[29]

Modularity offers the advantages of adjustment in leg length and rotation, anteversion, offset and proximal fill; however, these advantages over the non-modular, uncemented stems have not been clearly demonstrated in practice. Although the mid-term results with the modular, fluted, tapered stems have been excellent, these implants have their own set of complications[1,6,21,29]. The disadvantages of modular stems include fretting corrosion at hardware junctions and the increased cost, complexity and rates of stem fractures. Removal of the modular implants, if required, can also be a tough proposition fraught with complications.[19,29–31]

Subsidence is a common complication of distal fixation stems although the exact clinical significance is unknown.[7],21,32 In our series, only four cases had a significant level of early subsidence (7.7% cases). All stems however settled within a year and were clinically asymptomatic. This result correlates with the observations of other studies reporting subsidence of uncemented, distal fixing long stems.[31,33,34] Subsidence of a cementless femoral component early in the postoperative course may allow the stem to attain a more stable position within the femoral canal. Bone ingrowth may still occur and early subsidence is compatible with a durable implant fixation. On the other hand, subsidence which develops months or years after surgery generally implies that the implant is unstable.[1,7,21] The determination of small amounts of subsidence on serial plain radiographs is difficult because of differences in magnification, positioning on serial films and stress-related rounding of the calcar. Roentgen stereo photogrammetric analysis (RSA) allows precise determination of subsidence;

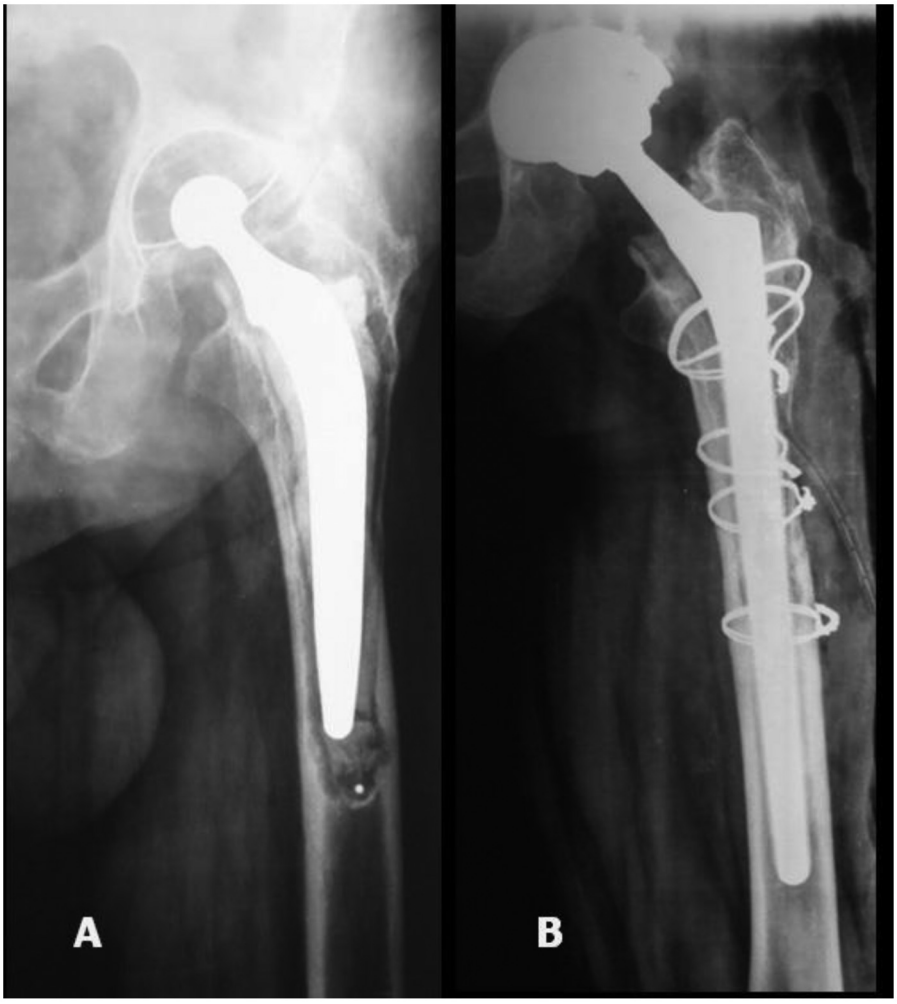

Fig. 7. (A) Aseptic loosening 11 years after primary THA in a 75-year-old male with a type IIIB Paprosky defect (B) Five year postoperative radiograph showing a well-integrated Wagner stem and healed osteotomy.

however, these are expensive and not available for routine use in most centers.

This study has its share of limitations which are the retrospective study design, relatively small sample size and absence of a control cohort. Nevertheless, the results of this study clearly demonstrate that uncemented femoral components provide excellent results in revision THA in patients with aseptic loosening of femoral stem. In summary, the primary implant stability is the key to success in revision of the femoral component in the face of bone loss. This can be best achieved by a non-modular or modular, distally-engaging cementless stem. Both extensively porous-coated and tapered, fluted long stems (Wagner SL stems) have an excellent clinico-radiological mid-term outcome and survival rates.

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Conflict of interest

None.

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Research paper

Potential damage to the femoral neurovasculature during approach to the hip

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ABSTRACT

Introduction: Femoral neurovascular injury is an uncommon, but potentially devastating complication following surgical approaches to the hip. The intraoperative misplacement of the anterior acetabular retractor is the most commonly cited mechanism for this injury yet there is no gold standard for a proper insertion location in the literature We examined the course of the femoral neurovasculature about the hip to identify safest location for retractor insertion and furthermore demographic populations who are at-risk for injury due to a decreased distance between the hip joint and the femoral neurovasculature.
Methods: A total of 100 non-pathologic hip magnetic resonance imaging (MRI) studies from adult patients were included. Patients were chosen at random from our medical center's digital radiographic archive and their demographic data recorded. Mean distances between the anterior acetabular wall and the femoral artery were measured at three axial levels (acetabular dome, superior iliopectineal ridge, and inferior iliopectineal ridge).
Results: Our data showed the femoral neurovascular structures pass closer in proximity to the acetabular wall as they progress distally about the hip. An average direct separation distance of 40.1 mm was seen at the acetabular dome while measurements at the inferior iliopectineal ridge demonstrated an average distance of 20.5 mm. Additionally, statistically significant ($p < 0.05$) decreases in distances between acetabulum and femoral neurovasculature were found in patients that were female, >45 years-old, <1.7 m, and <75 kg.
Discussion: By undertaking a large-scale MRI evaluation of the femoral neurovasculature about the hip, not only were we able to approximate the location of the femoral neurovascular bundle as it passes the hip joint, but also the safest location for insertion of anterior acetabular retractors at the level of the acetabular dome or above in close proximity to the bony cortex. Additional care should be taken placing retractors in patients when demographic risk factors including female gender, age >45 years old, stature <1.7 m, and body mass <75 kg are present.

1. Introduction

An estimated 400,000 + total hip arthroplasties (THA) will be performed yearly throughout the United States by the year 2026.[1] And while THA has repeatedly been shown to be a highly successful procedure,[2,3] it is not completely free from risk. Neural and vascular injuries occur in 0.09%–3.7% and 0.1%–0.2% of primary THAs respectively.[4] Femoral neurovascular injury is an uncommon, but potentially devastating complication of THA. These injuries can cause lower extremity weakness, chronic pain or parenthesis, paralysis, amputation, and in rare cases even death.[4–6] A variety of possible mechanisms have been identified as sources for these injuries including hematoma formation, cement extrusion and nerve lengthening.[4,7] However, the misplacement of anterior acetabular retractor around the acetabulum is the most commonly cited

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source of injury in the literature.[7–10]

Despite this known and established risk, literature has sparse examinations concerning the course of the femoral neurovascular structures about the acetabulum or the proper location for retractor placement. Additionally, most of the research in this area has been performed on cadaveric specimens.[9] In an effort to improve anatomic understanding and surgical technique, the present study sought to define the location of the neurovascular bundle as it relates to the acetabulum in living human subjects without altering tissue tension, tissue fluid content or structure displacement that would all occur from cadaveric dissection studies. Our secondary goal was to investigate the impact of patient demographic factors on the course of the femoral neurovascular bundle in relation to the acetabulum.

2. Methods

After obtaining Institutional Review Board approval, we retrospectively reviewed our medical center's Picture Archiving and Communication Software (PACS) (General Electric Medical Systems, Milwaukee, WI) for all magnetic resonance imaging studies of the hip performed from February 2001 to February 2015. In an attempt to include natural variation of hip anatomy a total of 100 patients were randomly selected for inclusion. Patients were required to be 18-years or older for inclusion into this study. Patients with hip pathologies that altered anatomic relationships, such as a history of tumor, fracture, or any evidence of prior hip surgery were excluded. Patients were de-identified and compiled in a database with demographic information including gender, age, height, weight, and ethnicity.

Utilizing our PACS system, side-by-side mid-coronal and axial MRI images were generated. To localize the femoral bundle we elected to measure the distance from the acetabular ridge to the femoral artery, the nearest portion of the femoral neurovascular bundle.[11] The location of the femoral artery was examined at three cross-sections about the acetabulum: at the level of the acetabular dome, superior iliopectineal ridge, and inferior iliopectineal ridge [Fig. 1]. For each axial level, the distances between the femoral artery and the lateral-most aspect of the anterior acetabular wall were recorded in anteroposterior (AP), mediolateral (ML), and vector (V) directions. In the ML direction, if the femoral artery appeared lateral to the anterior acetabular wall it was defined as a negative distance [Fig. 2].

Demographic information for each patient in the study was gathered from our medical center's electronic medical record (Powerchart, Cerner Corporation, Kansas City, MO). Recorded data included patient gender, ethnicity, age, height, and weight nearest to the time of the MRI scans. In an attempt to identify demographic groups where the femoral neurovasculature courses closer to the acetabulum, we utilized the average age, height and weight, of our patient cohort, and compared the mean distances for patients above and below the mean. Genders differences were also included. Thus the demographic risk factors we examined were male v female gender, age greater than vs. less than 45 years old, stature greater than vs. less than 1.7 m, and body mass greater than vs. less than 75 kg.

Two physician reviewers, an orthopaedic surgeon and a radiologist, evaluated all MRIs. Inter-rater reliability was determined for a random sample of 20 patients between the reviewer and a second author. A kappa value was calculated for this value. Statistical analysis for demographic comparison was performed using Student's independent *t*-test. All statistics were calculated using SPSS software version 22 (IBM corporation, Chicago, IL).

3. Results

The study population included 31 males and 69 females. The mean patient age was 44.7 years old (range 18–83). The mean patient height and weight were 1.69 m (range 1.31–1.98) and 74.7 kg (range 47.8–136.1), respectively. The breakdown in ethnicities was 3 Asian, 14 Hispanic, 16 Caucasian, and 67 African-American patients [Table 1].

After AP, ML, and V measurements were collected at each axial level and mean distances calculated, we observed the location of the femoral neurovascular bundle coursed nearer to the anterior acetabular wall, as it passed inferiorly. Examining our distances at the acetabular dome and moving inferiorly to the superior and inferior iliopectineal ridge, we see the AP distances were 22.1 mm, 14.9 mm, and 17.0 mm; ML distances were 33.2 mm, 7.3 mm, and 0.3 mm; V distances were 40.1 mm, 21.6 mm, and 20.5 mm respectively [Table 2].

Additionally, we were able to identify statistically significant ($p < 0.05$) reductions in a collection of mean AP, ML, and V distances

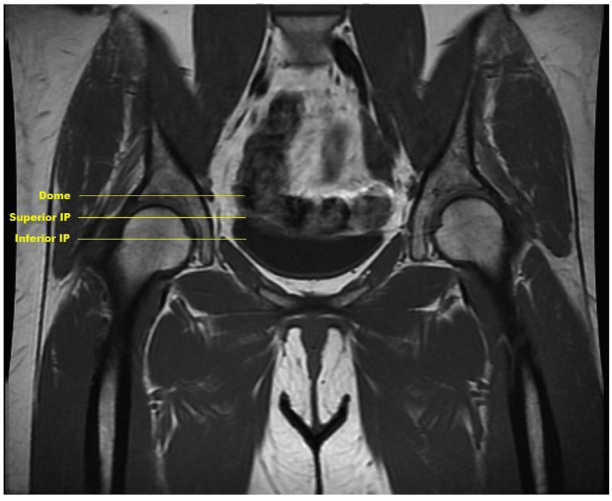

Fig. 1. Coronal MRI of the hip demonstrating the locations of the three axial cuts utilized for the examination of the femoral neurovascular bundle; these levels included the acetabular dome, superior iliopectineal ridge and the inferior iliopectineal ridge.

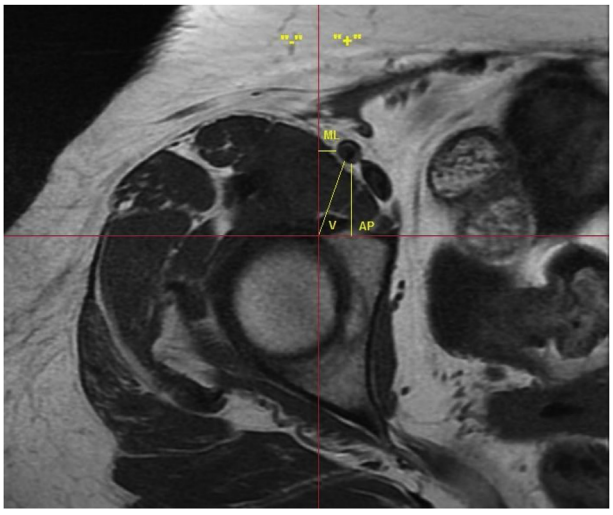

Fig. 2. Axial MRI of the hip with lines drawn to demonstrate methodologies for the measurement of the AP, ML, and V distances from the anterior acetabular wall to the femoral artery.

Table 1
Patient demographic distribution.

Demographic	N (%)	Mean
Gender		
Male	31	–
Female	69	
Ethnicity		
Asian	3	–
Hispanic	14	
Caucasian	16	
African-American	67	
Age (years)		
18-30	25	44.7
31-45	29	
46-60	24	
60+	22	
Height (meters)		
<1.6	12	1.69
1.6	28	
1.7	26	
1.8	26	
>1.8	8	
Weight (kg)		
<50	6	74.7
50-75	43	
75-100	35	
>100	16	

between the femoral neurovasculature and the acetabulum between each of our demographic groups of interest (female gender, age >45 years old, stature <1.7 m, and body mass <75 kg) when compared to their counterpart [Table 3].

The testing for the weighted Kappa coefficient yielded a strong inter-rater reliability (k = .919, 95% CI: 0.81–1.0).

4. Discussion

Although rare, neurovascular injury is a known risk of THAs. This injury can occur with any approach to the hip[7,8,12–17] with the highest incidence of femoral neurovascular injury seen with malpositioning of anterior acetabular retractors.[7–10] This may be appreciated more frequently in surgeons who transition to an unfamiliar approach. Observed in young residents and as many surgeons trained in the posterior or lateral approaches are seen transitioning to the direct anterior approach as it gains popularity.

Between neurologic and vascular injuries in THAs, neurologic impairment occurs more commonly, being reported in 0.09%–3.7% of cases for primary THAs and up to 7.6% for revisions.[4] When postoperative neuropathy does transpire, the peroneal nerve was shown to be the most commonly injured followed by the femoral and sciatic nerves.[13,15,18] One study showed 54.1% of nerve injuries post-THAs affected the peroneal nerve while the femoral and sciatic nerves were affected 24.6% and 21.3% of cases respectively (injuries to the obturator, superior gluteal and lateral femoral cutaneous nerves have been reported but are exceedingly rare).[4,19,20] The primary etiology for injury of the femoral nerve has been shown to be the insertion of an anterior acetabular retractor along the anterior acetabular rim at an incorrect plane or to an incorrect depth.[8–10]

In comparison, vascular damage during THAs occurs less frequently, in only 0.1%–0.2% of cases, but is more emergent in nature.[21,22] The vessels most frequently injured are the external iliac and femoral arteries and while arterial damage was similarly due most frequently to retractor placement, direct laceration, thermal injury from polymerization heat, and tearing due to prosthesis were all documented sources of vessel damage.[9,21]

To our knowledge, this is the first large cohort magnetic resonance imaging study with 100 patients assessing the relationship between the femoral neurovascular bundle and the osseous landmark of the acetabular ridge. Cadaver studies have demonstrated that the closer the neurovascular bundle is in proximity to the acetabulum, the greater the risk of encroachment by surgical instrumentation during hip arthroplasties.[8,9] Our study showed the course of the femoral bundle could dangerously approach the anterior wall of the acetabulum, particularly at the inferior IP ridge where the femoral artery had a mean distance of 20.5 mm from the acetabular ridge. Applying this data, anterior retractor placement should err superiorly and hug the wall of the acetabulum; moving inferiorly puts the femoral neurovasculature at risk.[23]

Table 2
Mean distances from the anterior acetabular wall to the femoral artery.

Location	Anteroposterior Distance (mm)	Mediolateral Distance (mm)	Vector Distance (mm)
Acetabular Dome	22.1 (range 10.7–36.9)	33.2 (range 21.6–48.3)	40.1 (range 27.3–59.0)
Superior Iliopectineal Ridge	14.9 (range 4.7–25.0)	7.3 (range −5.9 - 31.0)	21.6 (range 12.5–43.7)
Inferior Iliopectineal Ridge	17.0 (range 4.3–27.1)	0.3 (range −13.8 - 11.7)	20.5 (range 11.4–31.9)

Table 3
Statistically significant ($p < 0.05$) decreases in the mean AP, ML and/or V distances between the femoral neurovascular bundle and the anterior acetabular wall are shown where present by demographic groupings and axial level of measurement.

Location	Anteroposterior Distance (mm)	Mediolateral Distance (mm)	Vector Distance (mm)
Gender (Female vs. Male)			
Acetabular Dome	–	31.6 vs. 36.9 ($p < 0.001$)	38.0 vs. 44.9 ($p < 0.001$)
Superior Iliopectineal Ridge	14.2 vs. 16.2 ($p < 0.05$)	6.2 vs. 9.8 ($p < 0.01$)	20.1 vs. 25.0 ($p < 0.001$)
Inferior Iliopectineal Ridge	16.2 vs. 18.6 ($P < 0.05$)	–	19.6 vs. 22.6 ($p < 0.001$)
Weight (<75 kg vs. > 75 kg)			
Acetabular Dome	20.5 vs. 23.6 ($p < 0.01$)	31.7 vs. 34.7 ($p < 0.05$)	38.0 vs. 42.2 ($p < 0.001$)
Superior Iliopectineal Ridge	13.3 vs. 16.4 ($p < 0.001$)	–	19.9 vs. 23.3 ($p < 0.001$
Inferior Iliopectineal Ridge	–	–	–
Height (<1.7m vs. > 1.7m)			
Acetabular Dome	–	30.9 vs. 34.8 ($p < 0.001$)	36.9 vs. 42.3 ($p < 0.001$)
Superior Iliopectineal Ridge	–	–	19.6 vs. 23.0 ($p < 0.001$)
Inferior Iliopectineal Ridge	14.3 vs. 19.5 ($p < 0.001$)	–	18.3 vs. 22.7 ($p < 0.001$)
Age (<45yo vs. > 45yo)			
Acetabular Dome	–	–	–
Superior Iliopectineal Ridge	13.3 vs. 16.4 ($p < 0.001$)	–	19.9 vs. 23.3 ($p < 0.001$)
Inferior Iliopectineal Ridge	−1.3 vs. 1.9 ($p < 0.01$)	–	–

Our data also identified at-risk populations for femoral neurovascular damage during THAs. This study confirmed patients of the female gender to be at risk for decreased distances between the femoral artery and the acetabular wall, at each of the three cross-sectional levels. This known risk factor translates clinically as previous studies have cited greater than 7 out of 10 of cases of femoral neurovascular bundle injury during THAs occur in women.[9]

Our research found age >45, body mass <75 kg and shorter stature <1.5 m as three additional risk factors for neurovascular damage during THAs. To explain these trends, we examined the principle anatomic buffers between the femoral neurovascular bundle and the anterior acetabular wall, namely the muscle bodies/tendons of the iliocapsularis, iliopsoas and rectus femoris. It is reasonable to infer that a decrease in the muscle mass of these hip flexors may decrease the distance between the femoral bundle and the anterior wall of the acetabulum and thus places the neurovasculature at risk from injury. Heller and colleagues highlighted the importance of this notion when cautioning the use of anterior acetabular retractors in patients with diminished muscle mass due to their lack of psoas tendon protection.[7] As a direct relationship exists between increasing height and weight, and one's overall muscle mass, and an inverse relationship exists between muscle mass and increasing age. Anterior retractors placed in elderly patients should be placed with care as decreased muscle mass becomes more evident with age after the fourth decade of life.[24,25] Furthermore, using this information, the elevated incidence of femoral neurovascular damage seen in female patients when compared to men can be explained as the female population is traditionally shorter and of lower body mass. We can support this logic as we indeed see that women have been shown to have lower cross-sectional area of their iliacus muscle when compared to men.[11]

While this study was able to successfully calculate mean locations for the femoral neurovasculature along its anatomic course about the hip, and to identify various at-risk demographic groups, we must recognize that this study has limitations. First, the computed distance values are mean representations of a cohort of only 100 patients. Furthermore, while demographic trends were significant in this patient population with regards to femoral neurovascular anatomy, a larger cohort with a population more representative of a general patient body should be reviewed to ensure accuracy.

5. Conclusion

Understanding the correct plane for placement of anterior acetabular retractors is essential to prevent femoral neurovascular bundle damage regardless of surgical approach. Our study suggests that the safest insertion location for anterior retractors is at or above the level of the acetabular dome, in close proximity to the bony cortex. Furthermore, additional care should be taken placing retractors in smaller patients, particularly when demographic risk factors including female gender, age >45 years old, stature <1.7 m, and body mass <75 kg are present.

Conflicts of interest

There are no conflicts of interest related to this work.

Author's disclosures

SMM, RPM and MWM have none to declare.

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Research paper

A pilot study -role of DSA in assessing vascularity of proximal femur in idiopathic femoral head osteonecrosis

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1. Introduction

The increasing amount of idiopathic osteonecrotic femoral heads reporting to our outpatient department daily, challenges the current diagnostic and management protocols. Many contributing conditions are known to contribute towards the osteonecrotic femoral head pathogenesis like trauma, steroid-induced, alcohol abuse, hemoglobinopathy, Gaucher's disease, coagulopathies, Caisson disease, inflammatory or autoimmune diseases. The pathophysiology also includes the interruption of blood supply to the extraosseous area and embolism in subchondral blood vessels leading to venous stasis and increase in femoral head bone marrow pressure[15,16]

Our objective is to evaluate the vascular pattern of proximal femur in patients with idiopathic osteonecrosis femur head by DSA (Digital Subtraction Angiography). If untreated, the patients follow a progressive course toward subchondral fracture and collapse of femoral head and painful arthrosis of the hip joint.[1–4] Patients with a normal DSA of medial circumflex femoral artery (main arterial supply to the head) can be treated with conservative approach while those with a sluggish/hampered flow need to be prognosticated and better treated by more aggressive surgical management. The vascularised bone grafting has been demonstrated to achieve better clinical results than non vascularised bone grafting.[12–14]

2. Materials and methods

We included femoral head osteonecrosis stage IIa/IIb/III Ficet-arlet and ARCO II/III in our study. Five idiopathic osteonecrosis femoral head cases (4 males and 1 female) were included our prospective analytical study, of which four were bilateral and one was unilateral. Patients were between 20 and 55 years of age. Patients with femoral head osteonecrosis secondary to trauma or those presenting after previous surgical intervention were not included. A written informed was taken from all patients and ethical clearance taken. Our aim was to assess arterial, venous and total flow times of the proximal femoral vascular tree. Femoral artery was accessed by Seldinger technique and ascending branch of medial circumflex artery was approached via intra-arterial 24 a 3-F micro angiography catheter. 10 ml of contrast medium was injected with a speed of 4 ml/seconds and pressure of 320 kPa and studies on a Philips DSA machine.

Currently the five patients (9 hipswere evaluated by Digital Subtraction Angiography (DSA) of medial circumflex artery of the affected femoral head under all sterile precautions in our established DSA lab..

All patients had a normal Kidney function test (KFT) before undergoing DSA. Arterial and venous times were studied in affected clinico-radiologically proven osteonecrosis hips and comparison was done with normal time of blood flow for unaffected hipsas per the reference study[7] parameters that served as control. We used the Seldinger technique, using 24 a 3-F micro angiography catheter inserted to the ascending branch of the medial circumflex femoral artery (CFA) via the right femoral

Abbreviations: ONFH, osteonecrosis of femoral head; DSA, digital subtraction angiography; N, Normal.

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Fig. 1. Radiograph of pelvis with bilateral hip joints antero-posterior view showing left femoral head osteonecrosis.

arterial approach. 15 ml of contrast medium was injected with a speed of 4 ml/seconds and pressure of 320 kPa. The time-controlled X-rays were taken and the images were assessed. The display time of feeding arteries to the femoral head and the circulation time of the femoral head, which was defined as the time interval from the display of the ascending branches of the CFA to disappearance of contrast medium from the circumflex femoral vein, were recorded.

3. Results

Two patients showed a definite obstruction in the arterial tree. One showed blockage in external iliac artery branch that was not amenable to re-establishing the flow with intravascular procedures like ballooning. Another showed blockage at the origin of medial circumflex femoral artery that was ballooned at a second sitting followed by immediate pain relief correlating the pain with ischemia. Other three patients showed a definite increase in venous time indicating comparative stasis. Patient 1Fig. 1 and Fig. 2) was a unilateral case with left sided femoral head involvement (Ficet-arlet grade IIb) and normal rightsided femoral head architecture, who had an increased medial femoral circumflex arterial time and venous time on higher side indicating more stasis in one hip. The arterial time was 6.6 s and venous time 9.51 s for the left hip.

Patient 2 showed a partial block in the medial circumflex artery (atherosclerotic) with right hip arterial time only 9.9 s across the blockage site that was relieved at a second stage balloon angiography (Fig. 3). Patient 3 showed an atherosclerotic block higher up at the external iliac artery branch on right side with blockage in the medial circumflex arterial flow and slowing the total flow and venous return and a hamperedflow with multiple blockage along external iliac artery on the left (Fig. 4). The arterial time right side was 12.6 s and total flow time 28.83 s indicating a hampered flow (Fig. 5). Patients 4 and 5 had a difference of 3.23 s and 3.412 s respectively between the two hips venous time with no obvious blockage. The mean arterial time was 9.55 s and mean total time 23.325 s (Table 1) that was more than the normal range (Femoral Head Circulation time → 10–18

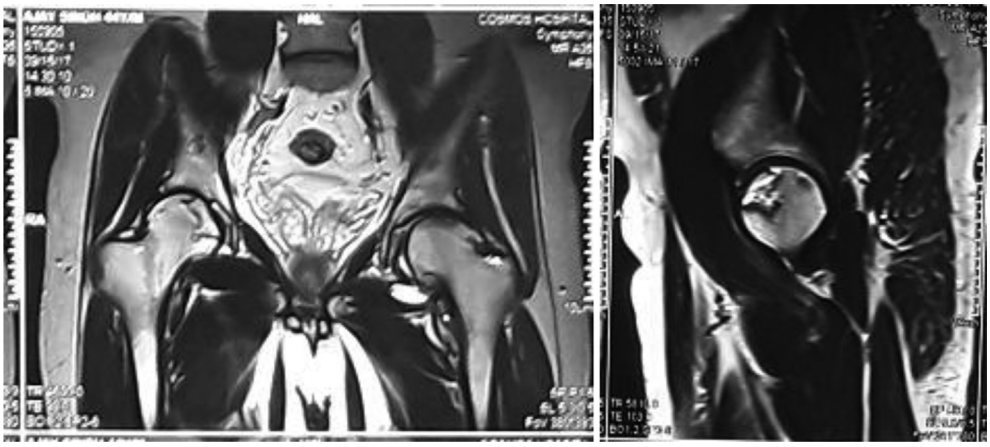

Fig. 2. MR image of the osteonecrotic femoral head showing the area of destroyed subchondral area.

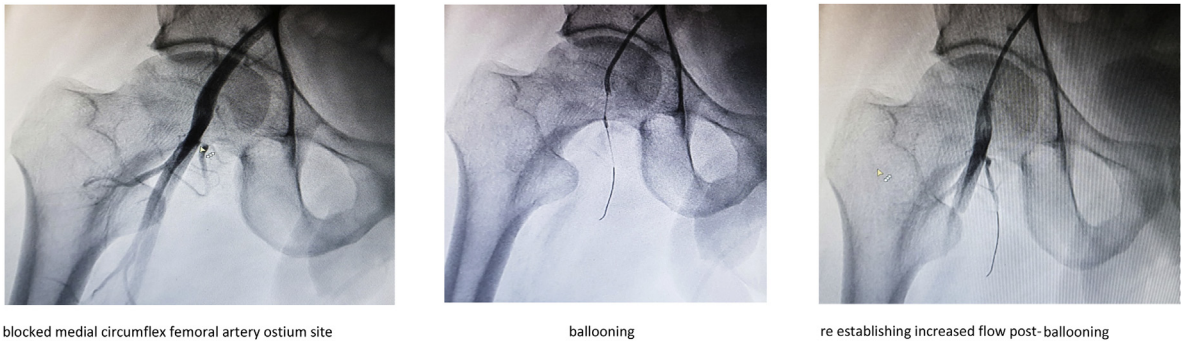

Fig. 3. Showing the blocked medial circumflex femoral artery being ballooned in the right hip.

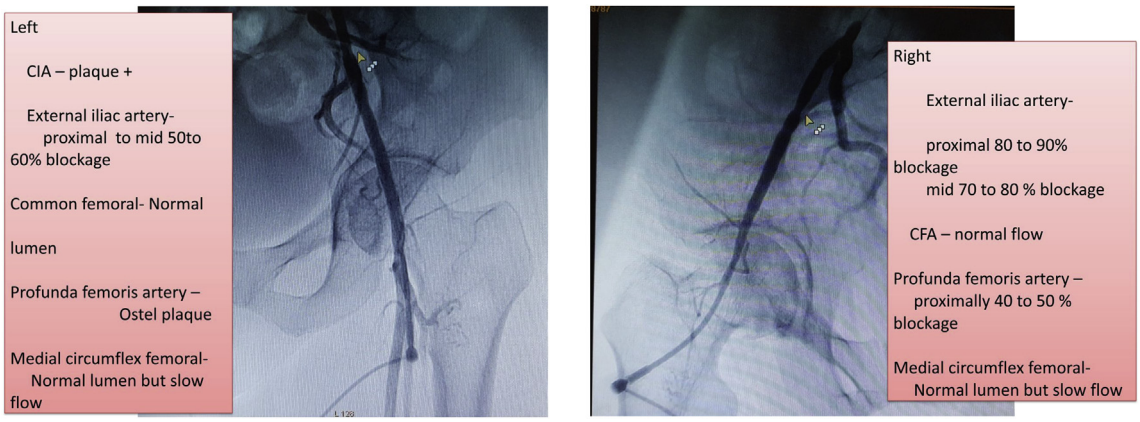

Fig. 4. Showing a hampered medial circumflex arterial flow due to external iliac artery blockage.
*CIA = Common Iliac Artery, CFA = Common Femoral Artery.

seconds & display time of feeding arteries→3–5 seconds) as per another similar study[7] and also when compared to the unaffected hip in our patient included in the study. These were planned accordingly by us as per the flow status. The normal parameters were taken as per experiences of another similar study in bilaterally affected hips.[7] Althogh long term follow up and more quantity of subjects are needed to establish treatment protocols according to evidence based medicine, vascularised fibular graft was planned for the patient with reduced arterial flow in affected hip (age less than 45 years) whereas core decompression and fibular strut graft was done for the patient with arterial block that was opened with angiography and also planned for others with venous stasis as per current evidences and protocols.[6,8]

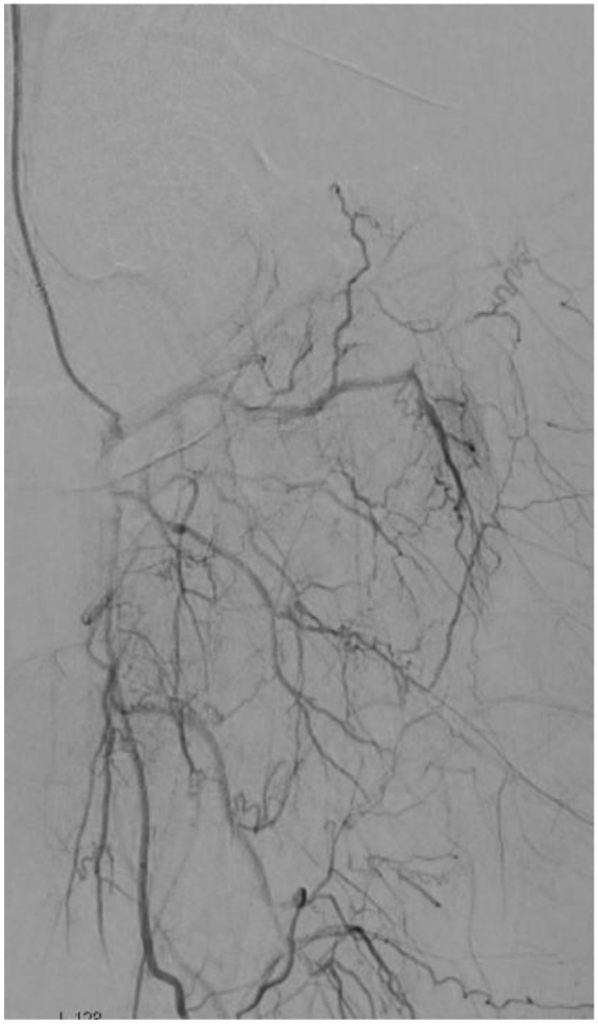

Fig. 5. Showing increased total return time in the vascular tree of left proximal femur indicating the femoral head venous stasis.

4. Discussion

The main arterial supply of femoral head is via medial femoral circumflex artery. The sluggish flow hypothesis has to be documented and evaluated in patients labelled with just idiopathic as the etio-pathogenesis. Normal arterial flow hips with venous stasis can be planned for conservative management of hip via core decompression while hypovascular flow hips planned for vascularised graft or replacement. Two patients showed a definite obstruction in the arterial tree. One showed a blockages in external iliac artery that was not amenable to re-establishing the flow with intravascular procedures like ballooning. Another showed block at the origin of medial circumflex femoral artery that was ballooned at a second sitting followed by immediate pain relief correlating the pain with ischemia. Clearly this study establishes a documentary proof of the hampered blood supply to femoral head undergoing osteonecrosis. Patients with the venous stasis in the early stage ONFH are considered the best candidates for the procedure of core decompression.[5,11] Core decompression offers a release in the symptoms of the pre-collapse stage of ONFH because of a reduction of pressure in the femoral head, and also helps its vascularization.[9,10]

Our analysis attempts to reduce the burden on the idiopathic group for which management and prognosis remains a dilemma without a proven supportive investigation. We also acknowledge our limitations as low sample size, unavailability of long term follow up of the incorporated patients at present and lack of documented population specific normal arterial and venous parameters.

5. Conclusion

DSA is a useful investigative tool for evaluating proximal femoral vascularity in our population's pilot study. Hypovascularity is a

Table 1
Shows the variation in osteonecrosis affected femur heads from normal.

Patient	Ficet arlet staging		Medial circumflex femoral Arterial time (seconds)in DSA**		Proximal Femoral Venous time (seconds)		Total flow time (seconds)	
	Left	Right	Left	Right	Left	Right	Left	Right
1	III	N	6.6	N	9.51	N	16.11	N
2	IIa	III	6.72	9.9	9.26	12.5	15.98	22.4
		Post ballooning		8.35		12.36		
3	III	III	8.4	12.6	12.53	16.23	20.93	28.83
4	III	III	9.85	10.34	12.44	15.67	22.29	26.01
5	III	III	10.4	12.2	12.68	16.1	23.08	28.3
	Mean arterial time			9.55 seconds*		Mean total time in affected hips (9)	22.325* seconds	
	Mean venous time			12.774 seconds*				

*N = normal **DSA = Digital Subtraction Angiography.

cause that needs documentation with DSA and hence reduces the number of hips labelled as to have merely an idiopathic cause. Hence DSA is a promising tool to diagnose occult vascular abnormalities of the proximal femur vascular tree and can be used for devising flow specific treatment protocols in future.

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