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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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Table of Contents

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3. **Having cleared the IELTS exam** before the interviews will be of advantage for final selections .
4. The Clinical posts would start in July 2021 although if candidates were to be interested for August 2022 start, they could still apply.
5. The MCh course is at the Edge Hill University and although most of the payment for the course can be made along the way in installments over the 2 years, there would be an initial Commitment of £8,000 to be made to secure the place before the formalities with Royal colleges and GMC are commenced at this End. The salary scales are detailed with the information sheet as well.
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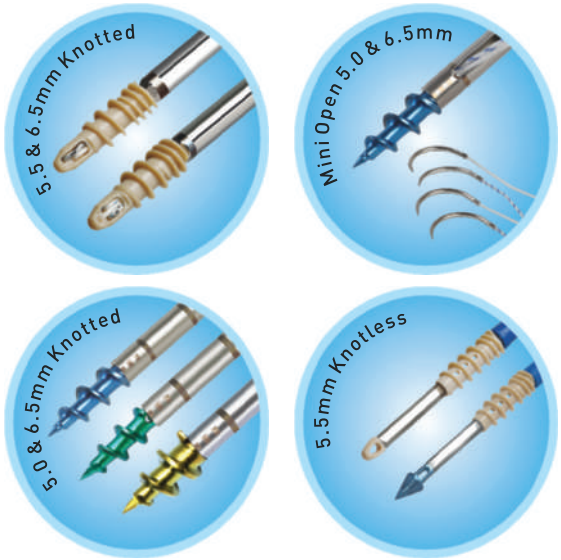

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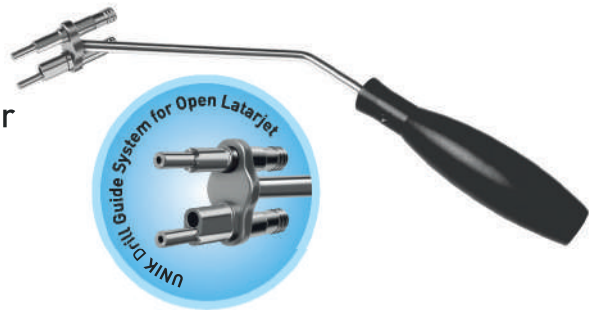

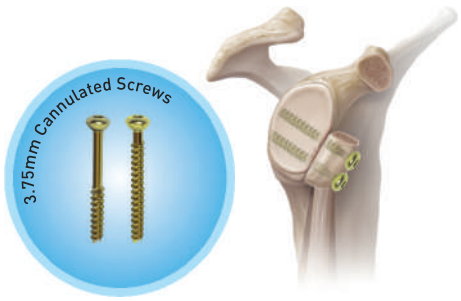

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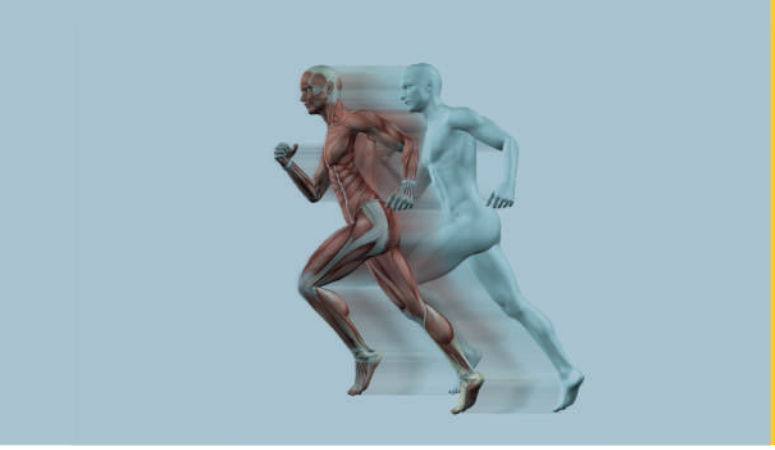

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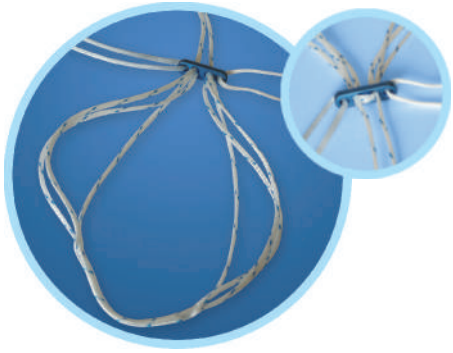

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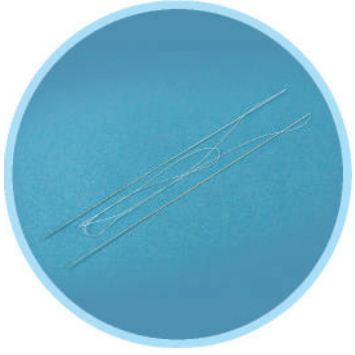

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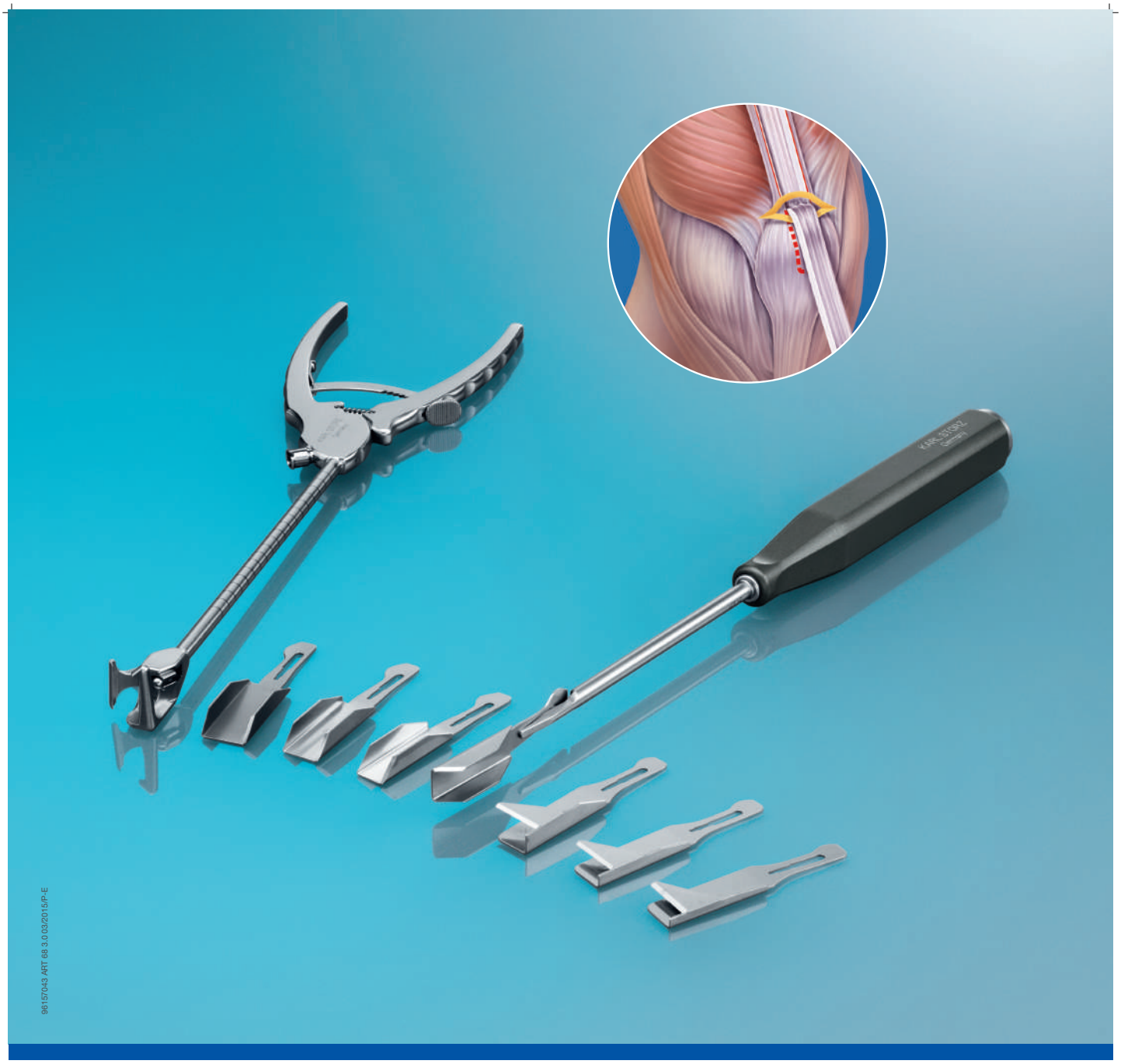

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Editorial

Sports medicine in COVID Era

Keywords:
Sports medicine
Conservative management
Sportspersons

A B S T R A C T

With impact of COVID-19 gradually increasing in many countries of the world with each passing day, there is a need to relook into the conservative management for some common sports related injuries. Awareness of all kinds of sports injuries, their symptoms, and preventive measures including education on rehydration, nutrition, monitoring team members, behavioural skills and techniques will further help in preventing the potential sporting injuries. Further, telemedicine and online portals including eSanjeevani outpatient department services should be encouraged.

With impact of COVID-19 gradually increasing in many countries of the world with each passing day, there is a dearth of health resources available to effectively manage the COVID scenario. With fear of phase-III transmission looming over developing countries like India, and the availability of vaccine still more than 6 months away, elective surgeries still remain no brainers to be pondered upon. But what about the injuries sustained while playing sports? Do they need to be looked upon again and a suitable protocol be made to deal with such problems as various sportspersons all over the world, who were either awaiting the surgeries from pre-COVID times or sustained during the unlocking period are at a great loss citing the highly competitive nature of the sports and fear of losing their place in the team or falling behind in practise sessions.

In this context of uncertainty and future prevalence of the COVID scenario, it is necessary that we should establish uniform treatment protocols, to safely resume the sporting activities and to prevent the injuries in the near future, in observance with the principle of 'maximal caution'. Awareness of all kinds of sports injuries, their symptoms, and preventive measures including education on rehydration, nutrition, monitoring team members, behavioural skills, techniques and treatment is of prime importance. Telemedicine and applications such as eSanjeevani outpatient department services where an individual can assess a specialised doctor should be popularised widely.

Conservative management for some commonly occurring problems should be the treatment of choice in some scenarios including:

Knee injuries (ligament or meniscal injuries): Neuromuscular electric stimulation of quadriceps, quadriceps strengthen exercises, neuromuscular training and focus on maintaining limb symmetry. With this non-operative treatment many athletes can even return to sports without surgery.[1] However, one should avoid return to sports if athletes experiences give away feeling during pivoting and cutting movement.

Shoulder dislocation: Patients with recurrent shoulder dislocation can be treated conservatively with aim of prevention further episodes of dislocation. Pendulum exercises from day 1 after reduction, abduction up to 90° in internal rotation and zero degree of external rotation for 6 weeks. After 6 weeks free active and passive movements, patients can return to sports after 3 weeks.[2]

Back injury: Backache is very common among the athletes reason for backache among the athletes are acute muscle spasm, degenerative disc disease and stress fracture in pars interarticularis. However, rest can improve the symptoms but doesn't address the underlying pathology. It was observed that strengthening of core muscles decreases the pain and decrease the chances of these injuries in future.[3]

Sprains: rest and anti-inflammatory medications. Return to sports should be gradual over few weeks.[4]

Strains: rest, anti-inflammatory medications, adequate warming up exercises during practise, strengthening and conditioning exercises.[4]

Knockouts and Punch Syndrome: forms the rare emergencies and should be managed on urgent basis at a specialised centre.[4]

Tennis Elbow: rest, anti-inflammatory medications, activity modification and physical therapy.[4]

Javelin Throwers Elbow: rest, anti-inflammatory medications, modifying technique which places a repetitive and prolonged strain on the forearm muscles, strengthening and conditioning exercises.[4]

Boxers elbow: rest, anti-inflammatory medications, activity modification, strengthening exercises and working on wrist flexion exercises will help to strengthen tendons.[4]

Runners Knee: rest, ice, compression, elevation, anti-inflammatory medications and physiotherapy.[5]

Jumpers Knee: activity modification, anti-inflammatory medications and physiotherapy.[5]

Shin Splints: Wearing proper footwear and modifying exercise routine, anti-inflammatory medications and physiotherapy.[5]

The aim of this letter is a call for action for all the sports medicine community to recommend a uniform management of sports

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injuries and to treat them in a conservative way. Further, preventing the potential sports injuries by taking maximal caution is the need of the hour for the resumption of sports activities. Moreover, a specific protocol to check pulse rate, oxygen saturation and, in general, systemic sequelae of COVID-19 before resuming sporting activities should be considered.

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Declaration of competing interest

The authors had no conflict of interest related to research and authorship is granted to only those individual who have contributed substantially to the manuscript.

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Akash Singhal*
Government Medical College and Hospital, Chandigarh, India

Anil Kapoor
Department of Orthopaedics, Government Medical College and Hospital, Chandigarh, India
E-mail address: anil88gmch@gmail.com.

Ravi Gupta
Sports Injury Center, Government Medical College Hospital, Chandigarh, India
E-mail address: ravikgupta@hotmail.com.

* Corresponding author.
E-mail address: akash15636@ymail.com (A. Singhal).

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Review article

Current concepts review: The management of acute and recurrent patellar dislocation☆

Mohmmed Elmajee [a], Ahmed Aljawadi [b,*], Lugman Elgayar [c], Alexander Dermanis [d], Hamza duffaydar [d], Anand Pillai [e]

[a] ST4 Spine Department, Royal Orthopaedic Hospital NHS Foundation Trust, Birmingham, B31 2AP, UK
[b] Trauma and Orthopaedics, Wythenshawe Hospital, Manchester, M23 9LT, UK
[c] Speciality Registrar, Trauma and Orthopaedics, Wales Deanery, UK
[d] 4th Year Medical Student, University of Birmingham, Birmingham, B15 2TT, UK
[e] Consultant Trauma and Orthopaedics, Manchester Foundation Trust, Southmoor Rd, Wythenshawe, Manchester, M23 9LT, UK

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ABSTRACT

Patellofemoral joint instability is a common condition with no consensus in literature about the best management strategies. Detailed history, clinical examination and imaging are necessary to establish a platform for further management. Primary patellar instability can be managed with a period of immobilization followed by physiotherapy. However, in cases of recurrent symptomatic patellar instability, surgery is necessitated to address soft tissue and/or bony defects. Many surgical procedures had been described in the literature with a poor clinical consensus about them. Nonetheless, the choice of surgical technique should be guided by a thorough and indiviualised clinical, patho-mechanical and radiological assessment.

1. Introduction

Patellofemoral joint (PFJ) dislocation or instability is a common, yet challenging treatment problem, with 5.8 primary dislocation cases per 100,000 people reported annually.[1,2] Recurrence rates are reported to range from 15 to 80%, with a greater than 50% chance of continued episodes after a second dislocation.[3,4] The incidence and recurrence rate are higher for younger, more active populations, the female gender, a positive family history, bilateral involvement and patients with anatomic abnormalities (patella alta, trochlear dysplasia, increased Q angle, increased tibial Tuberosity-Trochlear Groove (TT-TG) distance, quadriceps dysfunction and hypermobility).[5]

Recurrent PFJ instability or dislocation is a result of bony abnormalities and/or insufficient soft tissue restraint (static and/or dynamic structures). The management of recurrent PFJ dislocation or instability is a difficult task to achieve, with two main options available for patients, either non-operative or operative. Traditionally, the treatment algorithm for acute dislocators involves conservative management with closed reduction, followed by immobilization and then rehabilitation.[6] However, the sequelae of failed conservative management includes recurrent dislocation, persistent knee pain, decreased activity levels, and even patellofemoral arthritis.[6] More than 130 different surgical procedures have been described; however, no single surgery is universally successful.[5] Furthermore, heterogeneous cohorts and the lack of long-term robust clinical outcome studies increase the challenges facing both patients and clinicians. A treatment plan with due consideration for the patient's history, examination, anatomy, biomechanics and radiographic interpretation allows us to conclude effective management options for both acute and chronic cases. The aims of this review are to provide an up to date overview about the assessment and management of patients with PFJ instability.

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* Corresponding author.
E-mail addresses: Mohammedelmajee@doctors.net.uk (M. Elmajee), ahmed.aljawadi@doctors.net.uk (A. Aljawadi), AAD663@student.bham.ac.uk (A. Dermanis), hamzaduffaydar@gmail.com (Hamza duffaydar).

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2. Literature review

2.1. Surgical anatomy

The patella is the largest sesamoid bone and is situated within the tendon of the quadriceps femoris muscle. It provides a central point of attachment for the quadriceps tendon and patellar ligament[7] and improves quadriceps efficiency by increasing the lever arm of the extensor mechanism. Furthermore, the patella increases the compressive forces to which the extensor mechanisms can be subjected to and provides stability to the knee joint.[7,8]

The anatomical alignment of PFJ and soft tissue restraints (static and dynamic structures) operate in a synchronised fashion to ensure the stability of the PFJ. Soft-tissue structures include Vastus Medialis Obliquus (VMO) and the medial patellar ligament system.[9] This system consists of four distinct structures; the Medial Patello-Femoral Ligament (MPFL), the Medial Patella-Meniscal Ligament (MPML), the Medial Patella-Tibial Ligament (MPTL) and the medial superficial retinaculum.[7]

MPFL provides 50–60% of the medial patella-stabilizing force at 0°–30° degrees of knee flexion.[5,7] MPFL is a relatively thin band of retinacular tissue, variable in size, averaging 59 mm in length, 12 mm in width, and 0.44 mm in thickness.[10] The MPFL functions to deliver the patella from full extension into the central trochlea and then relaxes for the remainder of flexion.[11] The role of the MPFL is minimized from flexion of more than 30°, where the trochlea becomes the main patellar stabilizer. This concept of soft tissue and bony alignment integrations has significant implications for clinical assessment and management options.

2.2. Clinical assessment

A detailed history including age, skeletal maturity, sex, overall activity level, the activity and position of the knee at the time of dislocation and previous dislocation events should be carefully documented.[2] All previous treatment modalities should be reviewed with due consideration for the patient's expectations.[2]

Clinicians should use The Beighton hypermobility score to assess the patient for general ligamentous laxity[12] and examine lower limb alignment noting any abnormalities such as increased femoral anteversion, hyper-pronation of the foot, and external tibial torsion (miserable malalignment syndrome).[11] Gait observation should follow to describe any changes - a valgus thrust can generate an external rotation moment about the knee with laterally directed force onto the patella.[11]

On palpation, the clinician should assess for tenderness/palpable defects over the MPFL origin. Patella gliding associated with apprehension, which differs on the contralateral side is characteristic of instability.[2] Ahmad et al. have described the "moving patellar apprehension test", as the most sensitive (100%) and specific (88.4%) test for patella instability.[13] In this examination, the knee is held in full extension and the patella is manipulated laterally by the thumb. Whilst maintaining the lateral position, the knee is then flexed to 90°, before being brought back to full extension again. The second part of the test is exactly the same as the first except the index finger is used to manipulate the patella medially (rather than the thumb being used to move the patellar laterally). For a positive test in part 1, in response to knee movement the patient demonstrates oral apprehension and may activate the quadriceps in expectation of pain. In part 2, the patient expresses no apprehension and allows for free movement of the knee.

2.3. Radiological evaluation

After obtaining a detailed history and clinical assessment imaging modalities such-as X-ray radiography, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), are usually requested.

Standard X-ray radiography can be obtained in different views based on the clinical assessment. Standard anteroposterior bilateral weight-bearing radiographs and posteroanterior weight-bearing radiographs made with the knee at 45° degrees of flexion allow for the assessment of the coronal orientation of the tibiofemoral joint and the presence of arthritic changes.[2] The lateral 30° degrees of knee flexion provides information regarding trochlear anatomy, patellar height/tilt and the presence of arthritic changes.[14] The Merchant view (knee flexed to 45° degrees with the beam positioned 30° degrees distally) is utilised to assess for subluxation, patellar tilt and trochlear dysplasia.[2] The Lyonnaise school classification[15] - similar to Dejour classification of trochlear dysplasia[16] (Table 1).

Computed tomography can be used for persistent, recurrent dislocations once the verdict is reached to undertake surgery. CT images can more accurately characterise the anatomy of the trochlea, estimate the Tibial Tubercle-Trochlear Groove (TT-TG) value, measure patellar tilt and assess the femoral/tibial torsions as part of the Lower limb profile. The TT-TG value is defined as a measurement of the distance from the tibial tuberosity to the deepest aspect of the trochlear groove, reported in mm. This distance essentially measures the relative rotation at PFJ level and expresses the Q angle as a linear measurement. Normal TT-TG distance is 8–10 mm, with TT-TG greater than 20 mm considered pathological and which possibly warrants surgical correction.[17]

MRI uses thinner slices, avoids ionizing radiation and has higher resolution than CT.[2] MRI can show the cartilaginous PFJ surface and therefore has the advantage that it also allows measurements to be taken at cartilage level rather than at the level of the subchondral bone (as in normal X-ray measurements). Furthermore, MRI can assess the integrity of medial structures (MPFL). Sanders et al. have shown that standard MRI scans were found to be 85% sensitive and 70% accurate in spotting any injury to the MPFL when compared to the control (intraoperative findings).[18]

2.4. Management of patellar dislocation

Traditionally, acute patellar dislocation is managed conservatively[4] by closed reduction (knee in extension and applying a medial force), followed by a period of immobilization and then physical rehabilitation. To date, there is no agreement in literature regarding the period of immobilization, instruments utilised and the rehabilitation regime that follows.[19]

Immobilization devices may consist of bracing (J-brace),

Table 1
The lyonnaise school classification of trochlear dysplasia based on lateral X-Ray radiographs.[15]

Type	Description
Type A	The trochlear groove traverses the anterior border of the condyles - "crossing sign".
Type B	Supratrochlear spur can be seen.
Type C	A "double contour" can be observed- a neo-articulation between the patella and a severely dysplastic trochlea.
Type D	Presence of signs of all three types ("crossing sign", supratrochlear spur and "double contour") (on CT imaging this trochlea resembles a camel's hump).

McConnell taping, hinged knee braces or patella lateral stabilization braces.[4] Physical therapy focusses on strengthening the quadriceps muscles, namely vastus medialis obliquus and the gluteal musculature to improve patellar stability, limb positioning and balance.[20] In a recent systematic review[20] and a Cochrane review,[19] studies have shown that there is no statistically significant difference in Patients Reported Outcome Measures (PROM) scores between patients who had different modalities of these conservative therapies.

Surgical intervention in primary patellar dislocation is not routinely indicated and there is insufficient data to recommend it.[19] Furthermore, given the adverse events associated with surgery, it seems prudent for clinicians to adopt non-surgical approaches to the management of primary patellar dislocation until stronger evidence is established.[21] However, additional pathologies, such as the presence of an osteochondral fracture can indicate surgical intervention. These fractures can be fixed using bio-absorbable nails, pins, small screws, or sutures. Other indications may include intra-articular disorders within the knee joint or a major tear of the medial soft tissues stabilizing the patella.[21]

There is an extensive debate and controversy regarding the management of acute MPFL injuries.[19–21] Acute MPFL injury is a common soft tissue injury associated with patellar dislocation and it has been reported to be as high as 97%.[22] In the literature, there is no universal consensus on a proper protocol for patients with acute patellar dislocation.[21] Three available approaches have been described, conservative management, acute primary repair, and MPFL reconstruction. Yet there are some factors that assist clinicians in decision making when they are encountered with a patient with primary patellar dislocation and MPFL injury. These factors include the skeletal maturity of the patient, alignment abnormalities (For example, measuring Q angle & TT-TG distance), the osseous architecture of the patella and the trochlea, chronicity of the injury, association with bony injury and the location of MPFL injury.[22] Camnho et al. have demonstrated that if the MPFL was injured from the patellar or femoral attachment this can be surgically reinserted with satisfying results, which may even lead to a better outcome than nonsurgical treatment. However, mid-substance tears are difficult to repair.[22] In a recent meta-analysis conducted by Hussien et al. the authors have demonstrated high statistical significance ($P < 0.001$) favoring surgical management in reducing the rate of re-dislocation.[23] The surgical group demonstrated a significantly higher Kujala score (70.76) compared with the conservative group (59.82) and a significantly lower re-dislocation rate (6.74% vs 28.5%) ($P < 0.001$)[23]. However, and as mentioned previously, if other skeletal/soft tissue problems of the affected PFJ joint have not been addressed simultaneously with MPFL repair, the outcomes of primary MPFL repair could be inferior to reconstruction. Needless to say, further larger trials are warranted to assess the clinical significance of the 3 approaches mentioned. Schematic approach for primary patellar dislocation is summarised in Fig. 1.

Sillanpaa et al. estimated that 44%–60% of patients with primary patellar dislocation return to preinjury levels of physical activity.[20] The re-dislocation rate typically varies between 20 and 40%, but can be up to 70%.[24,25] Hing et al. have shown that 33% (6%–100%) of patients can experience patellar instability after primary dislocation.[21] Furthermore, 10–55% of patients with primary patellar dislocation will have another surgery after the index procedure.[21]

Patients with chronic patellar dislocation or instability can be managed with two main options, conservative or operative, with the latter being a more favorable treatment modality among many surgeons dealing with chronic PFJ instability.[2] The surgical options available for patients with chronic instability can be categorised into two options: soft tissue procedures and bony procedures.

2.5. Soft tissue procedures for chronic PFJ instability

The PFJ instability is a multifactorial problem.[2] The patellar is stabilised by multiple factors, namely its own intricate architecture, the corresponding architecture of the trochlea, the alignment of the lower limbs and the functional integrity of surrounding supporting soft tissue and muscular structures.[2] Therefore, the management of patellar instability requires due consideration for the complex relationships these structures possess and how one may clinically evaluate them.[2]

Lateral release procedure has shown to be ineffective in treating pure patellar instability unless associated with patellar tilt.[26] Lattermann et al. has conducted a review and reviewed the results from fourteen studies on lateral release for the treatment of PFJ instability.[26] The review showed initial patient satisfaction around 80%, which dropped to 63.5% after four years of follow-up.[26] The authors of this review have attributed the poor results of lateral release to the inability of the procedure to align the patella more medially and the risk of medial patellar instability should the release detach the vastus lateralis obliquus muscle by mistake.[26]

Medial imbrication is another soft tissue procedure that can be performed although it is not as commonly conducted as MPFL reconstruction.[3] Medial imbrication could cite the potential for overload of the patella medially.[25] Medial imbrication is a non-anatomic procedure, yet has the potential to lead to excessive medialisation of the patella and cause abnormal tracking.[25] Ostermeier et al. found that using lateral release and medial imbrication together with the knee flexed at 45° resulted in excessive internal tilt and medialised ($P < 0.01$) patellar movement when compared to the intact condition.[27]

The most commonly performed soft tissue procedure for chronic patellar instability is MPFL reconstruction.[2] As aforementioned the MPFL delivers the patella from full extension into the central trochlea and then relaxes during the remainder of flexion.[2] This is an important concept to grasp when operating on patients with chronic PFJ instability. MPFL reconstruction has shown to have good outcomes in different reviews and studies.[19,23] MPFL is indicated for lateral patellar instability secondary to laxity of the proximal medial restraints, with or without trochlear dysplasia. If a surgeon decided to perform only this procedure the patient has to be skeletally mature, have a normal Q angle, a TT-TG distance less than 20 mm and have low grade trochlear dysplasia.[23]

In the literature, there is no universal agreement about the graft choice, single Vs doubled strands, appropriate flexion angle for fixation, dynamic Vs static reconstruction technique and the fixation tool applied. Adductor magnus, semitendinosus or bone-quadriceps tendon autografts and semitendinosus, tibialis anterior or bone-patellar allografts have all been detailed.[23] The choice depends on surgeon preference, experience and patients' factors. In the literature authors such as Farr and Schepsis have encouraged use a double semitedinosus allograft due to its ability to accurately replicate the broad attachment site of the MPFL to the patellar.[28] However, mal-positioning of the doubled graft can be problematic as the graft can be stronger and stiffer than the native medial patellofemoral ligament, resulting in an increased moment across the medial facet after MPFL reconstruction with a doubled graft.[28] To minimize the stress on the medial facet of the patella and potentially reduce the risk of osteoarthritis, it has been advised that the doubled graft to be positioned 1 cm distal to adductor tubercle to avoid overloading the medial side.[28] The appropriate knee flexion angle at which to tension the graft is another controversial topic in MPFL reconstruction. Some studies have shown that the ligament has isometric properties, therefore tensioning of the graft at an angle less than 40 is advised, however, others have shown that the ligament is not an isometric structure and advocated the

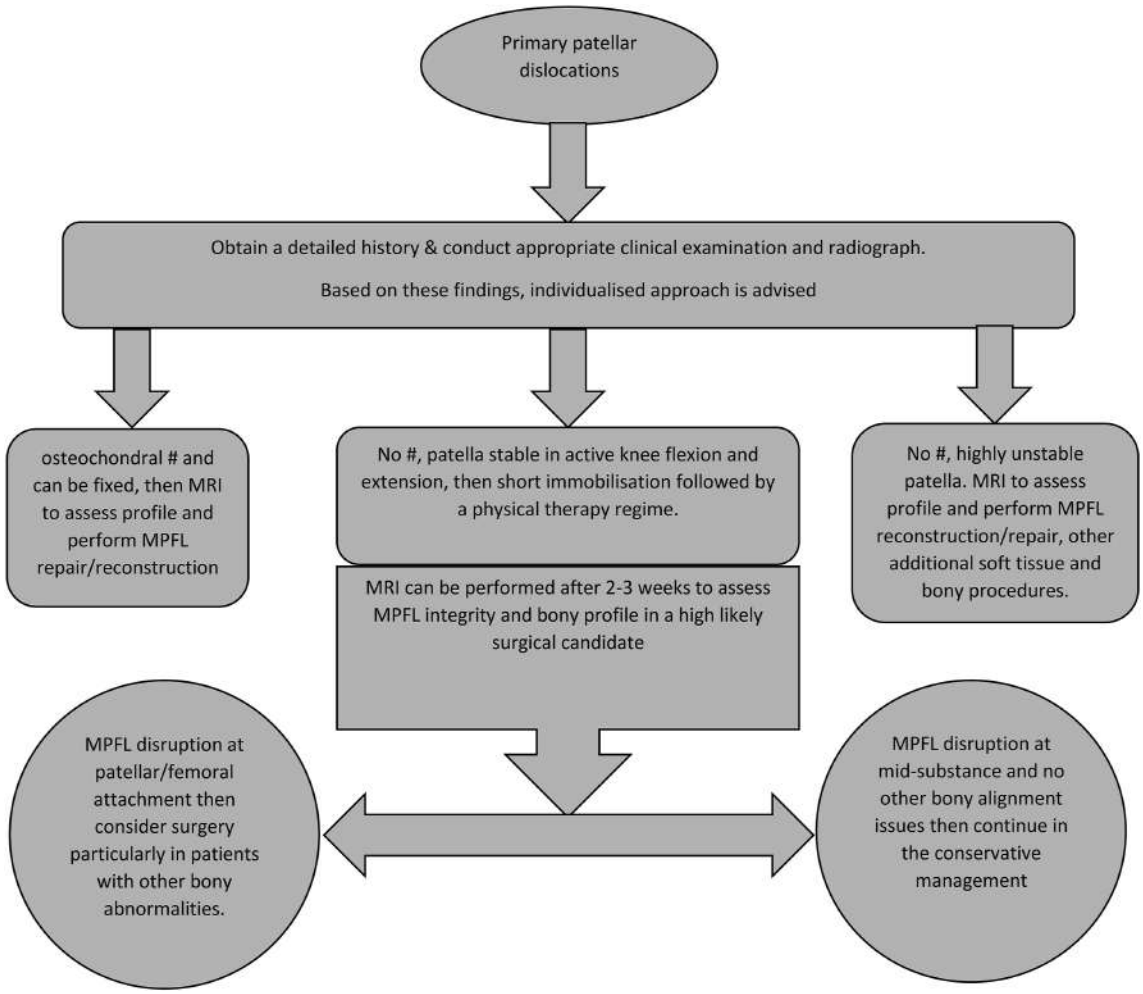

Fig. 1. Schematic approach for primary patellofemoral dislocation.

tension to be done at higher flexion angles.[28] Farr and Schepsis have suggested an "anatomometric" placement of the graft: tensing the graft with the knee in 30° of flexion so that it then subsequently becomes more lax with further flexion and tighter in terminal extension.[28]

Another topic which is not fully understood and investigated is the best way to reconstruct the ligament. Instead of a static reconstruction, it is thought a dynamic reconstruction of the medial patellofemoral ligament may be more favorable.[29] Some studies have shown that dynamic reconstruction demonstrated less patella medialisation and ultimately lesser forces and better clinical scores.[28] The type of fixation (tunnel type) of the medial patellofemoral ligament has also varied among different studies. Mountney et al. reported that the strength of reconstruction by through-tunnel fixation (defined as fixation in the lateral femoral condyle) was essentially identical to the intact medial patellofemoral ligament and distinct from the blind-tunnel fixation (ending in the medial femoral condyle).[10]

There are two important points that should be considered when performing MPFL reconstruction, firstly, ligament isometry/femoral attachment of the MPFL should not be placed too proximal or too distal as if too proximal the knee will be tight in flexion and the patient could develop subsequent pain and possibly osteoarthritis, and if too distal it will be tight in extension, which could lead to abnormal patella movement.[10] Secondly, it is important to understand that MPFL acts to keep the patella aligned and guides it to the groove rather than pulling the patella medially. Finally, there are some specific complications that need to be discussed with the patient before MPFL reconstruction, namely increased risk for patella fracture, chondromalacia patellae, and Osteoarthritis.

2.6. Bony procedures for chronic PFJ instability

Bony procedures are usually performed distally in contrast to the soft tissue procedures which are usually proximal. Bony realignment procedures classically rectify the pathological anatomic relationship between the femur and the patellar through moving the tibial tubercle. Therefore, in the presence of anatomic abnormalities, such as measurements indicating an increased TT-TG distance or Q-angle, bony procedures may be more direct and effective procedures than just soft tissue procedures alone.[2]

These bony procedures target different parts of the bony commonly around the tibial tuberosity but can involve PFJ itself or the trochlea, femur or tibia. All of these procedures have a common goal which is restoring the Q angle within a normal range or improve the TT-TG distance.

Tibial tuberosity can be medialised in Elmslie-Trillat procedure, medialised anteriorly as seen in Fulkerson osteotomy or distalised in patella alta procedure.[30] Nakagawa et al. studied the Elmslie-Trillat procedure in forty-five knees, followed them for 45 months and recommended performing the Elmslie-Trillat procedure early before any degenerative changes are present in the PFJ.[31]

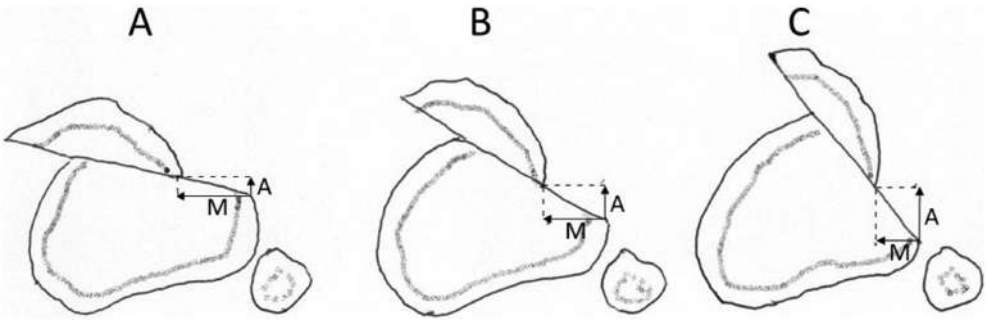

Fig. 2. Fulkerson anteromedial tibial tuberosity transfer.

The authors mentioned that the included patients have shown good outcomes initially, but less favorable outcomes on the longer term (chondromalacia patella & osteoarthritis). Finally, they concluded that any medial, diffuse or proximal lesions on the patellar and any central lesions on the trochlear were probable contraindications to having the operation. Changing in the load distribution across the PFJ after Elmslie-Trillat procedure is the most likely cause for the long-term deterioration in the outcomes of patients with PFJ instability.[31] In their study Carney et al. conducted a 26-year follow-up for patients with patellar misalignment and instability managed by the Roux-Elmslie-Trillat procedure, a procedure typically involving lateral retinacular release, medial capsular reefing and a medialising tibial tubercle osteotomy.[32] The rate of recurrent instability was reported at 7%, with the majority of the 14 patients studied (54%), reporting their knee condition as good to excellent through use of the cox grading system.[32] Elmslie-Trillat procedure has also been combined with different forms of soft tissue procedures such as electro-thermal shrinking of the medial retinaculum and an arthroscopic lateral release in different case series studies.[33,34] Although these case series have shown favorable outcomes initially, these outcomes were not demonstrated in the longer term and have not been replicated in other types of cohorts like sport professionals.

Fulkerson Anteromedial Tibial Tuberosity Transfer (Fig. 2) is the most commonly performed bony procedure for PFJ instability and patellar mal-tracking.[35] This operation is indicated in patients with an increased Q angle or TT-TG distance & Patella alta[2] and should be avoided in patients with medial, proximal or diffuse patellar lesions, medial/central trochlear lesions, an immature skeleton and incompetent MPFL unless a concomitant soft tissue reconstruction will be performed.[36] Palmer et al. reported satisfactory results after antero-medialisation for the treatment of both instability and painful patellar mal-tracking.[37] Eighty-four patients were followed up for a mean of 5.6 years with outcomes reported to be good to excellent in 80% of patients with dislocation and 71% of patients with pain from mal-tracking. Another recent case series study performed by Belmont et al. has shown good outcomes at short to mid-term follow-up (average 2 years); 80% of the included patients (military patients) who underwent Fulkerson osteotomy for PFJ instability returned to military duty with significant improvements in pain scores and a moderate postoperative instability and perioperative complication rate (10% across the whole cohort).[38] Furthermore, in a systematic review conducted by Payne et al. Fulkerson has shown good outcomes.[39]

Fulkerson osteotomy could result in complications, including osteotomy site nonunion, fracture (proximal tibia or tibial tubercle), infection, wound complications, neurovascular complications, deep vein thrombosis (DVT), and pulmonary embolism (PE) and the need for subsequent hardware removal.[39] To minimize these complications some authors suggested preventive measures, including avoiding step cuts, using at least a 5 cm in length and 0.75 cm in thickness osteotomy avoiding tuberosity fractures and protective weight-bearing over 6–8 weeks in a hinged knee brace, with progression to full weight-bearing once the site is fully healed.[39]

Trochleoplasty (Fig. 3) is another bony procedure that involves a deepening trochleoplasty following different techniques.[2] According to Dejour et al. 85% of individuals with recurrent PFJ instability have a variant form of trochlear dysplasia.[40] Trochleoplasty is indicated in normal or nearly normal trochlear articular cartilage, No rotational malalignment, aberrant patellar tracking identified by a J sign clinically, TT-TG distance >10 mm and abnormal trochlear morphology (identified on X-ray/CT/MRI).[41] Post-procedure

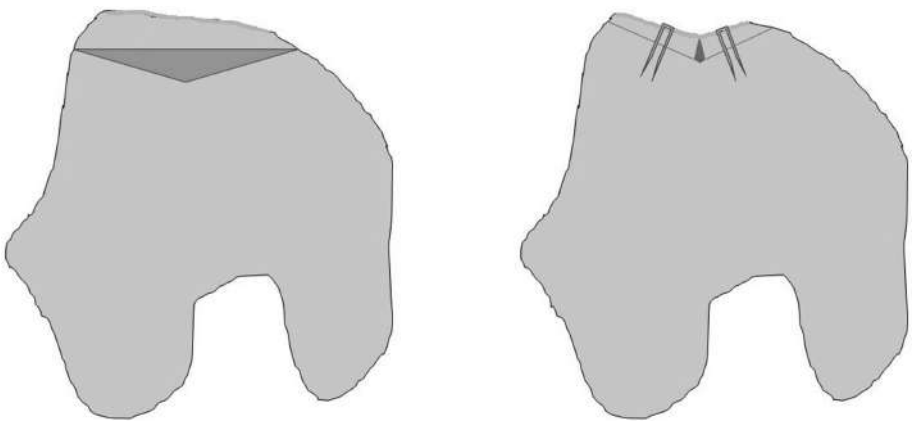

Fig. 3. Sulcus deepening trochleoplasty.

satisfaction rates range from 67% to 95.7%.[2,41] Iatrogenic cartilage damage, patellar incongruence, overcorrection, arthro-fibrosis, and advanced arthrosis are some of the reported complications following this procedure.[41]

Other bony procedures include femoral & tibial osteotomies,[42] which are indicated in failed soft tissue procedures or concomitantly with them in patients with excessive femoral anteversion >20 or external tibial rotation >30[42]. The osteotomy sites can be either proximal such-as inter-trochanteric region or supra-condylar regions or in the tibia as HTO or at the diaphyseal level.

3. Conclusion

Recurrent PFJ instability or dislocation is a result of anatomical (bony) abnormalities and/or insufficient soft tissue restraint. The management of recurrent PFJ dislocation or instability is a difficult task. Traditionally, the treatment algorithm for acute dislocators involving initial conservative management with closed reduction followed by brief immobilization and then rehabilitation. However, surgery (soft tissue or bony procedures or both) is sometimes required in symptomatic individuals with recurrent instability. An individualised treatment algorithm, addressing the history, physical examination, biomechanics, anatomy and radiographic interpretation is highly recommended by the authors.

Disclaimer

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Review article

Outcomes of total knee arthroplasty in synovial osteochondromatosis: A comprehensive review

Suresh Babu*, Abhishek Vaish, Raju Vaishya

Department of Orthopaedics and Joint Replacement Surgery, Indrparastha Apollo Hospitals, Sarita Vihar, New Delhi, 110076, India

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ABSTRACT

Introduction: Primary Synovial Osteochondromatosis (PSOC) is a synovial proliferative disorder. Its incidence is 1 in 100,000 with equal gender distribution. Total Knee Arthroplasty (TKA) is being routinely performed for end stage arthritis of the knee. The PSOC with osteoarthritis presents as a subset with early onset OA with a legacy of repeat surgeries, recurrences and decreased range of motion and rarely malignant transformation. The outcomes following TKA in this subset of patients is plagued by less than optimum outcomes, decreased post-operative range of motion and risk of disease recurrence leading to revision surgeries.

Material and methods: A comprehensive literature search of the online databases of PubMed, SCOPUS, Google Scholar and Research Gate was carried out. 26 articles were shortlisted and after deleting the repeats the search narrowed down to 21 articles that were relevant to our review, of which 19 were freely accessible and full text articles.

Results: We found that TKA with concurrent complete synovectomy is an excellent option to eradicate the pathology in PSOC and have good results in short and medium term. However, recurrence of the disease, joint stiffness and rarely malignant transformation is a problem with these cases.

Conclusion: The PSOC is a proliferative synovial disorder of mostly middle-aged people and may present as early onset Osteoarthritis in the younger population. It is associated with a high incidence of recurrence. Although not an uncommon finding at the time of doing TKA, there is paucity of knowledge in the existing literature on the outcomes of arthroplasty in such cases of PSOC with associated OA and more studies are needed to study the long term outcome patterns of TKA in this disease.

1. Introduction

Total knee arthroplasty (TKA) has now become a routinely offered surgery for the end-stage arthritis. Though the results and survival are excellent for primary osteoarthritis (OA), the results are less than optimum when indicated for other etiologies like Rheumatoid arthritis, post-traumatic arthritis, tumor surgeries and other synovial proliferative disorders like synovial chondromatosis.[1,2] The treatment of synovial osteochondromatosis (SOC) in early stages may be arthroscopic synovectomy and removal of loose bodies and in severe stages of Osteoarthritis (OA), TKA can be curative. As a cure for SOC, TKA is effective, but the long term results of TKA are reported less than optimal.[2]

Primary Synovial Osteochondromatosis (PSOC) is a rare proliferative disorder of the synovium arising as a result of sub synovial and synovial hyperplasia with no chromosomal mutations identified.[3] It has an incidence of 1 in 100,000 and mostly occurs between 3rd to 5th decades, with no gender predisposition. It is predominantly monoarticular and affects the knee more than 50% of the time, with hip, shoulder, elbows and the small joints of the hand being the other sites.[3] It can rarely undergo malignant transformation to secondary chondrosarcoma and is notorious for recurrences. The nodules of PSOC cause secondary cartilage damage and arthritis due to mechanical reasons and hence this type of secondary OA may present at an early age.[4] Another form is the secondary SOC, which occurs in response to trauma, OA, and in any situation where cartilage and bone are separated, to be free lying within the joint cavity and act as a nidus for calcification.[5]

We present a comprehensive review of the existing literature on the results of TKA as a treatment for PSOC with OA and study the

* Corresponding author.
E-mail address: yssureshbabu@gmail.com (S. Babu).

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outcomes concerning the relief of pain, range of motion, cure from disease, post-surgery range of motion and survival of the implants. This study was aimed to understand if:

1) Joints affected with primary synovial chondromatosis develop OA early?
2) Does a diagnosis of PSOC portend less than satisfactory outcomes following TKA?
3) Is TKA curative for patients with active PSOC, with arthritis?
4) What are the complications that affect TKA in a knee with PSOC?
5) Understanding the difference between primary and secondary SOC.

2. Materials and methods

A comprehensive literature search of the online databases of PubMed, SCOPUS, Google Scholar and Research Gate was carried out for MeSH words and their combinationsPSOC and TKR/TKA, SOC, TKA in PSOC, SOC and Arthroplasty (Fig. 1).26 articles were shortlisted and after deleting the repeats the search narrowed down to 21 articles that were relevant to our review, of which 19 were freely accessible and full text articles (Fig. 2).

Amongst the final 19 articles, two articles had a reasonable number of cohorts covering a substantial time interval and both came from the Mayo Clinic, USA. There were three articles as case reports, three articles detailing the management of PSOC and the rest were pictorial articles and basic science reviews.

3. Results (Table 1)

3.1. Pathology of PSOC

Coolican and Dandy,[6] reviewed their 18 cases and have elaborated on the patterns based on the macroscopic appearance of the synovium on arthroscopy. They have concurred with the views of Milgram et al.,[3] on the pathological stages in PSOC.

O'Connel[7] confirmed that SOC is a form of a synovial proliferative disorder and that primary chondrosarcomas are extremely rare neoplasms of the synovium. SOC has a surprisingly high rate of malignant transformation of 5%, is large and consistently presents as large soft-tissue masses.

3.2. Diagnosis and treatment

Mackenzie et al.[8] reported a case of PSOC and found clinical management dilemma when confronted with both SOC and OA.

Hallam et al.,[9] have observed that high clinical suspicion and histologic confirmation are essential to the diagnosis of SC.

Bassir et al.,[10] opined that surgical excision is the preferred treatment and that Radiotherapy and Chemotherapy have no role in the treatment of PSOC.

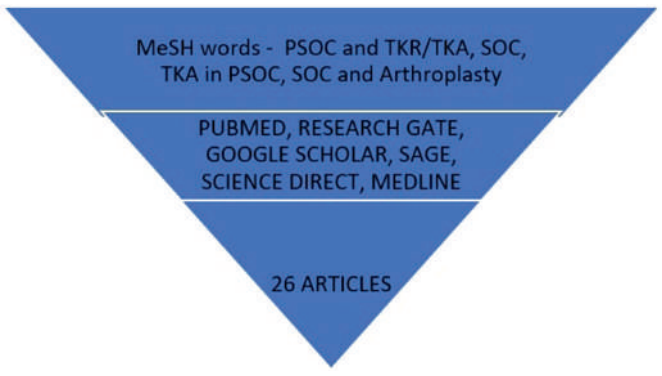

Fig. 1. Search pyramid.

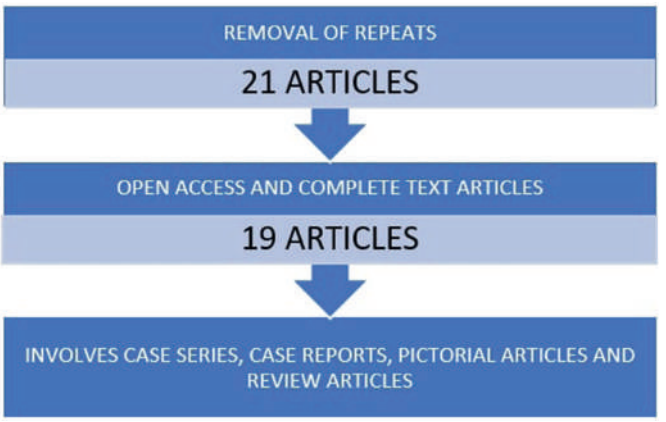

Fig. 2. Selection of papers for the Review.

3.3. Early OA and TKA in PSOC

Ryan et al.[11] stated that the main complication of long-standing PSOC is OA.

Deinum et al.[12] have also discussed that loose bodies due to their mechanical effect and disturbance of nutrition cause secondary OA.

Ackerman et al.,[13] found that delay in diagnosis or failure of treatment may lead to secondary OA.

Ackerman et al.,[13] reported that the patients who undergo total joint arthroplasty, have improved functional scores and range of motion, after the surgery.

Hallam et al.[9] had performed a radical synovectomy with TKA as a cure for SOC and have also noted increasing good results with arthroscopic synovectomy in comparison to open synovectomy.

Meagan et al.,[14] have shown that TKA consistently increases pain and functional outcomes, decreases recurrences and offers excellent disease-free survival, though it has increased complications and revision rates.

Harvey et al.[5] found a decreased pre-op ROM as is the case with SOC as a factor for deceased gain in ROM following TKA. .

Houdeket al.,[16] in a follow-up of seven years of patients who underwent TKA for SC found the majority to have active disease at the time of arthroplasty and a significant incidence (20%) of revision due to tumor recurrences.

3.4. Complications of PSOC

Mckenzie et al.[5] reported a recurrence rate of 3%–23% in PSOC and suggested as due to incomplete surgical resection.

O'Connel (10) have shown that SOC has a surprisingly high rate of malignant transformation of 5%, is large and consistently presents as large soft-tissue masses.

Deinum et al.,[14] presented the extensiveness of the disease in SOC and the pitfalls on missing secondary osteochondrosarcoma.

4. Discussion

The TKA is an excellent option for the treatment of end-stage arthritis across varied etiologies. Less than optimum results are seen in the cohort of patients who develop end-stage arthritis other than due to primary osteoarthritis.[12–14]

Table 1
Research of literature.

SL.NO	AUTHORS	JOURNAL	TYPE OF STUDY	Lvl	FINDINGS
1	Duncan Ackerman, MD, Patrick Lett, MD et al., 2008	The Journal of Arthroplasty	Retrospective	4	• The mean interval from the time of diagnosis to TKA was 7 years • Mean age of 62 years and mean weight of 85 kg at the time of surgery • All patients had a history of previous surgical procedures on the affected knee (mean, 3.5; range, 2–6). • Follow-up after TKA averaged 4.9 years • Preoperative knee society pain scores improved from a mean of 11 to a mean of 82 • Preoperative knee society functional scores improved from a mean of 54 to a mean of 88
2	Joukje Deinum, MD, Peter A. Nolte, MD, 2016	Clinics in Orthopedic Surgery	Case Report	5	• During a 2.5-year follow-up, there were no complications • Flexion was 130° and extension was not impaired. Postoperative X-rays • In case of primary or secondary osteoarthritis, total knee arthroplasty and removal of all corpora libra are indicated.
4	Matthew T. Houdek, MD, Cody C. Wyles, MD et al., 2017	The Journal of Arthroplasty	Retrospective	4	• Local recurrence occurred in 25% (5 patients) at a mean of 1 year after surgery Following TKA, 45% (9 patients) sustained at least 1 complication after TKA • Four of the 8 patients also sustained a postoperative hematoma • The most common additional procedure was manipulation under anesthesia • The mean Knee Society clinical and functional scores significantly improved • Knee moDon improved • Adjuvant radiotherapy has been used in recurrent cases of synovial chondromatosis; however, its use has been limited and still unknown • TKA is indicated for pain relief and functional improvement when severe articular cartilage damage results from disease process and loose bodies • The authors noted malignant changes were most common in older women, those with an early recurrence, soft-tissue extension and cortical destruction
5	Meagan E. Tibbo, MD, Cody C. Wyles, MD et al., 2018	The Journal of Arthroplasty	Retrospective	4	• Survivorship free from symptomatic disease recurrence was 89% at 5, 10, and 15 years 3 patients experienced recurrence • The overall 5-year, 10-year, and 15-year survivorship free from any revision was 96%, 82%, and 64%, respectively • This study demonstrated that arthroplasty for SC consistently improves clinical outcomes with a low rate of local recurrence at long-term follow-up. • SC is a disease of cartilaginous synovial metaplasia that can lead to significant pain and joint destruction
6	Glen McKenzie Nigel Raby David Ritchie, 2008	Eur Radiol	Pictorial Review	5	• “Apple-core” appearance of the affected bone Radiography, MRI, USG, Arthrography, CT • “Atypical” PSOC, two types - Giant synovial osteochondromatosis, Extraarticular PSOC
7	Rida-Allah Bassir,&, Farid Ismael et al., 2014	Pan African Medical Journal.	Case Report	5	• By Milgram's classification - plain film radiographs are only helpful in the third phase of the disease, once calcification has occurred • Radiotherapy and chemotherapy have no effect on synovial chondromatosis, surgical excision is the preferred treatment
8	M. R. Coolican, D. J. Dandy. 1989	British Editorial Society of Bone and Joint Surgery	Case Series	4	• Three patterns of macroscopic appearances were noted • Morphological classification of primary synovial chondromatosis • Three distinct arthroscopic appearances were noted • Recurences by Milgram, Jeffereys, and Christensen and Poulsen
9	Peter Hallam, Neil Ashwooda et al., 2001	The Knee	Case Report	5	• Diagnosis is often suspected clinically and radiologically and confirmed by histology • Radical open synovectomy and cemented condylar total knee replacement were performed • Histology of the retrieved tissue demonstrated evidence of low-grade chondrosarcoma. • In the knee, arthroscopic synovectomy has begun to replace open synovectomy
10	A. HARVEY, K. BARRY et al., 1993	J Bone Joint Surg [Br]	Case Series	4	• For increasing preoperative flexion deformity there is a lessening improvement in flexion deformity after surgery,
11	John X. O'Connell, MB, FRCPC. 2000	Am J Clin Pathol	Expert Opinion	5	• Synovial Proliferative Disorders* Bona fide chondrosarcomas of synovium are extremely rare neoplasms • Surprisingly high rate of malignant transformation of 5%. • Chondrosarcomas are frequently larger than synovial chondromatosis and more consistently present as soft tissue masses • Detritic synovitis is the descriptive term applied to the constellation of changes seen in the synovium and soft tissue that surrounds loose large joint arthroplasties
12	RS Ryan, AC Harris, JX O'Connell et al., 2005	Australasian Radiology	Evidence based Opinion	5	• Main complication of SOC is secondary degenerative osteoarthritis, particularly in long-standing disease • Secondary degenerative changes such as joint space narrowing, periarticular sclerosis and osteophyte formation are found in the late stages of the disease • A challenging management dilemma arises when confronted with both synovial chondromatosis and osteoarthritis.
13	Hugh Mackenzie, Vivek Gulati et al., 2010	Journal of Medical Case	Reports Case Report	5	• Three surgical options were considered, namely high tibial osteotomy (HTO), excision of the synovial and bursal chondromatosis alone, or excision combined with TKA total knee replacement

The pre-operative legacy of severe OA, previous surgeries, decreased pre-operative range of motion, inability to abolish the joint pathology after surgery (e.g., Rheumatoid Arthritis, recurrence of tumor, infection, synovial proliferative disorders, and osteoporosis) contribute to a poorer outcome in a section of patients who undergo TKA.[5]

PSOC was first described by Leannac in 1833. Only was in 1958, it was recognized as a separate pathological entity by Jaffe.[5,10] The incidence of PSOC is around 1:100,000 with no gender predisposition, being most symptomatic between the 3rd to 5th decades of life. It is mostly mono-articular and intra-articular, though extra-articular and giant type variants have been described. The knee joint is the most commonly involved.[5,11]

PSOC consists of numerous almost uniform nodules ranging from 2 mm to more than 1 cm and is usually more than five in number, distributed throughout the joint (Fig. 3). Secondary SOC is seen as secondary to osteoarthritis or a mechanical disorder. A useful differentiating feature is the fewer number, larger size (>1.5 cms) and irregular (bosselated) shape of the calcified lesions.[6] The nodules in Secondary SOC are initiated as a fibro-cartilaginous response to loose cartilage or bone fragment which come to lie freely in the joint cavity and are incorporated into the folds of the synovium with a long pedicle. It later gets calcified and hardened.

The PSOC is common in younger population (3rd to 5th decade) and the results of Arthroplasty reported in cases with the PSOC and OA also have younger age profiles.[11] This correlates well with our observation and indicates that these subset of patients develop early OA, as compared to the patients with primary OA. The OA is the main complication in knees with PSOC and the risk increases with unrecognized or inadequately treated PSOC, due to its mechanical damage to the cartilage and nutritional deprivation of the cartilage.[6,7]

The treatment of PSOC is surgical, in the form of surgical excision of the diseased synovium either arthroscopically or by open arthrotomy. If it is associated with severe secondary OA, arthroplasty along with the excision of diseased synovium is recommended. Bassir et al.,[10] have opined that surgical excision is the preferred treatment and that Radiotherapy and Chemotherapy have no role in the treatment of SOC. Hallam et al.[9] had performed a radical synovectomy with TKA as a cure for SOC and have noted good results with arthroscopic synovectomy in comparison to open synovectomy.

Although not an uncommon finding at the time of doing TKA, the results of arthroplasty in such cases of PSOC with associated OA have not been presented adequately in the literature. And there is a huge gap in the prevalence of this disease and the reported outcomes after TKA in this subset of patients.

Harvey et al.[15] have elucidated on the factors affecting the post-op range of motion in TKA, and have enumerated decreased pre-op ROM as is the case with SOC as a factor for deceased gain in ROM following TKA. As a corollary, literature by Ryan et al.[11] shows that manipulation under anesthesia was the most commonly performed secondary procedure in patients of PSOC following TKA. PSOC have shown recurrences following TKA and that TKA per se without complete synovectomy is not curative. Like-wise risk of revision surgeries is also increased.

Deinum et al.[12] have shown that TKA consistently increases outcomes, decreases recurrence with excellent disease-free survival, though it has increased complications and revision rates. Ackerman et al.,[13] found that patients who undergo total joint arthroplasty, have improved functional scores and range of motion after TJA. Recurrence of the disease and early failure of arthroplasty are the major concerns. Houdek et al.,[16] in a follow-up study of seven years in patients who underwent TKA for SC, found the majority to have active disease at the time of Arthroplasty and a significant (20%) incidence of revision due to disease recurrences.

A differentiation needs to be made between the primary and secondary SOC. The nodules of PSOC cause secondary cartilage damage and arthritis due to mechanical and nutritional reasons and hence this type of secondary OA may present at an early age.[15] Whereas, secondary SOC occurs in response to trauma, OA and in any situation where cartilage and bone are separated to be free lying within the joint cavity, and act as a nidus. The most common clinical situation with this pathology is osteoarthritis and therefore secondary osteochondromatosis is more commonly seen in OA of the knee.[12] The PSOC must also be differentiated from other inflammatory diseases of the joints like rheumatoid arthritis, crystal arthropathy, infective causes like tuberculosis, synovial proliferative disorders and neoplasms [17].

There is a possibility of malignant transformation in some cases, it is also a matter of conjecture as to whether such malignant forms were de novo malignant. John X O'Connel,[7] reported that the SOC has a surprisingly high rate of malignant transformation of 5%, and the malignant form consistently presents as a large soft-tissue mass. Hallam et al.[8] observed that high clinical suspicion and histologic confirmation are essential to the diagnosis of synovial

Fig. 3. Plain radiographs of a case of synovial chondromatosis, showing multiple loose bodies and osteoarthritis of the knee (Antero-Posterior and Lateral views).

chondrosarcoma in cases of PSOC. Deinum et al.,[12] in their case report on TKA in severe synovial chondromatosis in an OA knee, have discussed the extensiveness of the disease in SOC and the pitfalls on missing secondary osteochondrosarcoma.

The PSOC should not be considered an entirely benign disease, as it can not only produce loose bodies and cause secondary OA, there is also an increased risk of malignant transformation to chondrosarcoma and should therefore be actively pursued in case of recurrence or revision surgeries.[18,19]

5. Conclusion

Primary Synovial Osteochondromatosis (PSOC) is a proliferative synovial disorder of mostly middle-aged people. It may present as early onset Osteoarthritis in the younger population and is associated with a high incidence of recurrence even after surgery (synovectomy and arthroplasty). Although not an uncommon finding at the time of doing TKA, there is paucity of knowledge in the existing literature on the outcomes of arthroplasty in such cases of PSOC with associated OA. Although the limited available literature suggests good outcomes of TKA in short and medium terms, more studies are needed to study the long term outcome patterns of TKA in this disease. The major concerns are the possibility of malignant transformation, high recurrence and failure rates following arthroplasty.

6. Conflict of interests

None.

Author statement

Suresh Babu: Review of literature, Analysis, Original paper writing. Abhishek Vaish: Analysis, Revision paper writing. Raju Vaishya: Conceptualization, Revision.

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Research paper

Radiographical post-operative flexion gap balance was improved using a modified gap-balancing technique in navigation-assisted total knee arthroplasty

Seikai Toyooka [a], Jirapong Leeyaphan [b], Hironari Masuda [a], Nobuhiro Nishihara [a], Wataru Miyamoto [a], Hirotaka Kawano [a], Takumi Nakagawa [a, *]

[a] Department of Orthopaedic Surgery, Teikyo University School of Medicine, 2-11-1, Kaga, Itabashi, Tokyo, 173-8605, Japan
[b] Department of Deseases Control, Ministry of Public Health, Bamrasnaradura Infectious, Desease Institute, 38 Tiwanon, 14 Talat Khwan Mueang, Nonthaburi, 11000, Thailand

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ABSTRACT

Background: Adequate lower extremity alignment and knee joint stability are important factors in total knee arthroplasty (TKA) for achieving good prognosis after surgery. There is still controversy surrounding the best technique for TKA. Although several reports have compared the measured resection technique with the gap-balancing technique, little is known about the flexion gap difference after cruciate-retaining (CR) TKA. This study aimed to compare radiographic images of post-operative flexion gap balance after CR TKA using the navigation-assisted measured resection (NAMR) technique and the navigation-assisted modified gap-balancing (NAMGB) technique.

Methods: A total of 70 patients with knee osteoarthritis underwent CR TKAs (28 NAMR procedures, 42 NAMGB procedures). Flexion gap balance was compared by measuring the lift-off angle (LOA), which was the angle between the tibial cutting line and the posterior condylar axis, on axial radiographs of the distal femur at 3 months post-operatively. Furthermore, post-operative hip-knee-ankle (HKA) angles, range of motion (ROM), and Knee Society Score (KSS) were compared between the two groups.

Results: The mean post-operative LOA in the NAMGB group was significantly lower than that in the NAMR group (1.2 ± 1.7° varus versus 2.3 ± 2.7° varus; $p < 0.05$). No difference in post-operative HKA angle, ROM, or KSS was observed.

Conclusions: Based on post-operative axial radiographs of the distal femur, post-operative flexion balance was better in the NAMGB group after CT TKAs. We believe that the NAMGB technique provides better soft-tissue balancing than NAMR TKA.

1. Introduction

Adequate lower extremity alignment and knee joint stability are important factors in total knee arthroplasty (TKA) for achieving good prognosis after surgery, and creating a rectangular-shaped joint gap during extension and 90° flexion is essential to achieve these important outcomes.[1,2] Two major techniques can create a rectangular-shaped joint gap—namely, (1) the measured resection technique, which uses anatomical landmarks to direct bone resection with subsequent soft-tissue release to ensure equalization of the flexion and extension gaps,[3,4] and (2) the gap-balancing technique, which involves soft-tissue release to achieve balance in flexion and extension with subsequent equalization of the gap for determining bone resection.[3,4]

Recently, computer-assisted navigation systems have gained more acceptance as tools to increase implant alignment accuracy[5–7]; since 2012, we have applied this system to navigation-assisted measured resection (NAMR) for cruciate-retaining (CR) TKA. However, there were still some cases in which it was difficult to achieve the same flexion and extension gaps after bone cutting.

* Corresponding author.
E-mail addresses: blueocean1092@hotmail.com (S. Toyooka), lekortho@gmail.com (J. Leeyaphan), hironari@fj9.so-net.ne.jp (H. Masuda), surgerynishi5524@yahoo.co.jp (N. Nishihara), miyamoto@med.teikyo-u.ac.jp (W. Miyamoto), hkawano-tky@umin.net (H. Kawano), takumin-tky@umin.ac.jp (T. Nakagawa).

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To overcome this difficulty, we have developed a navigation-assisted modified gap-balancing (NAMGB) technique and have applied this technique for TKA since 2013. There is still controversy surrounding the best technique for TKA. Although several reports have compared the measured resection technique with the gap-balancing technique, which was performed by posterior cruciate ligament substitute (PS) TKA, little is known about the flexion gap difference after CR TKA.[3,8–10]

Our hypothesis was that the NAMGB technique brought about better implant positioning and post-operative lower extremity alignment than the NAMR technique in CR TKAs. The purpose of this study was to clarify the effectiveness of the NAMGB technique by comparing the clinical and radiological outcomes between NAMR and NAMGB.

2. Methods

2.1. Study design and patients

A total of 144 consecutive primary TKA procedures were performed between April 2012 and March 2015 at our institution. This study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki), and the study protocol was approved by the institutional review board of the authors' institution. Furthermore, all patients provided informed consent, and the privacy rights of all patients were always observed throughout the study. TKA was performed using the NAMR technique from April 2012 to March 2013, and the NAMGB technique was utilized from April 2013 to March 2015. In this study, patients who underwent CR TKA (Scorpio NRG; Stryker, Mahwah, NJ, USA) for knees with varus osteoarthritis and were followed up for at least 24 months after surgery were included. Exclusion criteria included valgus deformity, an alternative component model, previous knee surgery, rheumatoid arthritis, and osteonecrosis.

Pre-operative variables were recorded, including age, sex, affected side, hip-knee-ankle (HKA) angle, maximum extension, maximum flexion, and Knee Society Score (KSS).

2.2. Surgical technique

The Stryker imageless navigation system (Precision version 4.0; Stryker Orthopedics, Mahwah, NJ, USA), which does not need intra-operative fluoroscopy or pre-operative CT images, was used for computer-assisted implantation. A preliminary medial release was performed minimally until the mechanical axis of the limb reached neutral on the navigation screen. Firstly, a distal femoral cut and proximal tibial cut were made perpendicular to the mechanical axis with an extramedullary cutting block positioned under navigation guidance. The cuts were the same thickness as the implant. The created extension gap was evaluated with a spacer block and soft-tissue release or osteophyte resection was performed to obtain the rectangular extension space. Then, the femoral rotation axis on the navigation system was defined as the average rotational axis of the transepicondylar axis and the axis perpendicular to the Whiteside axis. After cutting the distal femur, the posterior reference guide was set. To improve the accuracy of the femoral component rotation, an additional reference axis was applied as per Inui et al.[11] We confirmed that the femoral component rotation, which was defined as the average rotational axis of the transepicondylar axis and the axis perpendicular to the Whiteside axis, was the same as the rotation on the pre-operative X-ray.

In the NAMR group, femoral rotation cutting was performed using bony landmarks, such as the area perpendicular to the Whiteside axis and the surgical epicondylar axis, using a posterior reference cutting block under navigation guidance. The amount of posterior cutting was the same as the implant thickness without considering gap balance. After every bone cutting, soft-tissue release or osteophyte resection was performed to create symmetric and balanced flexion and an extension gap.

In the NAMGB group, once the rectangular extension gap was created, it was evaluated using a seesaw-type tensioner, which is similar to a lamina spreader with a torque meter, tensor, and sliding rule. We applied 30 pounds of torque to the tensioner and subsequently evaluated the flexion gap at 90° flexion. This tensioner can also measure the degree of varus and valgus. During flexion gap measurement, care was taken not to withdraw the tibia forward under the influence of the resident posterior cruciate ligament. Then, the necessary bone cut thickness of the posterior condyle was calculated. The extension gap distance (mm) minus the flexion gap distance (mm) was considered the necessary bone cut thickness. The navigation system offers a four-in-one femoral rotational cutting planning step, which allows simulation of femoral component sizing and amount of bone cutting. A four-in-one cut cutting block was placed with reference to the necessary thickness under navigation. The femoral anterior/posterior and chamfer cutting block (four-in-one femoral cutting block) was positioned by monitoring on the navigation screen. The navigation system offers real-time feedback of femoral rotation, risk of anterior femoral notch, and thickness of posterior femoral bone resections. For instance, when the necessary bone cut thickness was greater than the planned thickness on the navigation screen, the cutting line was moved higher up, and care was subsequently taken to avoid poor anterior coverage and a smaller femoral implant was considered. Conversely, when the necessary bone cut thickness was smaller than the planned thickness, the cutting line was moved lower down, and care was subsequently taken to avoid anterior notching. Next, femoral rotation alignment was adjusted depending on the flexion gap angle. If the flexion gap angle, which had already been measured with the tensioner, was over 3° varus, the posterior cutting line was rotated externally to a maximum of 1°. The cutting block position was determined by the necessary bone cut thickness of the posterior condyle and the rotation alignment was determined by the alignment of the flexion gap.

After four-in-one femoral cutting, we checked that the extension and flexion gaps were the same as before implantation using a spreading and measuring device. Then, we confirmed that the knee with the implant was able to do full extension and deep flexion without insert lift-off. Femoral and tibial implantation was performed with cement. All patients in both groups received patellar resurfacing. Lateral release was performed if there was maltracking of the patella after implantation. Patients in both groups received the same post-operative treatment. Physical therapy started on the day after the operation. All patients were permitted to bear their own weight.

This consecutive series of TKA operations was performed by one surgeon in one hospital.

2.3. Clinical and radiographic evaluation

Clinical evaluation was performed using the range of motion (ROM) of the knee and the KSS. These were recorded pre-operatively and at 24 months post-operatively. A comparison between the two groups was performed at each period, and comparisons between evaluations conducted pre-operatively and at 24 months post-operatively were also performed.

Radiological evaluation was performed using two radiographs, an antero-posterior radiograph of the whole lower extremity and an axial radiograph of the distal femur using Kanekasu et al.'s method.[9]

All patients underwent standing antero-posterior radiography

of the whole lower extremity pre-operatively and at 3 months post-operatively to measure the HKA angle. Furthermore, axial radiographs of the distal femur using Kanekasu et al.'s method[12,13] were taken at 3 months post-operatively to measure the femoral component rotation angle, including the clinical twisting angle (CTA) and femoral condylar lift-off angle (LOA). In Kanekasu et al.'s method,[12] patients sit on a wooden table with their knees in 90° flexion with neutral rotation and the central ray of the radiograph beam is directed to the center of the patella at a 10° upward angle to minimize the influence of soft tissue. The distance between the radiograph tube and the film cassette is set at 100 cm.

To measure CTA, the clinical epicondylar axis (CEA) and posterior epicondylar axis (PEA) were drawn on the axial radiographs (Fig. 1). The angle between two orthogonal lines was defined as the CTA. The angle between the PEA and the tibial cutting line (TCL) was defined as the LOA and measured (external rotation was +, internal rotation was -) (Fig. 1). The acceptable range of outlier LOA measurements was a deviation >3° of internal and external rotation. The number of outlier LOA measurements was compared between groups.

At 3 months post-operatively, the HKA angle, CTA, and LOA were measured independently by five expert orthopedic surgeons with 8, 10, 12, 15, and 21 years of clinical experience. Surgeons were blinded to the surgical technique. The average value of the five surgeons was used in this study. The evaluation was conducted using a PACS workstation (V5 Impax, Agfa HealthCare). The images were anonymized and displayed in random order. Interobserver agreement was assessed using intra-class correlation coefficients (ICC).

2.4. Statistical analysis

Student's *t*-test or Mann-Whitney *U* test was used to compare pre-operative characteristics (age, sex, affected side, pre-operative HKA angle, maximum extension, maximum flexion, and KSS). Clinical outcomes, including ROM and KSS, in the two groups were compared at each period. Furthermore, a comparison between pre-operative assessments and assessments performed at 24 months post-operatively was carried out in each group using Student's *t*-test. Post-operative CTA and LOA were compared in both groups using Student's t-test, and LOA outliers were compared using Fisher's *t*-test. Statistical significance level was set at $p = 0.05$, and all calculations were performed using SPSS version 12 (SPSS Inc., Chicago, IL, USA).

3. Results

A total of 70 knees in 67 patients, including 28 knees in 27 patients belonging to the NAMR group and 42 knees in 40 patients belonging to the NAMGB group, met the inclusion criteria and were included in the study. Seventy-four knees were excluded due to valgus deformity (14 knees), a different component model (34 knees), revision surgery (6 knees), rheumatoid arthritis (10 knees), and osteonecrosis (10 knees).

The two groups showed no significant difference in pre-operative characteristics, including age, sex, affected side, HKA angle, maximum extension, maximum flexion, and KSS (Table 1). There was no significant difference in the degree of pre-operative deformity. Pre-operative HKA angles did not significantly differ between the two groups (10.5 ± 3.9 [mean ± SD] of varus for the NAMR group and 12.4 ± 5.5 of varus for the NAMGB group). On clinical evaluation, the post-operative KSS was significantly higher than the pre-operative KSS in both groups (Table 2). The post-operative maximum extension was smaller than the pre-operative maximum extension in both groups. Nevertheless, there was no difference between pre-operative maximum flexion and maximum flexion at 2 years after surgery in either group. No statistically significant differences in post-operative clinical outcomes, including the ROM and KSS, were noted between the NAMR and NAMGB groups (Table 3).

There was a significant difference between pre- and post-operative HKA angles in both groups (Table 2). Post-operative HKA angles did not significantly differ in the two groups, with the post-operative HKA angle being 0.2 ± 1.6° varus in the NAMR group and −0.8 ± 2.2° valgus in the NAMGB group (Table 3). No difference in the alignment of the components in the coronal plane was observed between the two groups.

The mean post-operative CTA of the femoral component was 3.2 ± 2.0° in the NAMR group and 2.8 ± 1.6° in the NAMGB group. Although the CTA showed external rotation in the NAMGB group and internal rotation in the NAMR group, there was no significant difference between the two groups.

As demonstrated by Table 3, the mean post-operative LOA was significantly lower in the NAMGB group (2.3 ± 2.7° varus in the NAMR group versus 1.2 ± 1.7° varus in the NAMGB group; $p = 0.046$). In other words, flexion alignment was significantly more rectangular in the NAMGB group. Additionally, there were seven outlier cases out of 28 (25.0%) in the NAMR group and three outlier cases out of 42 (7.1%) in the NAMGB group. The number of outliers was significantly lower in the NAMGB group ($p = 0.037$) (Fig. 2).

The interobserver agreement of the five surgeons was 0.98, 0.97, and 0.96, respectively, for HKA angle, CTA, and LOA at 3 months after surgery.

4. Discussion

The balancing technique for TKA is still a matter of debate among orthopedic surgeons. Numerous prior studies have compared the surgical outcomes of the measured resection technique and gap-balancing technique for TKA.[3,4,8–10,14] However, few reports have revealed the effectiveness of these techniques for CR TKAs with navigation assistance.

In the present study, the surgical outcomes of two techniques with navigation assistance were compared. One important finding of this study was that the post-operative flexion gap balance was better using the NAMGB technique compared to the NAMR technique. We found that the NAMGB technique made flexion alignment significantly more equalized and rectangular compared to the NAMR technique, thus rending the outcome of the surgery more indicative of a well-balanced knee. In addition, the number of outliers with a flexion gap balance of more than 3° (either internal rotation or external rotation) on axial femoral radiographs was significantly lower in the NAMGB group. This suggests that the use of NAMGB may lead to functional restoration of the knee joint and assist in obtaining appropriate contact pressure and kinematics of the tibiofemoral joint. Although the superiority of the NAMGB technique in achieving an equalized rectangular gap was not directly reflected in the clinical outcomes at 24-month follow-up, further long-term follow-up may reveal the longer-term effectiveness of the NAMGB technique.

There were two possible reasons for this difference in post-operative flexion balance between the two groups. Although only a trend was observed, the first reason might be the fact that implant rotation in NAMGB favored external rotation. There was no significant difference between the groups with respect to post-operative CTA; nevertheless, the post-operative CTA in the NAMGB group was larger. In other words, the femoral component in the NAMGB group was placed with more external rotation than that in the NAMR group. External rotation cutting contributes to varus at the flexion

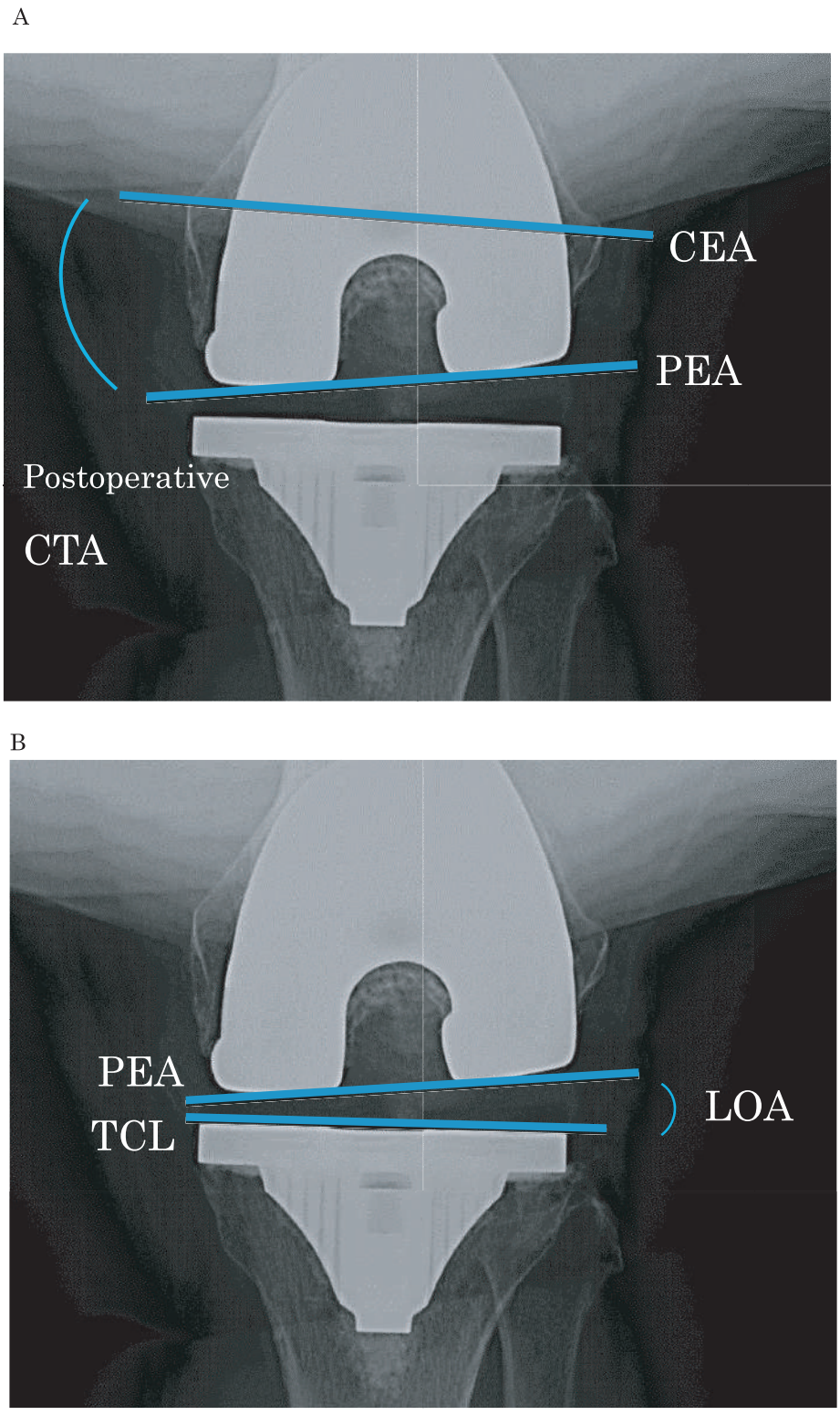

Fig. 1. A: Post-operative condylar twisting angle in femoral axial view.

gap, and that may account for the improved LOA in the NAMGB group. The second reason might be the smaller difference between extension gap distance and flexion gap distance. Past reports have stated the advantages of a flexion versus extension gap difference in the gap-balancing technique compared to the measured resection technique. In a study of flexion and extension gaps in 84 TKAs using the gap-balancing technique, Griffin et al. found that none of the evaluated knees demonstrated a flexion versus extension gap difference of more than 3 mm.[15] A bigger flexion gap may lead to instability in knee flexion and result in outlier LOA values. The improvements in the gap difference between flexion gap and extension gap, which were obtained with the NAMGB technique,

Table 1
Pre-operative demographic characteristics and knee function in both groups.

	NAMR TKA	NAMGB TKA	*p* value
Sample size (no. of patients)	28	42	*n.s.*
Age (years)	72.4 ± 6.4	75.4 ± 7.6	*n.s.*
Sex (female/male)	23/5	37/5	*n.s.*
Pre-operative HKA angle (°)	10.5 ± 3.9 (varus)	12.4 ± 5.5 (varus)	*n.s.*
Maximum extension (°)	−11.5 ± 6.1	−11.4 ± 7.5	*n.s.*
Maximum flexion (°)	121 ± 14.0	122 ± 22.5	*n.s.*
Knee Society Score	38.7 ± 11.1	44.2 ± 12.4	*n.s.*
Knee Society Score (Function)	50.4 ± 22.3	48.1 ± 16.0	*n.s.*

TKA, total knee arthroplasty; HKA, hip-knee-ankle; NAMR, navigation-assisted measured resection; NAMGB, navigation-assisted modified gap-balancing; *n.s.*, not significant.

might be another reason.

Several studies have compared the outcomes of the measured resection technique and gap-balancing technique when surgery was performed with conventional instruments. These studies reported the superiority of the gap-balancing technique for flexion stability and creation of a rectangular flexion gap. Dennis et al. compared the stability of measured resection CR and PS TKAs and 20 gap-balanced PS TKAs.[16] The presence and magnitude of femoral condylar lift-off were evaluated for each technique at 0, 30, 60, and 90° of flexion using an automated three-dimensional model-fitting kinematic analysis. The gap-balanced PS TKAs exhibited a much lower incidence of condylar lift-off than the measured resection technique. Furthermore, the gap-balanced PS TKAs showed a lower maximum magnitude of femoral condylar lift-off (0.9 mm) than either of the two measured resection groups (CR, 3.1 mm; PS TKA, 2.5 mm; $p = 0.0002$). In terms of femoral condylar lift-off, the flexion balance with the gap-balancing technique was better than that with the measured resection technique when using conventional instruments in both the PS and CR TKA models. The modified gap-balancing technique could also improve post-operative coronal laxity.[17]

Nonetheless, very few studies published in English have compared the flexion balance between the measured resection technique and gap-balancing technique under navigation control, especially for CR TKAs. The reason for this is that the gap-balancing technique is mainly applied to PS TKA in clinical practice. The findings of this study are very important for surgeons who perform CR TKAs. Additionally, navigation systems provide accurate bone cutting, rotation, adjustment of the amount of bone cutting, and regulation of rotation. Therefore, accurate procedures were performed in both groups in this study.

This study had certain limitations. First, this was a retrospective case series with a limited number of patients and a short follow-up period. Therefore, the long-term results of this technique remain unclear. Second, on post-operative evaluation, computed tomography was not performed to assess the femoral component rotation in this study. However, even though we only used the axial radiographs as described by Kanekasu et al.,[9] this method showed a strong correlation with conventional computed tomography when it was used to measure the angle between the clinical epicondylar axis and the posterior condylar axis; hence, we believe that it can be used to evaluate both the femoral component rotation and flexion gap balance after TKA.[9,10,18]

In the future, a randomized controlled trial comparing accurate objective post-operative evaluations that include computed tomography and long-term follow-up examination results is necessary to confirm the results of this study. However, NAMGB shows promise as a better method for improving the flexion gap balance after TKA.

In conclusion, the modified gap-balancing technique with navigation assistance improved soft-tissue balancing during CR TKA. It not only reduced the number of post-operative flexion alignment outliers but also permitted the achievement of a more rectangular flexion gap compared to the measured resection technique with navigation. Despite this, the long-term clinical outcomes were similar in the two groups.

CEA, clinical epicondylar axis; PEA, posterior epicondylar axis; CTA, condylar twisting angle.

Table 3
A: Post-operative clinical outcomes in both groups.

	NAMR TKA	NAMGB TKA	*p* value
Maximum extension (°)	−3.2 ± 4.8	−3.8 ± 5.1	*n.s.*
Maximum flexion (°)	119.8 ± 33.4	119.7 ± 36.9	*n.s.*
Knee Society Score	93.2 ± 4.1	88.8 ± 9.9	*n.s.*
Knee Society Score (Function)	66.7 ± 23.6	59.7 ± 23.3	*n.s.*

HKA, hip-knee-ankle; NAMR, navigation-assisted measured resection; NAMGB, navigation-assisted modified gap-balancing; TKA, total knee arthroplasty; *n.s.*, not significant.

B: Post-operative radiographic evaluation in both groups

	NAMR TKA	NAMGB TKA	*p* value
Post-operative HKA angle (°)	0.2 ± 1.6 (varus)	−0.8 ± 2.2 (valgus)	*n.s.*
CTA (°)	3.2 ± 2.0	2.8 ± 1.6	*n.s.*
LOA (°)	2.3 ± 2.7	1.2 ± 1.7	*p=0.046*[a]

HKA, hip-knee-ankle; NAMR, navigation-assisted measured resection; NAMGB, navigation-assisted modified gap-balancing; TKA, total knee arthroplasty; CTA, condylar twisting angle; LOA, lift-off angle; *n.s.*, not significant.
[a] Statistically significant difference.

Table 2
Comparison of pre- and post-operative clinical evaluations.

NAMR TKA			
	Pre-operative	Post-operative	*p* value
Maximum extension (°)	−11.5 ± 6.1	−3.2 ± 4.8	*p<0.0001*[a]
Maximum flexion (°)	121 ± 14.0	119.8 ± 33.4	*n.s.*
Knee Society Score	38.7 ± 11.1	93.2 ± 4.1	*p<0.0001*[a]
Knee Society Score (Function)	50.4 ± 22.3	66.7 ± 23.6	*p<0.0001*[a]
NAMGB TKA			
	Pre-operative	Post-operative	*p* value
Maximum extension (°)	−11.4 ± 7.5	−3.8 ± 5.1	*p<0.0001*[a]
Maximum flexion (°)	122 ± 22.5	119.7 ± 36.9	*n.s.*
Knee Society Score	44.2 ± 12.4	88.8 ± 9.9	*p<0.0001*[a]
Knee Society Score (Function)	48.1 ± 16.0	59.7 ± 23.3	*p<0.0001*[a]

HKA, hip-knee-ankle; NAMR, navigation-assisted measured resection; NAMGB, navigation-assisted modified gap-balancing; TKA, total knee arthroplasty; *n.s.*, not significant.
[a] Statistically significant difference.

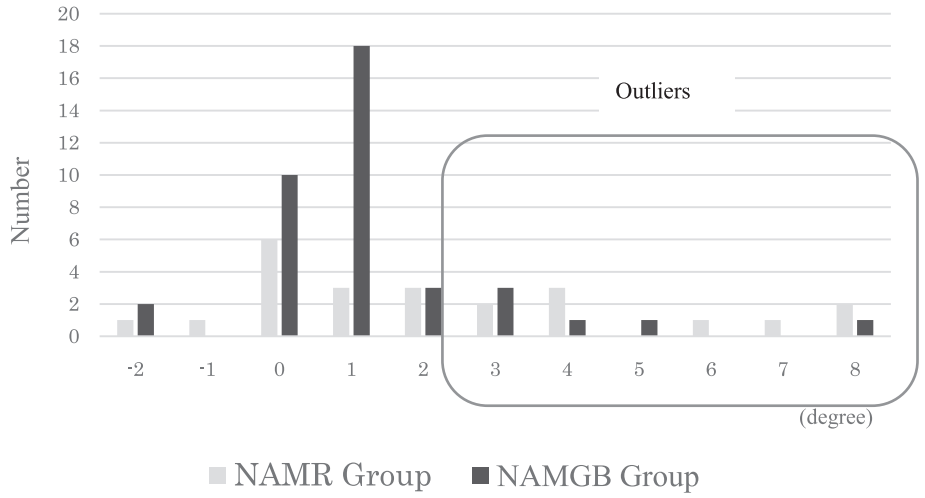

Fig. 2. Mean post-operative lift-off angle.

B: Post-operative lift-off angle in femoral axial view.

LOA, lift-off angle; PEA, posterior epicondylar axis; TCL, tibial cutting line.

Positive values represent varus, whereas negative values represent valgus.

LOA, lift-off angle; NAMR, navigation-assisted measured resection; NAMGB, navigation-assisted modified gap-balancing.

Declaration of competing interest

None.

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"Blood loss and tourniquet in total knee replacement surgery: A randomised control study"

Saqib Yasin [a, *], Chetan Sood [b], Col Romesh Dubey [c], Nooreen Manzoor [d], Akshit kompani [e]

[a] Graded Specialist, Department of Orthopaedics, 166 Military Hospital, Jammu, India
[b] Orthopedic Surgeon at Army Hospital RR, India
[c] Orthopedic Surgeon at MH 166 Jammu, India
[d] 16 CDU That is Corp Dental Unit, India
[e] Medical Officer, 166 Military Hospital, India

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ABSTRACT

Background: The primary aim of the study was to determine the efficiency of tourniquet in reduction of blood loss during Total Knee Arthroplasty.
Method: A total of 105 patients were randomised into two groups each consisting of 52 patients in one group and 53 in another. Pre-operative Haemoglobin (Hb) and Packed Cell Volume (PCV) measurement was done in every case. Every individual received Injection Tranexamic acid 1gm slow intravenous infusion before incision was given and one dose after 8hrs post-surgery. Meticulous care was taken to measure blood loss during surgery. A drain was placed in every case and removed after 24 h. Amount of blood loss in the drain was measured and post-operative Hb and PCV levels were ordered.
Results: No statistically significant difference in the amount of total blood loss was found between the two groups. However, the amount of blood loss during surgery was significantly lesser in patients who underwent surgery with tourniquet in comparison to patients who were operated without tourniquet. At the same time blood loss through drain during post op period was clearly found to be more in patients who were operated with tourniquet as compared to another group.
Conclusion: Our study concludes that there is no impact on blood loss as a result of tourniquet use in total knee arthroplasty. The study further proved that the decrease in blood loss during surgery with the use of tourniquet is associated with proportionate rise in blood loss in the post op period from the drain. Furthermore, our study concluded that optimisation of patient's pre surgery blood parameters can eliminate the need for post op transfusion.

1. Introduction

Total knee arthroplasty is a highly successful procedure to treat terminal knee joint arthritis in order to alleviate pain and correct deformities associated with the ailment. The procedure improves patient function dramatically and consequently enables a patient to lead a better and more productive life.[1] The success of this procedure has triggered an exponential jump in the number of total knee replacement surgeries performed every year globally.[2] Consistent attempts have been made to improve surgical techniques, design better implants and device better rehab protocols in order to achieve faster recovery and restore early function.

One of the most important aspect of every surgery is to minimise blood loss which has a bearing on overall recovery of the patient. Tourniquets have been used since times immemorial to prevent bleeding from injured limbs especially by soldiers during battle. Earlier designs were crude and caused numerous complications.[3] For example, Esmarch tourniquet (kind of rubber band that was wrapped tightly around the limb to exsanguinate the blood and tied it at the proximal end) generated very high pressures and shearing forces causing skin trauma, underlying nerve injury, and even fatal complications like pulmonary embolism. Harvey Cushing introduced pneumatic tourniquet which involves application of a cuff around the proximal aspect of the limb and

* Corresponding author. Department of orthopaedics, 166 Military Hospital ,Satwari Jammu, 180003, India.
E-mail address: saqib5531@gmail.com (S. Yasin).

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application of pressure way above the systolic blood pressure of the individual to stop blood flow to distal limb.[4] This is supposed to prevent blood loss during surgery, provide a clear and a drier operating field and help in better bone cement interdigitation during total knee arthroplasty.[5,6]

The use of tourniquet in primary total knee replacement has been a constant source of debate and discussion and a subject of multiple studies among joint replacement surgeons and a controversial subject since long.[7,8] While some surgeons always perform arthroplasties with tourniquet citing absence of blood loss from cut bony surfaces,[6] drier surgical fields, decreased surgical time and infection rates with better cement penetration; others find it to be of no benefit with some even calling it counterproductive due to potential risks associated with tourniquet use.[8] Several studies have shown increased post op pain, swelling and increased time of recovery[17] with isolated case reports of nerve injury[9] and increased incidence of deep vein thrombosis when tourniquet is used especially for longer durations.[10]

Our study was primarily focussed on effects of tourniquet usage on blood loss during total knee arthroplasty. This has been the most controversial subject among all the facets of tourniquet usage. While some studies have shown decreased total and intraoperative blood loss with use of tourniquet,[8,11] others have failed to demonstrate such reductions in total blood loss with tourniquet.[10,12–15] In fact, some recent studies have shown increased loss of blood due to tourniquet application.[16]

A randomised control study was undertaken at our centre to specifically study the efficacy of tourniquet in terms of blood loss during intraoperative and postoperative period. The results will further enhance knowledge and help in formulations of procedural guidelines in future.

2. Materials and methods

The present study was a randomised control study which initially enrolled 120 patients who were planned to undergo unilateral primary total knee arthroplasty. Patients who met following criteria were excluded: known cases of bleeding diathesis, inflammatory arthritis, patients on antiplatelet agents, known cases of peripheral vascular diseases, chronic smokers and revision cases. Finally, a total of 103 patients all having degenerative knee osteoarthritis were included in the study and randomised into two groups. Permission to undertake study was obtained from Hospital Ethics committee and an informed consent was taken from each individual.

All total knee arthroplasties were done using DJO EMPOWR 3D Knee (Armorcoat USA) from June 2019 to Nov 2019 by a single surgeon. All patients received injection Tranexemic acid 1gm intravenous before skin incision which was repeated at 8 h interval. Electrocautery was utilised for controlling whatever bleeders were encountered during the procedure in both groups. All patients were administered spinal anaesthesia and none received general or epidural anaesthesia.

The group which underwent surgery with tourniquet consisted of 51 individuals. The limb to be operated was exsanguinated before inflating the cuff and a standard pressure of 300 mmHg was applied in each case. The tourniquet was deflated once implants were inserted and cement fully set. Complete haemostasis was achieved with help of electrocautery before closure of deeper tissues and skin. A drain was placed in the joint and kept for 24 h.

Another group who underwent procedure without tourniquet consisted of 52 individuals. While electrocautery was used to control bleeding, at no point of time was tourniquet inflated. Bony surfaces for cementation were prepared using thorough pulse lavage and repeated thawing with dry swabs. A drain was placed into the joint before starting closure and kept in situ for next 24 h.

Blood loss during surgery was estimated meticulously by weighing all the swabs after surgery and subtracting their dry weight; and measuring the volume drained into the suction apparatus system. Similarly, amount of blood in the suction drain was carefully measured and recorded.

The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 21.0 statistical Analysis Software. The values were represented in Number (%) and Mean ± SD. Standard statistical formulas like mean, standard deviation, chi square test, student *t*-test and paired "t" test. The level of significance "P" value thus assessed determined the significance of observation

$p = 0.05$ Not significant $p < 0.05$ Significant

$p < 0.01$ Highly significant $p < 0.001$ Very highly significant.

3. Results

Most of the study population in both the groups belonged to age group of 61–70 years of age.

The patients in both the group were comparable for age. The distribution of male and female was similar in both the groups. The patients in both the group were comparable for gender as well (Tables1 and 2). Pre-surgical blood parameters like Haemoglobin levels (Hb) and Packed Cell Volume (PCV) levels were compared. There was no statistically significant difference in HB and PCV levels before surgery in either of the two groups. Blood loss during surgery and through drain in post-operative period were compared and were found to be significantly different amongst the two groups. Statistically significant increase in blood loss was found in patients who underwent surgery without tourniquet; whereas significant increase in blood loss through drain is observed to have occurred in patients who underwent surgery with tourniquet on (Fig. 1). Haemoglobin levels and PCV levels post-surgery in both the group were compared and no statistically significant difference was found in either of the two groups in terms of overall Haemoglobin or PCV levels (Table 3).

Estimation of overall blood loss during TKR showed significant decrease in both haemoglobin levels and packed cell volume after a total knee replacement with an average drop of around 2 gm per decilitre in Hb and 6% mean decrease in PCV levels (Table 4 and Fig. 2).

4. Discussion

The study clearly demonstrated the inability of tourniquet systems to limit overall blood loss in patients who underwent total knee replacement surgery contrary to what is usually assumed and found in some studies.[28] Multiple randomised control studies have explored this topic and multiple systemic reviews and meta-analysis have been published. In a meta-analysis and systemic review of 15 studies by Smith et al.[17] about tourniquet and total knee replacement consisting of about 1000 patients; it was found that there was no difference in overall blood loss between the two groups. In fact, they observed a trend of increased complications in patients who had surgery with tourniquet on. Similar conclusion that tourniquet use does not lead to overall decrease in blood loss have emerged from high quality studies undertaken by K.L. Jarolem et al.,[10] Yavarikia et al.[12] and Vandenbussche E et al.[14.] This has effectively put into question the usual practice of routine use of tourniquet in total knee arthroplasties.

Another pertinent finding of the study points to significantly less blood loss during surgery when tourniquet was applied. This has been almost a consistent finding among all the studies undertaken on this subject. This finding may be the only reason as to why tourniquets continue to be in practice today in knee arthroplasty. A

Table 1
Distribution of study population according to age group.

S.N.	Age Group	Group I (Without Tourniquet) N (%)	Group II (With Tourniquet) N (%)	Total N (%)	p- value $\chi^2 = 7.759$, df = 3; p = 0.051 (NS)
1-	<=50	2 (3.8)	2 (3.9)	4 (3.9)	
2-	51–60	21 (40.4)	10 (19.6)	31 (30.1)	
3-	61–70	23 (44.2)	36 (70.6)	59 (57.3)	
4-	>70	6 (11.5)	3 (5.9)	9 (8.7)	

Table 2
Distribution of study population according to Gender.

Gender Distribution					p- value
1-	**Female**	**25 (48.1)**	**26 (51.0)**	**51 (49.5)**	**$\chi^2 = 0.087$, df = 1; p = 0.768 (NS)**
2-	**Male**	**27 (51.9)**	**25 (49.0)**	**52 (50.5)**	

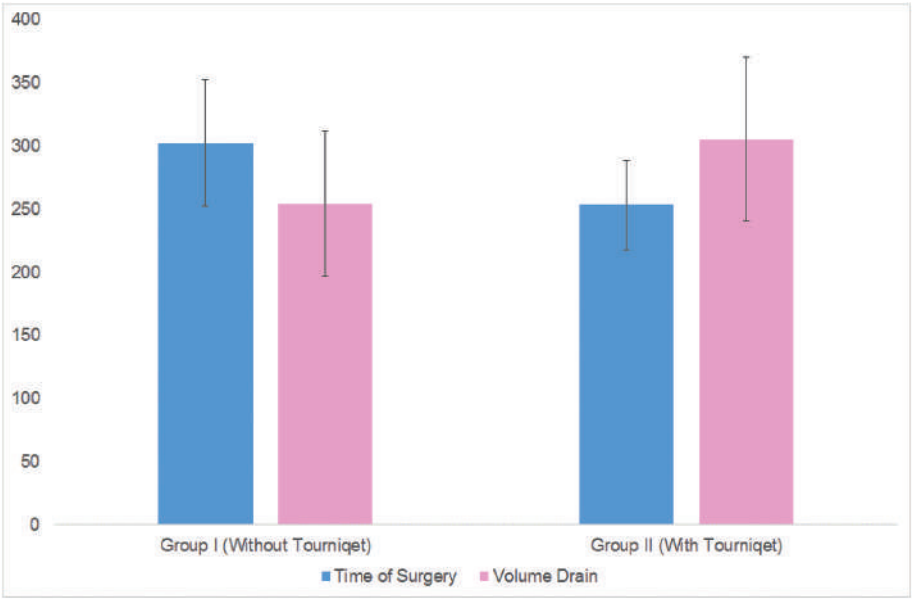

Fig. 1. Depiction of the blood loss at the time of surgery and through drain in the two study groups.

Table 3
Comparison of different variable between the two study groups.

S.N.	Variables	Group I (Without Tourniquet)		Group II (With Tourniquet)		'p' value
		Mean	SD	Mean	SD	
1-	Pre-Surgery Serum Haemoglobin	12.78	1.81	12.88	1.67	0.773
2-	Pre-Surgery PCV	36.88	4.88	38.67	7.17	0.143
3-	Blood loss at the time of Surgery	302.19	50.00	253.24	35.40	<0.001
4-	Blood loss through Drain	254.44	57.40	305.10	64.79	<0.001
5-	Post-Surgery Hb	10.88	1.78	10.90	1.61	0.959
6-	Post-Surgery PCV	32.75	4.67	31.94	4.61	0.379

Table 4
Estimation of overall blood loss.

S.N.	Variables	N	Mean	SD	'p' value
1-	Pre-Surgery Haemoglobin	103	12.83	1.73	<0.001
2-	Post-Surgery Haemoglobin	103	10.89	1.69	
3-	Pre-Surgery PCV	103	37.77	6.16	<0.001
4-	Post-Surgery PCV	103	32.35	4.64	

systemic review and meta-analysis by Ilhan Alcelik et al.[28] included some ten studies which confirmed decreased intraoperative blood loss with tourniquet on. The absence of bleeding from the bony surfaces and drier surgical fields is supposed to increase the ease of surgery, improve visualisation, reduce surgical time,[8,38] decrease rate of infections[26] and improve bone cement interdigitation. However, studies have contested such claims. Serhat Mutlu et al.,[8] A. Yavarikia et al.[12] in their studies did observe improved surgical timings with tourniquet but no such advantage was noted by studies done by Salam et al.[20] or Wakankar et al.,[35] Studies by

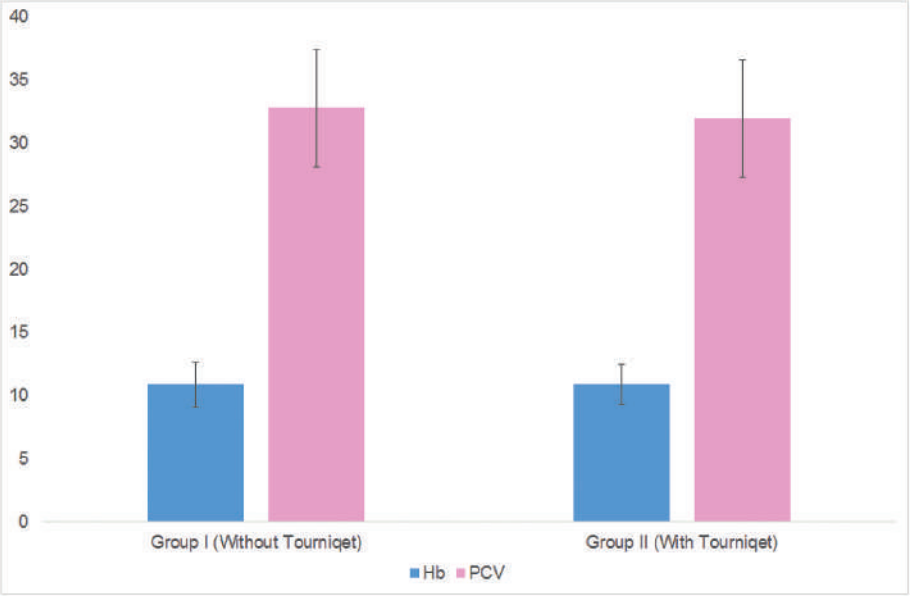

Fig. 2. Depiction of blood parameters in the two groups in post OP period.

Asperberg p et al.,[29] Ejaz A et al.,[30] M Molt et al.[27] and Jawhar A et al.[32] have shown that tourniquets do not improve cement penetration or fixation of components in knee arthroplasty.

This study further demonstrated statistically significantly increased blood loss through the drain in patients who underwent surgery with tourniquet than those without($p < 0.001$) compensating for the decrease during the procedure. Increased blood loss post-surgery could be because of induction of sustained hyperaemia in the soft tissues surrounding the wound, enhanced fibrinolytic activity[36]; and continuous bleeding from the vessels in the posterior structures released during surgery which are often inaccessible and difficult to coagulate once implantation is done and tourniquet released.[16,34] This phenomenon has been noted by most of the workers in their studies, systemic reviews and meta-analysis; and the evidence is so much that it is widely accepted as a fact.[8,10,12,13,15,17] Tetro and Rudan[13] even observed that overall blood loss was more in the tourniquet group in their prospective randomised study. Our randomised controlled prospective study has yet again confirmed this observation.

Another interesting observation that emerged from the study pointed to a mean drop of 2 gm/dl in Haemoglobin levels and decrease of 6% in Packed Cell Volume levels from both overt and covert blood loss that occurs due to a total knee arthroplasty. Mean pre-surgery Hb and PCV levels of subjects in this study was 12.83 gm/dl and 37.77%. Owing to high pre-surgery levels of Hb and PCV among both the study groups, the drop post-surgery did not lead to any of our patients requiring post op transfusions. This points to the importance of optimisation of blood parameters pre-surgery. Medical management of anaemia with intravenous iron injections,[39] Injection Erthropoietin[40] and treatment of other ailments especially parasitic infections of GI tract play an important role in optimising blood parameters in the preoperative stage. Similarly, administration of Injection Tranexamic Acid[37] before incision and hypotensive anaesthesia[41] have proven to play a key role in minimising blood loss intraoperatively. Our study reemphasizes the need for developing a comprehensive strategy for minimising blood loss and avoiding the need for often harmful blood transfusion in post op period.[18,19,33]

Review of literature related to tourniquet use points to complications ranging from local minor problems like skin blistering, erosions, superficial infections, tourniquet pain, delayed wound healing to major eventualities like nerve palsies,[9] deep vein thrombosis, severe ischaemic injury to digits, massive pulmonary embolism[21,23] and reperfusion injury.[22] Altercation of Acid Base balance and rise in serum potassium levels takes place when blood from the anoxic limb returns to systemic circulation once tourniquet is released.[4] Similarly, free radicals present in that blood have been postulated to be the cause of muscle damage[11] and rhabdomyolysis.[24] *Evidence from various studies points to the practice of routine tourniquet use in joint arthroplasty as not just useless and unnecessary but harmful.*[25] *However, in our study except for a few cases of mild tourniquet pain and superficial blistering no major complication was encountered.*

Our study has various limitations; mainly the small sample size and a single centre study. Also, the study was primarily focussed on effects of tourniquet on blood loss; and other aspects of tourniquet usage were not studied in great detail. Still the results have added evidence to the evolving concept that tourniquet use in arthroplasty of knee is not of much clinical use and does not lead to decreased blood loss.

5. Conclusion

Our study concludes that there is no impact on blood loss as a result of tourniquet use in total knee arthroplasty. The study further proved that the decrease in blood loss during surgery with the use of tourniquet is associated with proportionate rise in blood loss in the post op period from the drain. Furthermore, our study concluded that optimisation of patient's pre surgery blood parameters can eliminate the need for post op transfusion.

Credit author statement

Saqib Yasin: Conceptualisation, Methodology, Chief surgeon, Writing draft, Chetan Sood: Conceptualisation, Supervision, Romesh Dubey: Visualisation, Investigation, Project administration, A Kampani: Methodology, Data collection, Writing Original draft, Nooreen Manzoor: Software, Validation, Formal analysis.

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Research paper

Posterior femoroacetabular impact in patients with suspected anterior femoroacetabular impingement evaluated with a 3-dimensional dynamic study

Bernardo Aguilera-Bohorquez [1, *], Ruddy Coaquira [1, b], Erika Cantor [3]

[1] Hip Preservation Unit, Institute of Osteoarticular Diseases, Centro Médico Imbanaco, Cali, Colombia
[b] Pontificia Universidad Javeriana de Cali, Cali, Colombia
[3] Research Institute, Centro Médico Imbanaco, Cali, Colombia

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ABSTRACT

Background: Recently, posterior femoroacetabular impact (PFAI) is considered as a cause of hip pain. The purpose of this study was to estimate the frequency of PFAI in patients with suspected symptomatic Anterior femoroacetabular impingement (AFAI) through 3D dynamic study.
Methods: We performed a retrospective observational study of patients with suspected of symptomatic AFAI evaluated by computed tomography (CT) from February 2015 to December 2017. PFAI was identified through a 3-dimensional (3D) dynamic study with Clinical Graphics software (Move Forward™, Zimmer Biomet, Inc. Miami, USA). Acetabular anteversion, femoral anteversion, neck-shaft angle, lateral central-edge (LCE) angle, alpha angle and range-of-motion were collected.
Results: The study included 181 hips in 131 patients with a median age of 48 (Interquartile range-IQR: 38–59) years; 61.1% (80) were women. PFAI was found in 18.8% (34/181) of hips [95% confidence interval: 13.8%–25.1%]. Among hips with PFAI, 15 had AFAI. External rotation (PFAI: 40; IQR:40–45, AFAI: 45; IQR: 40–60) and neck-shaft angel were lower in the PFAI group (PFAI: 128.4 ± 4.3, AFAI: 133.7 ± 5.4).
Conclusion: The impact between the acetabulum and femoral neck on the posterior-superior zone is a frequent finding in patients with symptomatic AFAI through a 3D dynamic study.
Level of evidence: level IV, Case-series

1. Introduction

Anterior femoroacetabular impingement (AFAI) is considered as one of the main causes of hip pain in young adults.[1] It is caused by an irregular contact in the intra-articular area between the acetabulum and femoral neck, which usually affects the anterior-superior zone of the joint.[2] However, it is possible that an irregular contact between these structures occurs on the posterior-superior zone, a condition known as posterior femoroacetabular impingement (PFAI). This irregular contact generates a symptomatology similar to AFAI which makes it difficult to recognize it as the sole cause of intra-articular hip pain.

The presence of groin pain and a limited hip ROM on FADIR (Flexion-adduction-internal rotation) test are considered to be frequent signs and symptoms to diagnose AFAI. To identify PFAI, there are no specific clinical signs or test. However, pain and limited ROM while performing limb movements contrary to the ones made to identify impacts on the anterior-superior zone such as flexion-abduction-external rotation and extension-external rotation, could suggest impingement on the posterior-superior zone.[3–5]

With the aid of advanced software in imaging studies and the incorporation of diagnostic tools such as 3-dimensional (3D) reconstruction, it is possible to evaluate the 10 most common dynamic movements of a joint, which has improved the identification of pathologies causing hip pain from a different source other than the intra-articular. In current literature, there are limited studies about PFAI and the prevalence of this finding in patients with symptoms that suggest hip impingement is unknown.[3] The objective of this study was to estimate the frequency of PFAI in patients with suspected symptomatic AFAI through 3D dynamic

* Corresponding author. Carrera 38A, No 5a-100 Tower A Office 105, 760042, Colombia.
E-mail address: baguilera@imbanaco.com.co (B. Aguilera-Bohorquez).

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study. We hypothesized that the frequency of PFAI would be higher than expected during routine clinical practice

2. Methods

We performed a retrospective observational study of patients with suspected symptomatic AFAI who underwent a 3D dynamic study with a computed tomography (CT) scan from February 2015 to December 2017. The institutional hip arthroscopy registry was reviewed to identify patients with a 3D dynamic study. The cases were eligible if they had a positive FADIR test with hip pain symptoms. Our institutional review board approved this study.

The radiologic cuts for the hip and knee and 3D reconstruction were obtained through CT scan (Brilliance CT 6 Slice, Philips, Healthcare, Cleveland, USA) and Clinical Graphics software (Move Forward TM, Zimmer Biomet, Inc, Miami, USA), in the same institution and under a standardized protocol. The software creates segmentations and subsequent 3D models of the femoroacetabular morphology using an active shape modeling technique.[6] The software uses the 3D models to simulate range of motion of the femoroacetabular joint based on the recommendations of the International Society of Biomechanics[7] and the equidistant method described by Puls et al.[8] Measurements of acetabular anteversion, femoral anteversion, neck-shaft angle, lateral center-edge (LCE) angle and alpha angle were obtained by the same software. The range-of-motion (ROM) data (i.e., flexion, internal and external rotation) was gathered from medical records. These measurements were obtained during the physical examination before the 3D dynamic study.

The identification of PFAI was assessed using 3D CT dynamic reconstruction through a consensus panel of two orthopaedic surgeons, each image was evaluated until they reached a consensus. A case would be considered positive of PFAI if an abnormal contact on the posterior-superior zone between the femoral head neck junction and the acetabular rim was observed (Fig. 1). The posterior-superior area was identified as zone 4 according to Ilizaliturri et al.[9] and graphically represented as a time position between 9:00 and 11:00 (clock-face method) according to Sampson TG et al.[10]

2.1. Statistical analysis

All of the analysis were made using Stata 13® (StataCorp, College Station, Texas, USA) and R 3.3.3 with the "*nlme*" package. The frequency of PFAI was calculated with the Wilson method. A comparative analysis was performed between hips with AFAI and hips with PFAI. The chi-square test and *t*-test were used to compare the groups according to sex and age. A mixed linear regression model was used to evaluate the differences in ROM, the alpha angle, LCE angle, acetabular and femoral anteversion, adjusted for the individual effect. P value < 0.05 was considered statistically significant.

3. Results

One hundred and eighty-one hip images were evaluated and only 132 hips had a knee cut to assess femoral anteversion. A total of 131 patients (181 hips) were included, with a median age of 48 (IQR: 38–59) years; 61.1% (80) were women. Based on the 3D dynamic study, 147 hips were classified with AFAI and 66 with extra-articular impingement. The proportion of PFAI was found in 18.8% (34/181) of hips [95% confidence interval: 13.8%–25.1%]. Among hips with PFAI, 15 had AFAI. Patients identified with AFAI were younger than subjects with PFAI ($p < 0.001$).

The physical examination findings between hips with and without PFAI are described in Table 1. There were no statistically significant differences in flexion and internal rotation according to the type of impingement. External rotation and neck-shaft angle were lower in the PFAI group than AFAI group ($p < 0.05$). Acetabular anteversion and LCE angle were greater in the PFAI group ($p < 0.05$) (Table 2).

4. Discussion

In our study, we found that approximately 2 of every 10 hips had an impact between the femoral neck and acetabulum in the

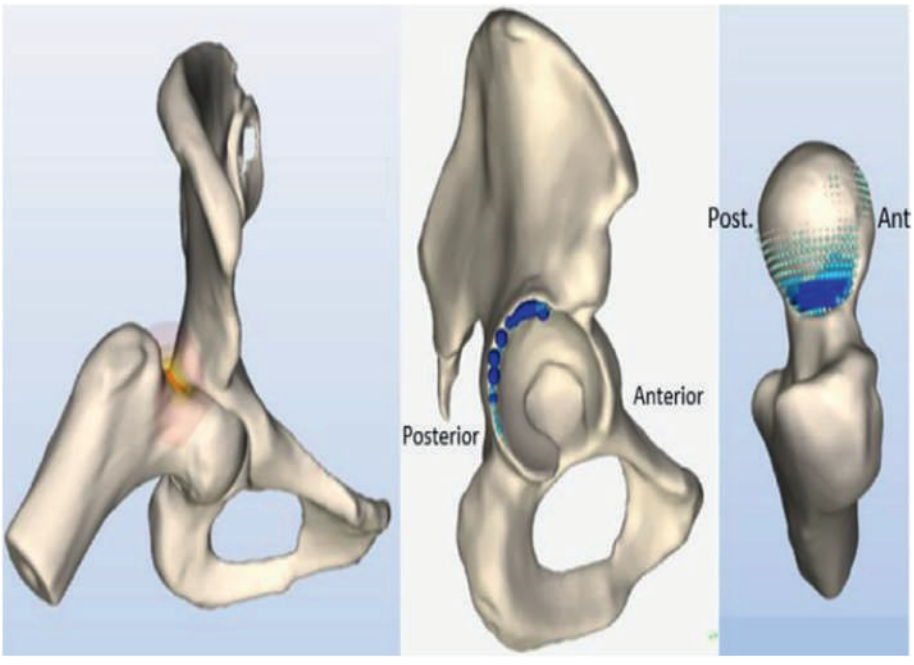

Fig. 1. Three-dimensional dynamic reconstruction of right hip. Area of impingement on union head-femoral neck with acetabular rim on the posterior area of the hip joint.

Table 1
Demographic data and physical examination findings.

	With PFAI N = 34	Without PFAI N = 147	P value	Total N = 181
Sex[a], n (%)				
Female	20 (74.1)	60 (57.7)	0.129	80 (61.1)
Male	7 (25.9)	44 (42.3)		51 (38.9)
Age[a]				
Median (IQR)	48.0 (38.0–59.0)	38.0 (23.5–48.7)	0.000	39.0 (27.0–49.0)
Laterality, n (%)				
Left	14 (41.2)	76 (51.7)	0.269	90 (49.7)
Right	20 (58.8)	71 (48.3)		91 (50.3)
Flexion				
Median (IQR)	120 (110–130)	120 (110–130)	0.107	120 (110–130)
External rotation				
Median (IQR)	40 (40–45)	45 (40–60)	0.028	45 (40–50)
Internal Rotation				
Median (IQR)	30 (20–40)	30 (20–40)	0.857	30 (20–40)

[a] Summarized measurements of 131 patients, 27 of which had PFAI; IQR: Interquartile Range; PFAI: posterior femoroacetabular impact; AFAI: anterior femoroacetabular impingement.

Table 2
Findings of 3D dynamic study.

	With PFAI N = 34	Without PFAI N = 147	P value	Total N = 181
Alpha Angle,				
Median (IQR)	58.9 (52.5–63.4)	56.9 (52.9–63.9)	0.199	57.3 (52.8–63.7)
Tönnis angle				
Median (IQR)	−1.3 (−4.6-4.5)	1.3 (−2.0-6.9)	0.042	1.2 (−2.5-6.4)
LCE angle				
Mean ± SD	41.9 ± 5.9	36.5 ± 7.3	0.000	37.5 ± 7.4
Neck-Shaft Angle				
Mean ± SD	128.4 ± 4.3	133.7 ± 5.4	0.000	132.7 ± 5.6
Femoralanteversion[a]				
Median (IQR)	12.9 ± 7.2	10.4 ± 9.8	0.332	10.9 ± 9.4
Acetabular anteversion				
Mean ± SD	21.4 ± 7.2	18.8 ± 6.2	0.045	19.3 ± 6.5

PFAI: posterior femoroacetabular impact; AFAI: anterior femoroacetabular impingement; SD: standard deviation; IQR: interquartile range; LCE: Lateral center edge; 3D: 3-dimensional.
[a] overall, 33 hips, 15 of which had IFAP.

posterior-superior area. This finding suggests that it is common to observe an abnormal contact on the posterior-superior area of the hip in patients with hip pain and suspected AFAI. The clinical manifestations of PFAI cases are unspecific which makes it difficult to distinguish from AFAI, causing a sub-diagnosis of this pathology. It is possible to suspect an impact on the posterior-superior area in cases that have a restriction in combined movements of extension-external-rotation.[3–5]

James et al. reported during a study done in patients with clinical suspicion of AFAI, a frequency of injuries on the posterior-superior zone of 3% (1/37) using images from magnetic resonance imaging (MRI) and confirmed through arthroscopy.[11]

Haldane et al. in a systematic review reported that only 2% of patients who underwent hip arthroscopy were evaluated with the posterior impingement test during the preoperative physical exam.[12] These studies suggest the lack of screening test during the clinical practice for pathologies located on the posterior area of the hip.

Hips identified with PFAI had a lower neck-shaft angle compared to hips without PFAI. Although recently, hips with a shaft-neck angle$\geq$135° and femoral anteversion>25° have been associated with a predisposition to PFAI and posterior extra-articular impingement, as suggested by Siebenrock et al.,[13] who investigated the relationship between ROM and the location of impingement (anterior or posterior) on the acetabular and femoral sides on valgus hips with increased antetorsion compared to normal hips and hips with idiopathic FAI, based on CT scan reconstructions. In our sample, only 8.8% (3/34) were classified as valgus hip or with increased antetorsion.

A study performed with cadaveric models found that increased femoral and acetabular version was associated with loss of external rotation. Conversely, increased neck-shaft angle was associated with a reduction of external rotation. The authors concluded that relative femoral and acetabular anteversion contribute to earlier posterior femoroacetabular impingement.[14] Other authors have described that an excessive acetabular anteversion could also lead to posterior overcove[15] rage and consequently, to PFAI

Considering that this study reported a frequency of 18.8%, we encourage hip surgeons to include in their clinical practice the posterior impingement test. During the physical examination, a combination of maneuvers has been proposed to identify cases with PFAI, such as the Thomas test, the posterior impingement test and the flexion/abduction/external rotation (FABER), which can cause posterior hip pain.[5,15] Although the radiographic plan used in cases with suspected PFAI is similar to cases with FAI, the use of a 3D dynamic study could be useful to identify abnormal contact on the posterior-superior zone.

4.1. Limitations

The limitations encountered in this study were as follows: 1) The study was based on a set of 64 axial cuts from a CT scan followed by a 3D dynamic reconstruction which limits its projection on low complexity institutions. 2) The cases were enrolled from a single institution, which does not allow generalization and estimation of the frequency of PFAI with accuracy. 3) We did not measure the alpha angle on the superior area of the femur due to the hip radiographic images was not evaluated. This would allow to identify morphologic cam type alterations that could cause injuries on the posterior zone of the hip. 4) The interobserver and intraobserver reliability was not reported because image interpretation was not done independently by the two orthopaedic surgeons. However, we considered that the trustworthiness of identifying the impact on the posterior-superior zone did not decrease because the software can automatically identify the contact in this zone.

5. Conclusion

In conclusion, the impact between the acetabulum and femoral neck on the posterior-superior zone is a frequent finding in patients with symptomatic AFAI through a 3D dynamic study.

Author's Contribution

BA, RC and EC made the design of the study. RC and BA collected the data from the clinical records. EC helped with the statistical analysis. The interpretation of the results and the draft of the manuscript were made by all authors. All authors read and approved the final manuscript.

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Declaration of competing interest

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Review article

Endoscopic iliopsoas tenotomy following total hip replacement: Retrospective study of 19 cases☆

O. Amellal*, K. Lamraski, M. Penasse

Centre Hospitalier Wallonie Picarde, Rue des Sport 51, 7500, Tournai Belgique, Belgium

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ABSTRACT

Introduction: Iliopsoas impingement (IPI) is a cause of groin pain after hip arthroplasty (HA) with a 4.3% frequency. For many years the standard treatment has consisted of acetabular revision or open tenotomy. Recent advances in hip arthroscopy have made it possible to propose an arthroscopic tenotomy technique, either extra- or intra-articular (endoscopic). The main purpose of this study is to analyze endoscopic tenotomy outcomes in the treatment of IPI following HA. The others objectives are to prove the low morbidity and to identify pre-operative factors associated with good outcomes.
Methods: Between 2012 and 2019, 19 patients affected by iliopsoas tendinopathy after hip arthroplasty were treated endoscopically by 3 surgeons. The surgical procedure was performed on traction table, using an inferior endoscopic and a superior instrumental approach. The tenotomy was practised at the tendon insertion on the lesser trochanter using electrocoagulation system (VAPR). The study was retrospective with a mean follow-up of 36 months. Outcomes at last follow-up were assed based on the improvement in pain, satisfaction index, Oxford Hip Score, and complications.
Results: After 36 months of mean follow-up, we found a significantly improvement in functional score (Oxford-12 Hip Score) and pain according to VAS from preoperatively to postoperatively, 15 patients reported pain relief (79%), four patients referred a recurrence of pain. No major complications were noted. We found no predictive factor. The four surgical failures involved cup malposition (2) and impingement with screw (2).
Conclusion: Endoscopic tenotomy to treat IPI after HA seems to produce good clinical outcome, pain relief and low complication rate. Endoscopic tenotomy may be considered as a first-line treatment option in IPI. Cup revision should only be reserved after failure of tenotomy in case of cup malposition or anterior cup prominence. The benefit seems to be limited for tendinitis caused by intramuscular screw.

1. Introduction

Total hip arthroplasty is one of the most successful procedures in orthopaedic surgery with a relatively low complication rate.[1]

The main purpose of this surgery is to restore the biomechanics and function of the operated hip. One of the priorities for the success of the procedure is the reaming and the anatomic positioning of the acetabular component.[2]

Iliopsoas impingement (IPI), first described in 1991 by Lequesne,[3] may be a cause of persistent groin pain following hip arthroplasty (HA), with a 4.3% frequency according to literature.[4–8]

Many etiologies of impingement between the iliopsoas tendon and the acetabular component have been described by the authors.

- acetabular cup malposition (inadequate cup anteversion, excessive inclination)
- anterior wall hypoplasia in the acetabular dysplasia
- excessive cup diameter
- excessive anterior wall reaming
- fixation screw or reinforcement rings protruding through the ilium
- extruded cement debris.[3,4,9–12]

Iliopsoas tendinotis can also be caused by not mechanical reasons: increased femoral offset or leg length.[13,14]

☆ Level of evidence: IV, retrospective observational study.

* Corresponding author.
E-mail address: omar.amellal@student.uclouvain.be (O. Amellal).

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IPI is a major cause of cup revision,[15] associated with high morbidity.[16,17] For that reason, we need to develop minimally invasive techniques. Arthroscopic tenotomy is a recent technique with a relative poor literature; we find it important to present our outcomes.

The aim of the study is to validate endoscopic tenotomy for IPI after hip arthroplasty reporting clinical and functional results of a retrospective 19-case series.

1.1. Hypothesis

The main hypothesis of the study is to prove the safety and the effectiveness of the procedure in relief pain and functional recovery.

2. Material and methods

2.1. Patients

Between April 2012 and June 2019, 19 patients affected by iliopsoas tendinopathy after total hip arthroplasty (16) or total hip resurfacing (3) were treated endoscopically by three experienced surgeons (Table 1). The study was retrospective and monocentric. The main follow-up was 36 months (6–66). The average time between hip arthroplasty and tenotomy was 48 months (6m-7y) (see Table 1).

Nine patients were males (48%) and ten were females (52%).

The mean age was 66 years (range 36–88). Mean BMI was 28.1 kg/m^2 ± 1.8 (21–43).

2.2. Inclusion criteria

Inclusion criteria were: typical clinical and imaging findings of IPI, follow-up longer than 6 months.Table 2

Exclusion criteria were presence of a biological inflammatory syndrome, hyperfixations on bone scintigraphy.

2.3. Preoperative assessment

- All the patients underwent physical preoperative examination. Clinical study parameters included age, sexe, BMI (body mass index), groin pain evaluation (VAS), circumstance of pain occurrence (walking, getting out of a car, climbing stair, at night).
- The imaging assessment systematically included X-ray (anteroposterior and “Lequesne’s lateral view”) and computed tomographic (CT) scan. X-ray allowed to measure cup inclination and to exclude another cause of pain. The CT-Scan was used to confirm the impingement (Fig. 1) and to measure the cup prominence (mm) and the anteversion (°) (Fig. 2). Bone scintigraphy was prescribed for eight patients to rule out acetabular hyperfixation.
- All 19 patients (100%) received a preoperative infiltration, performed by a radiologist under ultrasound (2) or CT-Scan (17), using a local anesthetic (Naropin®) and a long-acting corticosteroid (Depo-Medrol®) between the tendon and the anterior edge of the cup.
- Ten patients underwent biological analysis to rule out sepsis (52%).

Table 1
Preoperative descriptive data.

	N = 19
Age, years, mean ± SD (range)	66 ± 11 (36–88)
Males, n (%)	9 (48%)
Females, n (%)	10 (52%)
BMI, kg/m2, mean ± SD (range)	28.1 ± 5.6 (21–43)
Primary THA, n(%)	15 (79%)
Revision THA, n(%)	1 (5%)
Total hip resurfacing, n(%)	3 (16%)
Time from HA to tenotomy, months, mean ± SD (range)	48 (6–87)
Follow-up, months, mean ± SD (range)	36 (6–66)

Table 2
Preoperative assessment.

Para-clinical examination	Rate
Radiography, n (%)	19 (100%)
CT-Scan, n (%)	19 (100%)
Infiltration, n (%)	19 (100%)
Biological test, n (%)	12 (52%)
Bone scintigraphy, n (%)	8 (42%)

Fig. 1. Preoperative CT-Scan: acetabular screw protruding.

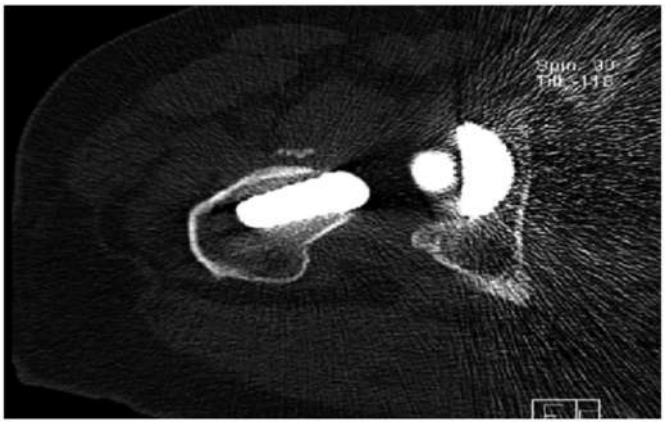

Fig. 2. Preoperative CT-Scan:inadequate cup anteversion (0°).

All patients were treated by tenotomy performed under extra-articular arthroscopy ("endoscopic"). Three experienced surgeons who were familiar with the technique participated in this study.

2.4. Surgical technique

All the patients were operated on using the same surgical procedure. The surgery was performed under general anesthesia.

The patient was positioned in dorsal decubitus on a radio transparent table. No traction was applied during the surgical procedure. The operated lower limb was positioned in external rotation to release the liopsoas tendon and uncover the lesser trochanter.

The surgeon stood on the operated side and the fluroroscopic guidance on the controlateral side with an anteroposterior view. Only 2 antero-lateral portals were usually required, an inferior endoscopic portal and a superior instrumental portal.

The inferior was first performed under fluoroscopic guidance, in front of lesser trochanter, the optical trocar was inserted staying in contact with the anterior surface of the femur and then a standard 30° arthroscope was positioned at the lesser trochanter.

The second approach was similar, 5 cm more proximal on the same vertical line, with 45° angle to allow good triangulation using both endoscopic and fluoroscopic guidance (Fig. 3).

After thorough debridement of adhesions and soft tissues around the lesser trochanter using a shaver until optimal visualisization of the distal tendon insertion, the tenotomy was practiced. The tendon was sectioned using a radiofrequency electrocoagulation system (VAPR), in the extra-articular compartment at its bone insertion on the lesser trochanter (Fig. 4) to obtain a better release and preservation of muscle strength.[8] The tendon section was complete and the stump retraction was endoscopically visualized, thus allowing the disappearance of the impingement.[18]

The tendon remaining on the lesser trochanter was carefully thermocoagulated at the end of the procedure.

2.5. Postoperative rehabilitation

The hospital stay was 1 day, and full weight-bearing was immediately allowed. All patients received thromboprophylaxis with a low molecular weight heparin administered for ten days.

All patients were treated with NSAIDs (Indomethacin®) for ten days to prevent possible heterotopic ossification.

Postoperative physiotherapy was systematically prescribed focus on iliopsoas stretching, muscle strengthening and walking rehabilitation.

All patients were reviewed at 1 month postoperatively for a first postoperative check-up.

2.6. Assessment methods

Outcomes at last follow-up were assessed based on:

- Visual Analogue Scale (VAS) for pain evaluation.
- Oxford-12 Hip Score for hip function.
- Persistence of psoitis
- satisfaction index.
- complications.

2.7. Statistical analysis

Descriptive variables are presented as mean ± standard deviation (range). Continuous variables were compared using T-Student test or analysis of variance. A p value < 0.05 was considered as statistically significant.

Fig. 3. Fluoroscopic guidance of instrument insertion.

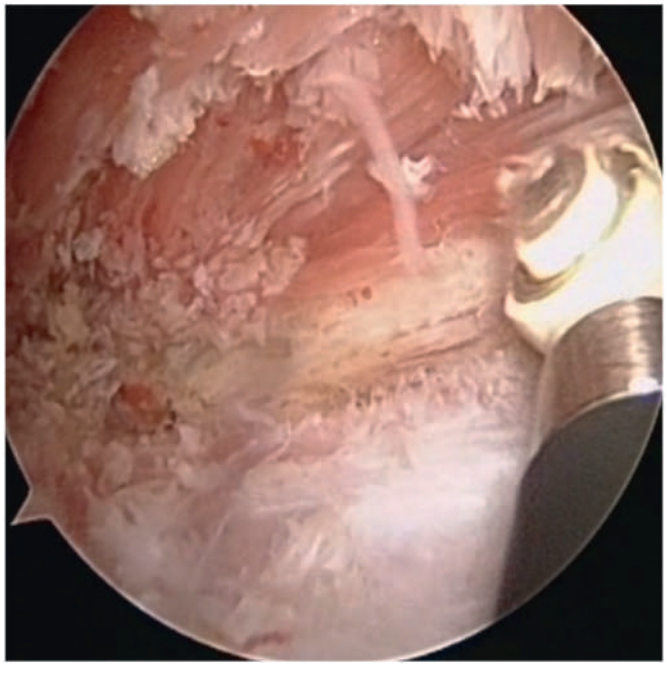

Fig. 4. The tenotomy was performed using a VAPR in the extra-articular compartment.

3. Results

Initially twenty-three were treated for IPI. Of these, 1 patient was excluded because of a follow-up shorter than 6 months, 2 were treated by transcapsular approach (intra-articular) and 1 patient was lost at last follow-up.

Finally, nineteen patients met the inclusion criteria were included into our study.

3.1. Preoperative data

Preoperative inguinal pain was present in 100% of cases. The circumstances of pain were (Table 3);

- climbing stairs (89%)
- getting out of a car (84%)
- walking (42%)
- at night (5%)

A psoitis was reported for the 19 patients (100%)

Mean VAS was 6.15 (range 4–8) Mean Oxford-12 score was 25.2 (±6.4).

CT-Scan found mean anteversion of 12.3° (±4.9) and acetabular cup prominence greater than 5 mm for 10 patients (52%)

The cup frontal inclination was between 40° and 50° for 18 patients (95%), and greater than 50° for 1 patient.

Causes of anterior impingement were:

- inadequate anteversion (<15°): 5
- excessive frontal inclination (>50°): 1
- cup oversized: 2
- excessively long screw: 2
- anterior uncovering in acetabular dysplasia: 3
- tendon ossification: 1
- others: 5

The results for the injection test was positive for 9 patients (48%) and negative for 10 patients (52%)

3.2. Postoperatives outcomes

After 36 months of mean follow-up, a statistical significant improvement was found in functional score (Oxforf-12 Hip Score) and pain according to VAS score from preoperatively to final follow-up. Table 4 shows results at the last follow-up. Fifteen patients reported pain relief (79%). Relief pain was total for 12 patients and partial for 3 patients. The mean VAS decreased to 2.4 (range 0–7). A disappearance of psoitis postoperatively was found for 12 patients (63%). The mean postoperative Oxford-12 score increased to 38.02 (±12). Forteen patients were totally satisfied with the surgery (73%). Four patients referred a recurrence of pain (21%), 3 were treated conservatively and 1 by screw removing. There were no major complications; we only observed only three postoperative hematomas, all spontaneously resolved.

Table 3
Preoperative data.

	N = 19
Pain	19 (100%)
- Climbing stairs	17 (89%)
- Getting out of a car	16 (84%)
- Walking	8 (42%)
- At night	1 (5%)
VAS (0–10) ± DS (range)	6.15 ± 1.16 (4–8)
Psoitis	19 (100%)
Mean Oxford-12 Hip Score	25.2 (±6.4)
Mean anterior cup prominence (mm)	5.9 mm (±2.8)
Mean cup anteversion (°)	12.3 (±4.9)
Mean cup inclination (°)	45.7 (±4.8)
Positive infiltration test	9 (48%)

Table 4
Postoperative outcomes.

Outcomes at last follow-up	N = 19
Pain relief	15 (79%)
- Complete	12 (63%)
- Partial	3 (16%)
Main VAS (0–10) ± DS (range)	2.4 ± 2.6 (0–7)
Satisfaction	14 (73%)
Main Oxford-12 Hip Score	38.02 (±12)
Psoitis alleviation	14 (73%)
Complications:	3 (16%)
- Hématoma	3 (16%)

4. Discussion

The results obtained in this study are hopeful considering the success of the surgery on pain, functional recuperation and also the low complication rate.

The treatment of the IPI has evolved considerably in last 20 years.

Nonoperative treatment focus on non-steroidal anti-inflammatory drugs (NSAIDs), local corticosteroid and physiotherapy shows limited therapeutic value.[4,16,19]

Many surgical options have been described, by open surgery or arthroscopy intra- and extra-articular.

Acetabular revision has for many years been considered the first-line treatment. The aim was to eliminate the cause of the impingement: cup prominence or malposition, protruding screw, Series show good results of groin pain resolution and clinical outcomes but associated with high complication and revision rates.[6,9,11,15–17,27,28,30] Acetabular revision is recommended when cup prominence is $\geq$ 8 mm with or without tenotomy.[16,17,28]

Open tenotomy allows good evaluation of the components and others causes of groin pain. Many techniques have been described with high success rate.[6,13,16,21] Anterior (Heaton) and medial approach (Keats) are the most commonly used.[13,20] This technique requires a longer hospital stay and recovery period than the minimally invasive techniques using arthroscopy or endoscopy.

Benad et al.[22] described a capsuloplasty technique using a polyglactin plate positioned in the impingement zone. Arthroscopic tenotomy is the most recent technique and literature is still poor on the subject.

Most studies are retrospective and include small numbers of patients,[23–25] currently only one prospective series has been published.[26]

Both arthroscopic and endoscopic techniques are reported with good results. Table 5 shows the results of the different series.

Our study agrees with the literature showing good results regarding pain relief and functional recovery.

The complication rate reported in the series is low (3.2%) [24. 25. 26]. Guicherd et al.[26] in a multicenter 64 cases series reported two complications: one case of anterior dislocation in transcapsular tenotomy and one compressive hematoma resolved by surgical drainage. In our series, hematoma is the only complication that we have found for 3 patients.

Iliopsoas tenotomy may be performed in the extra-articular compartment at the level of the lesser trochanter (endoscopic) or in the impingement zone by a transcapsular approach (arthroscopic).

Table 5
Studies reporting arthroscopic and endoscopic tenotomy for IPI.

Authors	*Patients*	*Design*	*Technique*	*Pain relief*	*Pre-and postoperative Functional score*
Dora et al. (2007)[16]	6	Retrospective	Arthroscopy	85%	Harris 44-75
Van Rietet et al. (2011)[23]	9	Retrospective	Arthroscopy	77.7%	Womac 34-84
Gedouin et al. (2012)[24]	10	Retrospective	Endoscopy	80%	Harris 59-73
Filanti et al. (2016)[25]	35	Retrospective	Arthroscopy	90.9%	Harris 44.1–75.7
Symposium SFA (2017)[26]	64	Prospective	Arthroscopy + Endoscopy	92%	Oxford 22-44

Illizaliturri (19 patients) and Guicherd (64 patients) compared endoscopic and arthroscopic tenotomy and reported no significant differences in results [26 +].

We have opted for the endoscopic technique which has some benefits. The procedure is simple and does not require a long learning curve. The whole procedure takes place in the extra-articular compartment reducing the risk of implant infection or bearing surface damage. The access to the tendon is direct and does not require anterior capsulotomy reducing the risk of instability. In case of doubtful diagnosis, an arthroscopic exploration of the joint can easily be performed through an anterior capsulotomy using the same installation.

The advantages of the arthroscopic technique are the optimal joint exploration allows the visualization of the impingement and exclude other potential cause of groin pain (infection, metallosis, loosening, bearing surface wear…).

The value of preoperative infiltration as diagnostic test is controversial. Some authors consider preoperative infiltration essential because of its positive predictive value for treatment.[24]

On the other hand, most authors[8,18,25,26] do not recommend this infiltration because of the risk of infection and systematic recurrence of the symptomatology. In our study, infiltration test does not demonstrate positive diagnostic predictive.

No factor predicting tenotomy outcomes was identified. Statistical analysis did not show correlation between the measurement of anterior cup prominence and response to tenotomy.

Although acetabular revision is recommended for prominence exceeding 8 mm, we have registered successful results for prominence greater than 8 mm.

Our four failures concerned, two impingement with protruding screws and two cup malposition, one excessive verticalization (>50) and one inadequate anteversion (<5°). These failures will require revision surgery.

The limitations of the study mainly concern its retrospective design and the lack of control group. Furthermore, postoperative muscle strength was not assessed, and thus no conclusions can be drawn about the muscular repercussion of a tenotomy.

The strength of the study is the relative large sample (19). Previously only one study has a larger number of patients than ours.[26] The monocenter cohort allowed a good homogeneity in indications, surgical technique, and postoperative recommendations.

5. Conclusion

Endoscopic tenotomy seems to produce good clinical outcome, pain relief and low complication rate. The technique is simple and relatively non-invasive.

Endoscopic tenotomy may represent gold standard to treat iliopsoas impingement after HACup revision should only be reserved after failure of tenotomy in case of cup malposition or anterior cup prominence. The benefit seems to be limited for tendinitis caused by intramuscular screw.

Declaration of competing interest

The authors declare that they have no conflicts of interest concerning this article.

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Research paper

Functional outcome of arthroscopic repair of bucket handle and longitudinal medial meniscal tears in a military population by inside out and outside in technique: A prospective observational study.

Hrishikesh Pande [a, *], Prashant Pratim Padhi [b], M. Bhattacharya [a]

[a] Department of Orthopaedics, Command Hospital, Lucknow, IN, India
[b] Department of Orthopaedics, Command Hospital Air Force, Bengaluru, India

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ABSTRACT

Objective: To assess if young military personnel who had sustained medial meniscal bucket handle/longitudinal tears could return to full, unrestricted active duty after meniscal repair by outside in/inside out technique.
Methods: 32 medial meniscal longitudinal/bucket handle tears were repaired by inside-out and outside in technique between Jul 01, 2017 and June 30, 2018 and followed up for at least 18 months.
Results: There were 03 failures of repair. The first 05 patients developed para-meniscal cyst due to irritation of soft tissue by PROLENE® suture hence the suture material was changed to ULTRABRAID® in next 27 patients and there was no occurrence of this complication. The mean IKDC, Lysholm and Tegner scores showed significant improvement till 12 months post op and thereafter there was marginal improvement in these scores. Most patients who had successful outcome at one year were able to carry out preinjury level of activities and join unrestricted active duty.
Conclusion: With more than 90% able to re-join active duty, we could demonstrate that inside out/outside in technique is an excellent method of reliably and economically repairing a torn meniscus even for very high demand military personnel.

1. Introduction

The menisci which were once considered vestigial are now considered vital structures in the knee for their role in weight transmission, shock absorption, stability and prevention of knee degeneration.[1–3] The menisci are commonly injured as a result of sporting injuries, road traffic accidents and falls. In addition, in the military population menisci are commonly injured during training activities and while serving in difficult terrain. Usually the medial meniscus is more commonly injured than lateral meniscus as it is less mobile compared to lateral meniscus. The aim of treatment of meniscal injury is immediate pain relief, healing of the tear, prevention of degenerative changes of the joint in the long term and return to active duty in case of a soldier. Studies have shown that degenerative changes of the knee joint develop in the long term even after partial menisectomy as the degree of meniscal deficiency correlated with joint contact pressures[4–6] hence benign neglect is an acceptable way of managing small stable incidentally detected meniscal tears[7–13] and larger unstable tears are ideally managed with repair. The ultimate aim of both the modalities of management is to preserve the meniscal tissue.

Meniscal repair was initially performed open, until in 1969 when Ikeuchi[14] performed the first reported arthroscopic repair. In present times, arthroscopic meniscal repair can be performed by (1) Inside-Out repairs (IO), (2) Outside-In repairs (OI), (3) All-Inside repairs (AI) and (4) Hybrid repairs. All these methods have their fair share of advantages and disadvantages. Comparing results of meniscus repair in the literature is quite difficult because of the variety of techniques used and the variables within each series (patient age, chronicity, type of tear, rim width, concomitant procedures etc.). There is no universally acceptable established gold standard for managing symptomatic meniscal tears in contemporary literature though the AI repair devices are gaining wide

* Corresponding author. Department of Orthopaedics, Command Hospital Lucknow, 226002, IN, India.
E-mail address: hrishp2013@gmail.com (H. Pande).

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popularity.

The outcome of arthroscopic meniscal repair whatever the method of repair has been generally reported as good to excellent in many short, medium and long term studies but if a similar outcome is good enough to enable a young soldier to rejoin full active duty is not clearly known due to paucity of studies. The present study was designed as a pilot study to assess if military personnel who had sustained knee injuries resulting in medial meniscal bucket handle/longitudinal tears could return to full, unrestricted active duty after meniscal repair by outside in/inside out technique. We chose IO/OI technique as we believed that the failure rates of AI repair (due to various reasons like toggle anchors pulling out of the meniscus, failure of engagement of toggle device, of improper deployment, rupture of suture during knot tying, and the implants remaining extra-articular, potential for vascular injury when used for posterior horn etc.) were marginally higher than the other methods of repair as per the available literature[15–23] and also their higher cost upfront.[24,25]

2. Materials and methods

This was an institutional ethical committee approved prospective study. Out of 196 patients who underwent arthroscopy of knee in our institute between Jul 01, 2017 and June 30, 2018, 32 cases of medial meniscal tear with or without concomitant ACL tear who met the inclusion and exclusion criteria (Table 1) were studied prospectively. All surgeries were performed by a single surgeon who at the start of study had 8 years of experience in performing arthroscopic procedures and at least two years of experience in meniscal repairs.

All patients who sustained injury to the knee presenting with symptoms of pain, swelling, instability, who on clinical examination showed signs of joint line tenderness and or ACL insufficiency and no demonstrable bony injury on an x ray were initially treated symptomatically with ice, analgesics, bracing, protected weight bearing and sheltered employment for a period of at least 1 month except patients presenting with locked knee where in early intervention was carried out. The patients were subjected to arthroscopy of knee after an MRI and taking informed written consent for the study. The tear length and meniscal width were measured during arthroscopy using a calibrated probe. The tears within 2 mm of the menisco-capsular junction were considered as the red-red zone, and those within 4 mm were considered as in the red-white zone. After reduction of tears, the anteriorly located tears were repaired by OI method (for ease of performing the procedure) and those in the body and posterior horn by IO method (Figs. 1 and 2). The OI technique was carried out using wide bore hollow needles and the IO technique using Meniscal Stitcher Set® (Smith & Nephew) with hollow site specific cannulas and flexible needles. The meniscus was sutured after debriding the tear edges with shaver and rasp. The suture material used in first 5 cases was No.1 monofilament Polypropylene PROLENE® (Ethicon) and in subsequent 27 cases, No. 2.0 ULTRABRAID® (Smith & Nephew). The sutures were placed every 8–10 mm hence the number of sutures required depended on the size of the tear (Fig. 3). Additional posteromedial incision was made for retraction of neurovascular structure during repair of posterior horn tears. The concomitant ACL tear was treated by single bundle ACL reconstruction (ACLR) with autologous ipsilateral quadrupled semitendinosus graft with the femoral tunnel drilled by modified trans-tibial method[26] which was the preferred method of the surgeon. The graft was fixed with Endobutton CL® (Smith & Nephew) on femoral side and either BIORCI HA ® (Smith & Nephew) or GENESYS™ Matryx® interference screw (ConMed) on tibial side. Additional drilling of the nonarticular portion of intercondylar notch with 4.5 mm drill bit was done in patients of meniscal tear without ACL insufficiency to generate biological factors to promote healing of meniscal tears.

Postoperatively, the involved knee was placed in a hinged knee brace for 6 weeks. Knee movements were started using CPM from day 2 with gradual increase by 5º every day to max 90º during first 6 weeks. Toe touch weight bearing was allowed from day 2 with the brace locked in full extension. Closed chain exercises up to four weeks followed by open chain quadriceps and hamstring exercises of the knee were instituted. Full weight bearing was allowed after 6 weeks. Concomitant ACLR did not affect the rehab protocol. Brisk walking, cycling were begun at 3 months. Light jogging, swimming allowed after 6 months. Return to unrestricted sport participation and military training was allowed at 12 months if there was no pain, knee flexion was near full, hamstring and quadriceps strength >90% and quadriceps wasting less than 2 cm compared to contralateral thigh. Re-look arthroscopy was planned only for patients who were symptomatic with pain, discomfort and unsatisfactory outcome at 06 months following repair to assess the state of meniscal healing. No patient in our series was subjected to repeat MRI for documentation of healing.

The pre-operative Lysholm, IKDC and Tegner activity scores were recorded after admission of the patients for surgery. The follow up evaluation IKDC, Lysholm questionnaire and Tegner

Table 1
Inclusion, exclusion criteria.

Inclusion Criteria:	1. Medial meniscal tears Unstable (Displaceable on probing) longitudinal tears. Bucket handle tears. In the red-red/red-white zone. 2. With or without associated ACL tear. 3. Age less than 45 years.
Exclusion Criteria:	1. Lateral meniscal tear. 2. Small stable (Non displaceable on probing) tears of the medial meniscus. 3. Horizontal/Degenerative/Flap/Complex tears. 4. Root tears of the meniscus. 5. RAMP lesions. 6. Grade 3 or 4 Chondral defects. 7. Bony injuries around the knee. 8. Multiligamentous injury/generalised ligament laxity. 9. Limb malalignment (genu varum/valgum) 10. Uni/bi/tricompartmental osteoarthritis. 11. Previous surgical procedures around knee. 12. Infections around knee.

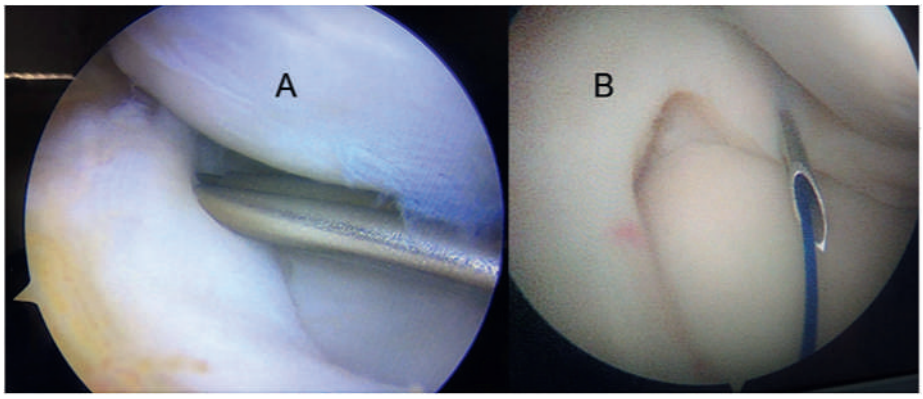

Fig. 1. A- IO technique; B– OI technique.

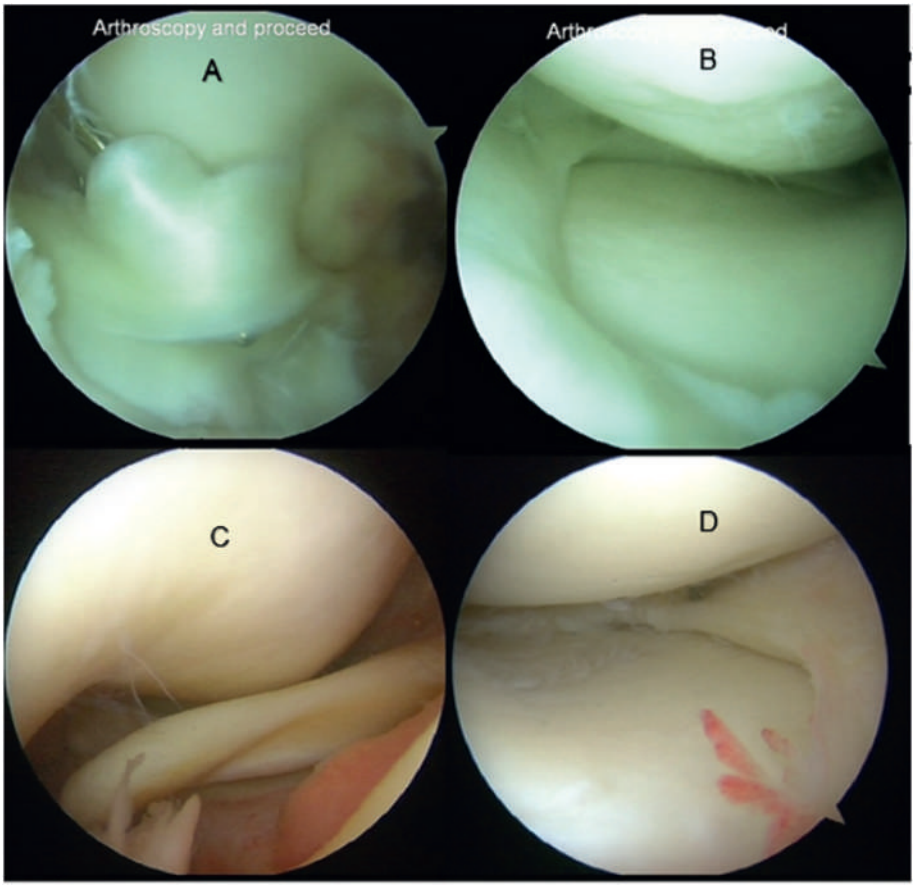

Fig. 2. A: Acute bucket handle tear, B: After reduction and repair, C: Chronic bucket handle tear with meniscus in the intercondylar area, D: After repair.

activity score was obtained and compiled from patients by a single observer at 06, 12 and 18 months along with follow-up clinical examination. The mean follow-up period in our study was 21.5 months with minimum of 18 months in all the cases. A successful outcome of meniscal repair was considered as one in which the patient was asymptomatic, there was no joint line tenderness, had almost full range of movements and was able to return to full, unrestricted active military duty.

3. Statistical analysis

The collected data was entered in Microsoft excel sheet. SPSS Statistics 22.0 was used for carrying out the statistical analysis. Descriptive data has been presented as mean (range). Categorical data has been presented as actual value and percentage. The paired sample *t*-test was used to determine the significance of change in the difference of mean IKDC, Lysholm and Tegner activity scores at 06, 12 and 18 months follow-up. Unpaired T test was used to compare the mean difference of age, injury to repair time and

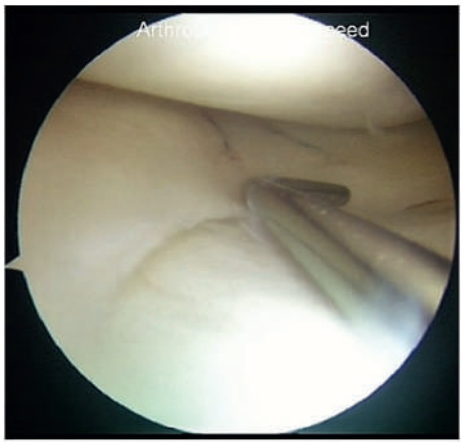

Fig. 3. Bucket handle tear of medial meniscus after suturing with multiple vertical mattress sutures.

number of sutures in the successful and failure subgroups. *P*-value of 0.05 was considered to be statistically significant.

4. Observation and results

The demographic and pre-operative variables are presented in Table 2. Military training activities like cross-country runs, ditch jump and fall while serving in hilly and uneven terrain etc. were second most common cause of meniscal tears in our study. Our study shows a predominance of male subjects consistent with the relative gender distribution of a serving military population.

The findings during arthroscopic evaluation are presented in Table 3.

The follow-up observations and complications observed are presented in Table 4.

The representative photographs of a healed meniscus during re look arthroscopy is presented in Fig. 4. Arthroscopy picture of a failed repair as seen during re-look arthroscopy, Para Meniscal cyst formation over the medial joint line due to irritation by suture material and removal of suture knot with para-meniscal cyst excision is shown in Fig. 5

The scores recorded pre-operatively, at 06, 12 and 18 months post operatively are shown in Table 5.

Various parameters analysed in cases with failed meniscal repair are shown in Table 6.

All the initial 05 patients in whom Prolene suture was used developed subcutaneous para-meniscal cyst around the knot of the suture material due to knot irritation which was noted at around after 04 weeks of surgery when the patients were routinely reviewed during post op follow up visit however functional scores were not recorded at this stage. It was left alone as we felt it was too early to intervene. All of them continued to have persistent discomfort due to the cyst even after 06 months of surgery for which they underwent re-look arthroscopy to look for the status of repaired meniscus and were found to have a healed meniscus on visual inspection and probing. The sub cutaneous sutures were removed in the same sitting and all of them recovered well. Learning from this complication early during the study, the suture

Table 4
Follow up and Complications: Mean period of follow-up 21.5 months (range 18–32 months).

Successful meniscal repair	29 cases (90.6%)
Failed repair	03 (10.4%) Overall
Subcutaneous Para meniscal cyst.	05 (seen in first 05 cases) – all underwent re-look arthroscopy and removal of suture knot.
Failed ACL reconstruction with residual instability	00
Neurovascular injuries	00
Surgical site infection	01
DVT	00

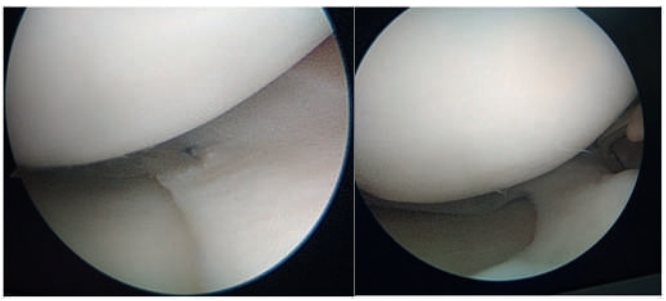

Fig. 4. Re-look arthroscopy showing healed tear and after suture removal.

Table 2
Demographic and pre-operative variables.

Total knees	32
Age/years (range)	Mean 29 years (range 18–43)
Gender (M/F)	Male-29 (90.6%); Female-03 (9.4%)
Laterality	Left – 20 (62.5%); Right –12 (37.5%)
BMI	Mean 21.40 (Range 19–28)
Mechanism of injury	Sports injury - 17 (53.13%)
	Military training and fall in hilly and uneven terrain - 10 (31.25%)
	Road traffic accident - 05 (15.7%)
Injury to repair time (Days)	Overall Mean 82 days (range-03-715)
	In Locked knees (7 patients) 05 days (range 03–08)
	In Non-locked knees (25 patients) 93 days (range 35–715)

Table 3
Arthroscopy findings.

Type of meniscal tear	Bucket handle-08 (25%) Longitudinal-24 (75%)
Concomitant ACL tear	26 (81.25%)
Meniscus only	6 (18.75%)
Number of sutures required for repair	Mean 2.2 (Range 1 to 5, Mode 3)

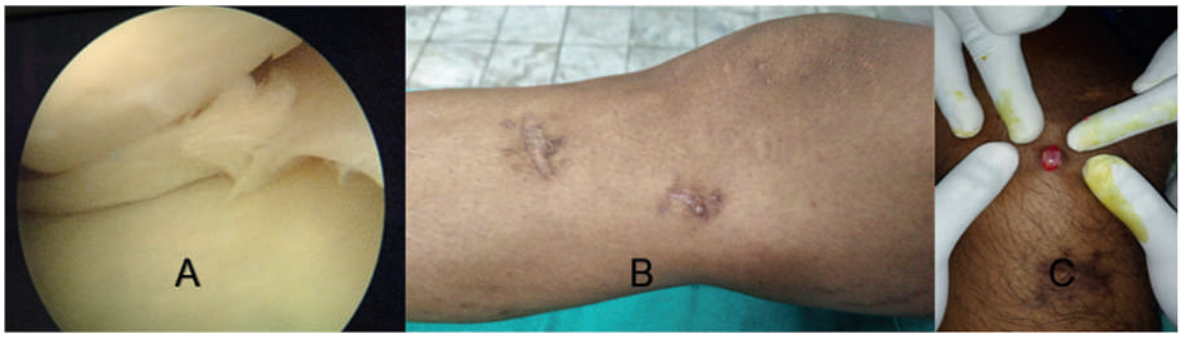

Fig. 5. A: Failed repair as seen during re-look arthroscopy; B: Para Meniscal cyst formation over the medial joint line due to irritation by suture material (Prolene); C: Removal of suture knot and para-meniscal cyst excision.

Table 5
Scoring.

	Lysholm score	IKDC	Tegner activity scale
Pre injury	–	–	6.88
Pre Op	32.84	55.31	1.67
06 months	83.69	88.38	3.84
P value for mean difference of score at 6 months compared to at Pre Op score	p value < .00001[a]	p value < .00001[a]	p value < .00001[a]
12 months	95.34	94.56	6.28
P value for mean difference of score at 12 months compared to at 6 months	p value < .00001[a]	p value < .00001[a]	p value < .00001[a]
18 months	95.91	95.22	6.68
P value for mean difference of score at 18 months compared to at 12 months	p value 0.06223[a]	p value 0.04026[a]	p value 0.02107[a]

[a] By paired T test.

Table 6
Subgroup analysis of successful and failed cases.

	Successful group (n 29)	Failure group (n 03)	p-value
Age	28.5 years	34.7 years	The p-value is .060,881[a]
Type of tear	22 Longitudinal tear repair. 07 Bucket handle tear repair.	02 Longitudinal tear repair. 01 Bucket handle tear repair.	The p-value is .726,226[b]
Injury to Repair time	84.8 days	54.7 days	The p-value is .34,999[a]
Concomitant ACLR	24 with concomittant ACLR. 05 Without ACLR	2 with concomittant ACLR. 1 Without ACLR	The p-value is .496,631[b]
Number of sutures	2.06	3.3	The p-value is .027,194[a]

[a] Unpaired T test.
[b] Chi square test.

material was changed to No. 2.0 Ultrabraid after first five cases and no further occurrence of cyst was observed. 03 subsequent patients after change of suture material who had persistant symptoms and unsatisfactory outcome at 6 months after surgery were also subjected to re-look arthroscopy for a possible failure of repair. All three were detected to be having a failure of repair. 02 had cut out of sutures through the meniscal tissue with extension of tear which was unrepairable for which subtotal meniscectomy was performed and 01 had breakage of suture material but reparable meniscus for which re suturing was performed but was considered as unsuccessful outcome.

No patient in the study had any residual instability during follow up evaluation/any neurovascular compromise or DVT post operatively. 01 patient had superficial surgical site infection, was managed with oral antibiotics and recovered completely without any surgical intervention.

The mean pre-operative Lysholm, IKDC and Tegner activity scores were 32.84, 55.31 and 1.67 respectively. The mean Lysholm, IKDC and Tegner activity scores rose significantly by 6 months post op (p value < 0.00001). Significant improvement in mean scores continued till 12 months post op for all the three scores (p value < 0.00001) compared to those recorded at 6 months. All patients doing well after 1 year after surgery (29 patients) were allowed to resume all the activities including military training, sports and returned to full, unrestricted active duty. There was further marginal improvement at 18 months in the three scores (p value of 0.06223, 0.04026 and 0.02107 respectively in Lysholm, IKDC and Tegner activity scores).

5. Discussion

The overall reported failure rates as per the available literature for meniscal repair by all methods ranged from 3 to 50%.[16,22,27–36] The failure rate of meniscal repair in our study was 3 out of 32 cases (9.4%) till 18 months post op follow-up. 02 out of three failed cases had concomitant ACL tear whereas 01 had a pure medial meniscal injury at the time of surgery. The subgroup failure rate was 7.7% in concomitant ACLR patients and 16.7% in pure meniscal repair patients but this was not statistically significant. The literature is replete with numerous studies with many reporting better healing rates of meniscal repair when done along with concomitant ACLR (possibly due to release of biological factors from tunnelling of bone)[37–41] but a few studies have also reported no difference in healing rates with or without simultaneous ACLR [42,43]

All the failures in our study were after repeat significant injury (02 after fall from two wheeler, 01 after fall from stairs) and there were no cases of atraumatic failure. On analysing and comparing our failed cases (03) with successful cases (29) we did not find any significant difference in the mean age (p-value 0.060881), injury to repair time (p-value 0.34999), repair done with or without concomitant ACL tears (p-value 0.496631) and repairs in longitudinal tears or bucket handle tears (p-value 0.726226). We found significant difference in the average number of sutures in failed compared to successful cases (p-value 0.027194) and since the number of sutures is directly related to the length of the tear our study shows that longer tears are more likely to fail than the shorter ones. Of the 3 failures of repair in our study, one was after repair of bucket handle tear (incidence of 12.5%) and two after repair of longitudinal tears (incidence of of 8.3%). Other previous studies also suggest that bucket handle tears do worse than vertical longitudinal tears after meniscal repair.[54–56]

The most common complication observed in our study was formation of subcutaneous para-meniscal cyst with associated pain and discomfort in all 05 patients (100% incidence) in whom the suture material used was synthetic monofilament nonabsorbable polypropylene. There was no associated failure of meniscal repair as confirmed on second look arthroscopy in all of these patients and all had complete resolution of symptoms on removal of the subcutaneous knot. Nishino et al. Reported occurrence of meniscal cysts in 14 of 102 cases (13.7%). The incidence of meniscal cysts was significantly greater in the AI group (12 of 30, 40%) than in the IO group (1 of 60, 1.7%).[44] The theories proposed about the aetiology of meniscal cyst formation are - traumatic displacement of synovial cells into the meniscus, with mucin production with cystic degeneration of the meniscus,[45] from absorption of synovial fluid through a tear in the articular surface of the meniscus,[46] micro trauma due to insertion of the suture needle causing degenerative change and migration of synovial cells via the meniscal suture hole,[47] interference between anchors resulting in cyst formation.[48] We believe that in our study, this complication was caused due to irritation of surrounding soft tissue by the thick, rigid and sharp suture ends of the knot. This observation was validated by absence of this complication in the next 27 cases where we opted for non-absorbable ultra-high molecular weight (UHMW) polyethylene braided suture (Ultrabraid 2.0) which was softer, more pliable and less irritating to the surrounding soft tissues. Based on this finding we do not recommend the use of monofilament polypropylene suture for repair.

There is no clear guideline as to the density of sutures required for a stable repair. Moatshe G et al. in their study of 60 patients reported good outcome with low failure rates by using a mean of 7 sutures for vertical tears and 11 for bucket handle tears[49] while other studies have not found any significant correlation between suture number or suture type with success and failures of repair.[37,50,51] The mean number of sutures used for repair in our study was 2.2 (Range 1–5) spaced every 8–10 mm which we believe is adequate provided the knee is stable. Residual pivot shift or anteroposterior laxity are the factors that negatively affecting the healing status of the meniscus[52,53] hence it is important to achieve stability of knee especially when there is a concomitant ACL tear.

Acute tears generally have higher healing rates with repair[53] and patients with injury to surgery time >1 year had a significantly higher rate of failure.[54] Gursu, S et al. showed that chronic flipped bucked handle tears also showed good healing rates when operated at a mean period 28 months from injury whether with an accompanying ACL tear or not.[55] 26 out of 32 patients in our study presented to our institution within few days of injury, remaining 06 patients presented to us more than 06 months after their injury (range 7 months to 2 years). Only the ones who presented with locked knees (07 cases) were urgently taken up for arthroscopy (mean injury to surgery time 5 days) whereas all others (25 cases) were taken up for surgery only after a trial of non-operative management. We did not find any difference in healing rates whether operated early of late after the injury as long as the meniscus was found reparable however many cases reporting late may not have a reparable meniscus or have other changes in the articular cartilage and would have been excluded from our study.

We performed repeat arthroscopy only in persistently symptomatic patients as this method is invasive, expensive and therefore hardly accepted by asymptomatic patients. The available literature also supports our contention.[56] Repeat MRI was also not performed in any cases of our cases to document healing as there is enough literature available to support our contention that even completely healed menisci might show frequent grade 3 signals on MRI [56] and that increased signal intensity changes, particularly grade 3 signal intensity, could persist at the repaired site for more than 13 years after repair.[57] Even 3-T MRI does not allow a definitive statement regarding structural meniscus healing.[58] It is well documented that young athletes (whose functional demand is similar to military personnel) demonstrate excellent results and return to sports rate even though MRI alterations are still present.[59]

Lastly we could keep the repair costs reasonable by using braided UHMW Polyethylene suture. We make this statement based on the fact that we could repair all of our menisci with just one or at the most two foils of sutures. The cost of a single AI device (with two implants) from any manufacturer is approximately 10–12 times the cost of a single foil of suture strand. Since the average number of sutures required for adequate repair in our study was 2.2, more than 1 AI device (with two implants) would have been required in almost all cases with proportionate increase in cost. The fact that the results of OI/IO/AI repairs are equivocal with no clear advantage/disadvantage of one technique over the other as regards the outcome,[23] saving the overall cost of surgery by performing inside out/outside in repair is a distinct advantage.

6. Strengths of the study

1. A prospective study.
2. A very exhaustive and tight inclusion and exclusion criteria.
3. Consistent surgical technique by a single experienced surgeon.

7. Limitations of the study

1. The follow up period was relatively short in our study.
2. Small sample size.
3. Satisfactory healing was assumed based on absence of clinical signs and symptoms, however repeat arthroscopy or MRI was not done in all cases to ascertain the same.

8. Conclusions

1. Very high demand young individuals like the military personnel can be sent back to active duty after meniscal repair irrespective the chronicity, length or type of the tear.
2. Outside in/inside out technique of meniscal repair is much more cost effective than using commercially available All inside devices.
3. Tough and unyielding suture material like monofilament Polypropylene should be avoided to avoid soft tissue irritation around the knot. We do not recommend its use.

Declaration of competing interest

The authors hereby declare that they have no conflicts of interest in the authorship and publication of this article.

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Research paper

Predictors of postoperative opioid use in NCAA Division 1 collegiate athletes

Ali Aneizi, Ian J. Wellington, Patrick M.J. Sajak, Dominic J. Ventimiglia, Cameran I. Burt, Jaron Santelli, Valerie E. Cothran, Jonathan D. Packer, R. Frank Henn III *

Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, MD, USA

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ABSTRACT

Background: With the growing severity of the opioid epidemic in the United States, it is increasingly important for surgeons to understand the opioid requirements of their patients, especially in the population of collegiate athletes. The purpose of this study is to determine variables influencing the quantity of total morphine milligram equivalents (TMEs) and percent of prescribed TMEs used following surgery in Division 1 collegiate athletes.

Methods: A consecutive cohort of 25 Division 1 collegiate athletes from one institution undergoing knee or shoulder surgery at a single hospital for sport-related injuries between December 2016 and December 2018 were retrospectively identified. A regional prescription drug monitoring program was used to verify discharge medications. Patients were instructed to bring their unused pills to a follow-up visit 2–4 days after surgery. The amount of opioids prescribed and used was standardized using morphine conversion factors to determine milligram morphine equivalents. TMEs Used was determined by summing the amount of morphine equivalents the patients used of their discharge opioids. The Percent of TMEs Used was determined by dividing the amount of TMEs used by the amount of TMEs prescribed at discharge. Demographic variables and other regulated prescriptions were also recorded. Bivariate and multivariate analyses were used to determine variables that influence and/or predict the amount of TMEs Used and Percent of TMEs Used.

Results: Multivariable regression found that a history of non-analgesic controlled substance use ($p = 0.027$) and the amount of TMEs prescribed at discharge ($p < 0.001$) were both independent predictors of the amount of TMEs Used. Operative site ($p = 0.047$) and number of prior orthopaedic surgeries ($p = 0.016$) were independent predictors of the Percent of TMEs Used.

Conclusions: Providers for Division I collegiate athletes should carefully consider a patient's nonanalgesic controlled substance history, comorbidities, and prescribed opioid burden when planning a postoperative pain management course.

1. Introduction

The opioid epidemic in the United States has become increasingly problematic. Drug overdose has become the leading cause of accidental death in the US, with over 72,000 lethal overdoses in 2017.[1] 49,000 of these deaths were related to opioid overdose, of which 40% were due to prescription opioids. Furthermore, misuse of prescription opioids is associated with heroin use, with approximately 3 in 4 new heroin users reporting recent prescription opioid misuse.[2] Although the prescribing rate of morphine milligram equivalents (MME) per person has decreased by 19% from 2006 to 2017, it remains about 3 times higher than in 1999.[1] Therefore, it has become increasingly important for physicians to exercise caution when prescribing narcotics to their patients. Unfortunately, there is little consensus on proper postoperative narcotic prescribing practice, with wide variability in the quantity of opioids prescribed for even the most common surgical procedures.[3]

* Corresponding author. Department of Orthopaedics, University of Maryland Rehabilitation and Orthopaedic Institute, 2200 Kernan Drive, Baltimore, MD, 21207, USA.
E-mail address: fhenn@som.umaryland.edu (R.F. Henn).

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Efforts have been made to reduce narcotic prescribing habits in physicians, such as the implementation of statewide prescription drug monitoring programs.[4] While these efforts have been effective, it is important for physicians to understand the narcotic needs of the patients in order to avoid over-prescribing. Collegiate athletes self-report lower rates of non-medical prescription opioid use than their non-athlete counterparts, however, there is little data regarding medically indicated narcotic use by college athletes postoperatively.[5] It has previously been shown that high-intensity athletes have a higher pain tolerance when compared to their non-athlete counterparts.[6–8] This may result in a difference in narcotic demand postoperatively in this patient population, and an understanding of their needs would benefit physicians caring for these patients. The aims of this study were to determine what factors influence (1) the total amount of discharge opioids used and (2) the percentage of discharge opioids used in Division 1 collegiate athletes undergoing surgical intervention for sport-related injuries.

2. Methods

This study retrospectively identified a consecutive cohort of Division 1 collegiate athletes from one institution undergoing knee or shoulder surgical intervention at a single hospital for sport-related injuries between December 2016 and December 2018. The data was collected through retrospective chart review. The variables analyzed for this study were age, gender, race, ethnicity, BMI, weight, insurance, sport, ASA score, total comorbidities (heart disease/abnormal EKG; hypertension; lung disease or asthma; liver disease; gastric reflux, hiatal hernia, or stomach ulcers; diabetes; kidney disease, stones, infections; stroke, seizures, paralysis; depression or anxiety, back pain), recreational drug use, preoperative opioid use, and history of non-analgesic controlled substance use.

Patients who returned to campus after surgery were instructed to bring the unused discharge opioid medications to a follow-up appointment with the primary care sports medicine team physician three days postoperatively. If they were still requiring opioids at this visit, they were further counseled about weaning and were instructed to bring their unused pills to the next follow-up appointment in 2–4 days. Once they were no longer requiring opioids, any unused pills were counted and then destroyed. The students-athletes also followed up with the orthopaedic surgeon, but the orthopaedic surgeon did not count or destroy pills.

The amount of opioid medication prescribed and used was standardized using morphine conversion factors to determine milligram morphine equivalents. Total morphine equivalents (TMEs) used was determined by summing the amount of morphine equivalents the patients used of their discharge opioid following their surgical procedure. The percentage of TMEs used was determined by dividing the amount of TMEs used by the amount of TMEs prescribed for each patient at the time of discharge. All opioid data found in the patients' medical records were confirmed using the Chesapeake Regional Information System for our Patients (CRISP); a regional prescription drug-monitoring program. Other non-analgesic regulated prescriptions such as codeine-based cough suppressants and stimulants were also recorded.

A total of 39 collegiate athletes were identified who underwent surgery during this time period. Twenty-five of the 39 athletes had postoperative pill counts available for analysis. It is common for collegiate athletes to have non-urgent orthopaedic surgery during winter and summer break, and those athletes frequently return home after surgery and discard their pills as soon as they are no longer required. The 14 athletes who did not have postoperative pill counts were compared to those that did have their pills counted based on age, gender, race, sport, weight, BMI, operative site, laterality, number of concomitant procedures, number of total comorbidities, ASA score, number of prior knee surgeries, number of prior orthopaedic surgeries, number of prior surgeries on the operative joint, preoperative total morphine equivalents, recreational drug use, preoperative opioid use, use of other controlled substance, time to follow-up, and TMEs at discharge. Only two significant differences ($p < 0.05$) were identified. Patients who did not have their pills counted received significantly more TMEs at discharge than patients who did have their pills counted (mean 402 TMEs versus 251 TMEs, $p = 0.030$), and all but one of the patients who did not have their pills counted only followed up with the orthopaedic surgeon at a significantly longer time to first follow-up (mean 5.8 days versus 3.4 days, $p = 0.030$).

2.1. Statistical analyses

Categorical variables were evaluated with Wilcoxon Rank Sum and Pearson Chi-squared tests to determine variables that influence the amount of TMEs Used and Percent of TMEs Used postoperatively. Spearman's correlation coefficient was used to measure associations with continuous variables. Statistical significance was set as $p < 0.05$. Finally, multivariable modeling using backwards, stepwise, regression was used to identify independent predictors for both TMEs Used postoperatively and Percent of TMEs Used postoperatively. The three variables with the smallest p-values in bivariate analysis ($p < 0.05$) were entered into the models. All statistical analyses were carried out using JMP 14 statistical software (SAS institute, Cary, North Carolina).

3. Results

The perioperative data for each of the 25 athletes is shown in Table 1. Pills were counted an average of 3.4 days postoperative with a standard deviation of 0.9 days. Of the categorical variables evaluated (Table 2), patients who had a history of using non-analgesic controlled substance used significantly more TMEs per day (69 ± 47 vs 29 ± 24, $p = 0.020$) and total TMEs (239 ± 146 vs 100 ± 97, $p = 0.016$) than patients without a history of non-analgesic controlled substance use. Patients with an ASA score of 1 used more TMEs per day and total TMEs than those with an ASA score of 2 ($p = 0.034$ and $p = 0.049$, respectively).

Of the continuous variables evaluated, only TMEs prescribed at discharge showed a significant relationship with TMEs Used per Day postoperatively (Table 3). Patients with a greater amount of TMEs prescribed at discharge following their operative procedure took a significantly greater amount of TMEs postoperatively ($p \leq 0.0001$). None of the other continuous variables analyzed showed any significant correlation with TMEs Used per Day postoperatively.

Analysis of the relationship between categorical variables and Percent of TMEs Used per Day postoperatively showed that prior surgery on the operative joint, operative site, and a history of non-analgesic controlled substance use were all significantly correlated with an increased Percent of TMEs Used (Table 2). Patients undergoing knee surgery had a significantly lower Percent of TMEs Used of their postoperative opioid medication compared to those undergoing shoulder surgery (46 ± 26 vs 85 ± 21, $p = 0.005$). However, patients who underwent knee surgery were not prescribed a significantly different amount of opioids at discharge when compared to patients undergoing shoulder surgery (253 ± 206 vs 244 ± 150, $p = 0.64$). Finally, patients with a history of non-analgesic controlled substance use were found to have a greater Percent of TMEs Used postoperatively when compared to those without a history of controlled substance use (77 ± 24 vs 45 ± 27, $p = 0.020$).

Table 1
Patient data.

	Age	Gender	Sport	Regional Anesthesia	Procedure	Total TMEs Used	Percent TMEs Used	TMEs per Day	Refill
1	22.3	M	Football	Interscalene single	Arthroscopic shoulder SLAP repair (29807)	487.5	100	162.5	Yes
2	20.8	F	Gymnastics	Femoral catheter	Arthroscopic knee osteochondral allograft (29867), tibial osteotomy (27455)	360	40	90	Yes
3	23.8	M	Football	Femoral single	Arthroscopic knee osteochondral allograft (29867)	22.5	20	7.5	No
4	19.2	M	Football	None	Arthroscopic meniscus repair (29882), abrasion arthroplasty (29879)	75	50	25	No
5	20.3	M	Soccer	Femoral single	Open knee osteochondral allograft (27415), open capsule repair (27405) arthroscopic meniscus repair (29882)	165	78.6	41.3	No
6	20.1	M	Wrestling	Interscalene single	Arthroscopic shoulder capsulorrhaphy (29806), Mumford procedure (29824), subacromial decompression (29826)	345	92	86.3	No
7	21.7	F	Soccer	Femoral catheter	ACL reconstruction (29888)	180	48	13.8	No
8	20.9	M	Football	Femoral single	ACL reconstruction (29888), meniscus Repair (29882)	375	78.1	125	Yes
9	19.5	M	Football	None	Arthroscopic meniscectomy (29881)	22.5	30	22.5	No
10	22.0	F	Soccer	Femoral single	Arthroscopic knee abrasion arthroplasty (29879), lateral release (29873)	225	71.4	75	Yes
11	22.6	M	Football	Femoral single	Arthroscopic knee osteochondral allograft (29867)	150	40	50	No
12	23.2	M	Lacrosse	Femoral single	Arthroscopic knee synovectomy (29876), loose body removal (29874)	85	85	28.3	No
13	20.4	M	Lacrosse	Femoral catheter	ACL reconstruction (29888), medial and lateral meniscal repair (29883)	247.5	47.1	61.9	No
14	22.0	M	Football	Femoral single	Open knee osteochondral allograft (27415)	30	13.3	10	No
15	19.4	M	Football	Femoral catheter	ACL reconstruction (29888), meniscus repair (29882)	135	90	45	No
16	23.5	M	Wrestling	Interscalene single	Coracoid process transfer (23462), Open treatment glenoid fracture (23585)	150	100	37.5	Yes
17	19.9	M	Football	Interscalene single w/Exparel	Coracoid process transfer (23462), Open treatment glenoid fracture (23585)	135	90	45	No
18	22.8	F	Lacrosse	None	Arthroscopic knee loose body removal (29874), synovectomy (29875)	15	10	5	No
19	20.2	F	Lacrosse	None	Arthroscopic knee meniscectomy (29881), synovectomy (29876)	45	45	11.25	No
20	19.8	M	Football	Femoral catheter	Arthroscopic knee meniscus repair (29882), abrasion arthroplasty (29879)	0	0	0	No
21	20.8	M	Baseball	Interscalene single w/Exparel	Arthroscopic shoulder SLAP repair (29807), Biceps tenodesis (29828)	127.5	85	42.5	Yes
22	19.8	M	Track & Field	PEC 1,2 Serratus Single	Open pectoralis major repair (23410)	67.5	45	33.8	No
23	18.4	F	Softball	Femoral catheter	ACL reconstruction (29888)	37.5	25	7.5	No
24	19.3	M	Football	None	Arthroscopic meniscectomy (29881), synovectomy (29876)	60	53.3	15	No
25	18.6	F	Lacrosse	Femoral single	Arthroscopic knee synovectomy (29876)	75	50	25	No

Of the continuous variables analyzed, total comorbidities, number of prior knee surgeries, number of prior surgeries on operative joint, and number of prior orthopaedic surgeries were all significantly associated with the Percent of TMEs Used postoperatively (Table 3). A greater number of comorbidities in patients was correlated with a smaller Percent of TMEs Used postoperatively ($p = 0.032$). A greater number of prior knee surgeries, number of prior surgeries on the operative joint, and number of prior orthopaedic surgeries in a patient were associated with a lower Percent of TMEs Used postoperatively ($p = 0.008$, $p = 0.031$, $p = 0.005$, respectively).

Multivariable regression modeling was used to evaluate independent predictors of postoperative TMEs Used. A history of non-analgesic controlled substance use ($p = 0.027$) and amount of TMEs prescribed at discharge ($p < 0.001$) were significant independent predictors of TMEs Used (Table 4A). A history of non-analgesic controlled substance use and the amount of TMEs prescribed at discharge were also significant independent predictors of TME Used per Day ($p = 0.038$ and $p < 0.001$, respectively) (Table 4b). Multivariable regression modeling also showed that operative site ($p = 0.047$) and number of prior orthopaedic surgeries ($p = 0.016$) were significant independent predictors of the percent of prescribed TMEs used postoperatively (Table 4c).

4. Discussion

Injuries that require operative management commonly occur in high-level athletes. It is critical that the surgeons who perform these procedures are able to prescribe appropriate postoperative pain control while limiting a patient's opioid burden, particularly in student-athletes. The goal of this study was to determine factors that influence opioid use in college athletes following surgical intervention for sport-related injuries. A history of non-analgesic controlled substance use and the amount of TMEs prescribed at discharge were both found to be significantly related to the amount of discharge TMEs used postoperatively. Multivariable regression modeling supported that both of these variables were significant independent predictors for TMEs Used per Day and overall. It may be expected that an increased amount of TMEs prescribed at discharge would be significantly correlated with an increased amount of TMEs used, as described by Howard et al.[9] The amount of TMEs prescribed is decided by the patient's surgeon, based on their estimation of a patient's postoperative opioid need, or by predetermined protocol. The amount of opioids used after surgery is often influenced by factors such as type of procedure, severity of initial injury, complexity of surgical intervention, and expected patient opioid tolerance.[10–13] The correlation between TMEs prescribed and TMEs used may reflect the accurate judgement on the part of the surgeon in predicting a patient's postoperative opioid need. It may also suggest that patients will take a certain percentage of their opioids regardless of the amount prescribed. However, further research is needed to better elucidate this relationship.

A history of non-analgesic controlled substance use was related to an increase in TMEs used postoperatively. A majority of these substances were codeine-based cough suppressants. As codeine is an opioid, the patients who had previously taken these medications would not be opioid naïve. It is possible that the prior opioid exposure would lead these patients to have a slightly higher opioid tolerance and thus a greater need for analgesic opioids postoperatively. However, to date, there have been no studies linking short term opioid-based cough suppressant use with future increased opioid use or tolerance. A smaller portion of the non-analgesic controlled substances used in this patient population were psychostimulant medications for the treatment of ADHD such as dextroamphetamine, methylphenidate, or lisdexamfetamine.

Table 2
Analysis of total morphine equivalents used and % total morphine equivalents used by categorical patient demographic variables in college athletes.

	N	Mean TMEs Used (SD)	P value	Mean % TMEs Used (SD)	P value	Mean TMEs Used Per Day (SD)	P value
Gender **(n=25)**							
Male	18	149 (134)	0.856	61 (32)	0.130	43 (39)	0.694
Female	7	134 (127)		41 (20)		37 (34)	
ASA **(n=25)**							
ASA 1	18	168 (130)	0.049+	61 (29)	0.289	49 (38)	0.034+
ASA 2	7	84 (118)		42 (29)		22 (29)	
Race **(n=25)**							
Black	9	123 (117)	0.226	53 (29)	0.583	36 (31)	0.509
White	13	187 (147)		60 (30)		52 (45)	
Other	3	176 (147)		43 (43)		25 (22)	
Prior Surgery on Operative Joint **(n=25)**							
Prior Surgery on OP Joint	6	86 (85)	0.203	34 (24)		29 (28)	0.308
No Prior Surgery on OP Joint	19	163 (138)		62 (29)	0.045+	46 (39)	
Prior Orthopaedic Surgery[a] **(n=25)**							
Prior Ortho Surgery	11	128 (137)	0.298	40 (30)		37 (36)	0.528
No Prior Ortho Surgery	14	158 (127)		67 (25)	0.017+	45 (39)	
Sport **(n=25)**							
Baseball	1	127	0.373	85	0.352	43 (–)	0.440
Football	11	136 (157)		51 (34)		41 (48)	
Gymnastics	1	360		40		90 (–)	
Lacrosse	5	94 (90)		47 (27)		26 (22)	
Soccer	3	190 (31)		66 (16)		54 (18)	
Softball	1	38		25		8 (–)	
Track and Field	1	68		45		34 (–)	
Wrestling	2	248 (138)		96 (6)		62 (34)	
Operative Site **(n=25)**							
Knee	19	121 (113)	0.171	46 (26)	0.005+	33 (29)	0.069
Shoulder	6	219 (162)		85 (21)		68 (50)	
Laterality **(n=25)**							
Left	12	149 (128)	0.807	51 (26)		40 (32)	0.913
Right	13	141 (137)		59 (33)	0.399	43 (43)	
Current recreational drug use **(n=20)**							
Yes	3	213 (116)	0.397	85 (7)	0.152	57 (26)	.397
No	17	147 (142)		54 (33)		43 (42)	
Preoperative opioid use **(n=25)**							
Yes	13	137 (127)	0.683	45 (25)	0.047	38 (33)	0.849
No	12	145 (136)		67 (32)		45 (43)	
Other Controlled Substance Use **(n=25)**							
Yes	8	239 (146)	0.016+	77 (24)	0.020+	69 (47)	0.020+
No	17	100 (97)		45 (27)		29 (24)	
Regional Anesthesia **(n=25)**							
Yes	20	170 (133)	0.023+	60 (31)	0.208	49 (38)	0.021+
No	5	44 (25)		38 (18)		13 (8)	
Type of Regional Anesthesia **(n=25)**							
Femoral Single Shot	8	141 (117)	0.13	56 (28)	0.040+	41 (31)	0.157
Femoral Nerve Catheter	6	160 (134)		42 (30)		40 (34)	
Interscalene Single Shot	3	328 (169)		97 (4.6)		95 (63)	
Interscalene Single Shot w Exparel	2	131 (5)		88 (4)		44 (2)	
PEC 1,2 Serratus Single Shot	1	68 (–)		45 (–)		34 (–)	
None	5	44 (25)		38 (18)		13 (8)	

+Significance determined as p-value < 0.05. ASA: American Society of Anesthesiologists.
[a] All prior orthopaedic surgeries were knee surgeries.

Table 3
Baseline Demographics vs Discharge Total Morphine Equivalents Used and % Total Morphine Equivalents Used.

		Total TMEs Used		% TMEs Used		TMEs Used per Day	
	Mean Score (±SD)	Spearman's ρ*	P value	Spearman's ρ*	P value	Spearman's ρ*	P value
Age	20.9 (1.56)	0.22	0.288	0.05	0.799	0.24	0.241
BMI	27.8 (5.67)	−0.03	0.891	0.05	0.819	0.09	0.674
Weight (kg)	92.1 (28.2)	−0.03	0.890	0.08	0.694	0.10	0.645
Total Concomitant Procedures	2.52 (1.16)	0.23	0.276	0.28	0.176	0.21	0.326
Total Comorbidities	0.16 (0.47)	−0.13	0.546	−0.43	**0.032**	−0.16	0.446
Number Prior Knee Surgeries	0.56 (0.87)	−0.26	0.210	−0.52	**0.008**	−0.18	0.388
Number Prior Surgery on OP Joint	0.28 (0.54)	−0.29	0.162	−0.43	**0.031**	−0.24	0.250
Number Prior Ortho Surgeries	0.64 (0.99)	−0.29	0.163	−0.54	**0.005**	−0.21	0.317
TMEs Taken Preoperatively	371 (506)	−0.09	0.654	−0.37	0.072	−0.02	0.920
TMEs Prescribed at Discharge	251 (191)	0.77	**<.0001**	0.15	0.480	0.77	**<0.0001**

*ρ, Spearman's rank correlation coefficient. **BMI:** Body Mass Index, kg/m.^{2} **TME:** Total Morphine Equivalents. p-value < 0.05 are in bold font.

Table 4A
Multivariable regression model of discharge TMEs used (Adjusted R-squared = 0.69).

Variable	Estimate	Std Error	t Ratio	p-value
Other Controlled Substances [0]	−38.70	16.32	−2.37	**0.027**
TMEs Prescribed at Discharge	0.46	0.09	5.27	**<0.001**
Regional Anesthesia [0]	−19.56	19.34	−1.01	0.323

Table 4b
Multivariable regression model of discharge TMEs used per day (Adjusted R-squared = 0.59).

Variable	Estimate	Std Error	t Ratio	p-value
Other Controlled Substances [0]	−11.97	5.41	−2.21	**0.038**
TMEs Prescribed at Discharge	0.11	0.03	3.97	**<0.001**
Regional Anesthesia [0]	−6.78	6.41	−1.06	0.302

TME: Total Morphine Equivalent, **Sx:** Surgeries. Significance determined at $p < 0.05$.

Table 4C
Multivariable regression model of % discharge TMEs used (Adjusted R-squared = 0.50).

Variable	Estimate	Std Error	t Ratio	p-value
Operative Site [Knee]	−11.79	5.58	−2.11	**0.047**
Other Controlled Substances [0]	−9.09	5.00	−1.82	0.084
Number of Prior Orthopaedic Sx	−11.89	4.52	−2.63	**0.016**

These medications have been shown to correlate with a greater amount of narcotic use in patients due to an increase in patient alertness.[14] This is important as both medically indicated and illicit psychostimulant use has become increasingly common amongst college age students.[15] Thus, a thorough assessment of a patient's medications and social history are important when determining the opiate needs of a college athlete postoperatively. Another explanation for these findings is that athletes who are averse to taking any type of medication are also less likely to take postoperative medications, including opioids.

While understanding the factors that influence the total amount of TMEs taken following surgical intervention in this patient population is important, understanding what factors influence the percent of the prescribed TMEs taken may be of greater value. It is these factors that would indicate whether a surgeon should prescribe a lesser or greater amount of postoperative opioids than they normally would for a similar procedure in a similar patient. A study that investigated opioid use after knee arthroscopy in adolescents reported that patients used 32.4% of the postoperative opioids prescribed to them, which is similar to our finding of 46% of TMEs in knee surgery patients.[16] In bivariate analysis, patients undergoing shoulder surgery used a significantly higher percentage of their discharge opioids than patients undergoing knee surgery. This is most likely explained by the pain associated with the shoulder procedures performed in this cohort (three arthroscopic SLAP repairs, two coracoid process transfers, and one distal clavicle excision).[17,18] However, since both the knee and shoulder surgery patients received similar amounts of opioids at discharge, this finding could indicate that we as prescribers may be overestimating opioid requirements in athletes undergoing knee surgery.

The number of prior orthopaedic surgeries was an independent predictor of the percent of Prescribed TMEs Used. Patients who had more prior surgeries used a lower percentage of their prescribed medications. This could mean that patients who have had prior surgeries are more familiar with the quantity of opioids that they need to manage their pain and are more experienced with non-opioid pain management strategies such as cryotherapy. Thus, they use significantly less than the amount prescribed to them. Patients with a greater number of total comorbidities were more likely to use a smaller percentage of TMEs Used postoperatively when compared to patients with fewer total comorbidities. This contrasts with two studies of older patients undergoing total knee replacement and shoulder surgery that found patients with more comorbidities tend to use more opioids postoperatively.[19,20] Our cohort of young, high-level athletes is likely to have a different comorbidity profile than those studies. While the correlation was initially surprising, a history of these conditions in these patients may make them more concerned about medication interactions or more tolerant of pain, and thus reduce their use of opioid pain medication postoperatively. Similarly, it has been shown that athletes have higher pain tolerance than non-athletes,[7] so they may able to cope with their comorbidities better than the general population.

Regional anesthesia has been shown to decrease the amount of opioid consumption after surgery, and femoral nerve catheters have been shown to provide more analgesia than single shot femoral nerve blocks after ACL reconstruction.[21] Consequently, the utilization of regional anesthesia for most of the patients in this study likely decreased opioid utilization in our patients and should be considered when comparing these results to future studies.

This study has all of the inherent limitations of a retrospective chart review. While it was limited to 25 athletes, the sample size was large enough to identify several important statistically significant relationships. A potential weakness of the study is the lack of postoperative pill consumption data in 14 of the 39 athletes. Patients who did not have their pills counted were prescribed more TMEs at discharge and had later follow-up appointments compared to patients who had their pills counted. These differences can likely be attributed to their surgeons providing these patients more pain medication at discharge so that the medication would last until their later visit. Student-athletes frequently travel home for the initial postoperative period, and therefore would not be present on campus to return their pills. This is particularly common over school breaks and holiday weekends, when students-athletes are more likely to have elective surgery to minimize disruption to classes. Although contacting these athletes about postoperative opioid use was a potential option, this was not part of our protocol and it is probable that self-reported postoperative TMEs used would be less accurate. Our cohort consisted of a heterogeneous set of procedures, and allowed for comparisons between patients undergoing knee surgery and patients undergoing shoulder surgery. However, future studies may benefit from looking at one specific procedure in student athletes to help establish postoperative pain management guidelines for that procedure. Additionally, patients could have returned fewer opioids than they actually used, which would cause us to overestimate their opioid usage. Nevertheless, this study provides valuable information to the sports medicine specialists caring for these student athletes in the perioperative period. Future studies are needed to optimize postoperative pain management for Division 1 collegiate athletes.

Credit author statement

Ali Aneizi, Methodology, Software, Validation, Formal analysis, Data curation, Writing - original draft. Ian Wellington, Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - original draft. Patrick MJ Sajak, Software, Investigation, Data curation, Project administration, Dominic Ventimiglia, Software, Investigation, Data curation. Cameran Burt, Software, Investigation, Data curation. Jaron Santelli, Supervision, Resources. Valerie E. Cothran, Conceptualization, Supervision, Resources. Jonathan D. Packer, Supervision, Project administration, Writing - review & editing. R. Frank Henn, Conceptualization, Supervision,

Project administration, Writing - review & editing.

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Approval

This study was approved by the Institutional Review Board (IRB) Committee at the University of Maryland, Baltimore.

Declaration of competing interest

None. Each of the named authors have no conflict of interests to report, financial or otherwise

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Research paper

Arthroscopic reconstruction of acute acromioclavicular joint disruption using dog-bone button construct: A prospective study

Yashavantha Kumar C [a, *], P. Rahul [a], Srinivas B S Kambhampati [b], Singh Vanchit [a]

[a] Ramaih Medical College, Bangalore, India
[b] Sri Dhaatri 23, Lane 2, SKDGOC, Vijayawada, Andhra Pradesh, -531127, India

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ABSTRACT

Introduction: Injuries to the acromioclavicular joint (AC) are not uncommon accounting for 9% of all shoulder injuries. Surgical management is the mainstay of treatment in severe injuries. Numerous surgical techniques have been described in the literature with variable results. Arthroscopic stabilization using a suspensory fixation is one of the most commonly performed procedure. Current study was done to evaluate the functional and radiological results of arthroscopic acromioclavicular joint reconstruction using dog bone button, a special type of suspensory fixation.

Materials and methods: Our study included 14 cases of Rockwood type III and V acute AC joint disruptions. A thorough clinico-radiological evaluation was done preoperatively including a Zanca view and compared with the contralateral side. All patients underwent arthroscopic acromioclavicular joint reconstruction using dog bone button. Radiological and functional results were studied during follow up at 6 weeks, 3 months and 6 months. Functional results were assessed using DASH (Disabilities of the Arm, Shoulder and Hand) score.

Results: The mean pre-operative coracoclavicular (CC) distance was 16.11 mm with SD ± 1.94 and mean post-operative CC distance was 10.76 mm with SD of ±2.76. Mean DASH scores during follow up were 60, 9.71 and 0.36 at 6 weeks, 3 months and 6 months respectively. There was a significant difference in the pre and post-operative CC distance and DASH t scores ($P < 0.001$).

Conclusion: Our study results infer that arthroscopic AC joint reconstruction using dog bone button construct in acute cases provides good functional and radiological results. No significant postoperative complications were associated with the same procedure.

1. Introduction

Acromioclavicular (AC) joint injuries are one of the common shoulder problems, accounting for about 9% of all shoulder injuries.[1–3] Most of these patients are active, young, athletic requiring accurate treatment resulting in good functional outcome. While milder grades of AC joint disruptions of Rockwood Grade I and grade II can be managed conservatively, severe injuries of Grades (IV, V and VI) require surgical intervention. Many surgical techniques have been described in the literature with variable results.[4–6] More than 162 techniques for reconstruction of the ACJ have been described in the literature,[7] indicating no gold standard in the management of this injury. Arthroscopic suspensory fixations have been favored over open surgeries.[8,9] Dog Bone button was specifically developed for reconstructing the ACJ. The shape of the button gives good surface contact on clavicle and under the surface of the coracoid. To the best of our knowledge, there are no similar studies in the current literature looking at the results of fixation using this implant. Our study evaluates functional and radiological results of acute acromioclavicular joint disruptions treated by arthroscopic dog bone button fixation.

2. Materials and Methods

This study included patients with acute acromioclavicular disruption during the period 1 April 2017 to 28th Feb 2019 at a tertiary care hospital.

Informed consent was obtained from patients for the study and

* Corresponding author.
E-mail address: kumyashwanth@gmail.com (Y.K. C).

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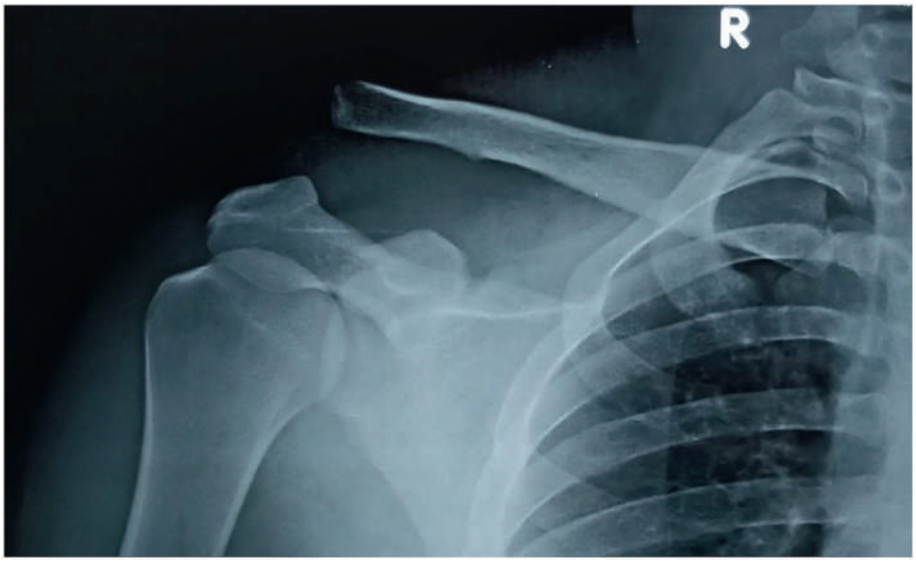

Fig. 1. Right shoulder Zanca View radiograph showing AC joint disruption Rockwood type V.

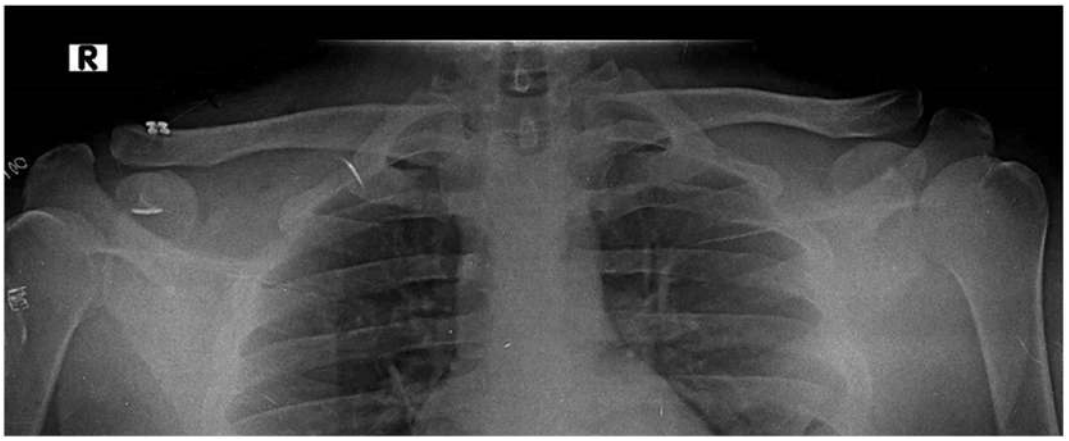

Fig. 2. Bilateral shoulder Zanca view radiograph after Dog Bone button fixation.

the study was done according to the guidelines laid down at the Declaration of Helsinki. Institute ethical board clearance was taken prior to the start of the study. We included all type III and V injuries in this study. All the included injuries were acute and less than two weeks old. Patients associated with upper limb fractures, previous shoulder surgeries and Rockwood type IV and type VI disruptions were excluded.

A thorough clinico-radiological evaluation was done preoperatively including Zanca View (Fig. 1). The Zanca view was performed with the patient's arm hanging down with the X-ray beam tilted upward 10° and source was placed on the back of both shoulders. Coracoclavicular distance measured between the superior cortex of the coracoid process and the undersurface of the clavicle. A normal CC distance is between 10 and 13 mm and greater than 5 mm difference compared to normal side is considered as coracoclavicular ligament disruption.[10,11]

Under general anaesthesia combined with interscalene block, the patient was positioned in a beach chair position. Diagnostic arthroscopy was performed through a standard posterior portal to rule out associated injuries and pathologies. An anterior portal made lateral to coracoid by outside-in technique. Coracoid was

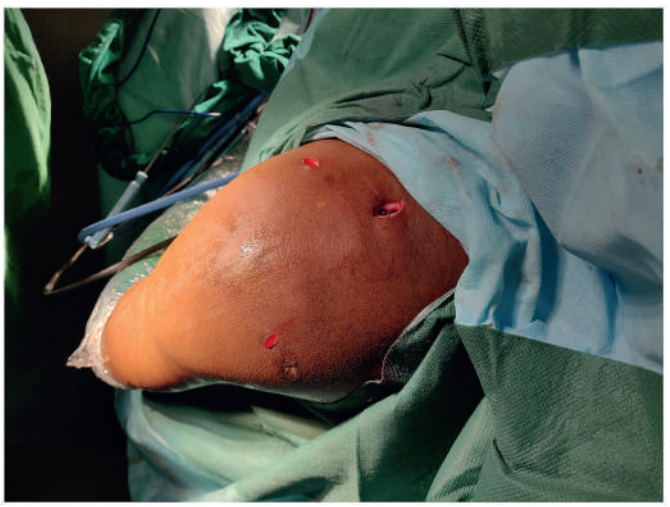

Fig. 3. Clinical image showing three portals.

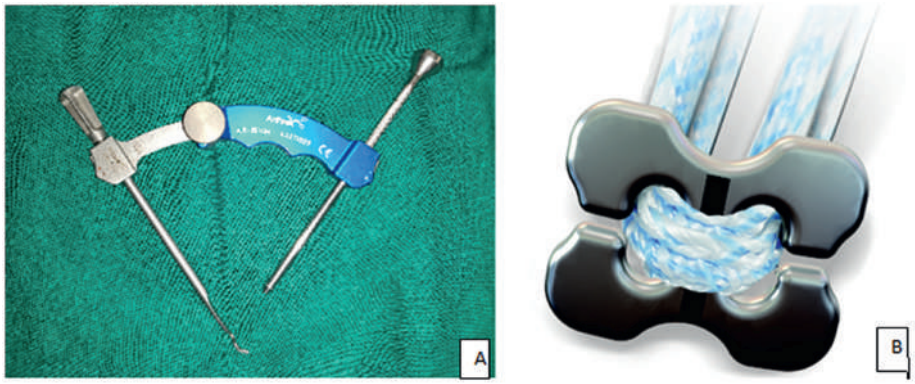

Fig. 4. AC joint reconstruction jig & dog bone button with fiber wire.

exposed through the rotator interval. AC joint reconstruction jig (Fig. 4) was placed through an anterior portal and a beath pin passed from clavicle 30 mm medial to the lateral end of the clavicle (Fig. 5). Over the beath pin, a 3 mm tunnel was drilled. A fibre tape was delivered through the anterior portal and retrieved on to clavicle and fixed with a dog-bone button (Arthrex, Inc.,Naples, Florida). After placing dog-bone buttons over the clavicle and on the undersurface of the coracoid, AC joint was reduced and the fibre tape tightened and locked (Fig. 6).

Postoperatively, the patient was placed on shoulder immobilizer for two weeks. At two weeks, shoulder immobilizer was discontinued and mobilization of shoulder started on pendulum and range of motion exercises by physiotherapist. Functional and radiological assessment was done using DASH score and Zanca view of shoulder respectively at 6 weeks, 3 months and 6 months (Fig. 2). The surgery and scoring at each follow up was done by the same surgical team (5).

Statistical tests were done using SPSS 21.0 version for windows. The paired *t*-test was used for comparing the difference in means at two points of time for the same group.

3. Results

Our study included 14 cases of Rockwood type III and V acute AC joint disruptions. Table 1 gives details of all patients.

The Patient demographics are shown in Table 2. The injuries were seen predominantly in males (12/14) and on Right side (10/14). Ten of the inuries occurred on the dominant side and four on non-dominant side. Road Traffic Accident (RTA) was the most common mode of injury (10/14). Other modes of injury were Fall (2/

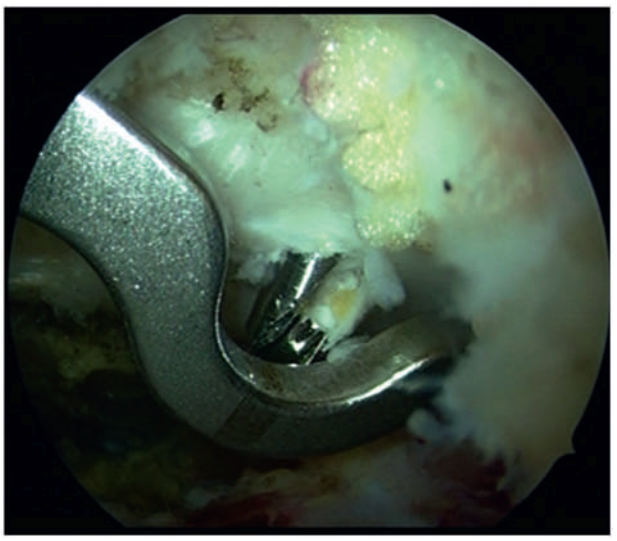

Fig. 5. Arthroscopic image showing passing of beath pin through jig.

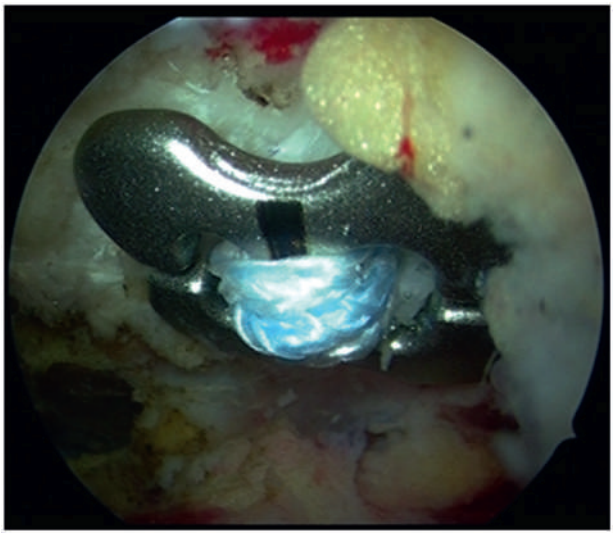

Fig. 6. Arthroscopic image showing dog bone button under coracoid.

Table 1
General characteristics of patients with AC Joint dislocation.

Sl No.	Age (Years)	Injury Side	Injury Mechanism	Dislocation grade
1	21	Right	RTA	III
2	26	Right	RTA	V
3	22	Right	RTA	III
4	36	Left	RTA	III
5	34	Right	RTA	III
6	30	Left	RTA	V
7	18	Right	SPORTS	III
8	55	Right	RTS	V
9	32	Left	SPORTS	III
10	27	Right	RTA	III
11	32	Left	RTA	V
12	21	Right	RTA	V
13	29	Right	RTA	V
14	33	Right	RTA	III

Table 2
Patient demographics.

Number of Patients in study	14
Age:	Mean 29.71 yrs (18–55)
Male: Female	12 (85.7%): 2 (14.3%)
Right: Left	10 (71.4%): 4 (28.6%)
Dominant: Non-Dominant	10:4
Mechanism of injury	RTA – 10 (71.4%)
	Fall – 2 (14.3%)
	Sports Injury – 2 (14.3%)

Table 3
DASH Scores during follow up $P < 0.0001$.

	Mean	Standard Deviation
DASH Score at 6 wks	60.00	4.91
DASH Score at 3 months	9.71	3.45
DASH Score at 6 months	.36	.74

14) and Sports injuries (2/14) (One person was a cricketer and the other was a volleyball player).

Acromioclavicular dislocation grade was III for 11 cases (78.6%) and grade V for 3 cases (21.4%). The mean time from injury to surgery was 3.8 ± 1.4 days (range: 2–12 days).

The mean pre-operative coracoclavicular (CC) distance was 16.11 mm with SD $\pm$ 1.94 and mean post-operative CC distance was 10.76 mm with SD of $\pm$2.76.

Mean DASH scores during follow up were 60, 9.71 and 0.36 at 6 weeks, 3 months and 6 months respectively as shown in Table 3.

There was a significant difference in the pre and post-operative CC distance (P value < 0.0001) and DASH t scores ($P < 0.0001$).

In one of the patients, CC distance was 1.5 mm postoperatively but he neither had deformity nor any symptoms. No secondary surgery was required.

4. Discussion

Acromioclavicular joint injuries are one of the common shoulder injuries in clinical practice.[1–3] The debate on the best form of treatment of grade 3 injuries continues to evolve.[4–6] A plethora of surgical techniques have been described in the literature for the treatment of AC joint disruptions but none of them is considered gold standard. Currently, arthroscopic fixation is preferred to reduce postoperative morbidity.[12–15]

Anatomic and non-anatomic fixation techniques have been described for surgical management of higher-grade injuries. Anatomical techniques are favored more than the non-anatomic techniques due to the superior biomechanics of anatomic techniques.[16] The goal of treatment of these injuries is anatomical reduction with a stable and functional joint. The commonly preferred procedures are modified Weaver Dunn procedure, autograft reconstruction and suspensory fixation.[7,17–20] All these procedures can be performed as open or arthroscopic procedures.

The rationale of performing arthroscopic suspensory fixation in acute AC joint disruptions is to reduce the joint anatomically so that native coracoclavicular ligaments heal.[8,9,12,13,21] This technique precludes the need for an autograft and its associated donor site morbidity.

In our study we have included Rockwood type III & V ACJ disruptions, as we could do all arthroscopic reconstruction. In Rockwood type IV and type VI open reduction is required as there is displacement into trapezius and inferior to coracoid respectively.

Primary repair of ruptured coracoclavicular ligaments has been described for acute injures which are less than 2 weeks old.[8,22,23] This procedure is done by open technique where an associated deltoid and trapezius sleeve avulsion are also taken care of. The problems associated with this technique are difficult surgical access and a large, prominent scar.

Advances in arthroscopic instrumentation and implants have tilted the balance towards arthroscopic fixation of these injuries.

Fig. 7. Clinical image after 6 months.

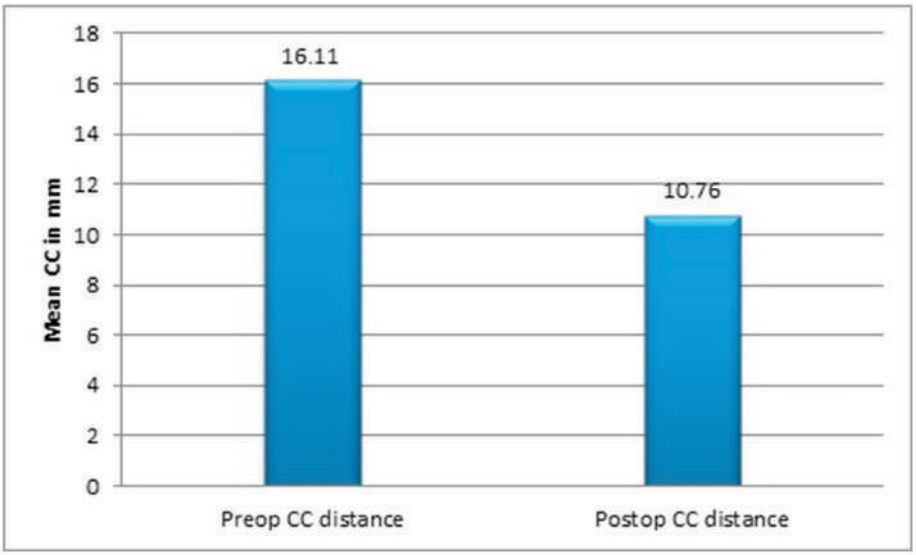

Fig. 8. Preoperative and postoperative coracoclavicular distance.

Advantages of arthroscopic techniques like less soft tissue injury, less blood loss, cosmetic scars, early discharge and possibility of performing as day care procedures with resultant savings in hospitalization costs have been well documented in the literature(Figs. 3 and 7).

Suspensory fixations are the most commonly used devices for stabilizing AC joint dislocations. Tightropes and Endobuttons have been used in the literature for treatment of these injuries. These suspensory fixations are proprietary items and manufactured by specific manufacturers. Conventional flip button rupture causing failure or residual deformity.[24] In a study comparing outcomes between two double button techniques for acute ACJ dislocations, Vulliet et al.[25] found no difference between Tightrope fixation and Dog bone button fixation in terms of clinical and radiological parameters.

In a finite element model, two fixation methods were compared.[26] One with CC fixation with Dog bone button alone vs CC fixation with suture button combined with ACJ repair. The authors found the later method to be more stable in both vertical and horizontal planes and reduces stress on the suture button. However, there are no clinical studies yet supporting results of this study.

Recently, Seo et al.[27] compared clinical results using ASES and Korean Shoulder Score(KSS), two methods of fixing ACJ dislocations. Tunneling first technique, where the tunneling was done before reduction of dislocation and the reduction-first technique where the dislocation was reduced prior to tunneling. They found significantly better results with the KSS in patients where the joint was reduced before the single coraco-clavicular tunnel was drilled for Dog Bone button fixation. Our technique involved drilling the tunnel before reducing the ACJ.

The Dog Bone Button (Arthrex Inc) is a precontoured, titanium button that allows the use of multiple Fiber Tapes for AC joint reduction, providing a construct that is twice as strong as existing AC joint repair devices. Since the buttons are attached to the Fiber Tapes independently, only suture material is passed through the clavicle and coracoid tunnels, allowing the repair to be completed through smaller tunnels (Fig. 3).

In one of our patients the coracoclavicular distance was 1.5 cm postoperatively but patient did well postoperatively (Fig. 8). There was no deformity and functional limitation, hence no secondary surgery was required. The reason probably is not adequately tightening fiber wires, it had failed on the table. Such errors can be avoided by adequately tightening the fiber tape and checking coracoclavicular distance intraoperatively by fluoroscopic images.

Dogbone button construct has been claimed to have distinct advantages over other suspensory fixation in following ways (manufacturer's manual may be referenced for this).

1. Dog bone shape of the implant allows good surface contact over the bone unlike in tightrope and other fixation devices
2. The concave surface of the dog bone snuggly fits under the coracoid process whereas, tightrope is flat surface device
3. Two strong fiber tapes are used for compression between clavicle and coracoid
4. Smaller tunnels (3 mm) are made as only fibre tape are passed

The cost of dog bone construct (2dog bones, 2 fiber wires) is slightly expensive than other suspensory fixations like mini tight rope.

The functional assessment was carried out by DASH scoring. The DASH score is a 30-item self-reported questionnaire in which the response options are presented as 5-point Likert scales. Scores range from 0 (no disability) to 100 (most severe disability). This score was designed be useful in patients with any musculoskeletal disorder of the upper limb.

Main limitation of our study includes the small number of cases. Further long term follow up is needed to assess the outcomes of this technique given the good results we have seen.

5. Conclusions

Our results show that the arthroscopy assisted dog-bone button technique provides very good radiological and functional outcomes for ACJ dislocations. Dog bone button gives good, stable reduction of AC joint without significant postoperative complications.

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No funding was sought in any form for this study.

An informed consent was taken from all the patients for this study according to local protocols and guidelines.

All procedures performed in this study were in accordance with the ethical standards of the institutional committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Declaration of competing interest

All authors declare that they do not have any conflict of interest with this study.

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Technical note

Arthroscopic treatment of lateral epicondyle avulsion fracture of the elbow during adolescence: A technical note

Sung-Hyun Yoon, Joong-Bae Seo, Kwon-Young Kwak, Jae-Sung Yoo*

Department of Orthopedic Surgery, Dankook University College of Medicine, Cheonan, South Korea

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ABSTRACT

Fracture of the ossification center of the humerus lateral epicondyle during adolescence is a rare injury. Generally, nondisplaced fractures of the humerus lateral epicondyle heal after conservative treatment, such as short-term immobilization using either a cast or a sling. However, complications such as stiffness, instability, pseudarthrosis, and incarceration of the fracture fragment within the elbow joint are associated with relatively displaced fractures of the humerus lateral epicondyle during adolescence. Recently, it has become possible to arthroscopically repair the lateral collateral ligament complex using advanced arthroscopic techniques. We present a case of all-arthroscopic treatment of avulsion fracture of the humerus lateral epicondyle in an adolescent using a single working portal, two all-suture anchors, and the double-pulley repair technique.

1. Introduction

Fracture of the ossification center of the humerus lateral epicondyle during adolescence is a rare injury.[1,2] Because the common extensor muscles of the forearm originate in the lateral epicondyle, this type of fracture is believed to result from varus strain and traction injury in the elbow.[1,2] In most cases, there is little displacement of the fracture fragment, and the injury heals after conservative treatment, such as short-term immobilization using either a cast or a sling.[1,2]).

However, complications such as stiffness, instability, pseudarthrosis, and incarceration of the fracture fragment within the elbow joint have been reported to be associated with relatively displaced fractures of the humerus lateral epicondyle during adolescence.[1,3]).

Recent studies have demonstrated similarity in the outcomes of lateral collateral ligament (LCL) complex repair using the arthroscopic and open approach.[4–6]) By minimizing the complications that often develop in open repair, such as infection, stiffness, and scar formation, the arthroscopic approach was shown to be effective.[4–6]).

In this technical note, we describe our preferred technique for the arthroscopic treatment of humerus lateral epicondyle avulsion fracture with a single working portal using all-suture anchors. To our knowledge, a technique like the one presented here has not been formally published in the literature.

2. Surgical technique

Under general anesthesia, the patient's position was changed from supine to lateral decubitus, and a sterile pneumatic tourniquet was applied to the proximal portion of the humerus to control bleeding. The viewing portal was made at the soft spot, and the working portal was established at the direct lateral portal. Significant avulsion fracture of the humerus lateral epicondyle was observed (Fig. 1) by advancing the arthroscope into the lateral side of the radiocapitellar joint. In the lateral epicondyle, the fracture site was debrided using a shaver and ArthroCare device to remove scar tissue and any remnant debris. Two 1.3-mm Y-Knot suture anchors (ConMed Linvatec, Largo, FL, USA) were inserted proximally and distally into the fracture sites of the humerus (Fig. 2A and B). Using a spinal needle, 2–0 polydioxanone (PDS; Ethicon) was passed through the distal avulsion fracture of the lateral epicondyle, and using a grasper, sutures were pulled out through the direct lateral portal (Fig. 2C). PDS was connected using a FiberWire suture for shuttle relay. A suture retriever was passed through the incision to collect the sutures subcutaneously, pulling them out

* Corresponding author. Department of Orthopaedic Surgery, Dankook University College of Medicine, 119, Dandae-ro, Dongnam-gu, Cheonan-si, Chungnam, 330-715, South Korea. Tel.: +82 41 550 3060; fax: +82 41 556 3238.
E-mail address: osarthro@dkuh.co.kr (J.-S. Yoo).

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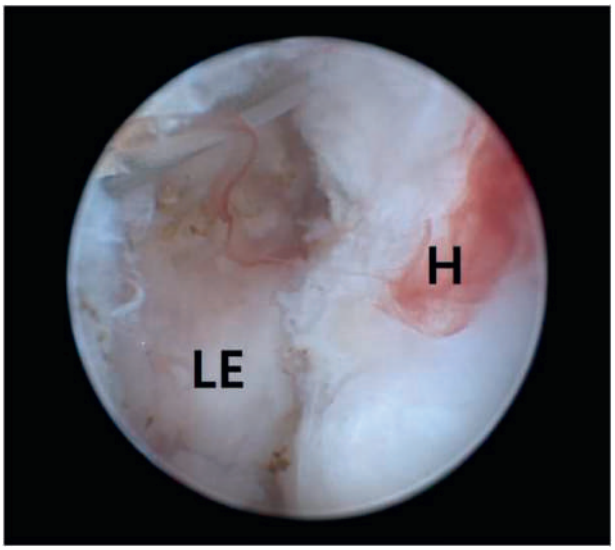

Fig. 1. Intraoperative arthroscopic images. Displaced avulsion fracture of the humerus lateral epicondyle (LE) was observed with an arthroscopic soft-spot portal established as the viewing portal. H, humerus.

through the direct lateral portal. Before tying the sutures, we found that removing any subcutaneous adipose tissue had favorable results when laying the ties directly on the capsule. Surgical knots were made using the double-pulley technique, and the suture ends were cut (Fig. 2D). Reduced avulsion fracture of the lateral epicondyle was examined by postoperative radiography (Fig. 3D).

3. Postoperative management

Postoperatively, long-arm splints were immediately applied to the patient while in the neutral position and the elbow was at approximately 90° flexion to relieve tension from the repair site. The first postoperative visit to the clinic was usually within the first week after surgery, and a hinged elbow brace was applied to allow comfortable movement. Physical therapy that focused on elbow range of motion (ROM) in a pain-free range was initiated at the first postoperative clinic visit. The exercises involved a full passive ROM after 2–4 weeks and an active ROM and strengthening exercises 4 weeks thereafter. The patient gained full activity after 6 weeks, although it depended on the type of activity. He recovered well for 6 months after surgery, ROM of the elbow joint was full, follow-up radiography at 6 months after surgery showed progression of union (Fig. 3E). Also, the visual analogue scale score at this time was 0 out of 10, and the Mayo elbow performance score was 100 of 100, and

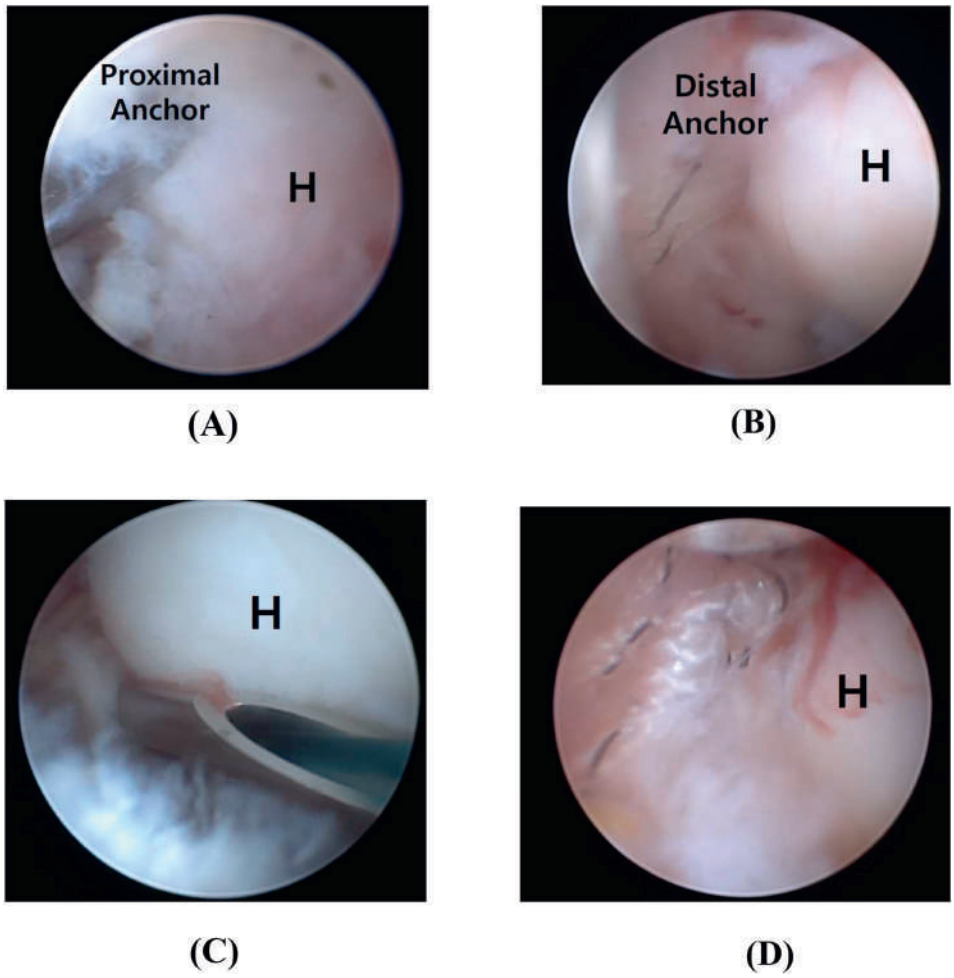

Fig. 2. Intraoperative arthroscopic images. (A, B) Two 1.3-mm all-suture anchors were placed through the direct lateral portal into the humerus at the proximal and distal fracture sites of the lateral epicondyle. (C) A spinal needle was percutaneously passed through the lateral collateral ligament complex stump at the distal lateral epicondyle fragment of the humerus. (D) Surgical knots were made with the double-pulley technique on the lateral humeral epicondyle fragment. H, humerus.

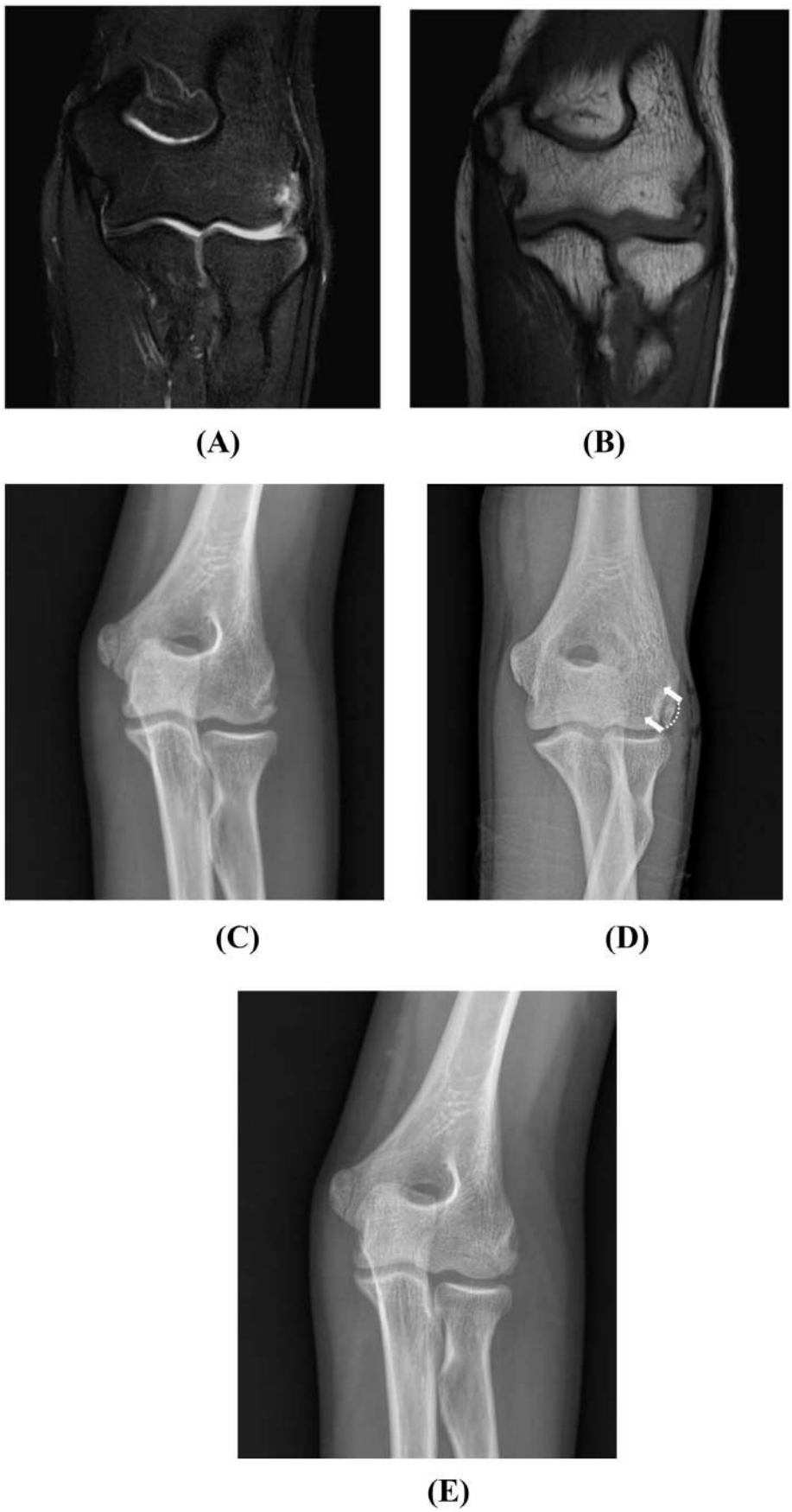

Fig. 3. (A and B) Preoperative magnetic resonance imaging in the coronal view showing displaced avulsion fracture of the humerus lateral epicondyle. (C) Preoperative anteroposterior radiograph of a 15-year-old boy showing displaced avulsion fracture of the humerus lateral epicondyle. (D) Postoperative anteroposterior radiograph showing reduced lateral epicondyle fragment of the humerus. Arrows, two all-suture anchors. Dotted line, FiberWire suture that was tied using the double-pulley repair technique. (E) Follow-up radiography at 6 months after surgery showed progression of union.

the Disability of arm, shoulder, and hand was 0 of 100 that represent the excellent prognosis respectively.

4. Discussion

Studies have suggested that nondisplaced fractures of the humerus lateral epicondyle heal after conservative treatment, such as short-term immobilization using either a cast or sling.[1,2] However, operative intervention is required for displaced fractures when the fragment is incarcerated within the elbow joint. There is no consensus on the degree of displacement if there is no fragment entrapped within the joint.

Sharrard3 observed that displaced fractures of the humerus lateral epicondyle seldom lead to disability if the injury is managed with conservative treatment, such as immobilization for 3–4 weeks. Moreover, Marion 7 and Faysse[7,8] have suggested that the operative choice for displaced fractures does not seem to be any specific treatment because they observed that no problems, including excessive laxity, occurred despite the development of pseudarthrosis.

Ogden[9] suggested that if the fracture fragment is displaced >3 mm, operative treatment should be considered. Price et al.[10] suggested that displacement of >5 mm can result in joint stiffness and that early excision of the epicondyle fragment might be necessary. Zionts and Mirzayan[1] also described that lateral epicondyle fractures that are displaced posteriorly or inferiorly by $\geq$ 5 mm can result in a clinically important loss of elbow motion. In 2011, Capo et al. reported a case of a 16-year-old adolescent with humerus lateral epicondyle fracture that resulted in acute elbow joint posterolateral instability.

Although there are many studies about open LCL complex repair, studies that evaluated the results of arthroscopic LCL complex repair are limited. These few studies showed meaningful results that were comparable to those of studies on open repair.[4–7] A surgical technique for arthroscopic repair of the LCL was described by Smith et al.[6] and Savoie et al.[4] who conducted studies comparing open repair with arthroscopic methods. Furthermore, Savoie et al.[7] reported that arthroscopic operation of the LCL was safer and more effective, with results similar to those of open repair of LCL. Furthermore, the arthroscopic technique has the merit of minimizing possible complications that often develop in open repair, such as infection, stiffness, and scar formation.

In this technical note, we describe the single working portal technique with the double-pulley repair technique and two all-suture anchors as a simple, less invasive, and safe procedure that minimizes complications.

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Ethical approval

This article does not include any studies with human participants or animals conducted by any of the authors.

Author statement

Jaesung Yoo: Conceptualization, Methodology, Software. Kwon young Kwak.: Data curation, Writing- Reviewing and Editing. Sunh-Hyun Yoon: Visualization, Validation. Joong bae Seo: Supervision.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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Case report

Isolated simple dorsal dislocation of the second and third carpometacarpal joints: A rare injury phenomenon

Prateek Garg, Nikhil Verma*, Anuj Jain, Simon Thomas, Shekhar Agarwal

Delhi Institute of Trauma and Orthopaedics (DITO), Sant Parmanand Hospital, 18 Sham Nath Marg, Civil Lines, New Delhi, Delhi, 110054, India

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ABSTRACT

Dislocation of the isolated second and third carpometacarpal joints without associated fracture is an exceedingly rare injury and optimal treatment option is still controversial. Early recognition and anatomical reduction are essential for good functional outcomes. We present a 24-year-old gentleman who had isolated simple dorsal dislocation of the second and third carpometacarpal (CMC) joints right hand after a road traffic accident. On examination swelling, tenderness and deformity was present. There was no open fracture and no distal neurovascular deficit. Patient was managed conservatively with closed reduction & below elbow cast after assessing the stability of CMC joints under image intensifier. At 18 months follow up, patient had pain free hand movements and had returned to his pre-injury level. No restriction of carpometacarpal movements or residual instability was noticed. Radiographic examination showed normal joint alignment and no signs of arthritis. Closed reduction and immobilization of simple CMC joints dislocation may be considered in selective group of patients. Prompt diagnosis and stable anatomical reduction with early mobilization is the key of success for type of treatment given.

1. Introduction

Carpometacarpal (CMC) joints dislocation are not so common injuries. Overall incidence of these injuries is below 1% of all hand injuries.[1] These injuries are difficult to diagnose and are easily missed due to profuse hand swelling and overlapping of bones that obliterate the radiographic features.[2] Dorsal & Volar both type of fracture dislocations has been reported in the literature and displacement depends on direction of the force occurred at the time of injury.[4,5] CMC joints are saddle joints and are stabilized by volar-dorsal ligaments, transverse intermetacarpal ligaments and by intrinsic muscles of the hand. 2nd and 3rd CMC joints are further stabilized by insertion of flexor carpi ligament and extensor carpi longus/brevis thus allow very little movement as compared to ulnar side CMC joints. Moreover, the metacarpal of 3rd CMC joint articulates with capitate bone and form the strongest joint due to its more proximal location. Therefore, frequency of dislocation increases from radial to ulnar-wards.[6,7] Massive oedema, interposed volar ligaments and overlapping metacarpal bases are the main obstacles for the successful closed reduction.[8] Multiple fracture dislocations of CMC joints are still reported in the literature but isolated simple dislocation of radial 2nd and 3rd CMC joints are further rare.[8] In most cases, these injuries were managed by open reduction and internal fixation or closed reduction with percutaneous pinning. We present arare case with isolated simple dorsal dislocation of second and third CMC joints that was managed by closed reduction and immobilization with excellent functional outcomes.

2. Case report

A 24 year old right hand dominant gentleman presented with pain and swelling over his right hand after falling on an outstretched hand following a road traffic accident. On examination, patient had diffuse swelling mainly over dorsum of the right hand. A bony bump was palpable overdorsal aspect of hand distal to wrist joint (Fig. 1). Tenderness was present over the deformity with restricted range of movement at wrist region. Isolated active and passive range of motion of the proximal and distal inter-phalangeal joints were normal. There was no distalneurovascular deficit.

After clinical examination, patient underwent radiographic

* Corresponding author.
E-mail addresses: gargprateek04@gmail.com (P. Garg), drnikhilucms@gmail.com (N. Verma), jain.doctor.anuj@gmail.com (A. Jain), simon_rac@yahoo.com (S. Thomas), shekhar1952@hotmail.com (S. Agarwal).

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Fig. 1. Clinical swelling and deformity of right hand with dorsal bony bump.

evaluation. Postero-anterior (PA), lateral and oblique views of wrist and hand were taken. PA view showed disturbed normal CMC joint space or parallel "M" lines concept as was described by Gilula LA[9] when traced from second through fifth metatarsal bases and lateral view showed dorsal dislocation of second and third CMC joints without any associated fractures (Fig. 2).

Patient was subjected to closed reduction attempt in emergency within 6 h of injury under wrist block. Closed reduction was accomplished by longitudinal traction to the index and middle finger and the metacarpal bases were pushed volarly opposite to the force of deformation and stability was checked before committing to conservative approach. Closed reduction was successful which was appreciated clinically by resolution of the dorsal bony bump and was confirmed under image intensifier (Fig. 3). To maintain the reduction, below elbow cast was given with wrist in neutral position and patient was discharged on same day. Active finger movements were started on first post -operative day. Patient was followed up with serial radiographs done weekly to see for loss of reduction if any and was immobilized till 3 weeks. After 3 weeks of immobilization, under supervision gentle active and passive movements were initiated to delineate the stiffness. Thereafter, 3 monthly follow up was done to evaluate the functional outcomes.

The hand was evaluated for the grip strength, residual pain and DASH score. The DASH score was improved from 73.26 during initial period of follow up to 1 at 18 months after the injury. At final

Fig. 2. X-ray PA and lateral view showing isolated 2nd and 3rd CMC joints dislocation dorsally without any associated fracture.

Fig. 3. Showing anatomically reduced and stable CMC joints.

follow up, he was able to make a normal pain free fist (grip) and carrying out his all routine activities (Fig. 4). Radiograph at last follow up showed there was no reduction in joint space or sclerosis suggested of any arthritic changes of both CMC joints.

3. Discussion

The bony and soft tissue stabilizers of CMC joints are numerous, which include variable articular congruity and strong with thick capsular ligaments. The second metacarpal articulates with trapezoid and trapezium while third metacarpal articulates with bases of second and fourth metacarpals and proximally with capitate. This bony stabilization along with dynamic stabilization provided by insertion of flexor carpi radials and extensor carpi radialis longus and brevis creates the need of high energy force to cause any significant disruption of radial side carpometacarpal joints. The mode of injury is usually motor vehicle collisions, fallon outstretched hand with full weight bearing over hand region or less commonly injury sustained during boxing.[10,11]

Carpometacarpal dislocations are invariably associated with fracture of the bases of metacarpals because of strong ligaments attachments.[10,12] Kumar and Malhotra[13] described a case series of multiple fracture dislocations of CMC joints with "divergent variant" including both dorsal and volar dislocations. Both Dorsal or volar type of dislocation have been described in the literature and depends on direction of force occurred at the time of injury.[5] In this young patient, the resistance of the bone was probably stronger than that of capsulo-ligamentous complex thereby resulting in pure

Fig. 4. After 18 months of follow up showing full movements and grip of right hand.

dislocation. This is a rare injury pattern because of no associated fractures of either of the metacarpal bones occurred and there was isolated dorsal dislocation of radial sided 2nd& 3rd CMC joints. The diagnosis can be easily missed due to gross swelling which may mask the characteristic deformity and routine AP view may miss the dislocation due to overlapping of bones. Hence true lateral x-ray view must always be taken whenever this kind of injury is suspected. A CT scan may be required when one is suspecting associated fracture with dislocation, because that may alter the line of management. Kumar and Onley [14] stated that if associated fractures are there then reduction may be unstable and might require open reduction and internal fixation.

In the literature almost, all cases were managed with open reduction and internal fixation. It has been said that conservative management has high chances of loss of reduction with poor functional outcomes as compared to open reduction and fixation.[15] Similarly, one would assume for any form of surgical intervention in our case but we believe timely diagnosis, wrist block and adequate analgesia followed by gentle reduction maneuvers allowed us to achieve near anatomical reduction which was then managed conservatively in form of below elbow cast for 3 weeks and removable wrist brace for another 3 weeks. Maintenance of stable reduction is essential in order to prevent muscle weakness, imbalance and eventually traumatic arthritis.[1] At 18months of followup our patient displayed normal range of motion and grip strength and was able to carry out his normal routine activities.

This case highlights arare injury pattern. These injuries are missed easily so careful clinical and radiographic evaluation is needed for accurate and prompt diagnosis. As demonstrated in our case, early diagnosis and timely intervention can keep these patients out of surgical intervention if any. Anatomical and stable reduction with early mobilization are the key stones for full functional recovery with good DASH scores. Though one should keep in mind that when conservative approach is chosen regular follow up with serial radiographic evaluation is recommended to ensure maintenance of reduction and recovery of hand function.

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Author information

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Declaration of competing interest

There is no conflict of interest among the authors in our case report.

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The work is original and can be considered for the publication.

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