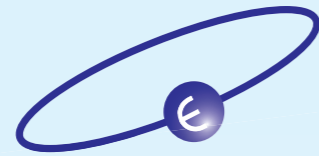


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JOURNAL OF ARTHROSCOPY AND JOINT SURGERY

# JAJ S

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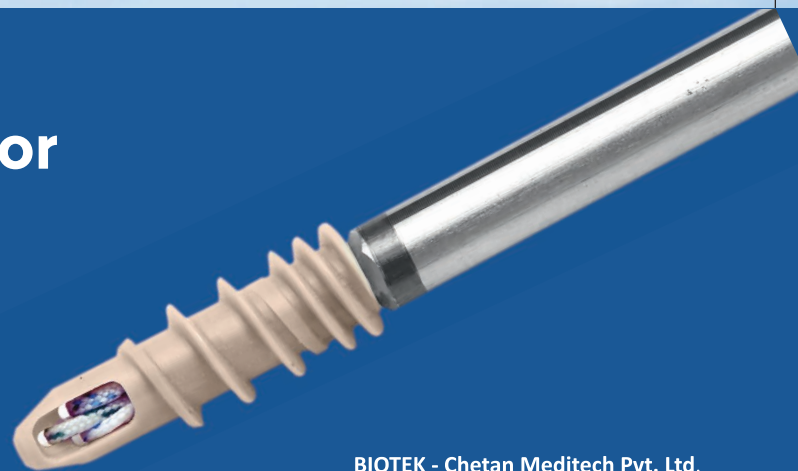
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# Journal of Arthroscopy and Joint Surgery

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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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## Editorial

## Unicompartmental knee replacement



### 1. Introduction

Osteoarthritis (OA) of the knee is one of the most common causes of painful loss of mobility in middle and elderly aged population. OA is the main indication for knee joint replacement surgery. Unicompartmental knee replacement (UKR) is beneficial procedure for patient with degenerative OA which is limited in medial or lateral compartment providing reliable pain relief, improving function with significantly less morbidity and mortality as compared to total knee replacement (TKR). This editorial provides an overview of UKR, its relevance for Indian population, synopsis of results and future prospects.

### 2. History of UKR

The concept of UKR first dates back to Campbell who reported his preliminary results on the interposition of vitallium plates in the medial compartment of arthritic knees in 1940 which was to prevent direct bone-to-bone contact to relieve the pain.<sup>1</sup> This clinical trial was followed by vitallium tibial plateau prosthesis by McKeever,<sup>2</sup> and tibial plateau insert by MacIntosh from 1950th until 1960th. MacIntosh reported that overall pain relief was achieved in most patients at a mean follow-up of six years in 1967. However, migration of the implant may lead to the unsatisfactory results.<sup>3</sup> So to overcome this problem, tibial plateau prosthesis with keel was developed by McKeever. The first modern design which had cemented polycentric metal femoral condyle articulating on flat polyethylene tibial components were St Georg (1969) and Marmor (1972).<sup>4</sup> The problem with first generation modern UKR was distortion of the polyethylene followed by loosening.<sup>5</sup> It led to the introduction of metal-backed tibial implants rather than all-polyethylene components. However, this meant that the thickness of the polyethylene was reduced and this contributed to problems associated with excessive wear due to the high contact stresses.

Oxford UKR (Zimmer Biomet, Bridgend, UK) was developed in 1970<sup>6</sup> and was the first fully congruent mobile spacer with spherical concave femoral and flat and keeled tibial components.<sup>7</sup> This concept is to make both interfaces be congruent throughout the range of knee movement to minimize polyethylene wear and reduce contact stresses between bone-implant interface

without constraint. These features of Oxford UKR phase 1 have remained unchanged up to present day. On the basis of clinical observation, good results were achieved when the anterior cruciate ligament (ACL) was intact and the arthritis was located anteromedial part of the tibia and distal part of the femur.<sup>8,9</sup> In 1987, Oxford UKR phase 2 was introduced along with the mill which allowed incremental bone resection to match the flexion and extension gaps intraoperatively whilst simultaneously shaping the bone to fit the implant. This system could restore not only ligament tension but also knee kinematics thus decreasing insert dislocation. Low level of polyethylene wear was observed after implantation due to the design concept of Oxford UKR and surgical technique to balance the ligament and restore the native tension. These are considered to contribute the postoperative high function and better satisfaction compared to TKR.

In 1998, Oxford UKR phase 3 was introduced and it enabled to be implanted with not an open approach with patellar dislocation but with a minimally invasive approach. Five sizes of femoral components were introduced (instead of just one) and tibial components were made side specific to reduce component overhang. The functional results of cemented phase 3 and recovery were found to be better than those of phase 1 and 2.<sup>12</sup>

In 2004 cementless femoral component with two pegs was introduced to reduce the incidence of physiological radiolucency around the cemented tibial components which although was asymptomatic and harmless, it did contribute to unnecessary revisions. Randomized controlled trial was conducted and similar clinical outcome (as cemented UKR) but with significant reduction in the incidence of tibial radiolucency was reported.<sup>14</sup> Subsequently a two peg cemented femoral component was introduced and reported to work well.<sup>15</sup>

### 3. Indications of UKR

TKR is an effectively treatment for most types of arthritis in which both the tibio-femoral compartments were involved. On the other hand, Oxford medial UKR is indicated for the treatment of anteromedial OA (AMOA) and spontaneous osteonecrosis of the knee.<sup>16</sup> In AMOA, there should be (1) bone-on-bone arthritis in the

medial compartment; (2) retained full thickness cartilage in the lateral compartment, best visualized on a valgus stress X-ray; (3) a functionally normal medial collateral ligament; and (4) a functionally normal ACL. The status of the patellofemoral joint (PFJ) is considered to be a contraindication only if there is a bone loss with grooving laterally.<sup>17</sup>

Various contraindications to UKR were proposed by Kozinn and Scott. The best candidates for UKR were reported to (1) patients older than 60 years of age and weigh less than 180 pounds, (2) not extremely physically active or heavy labourers, (3) preoperative knee pain should be minimal at rest, (4) have a more than 90° flexion arc, with 5° or less of flexion contracture, (5) less than 15° of angular knee deformity, limits being 10° varus to 15° valgus.<sup>18</sup> According to these criteria, only around 6% of patients may be considered appropriate for UKR. However, candidacy for Oxford UKR is much wider accounting for 47.6% of knee arthroplasties in a series of 200 consecutive knees.<sup>15</sup> Additionally, lateral osteophytes had been reported to be associated with lateral compartment disease and as such it was unclear whether medial UKR should be performed if present. Hamilton et al. performed the survey of the presence and size of lateral osteophytes, and their impact on clinical outcomes and Oxford UKR survival and demonstrated that the presence of lateral osteophytes is not a contraindication to medial meniscal-bearing UKR.<sup>19</sup>

#### 4. Contraindication of UKR

Kozin and Scott's contraindications for UKR (as outlined above) were based on their experience of fixed bearing UKR. Outcome of patients with and without these potential contraindications in a prospective series of 1000 Oxford UKRs was compared.<sup>22</sup> The outcome was assessed using the Oxford Knee Score (OKS), American Knee Society Score, Tegner activity score, revision rate and survival rate. Clinical outcome of patients with these potential contraindications were similar to or better than those without potential contraindications. The 10-year survival was 97% or those with potential contraindications and 93.6% without these contraindications. This difference maintained at 15 years as well, with implant survival of 94% in those with potential contraindications and 90% without these contraindications.

Based on these and various other observations, the contraindications for Oxford UKR are: inflammatory arthritis, absent or severely damaged ACL, PCL or MCL, partial thickness disease in the medial compartment, presence of a central ulcer in the weight bearing portion of the lateral compartment, bone loss with eburnation and grooving in the lateral part of the PFJ, and previous history of valgus tibial osteotomy.

#### 5. Clinical results after UKR

The data from joint registries confirms that patients undergoing TKR had lower revision rates, they had higher rates of morbidity and mortality, longer hospital stays and inferior patient reported outcome measures compared with patients undergoing UKR.<sup>23</sup> Surgeons who perform UKR frequently significantly had lower revision rate and superior patient reported outcomes. Increasing usage of UKR leads to better results. Surgeons with optimal usage (up to 20% of knee replacements in the surgeon's practice is UKR) achieved revision or reoperation rates similar to matched patients who undergoing TKR up to eight years postoperatively and 10 year survival is reported to be about 95%.<sup>24</sup>

The revision rates of the UKR are reported to be much higher in national registries than in most published studies. Most surgeons perform very small numbers of UKR and the most common number implanted per year is one or two and average is five.<sup>25,24</sup> Improper patient selection, inadequate surgical usage and/or unnecessary revisions can contribute to high UKR revision rates in the National Joint Registry (NJR). Matched comparison of UKR and TKA was performed based on the NJR for England, Wales and Northern Ireland including 100,000 cases of knee arthroplasty, UKR was reported to have several advantages for example, shorter hospital stay, reduced rates of readmission, intra-operative complications and need for blood transfusion as compared with TKR.<sup>23</sup> Additionally, frequency of major complications such as thromboembolism, postoperative infection, stroke and myocardial infarction were also less about a quarter to half as compared with TKR thus resulting in less mortality.<sup>23</sup> Comparing the patient oriented outcome measures (PROMs) between matched groups of UKR and TKR postoperative OKS after 6 months was significantly better with UKR than TKR and significantly more patients after UKR achieved an excellent clinical outcome.<sup>26,27</sup> Overall EuroQuol score was also better with UKR in four subscales relating to mobility, pain, function and self care.<sup>28</sup>

Various cohort studies of cemented Oxford UKR have demonstrated high levels of function and excellent long-term survival rate can be achieved. In an independent study the 20-year survival was similar to the best TKR. The proposed contraindication for UKR (youth, obesity, activity, PFJ damage, and chondrocalcinosis) did not compromise the outcome. This suggests that if patients have AMOA, these proposed contraindications can be ignored. AMOA is present in about 50% of patients needing knee replacement. There is little evidence as to the optimal usage with the fixed bearing. However, there is a report that the fixed bearing should not be used with significant PF joint problems.<sup>29</sup>

#### 6. Complication after UKR

Complication rate after UKR is reported to be lower than that after TKR. Revision surgery after UKR tend to be much easier than that after TKA because latter one needs may be much more invasive to the patients. In the long term, the commonest cause of failure is progression of arthritis in the lateral compartment although incidence is not high.

##### 6.1. Infection

The incidence of infection after UKR is about half of that after TKR.<sup>30</sup> C-reactive protein (CRP) or erythrocyte sedimentation rate (ESR) are the most useful diagnostic test but may not be positive in the first 2–3 weeks. Acute infection is diagnosed and treated in the same way as TKR. Early open debridement and change of meniscal bearing and intravenous antibiotics can arrest the infection and save the arthroplasty. Arthroscopic irrigation is not recommended. The earliest radiological sign may be in the retained compartment in the form of thinning of the articular cartilage and juxta-articular erosion of the non-implanted joint or progressive radiolucency line may occur around the tibial component. Treatment should include removal of the implant and excision of the inflammatory membrane followed by one or two staged revision TKR.



## 6.2. Medial tibial plateau fracture

In the NJR, 0.30 revisions for periprosthetic fracture per 1000 years after UKR are reported.<sup>31</sup> This did not include cases undergoing internal fixation so incidence may be underestimated. Periprosthetic fractures tend to occur in the hands of inexperienced surgeons both with cement and cementless implants. It mainly occurs intraoperatively or around 2–12 weeks after surgery. Weakening of the condyle by removal of its articular surface and subchondral bone plate is probably the main reason for fracture. This is unavoidable in UKR, so great care should be taken not to add any additional damage to the bones. The most potent case of that fracture is damage to posterior tibial cortex and the cancellous bone when using vertical saw blade that goes deeper than needed. Management of the tibial plateau fracture depends on the stage at which the fracture is diagnosed and the degree of varus deformity. If the fracture is diagnosed at the time of arthroplasty, it should be reduced and internally fixed. After the fixation, UKR can be completed and good result is expected.<sup>32</sup> If the medial fragment is comminuted, it should be fixed using buttress plate.

## 6.3. Dislocation of a mobile bearing

In the NJR, the incidence of the dislocation of a mobile bearing is reported to be 1.2 revisions for dislocation/subluxation per 1000 component years (95% CI 1.05–1.37) for mobile bearing UKR. Most dislocation occur early postoperative periods and incidence of dislocation using phase 3 Oxford UKR is reported 0.73% in a meta-analysis.<sup>33</sup> Primary dislocation is usually caused by a combination of distraction of the joint and displacement of the bearing due to impingement. They are usually due to surgical error. Secondary dislocation is the result of loss of entrapment from loosening and subsidence of the metal components. Spontaneous elongation of ligaments does not occur unless there is impingement, when forced flexion or extension may stretch ligaments. Traumatic dislocation is sometimes encountered when a normally functioning Oxford UKR has been forced into an extreme posture and MCL has been stretched or damaged.

To diagnose the dislocation, radiographs demonstrate the site of the displaced bearing, and may suggest its cause such as osteophytes, retained cement, or displacement of a metal component. The dislocated bearing is most commonly found in the anterior joint space because the anterior rim of the bearing is higher than its posterior rim. Manual reduction under anesthesia succeeds on a few occasions. However, arthrotomy is almost always required to remove the bearing and determine the cause of its displacement. When the both metal components are fixed to the bones, any bone or cement might impinge on the bearing. After removing these, usually one thicker bearing should be inserted to tighten the ligaments. In case of recurrent dislocation, MCL dysfunction, or serious mid flexion gap, conversion to TKR should be performed because revision of failed UKR to another UKR was reported to results less successful by Australian Orthopaedic Association National Joint Registry.<sup>34</sup>

## 6.4. Loosening of a fixed component

Loosening of the component is one of the commonest causes of failure in the national registries. The rate of loosening is 4.01 (CI 3.73–4.32) per 1000 patient years in the NJR.<sup>31</sup> To diagnose the loosening, the only reliable radiographic evidence is the

displacement of a metal component: for example, a loose tibial component may tilt or femoral component may rotate (as compared with serial radiographs). Stable radiolucency at the bone-cement interface is common and it does not indicate the evidence of loosening. Femoral component loosening is difficult to diagnose because of the difficulty to see radiolucency on the X-rays.<sup>35</sup> Radionuclide bone scan is not recommended because there is increase of uptake under the tibial component last for many years which indicates remodeling. The cause of early failures are mainly result of poor initial fixation. Late tibial loosening may be due to the accumulated effects of impact loading from impingement of the front of the bearing on the femoral condyle in full extension.<sup>36</sup> In early loosening without seriously eroded bone, cementing a new component is a possible option however, in late loosening with extensively eroded bone, revision to TKR is better.

## 6.5. Lateral compartment arthritis

In a series of 1000 cases of Phase 3 Oxford UKR with 15 years follow up, lateral OA progression that required revision occurred in 2.5% at a mean follow up of 7 years.<sup>37</sup> To diagnose the lateral compartment arthritis, pain which is not always on the lateral side is the main symptom. Narrowing of the lateral compartment joint space occurred first and this may long precede the onset of pain. Subchondral sclerosis and disappearance of lateral joint space ensue. Osteophyte of the lateral compartment is not portend progressive arthritis. Overcorrection of the varus deformity into valgus is an important cause of progression of lateral OA. So intact MCL is of importance so that overcorrection is avoided. If the symptom persists after conservative treatment, revision to TKR is indicated, however some surgeons may choose to perform lateral UKR in case medial UKR remains satisfactory.

## 6.6. Pain

Pain can be a problem and often leads to unnecessary revision. Pain can be encountered over the proximal tibia. This type of pain is not unusual in the first six months after surgery and usually settles spontaneously. The incidence is about 2% at one year after surgery.<sup>38</sup> The causes of pain after UKR may be multifactorial. Inappropriate indications or bone overload are the most common causes.<sup>39,40</sup> Impingement, soft tissue irritation, cementing errors, pes anserinus bursitis or neuroma have been implicated.

## 6.7. Partial thickness cartilage loss (PTCL)

It is generally thought that UKR is best used in young patients with early arthritis. However, Oxford UKR only should be offered to patients with bone-on-bone arthritis because cadaveric studies have shown that asymptomatic PTCL is common.<sup>41</sup> So if a patient has pain and PTCL, PTCL is not necessarily the cause of pain.

## 6.8. Component overhang

Medial tibial overhang of more than 3 mm was associated with pain and poor function that tended to get worse postoperatively. This may be due to soft tissue irritation. The tibial component increases in size parametrically by 2 mm so overhang of 2 mm or more can be avoided by selecting the appropriate component size or performing the vertical cut again further laterally. Also anteromedial femoral component overhang may cause pain.<sup>42</sup>

## 7. Investigations

Radiographs are the most useful and AP radiographs aligned with the tibial component should be obtained at the first and subsequent follow ups. Physiological radiolucencies must be ignored because they are not source of pain.<sup>43</sup> If femoral component loosening is suspected, lateral views of 0 and 90 degrees should be obtained and examined the movement of the component.<sup>35</sup> Radionuclide bone scans are not helpful and often misleading. Even if patient is asymptomatic, they are hot lesions for many years. If the pain is located laterally, MRI scan is useful to identify meniscal tear. An ultrasound aspiration can be useful to exclude infection. Arthroscopy is useful only when lateral meniscal lesions, cement loose bodies, impingement or chondral flaps in the PFJ are suspected.

### 7.1. Treatment of unexplained pain

Early revision because of pain should be avoided because most patients revised for unexplained pain, could not recover from pain. For example, 75% of patients who were revised to TKR and had no mechanical problems identified at surgery had no improvement of symptoms.<sup>36</sup> Patients should be treated conservatively as their pain tends to settle spontaneously. Patients should be informed they are likely to have some pain for three to six months and that there is a small chance that it may take one to two years to fully settle. If patients have pain, they should decrease their level of activity and use a walking clutch. Steroid injection is recommended if the pain is focal.

### 7.2. Limited motion

Knee movements are usually recovered rapidly after surgery. However, occasionally manipulation under anesthesia has been employed if the knee has not recovered 90° of knee flexion at six weeks after surgery. In these cases, unlike manipulation of a stiff joint after TKR, there are no adhesions in the suprapatellar pouch and the knee flexes fully when a little force was applied. Extension improves spontaneously after Oxford UKR and rarely lacks more than 3° of knee extension at one year after surgery. If a flexion contracture persists, it is usually because osteophytes in the roof of the notch or on the tibia in front of the ACL insertion that have not been resected at the time of surgery.

### 7.3. Implant failure

There are some cases of fractures of Oxford UKR bearing.<sup>32,44</sup> Fractures often occur with the thinnest (3.5 mm) bearings and is associated with impingement that results in increasing wear. Treatment should be done by replacement with a new bigger bearing and addressing impingement.

### 7.4. Results of revision surgery

The re-revision rate after a UKR to UKR revision is higher than a UKR to TKA revision. Therefore, UKR to TKR revision is generally recommended. However certain circumstances when a UKR to UKR revision should be considered for example, replacing a bearing for a dislocation; a lateral or medial UKR for disease progression; and loosening with minimal bone loss that needs implanting a new component. If there is a mechanical cause for the failure such as disease progression component loosening, recurrent dislocation, or damage to deep fiber of MCL, conversion

for TKR should be considered. The results of the revision surgery tend to be as good as those of a primary TKR. However, if there is no mechanical cause of pain, the results are poor. The typical case is a patient with early OA and partial thickness cartilage loss treated with UKR. Then, UKR does not relieve the pain and surgeons misinterpret the physiological radiolucency as indication revision TKR for loosening.

If there is a severe bone loss due to tibial plateau fracture, infection and deep tibial resection with ligament instability, revision TKA should be performed with stem and augment which increase constraint.<sup>45,46</sup>

## 8. Lateral UKR

Lateral UKR is a relatively rare and said to account for about one eighth of all unicompartmental OA.<sup>47</sup> To identify lateral OA reliably, either a valgus stress radiograph in 45° of knee flexion or a Rosenberg view is necessary.

### 8.1. Anatomy and kinematics

The stabilizing effect of the LCL is quite different from MCL. MCL provides stability throughout the knee movement and therefore dislocation of the mobile bearing is rare. Conversely, LCL is tight only in knee extension and in 90 degrees of knee flexion, 5–10 mm distraction is possible in the lateral compartment.<sup>49</sup> So dislocation of the mobile bearing is a potential problem in mobile bearing lateral UKR.

### 8.2. History and development of lateral Oxford UKR

The results of lateral arthroplasty have been marred by dislocation of the bearing.

So it was recommended not to use mobile bearing into the lateral side but to use fixed bearing.

## 9. Indications

Requirement on the indications for successful lateral UKR are: Bone-on-bone OA in the lateral compartment. There should be a full thickness cartilage in the medial compartment and correctable intra-articular deformity. This is best demonstrated by a varus stress radiograph.

Like the medial UKR, age, activity, obesity and chondrocalcinosis would be ignored.

Due to the high dislocation rate of the mobile bearing, using the fixed bearing components is recommended for surgeons. Recently Fixed Lateral Oxford (FLO) prosthesis is introduced and used with the same instrumentation.

There have been some independent studies of the domed lateral UKR, which have confirmed good results.<sup>50,51</sup> Use of the modified surgical technique and new design with a domed tibial component appears to reduce the early dislocation rate. However, it is still higher than in the medial compartment. Knees that dislocated tended to be overcorrected compared with those that did not dislocate. To avoid the overcorrection, selecting the bearing thickness that just tightens the ligaments in full extension and the size of the gap between the femoral and tibial components should be minimized.<sup>52</sup>

Dislocations commonly occur medially over the wall of the tibial component. Usually the bearing dislocation is not reduced by manipulation and the bearing should be retrieved under direct vision through old incisions. Care should be taken to identify any

potential causes of bearing dislocation such as impingement, component loosening, bow stringing of popliteus or ligament injury. Dislocation is addressed when new thicker bearing is inserted but sometimes occurs.

## 10. Indian perspective

Indian patients have high prevalence AMOA and are well suited to receive Oxford UKR provided the indications are correct and surgical technique is optimal. Small components are usually needed and careful attention to prevent posterior tibial blow out is crucial. Patients with tibia vara tend to perform well with Oxford UKR although at present the follow up is up to 10 years.

Careful documentation of surgical findings, close patient follow up and data sharing will help improve outcomes of Oxford UKR in the Indian scenario and it seems that in the past two to three years there is increasing recognition amongst surgeons that indeed UKR does work and Indian patients will benefit with it due to associated reduced morbidity, better function and ability to sit cross legged and squat after Oxford UKR.

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## Research paper

# Prophylactic intrawound application of vancomycin in total knee arthroplasty



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## ABSTRACT

**Background:** Infection after knee arthroplasty is a serious concern of arthroplasty surgeons and various methods are described to reduce the same. Local application of antibiotic can reduce the chance of infection without systemic side effects.

**Method:** A retrospective review of 115 patients operated over a period of two years (February 2014–January 2016) was performed. In the vancomycin or treatment group the vancomycin was applied in subfascial layer just before wound closure.

**Result:** Five patients experienced infection in treatment or vancomycin group while eight patients had infection in control group. The difference was not statistically significant ( $p=0.771$ ). Deep seated infection was noted in four patients in the vancomycin group and among six patients in the control group.

**Conclusion:** Local wound application of vancomycin does not lead lower infection rate in total knee arthroplasty.

**Level of evidence:** Level III, Retrospective Cohort.

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## 1. Introduction

In spite of advances in surgical techniques and operative room environment, approximately 0.72% patients develop infection after knee replacement.<sup>1–3</sup> This can result in significant morbidity to the patient and pose a surgical challenge. Regarding treatment of infected knees, there is still ambiguity and the guidelines are not clear. We are getting into more complex situations with increasing number of geriatric patients with comorbidities, immunocompromised patients, revision cases and antibiotic resistance.

Despite systemic use of antibiotic prophylaxis, post-surgery infection remains a cause of concern in joint replacement surgery.<sup>4</sup> Infection has marked impact on patients and their resources as they had to undergo repeated surgical procedures, delayed rehabilitation and poor surgical outcome.<sup>5</sup> Despite improvement in surgical techniques, total knee arthroplasty requires extensive surgical dissection leading to formation of local hematoma which is not accessible to systemic antibiotics.

Local application of antibiotic results in high concentration at the operative site and systemic effects are thus avoided.<sup>6–8</sup> Staphylococcus is one of the commonest organism causing surgical site infection and application of vancomycin locally can reduce its incidence.<sup>9–10</sup> There are no reported serious complications with the use of vancomycin locally.<sup>11</sup> Extensive studies have been conducted on its local application in spine surgeries but its use in other regions have been limited. Vancomycin mixed in cement is currently used in arthroplasty procedures.<sup>12</sup> However, adding antibiotic to cement adds to the total cost of surgery.<sup>13</sup> The objective of this study was to evaluate safety and efficacy in local wound application of vancomycin in total knee arthroplasty. We hypothesized that local application of vancomycin shall result in a lower infection rate without any systemic or adverse clinical effects.

## 2. Material and methods

A retrospective review of the patients was performed undergoing total knee arthroplasty during the period between February 2014 and January 2016 at two arthroplasty centers. The study was conducted with the approval of ethics committee of respective institutions and surgery was performed by the two senior surgeons

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(DB, RS). The patients who were to undergo primary knee arthroplasty and above the age of 40 years were included in the study. Exclusion criteria was defined as any prior history of knee joint infection, sensitivity to vancomycin, postoperative follow up of less than six months. The patients lost to follow up were also excluded from the study.

All patients were given prophylactic preoperative antibiotic dosage of cefuroxime (1.5 gm intravenous) within one hour of skin incision and dosage was repeated every twelve hourly till drain removal. All surgical procedures were carried out in modular operation theatres. The procedure was carried out under tourniquet control with pressure inflated 100 mm Hg above the systolic blood pressure. Patients were prepared with povidine-iodine (betadine) scrub solution followed by iobane drape (3 M) application over the site of skin incision. The knee arthroplasty was performed through standard parapatellar approach. Prior to skin closure the wound was washed with 5 litres of normal saline. No drain was used in either group. Group A (treatment group) consisted of patients treated by one author and a total of one gram of vancomycin powder was applied in subfacial layer. Group B (control group) consisted of patients treated by other surgeons and using no antibiotic for local wound application. The parapatellar wound was closed with ethibond no.2. The superficial wound was closed with absorbable sutures in fascia and subcutaneous tissue. The skin was closed with interrupted monofilament suture. The sterile dressing was changed on second postoperative day.

The primary knee arthroplasty was performed in one hundred and fifty-nine patients during the mentioned time period. Twelve patients were excluded from the study which did not meet the inclusion criteria. Five patients had died; twenty-seven patients could not be located or lost to follow up. So, ninety-five patients (72 males and 23 females) were included in this study.

The hospital records included clinical history sheet and operative notes. They were studied for demographics, diagnosis, duration of procedure and approximate blood loss. Intra operative complications and revision surgery if any required. The data regarding comorbid conditions like diabetes mellitus and hypertension was also collected. The history sheets were looked upon specifically for use of tobacco for more than six months and steroids. The patients were followed up for six months. The primary outcome measured was the incidence of superficial and deep infection of wound. The superficial infection was observed directly by wound inspection however the deep infection was evaluated by wound exploration and debridement. The cultures were sent in both cases after stopping administration of any form of antibiotics for two days. The subsequent treatment was tailored according to culture sensitivity. Superficial skin infection was managed with oral antibiotics while deep infection was treated with repeated debridements, intravenous antibiotics and two stage procedures wherever required. The functional assessment of the operative procedure was done using oxford knee scoring.<sup>14</sup> The patients were asked about the degree of pain in knee, ability to perform household activities, any difficult in toilet activities, ability to kneel and stand again, climbing up or down stairs, any

limp in the operated limb, ability to knee, night pains, any discomfort in washing and drying oneself due to knee and various other questions. The patients were graded as poor (0–19), moderate (20–29), good (30–39) and excellent (40–48). The patients who had scored more than 40 were considered as cases with satisfactory functional outcome and minimal disability.

The end point of study was findings noted at the time of last follow up. Data are presented as means  $\pm$  standard deviation. The statistical difference between two groups in demographics, operative time, and presence of diabetes was assessed by using student t test. Fischer's exact t test was used for categorical data. Statistical significance was considered at the 5% level.

### 3. Results

One hundred and fifteen patients fulfilled the inclusion criteria. The vancomycin group (group A) consisted of 51 patients and control group (group B) included 64 patients. Both groups were similar in terms of patient parameters (Table 1). The approximate intra operative blood loss was almost similar in two groups ( $263 \pm 140$  ml vs  $270 \pm 150$  ml). The duration of procedure was longer in control group ( $126 \pm 19.6$  min. vs  $140 \pm 22.3$  min.). The functional outcome assessed using oxford knee scoring was comparable in two groups (30.96 in vancomycin group vs 32.81 in control group,  $p=0.15$ ). The patients who had developed infection experienced poor functional outcome as compared to other patients.

Five patients experienced infection in treatment or vancomycin group while eight patients had infection in control group. The difference was not statistically significant ( $p=0.771$ ).

One patient in treatment or vancomycin group had developed superficial infection on fifth postoperative day. The infection was treated with local wound care and there was resolution of infection with local wound care and oral antibiotics (tab cefuroxime twice a day for fourteen days). The patient was known diabetic on intermittent control of blood sugar and hypothyroid on regular treatment (oral levothyroxine 50  $\mu$ g daily). Four patients had developed deep seated infection in the vancomycin group (Table 2). Two patients among the eight patients in the control group had developed superficial infection while six patients had developed deep seated infection (Table 3). The patients who had superficial infection was treated with local wound care and oral antibiotics for 2–3 weeks while deep seated infection required debridement and intravenous antibiotics.

There were no reported systemic effects like hypotension or renal toxicity of local wound application of vancomycin powder.

### 4. Discussion

Knee arthroplasty is an extensive surgical procedure involving the risk of infection. Though the risk of infection is low (less than 1%) but the consequences to the knee joint are catastrophic.<sup>15</sup> In our case series, the patients in control group encountered infection in 12.5% cases and 9.8% in vancomycin group. The infection rate

**Table 1**  
Patient characteristics.

	Vancomycin group	Control group	P value
Gender (male/female)	32/19	44/20	0.554
Diabetes mellitus	17	23	0.845
Hypertension	22	25	0.705
Tobacco user (>6 months)	6	5	0.534
Systemic steroids used before surgery	9	13	0.813
Oxford knee score	32.7	35.6	0.15

**Table 2**

Patient who had developed infection in vancomycin group.

S.no.	Age (in years)/sex	Comorbidities	Culture	Treatment
1	73/M	HTN, DM,RA	MRSA	Multiple debridements and intravenous vancomycin and gentamycin
2	68/M	HTN	–	Debridement and intravenous gentamycin and vancomycin
3	69/F	DM	Polymicrobial	Debridement and intravenous vancomycin and gentamycin
4	73/M	–	–	Debridement and intravenous vancomycin and gentamycin

**Table 3**

Patients in the control group who had experienced deep seated infection.

S.No.	Age/sex	Comorbid condition	Culture	treatment
1	59/M	HTN, DM	No growth	Debridement and intravenous vancomycin and gentamycin
2	65/F	DM, RA	MRSA	Multiple debridements and intravenous vancomycin
3	64/M	–	No growth	Debridement and intravenous vancomycin
4	72/M	HTN	MRSA	Debridement and intravenous vancomycin
5	67/M	HTN, DM, RA	MRSA	Debridement, 2 stage exchange and intravenous vancomycin and gentamycin
6	78/M	HTN	No growth	Debridement and intravenous vancomycin

reported in both the groups was higher than reported in literature. As expected, the functional outcome was better in non-infected group in comparison to infected group.

Coagulase negative staphylococcus aureus remains one of the commonest organism isolated from the prosthetic knee joint infection and vancomycin is the drug which is consistently effective against it.<sup>16</sup> However, in our study, methicillin resistant staphylococcus aureus (MRSA) was the commonly organism isolated and no organism could be isolated in few of the cases.

Vancomycin is a bactericidal agent with inhibits the cell wall synthesis by binding to precursor required for peptidoglycan cross linking.<sup>17</sup> Vancomycin is known for adverse drug reaction or anaphylactic reaction on intravenous administration.<sup>18,19</sup> Use of local antibiotics in the form of cements and beads are now an accepted form of treatment in the management of open fractures and osteomyelitis.<sup>20,21</sup> The intrawound application of vancomycin powder in spine patients is associated with decreased rate of infection.<sup>22</sup> Locally the drug concentration rises much higher than the minimum inhibitory concentration for methicillin resistant staphylococcus aureus and coagulase negative staphylococcus aureus. The local antibiotic concentration exceeds far more than the minimum inhibitory concentration (MIC) in the wound and the drug levels remains high for at least two days post operatively.<sup>23</sup> Moreover, the drug is poorly absorbed from the surgical site so systemic effects of the same are low.<sup>24,25</sup> Poor absorption of vancomycin from the local surgical site results in lower blood levels and lesser risk of development of resistant organisms and adverse effects.<sup>26</sup>

The primary concern in the study was toxic effect secondary to direct application of vancomycin powder over the wound. However, there was no case of renal toxicity, hypotension or any drug allergy in the treatment group (vancomycin group). The direct wound application also helps in achieving high concentration of vancomycin which has shown to inhibit bone formation, thus preventing heterotopic ossification.<sup>27</sup> Direct application of vancomycin powder has not been associated with any difference in functional outcome and non infective complications, thus it is a safe procedure.

The patients who had developed deep seated infection were subjected to multiple debridements and intravenous antibiotics (vancomycin and gentamycin). Due to the limited number of cases, factors associated with increased risk of infection could not be statistically evaluated. Considering the cost effectiveness of local

application of vancomycin over wound and reduction in infection rate it's application has been advocated in spine surgery and other disorders. The present study was conducted on the presumption that the local wound application of vancomycin could reduce the rate of infection significantly. But the study failed to prove the same. We acknowledge that there are multiple factors are involved in a case of infected arthroplasty and a single factor cannot reduce the infection rate.

There are limitations of the study. The retrospective nature of the study inherited selection bias. All factors affecting postoperative infection was not assessed. Preoperative nutritional status, associated comorbid conditions were not controlled in the study. The operative procedure in vancomycin or treatment group were performed by a single surgeon while in control group the operations were performed by multiple surgeons. The serum levels of vancomycin were also not measured so the rate of absorption and bioavailability could not be ascertained. However, this study provides material for further studies to be conducted on infection control in all form of arthroplasties at other joints.

## 5. Conclusion

Local wound application of vancomycin powder does not significantly decrease the incidence of infection in a case of knee arthroplasty. No adverse reaction or complication was encountered on application of vancomycin over the wound. However, further large prospective randomised control trials are required to refute or support the claim of routine use of intra wound application of vancomycin in knee arthroplasty.

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None.

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Research paper

# A study assessing intra-articular PRP vs PRP with HMW HA vs PRP with LMW HA in early knee osteoarthritis



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## ABSTRACT

**Objective:** We aim to study the effects of platelet rich plasma (PRP) and hyaluronic acid injections in treatment of early Osteoarthritis (OA). We assess which form of HA is most beneficial and whether combining PRP and HA have a better clinical outcome.

**Design:** Data: Cases diagnosed with early knee OA in the department of Orthopedic's, K. S. Hegde Medical Academy.

**Sample Size:** Total 51 patients divided into 3 groups

- Group 1: PRP group
- Group 2: PRP with LMW HA
- Group 3: PRP with HMW HA

### Inclusion criteria

- Pain or swelling of knee >4 months
- Kellgren Lawrence 0-III on X-ray

### Exclusion criteria

- Kellgren-Lawrence >grade 3
- Rheumatoid arthritis
- Haematological diseases
- Severe cardiovascular diseases
- Infections
- Diabetes Mellitus
- Patients in therapy with anticoagulants or anti aggregants

**Study Method:** Patients selected based on inclusion criteria and using block randomisation divided into a group. Pre injection visual analogue score (VAS) and International knee documentation committee score (IKDC) proforma are done. The decided injection is then performed and the patient followed up at 6 weeks and 6 months.

**Statistics:** Paired T test

One way Anova and Posthoc test

P = 0.05 significant

**Results:** All groups showed statistically significant decrease in VAS score and increase in IKDC scores with P < 0.05. LMW+ PRP injection showed the greatest difference in IKDC and VAS scores though this difference was not statistically significant.

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**Conclusion:** All injections are a beneficial form of treatment. LMW HA+PRP is the most beneficial injection all though not statistically significant.

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## 1. Introduction

Osteoarthritis (OA) is the most common disease of joints in adults around the world. Felson et al. reported that about one-third of all adults have radiological signs of osteoarthritis.<sup>1</sup> It is a clinical syndrome of joint pain characterized by the gradual loss of articular cartilage, osteophyte formation, subchondral bone remodeling, and inflammation of the joint.

Tackling the progression of the disease and attenuating the degradation of cartilage and joint health has been a major dilemma in the field of orthopedics. Many methods and treatment have been proposed in order to avoid the total knee arthroplasty. Non-steroidal anti-inflammatory drugs (NSAIDs) have been essential in treatment and highly effective in pain control but do not play any role in addressing the joint health.

Exercise and physiotherapy have been in wide agreement as adjuvant in treatment. Reduction of weight is paramount and it is well understood that the cartilage in the joint is under more insult with higher body mass indexes. Off loading braces to reduce axial forces acting on the more worn side of the joint and even tibial osteotomies to re align the entire lower limb and weight transmission have been advocated. Nutraceuticals such as chondroitin and glucosamine have been employed but are not widely accepted to have any role in prevention or effects of the disease.

Platelet rich plasma (PRP) is a sample of autologous blood, which has been prepared to have a high concentration of platelets, associated growth factors and cytokines. PRP use was first published by Marx et al, a maxillofacial surgeon who used it to fill cancellous mandibular defects.<sup>2</sup> The uses of PRP since have been many showing promising results in some fields and less so in others. The general idea being that it contains the necessary recipe of ingredients to stimulate repair and to some extent regeneration.

Hyaluronic acid (HA) is a glycosaminoglycan that is found throughout the connective, epithelial and neural tissue in the body. It is postulated to be an integral part of synovial fluid in that it not only stimulates cell proliferation and migration, but also serves as a

lubricant to the joint propagation.<sup>3</sup> Osteoarthritis is associated with a reduced amount of hyaluronic acid within the joint. Many different forms of the molecule have been derived varying in primary source to molecular weight and more recently combined with other drugs such as chondroitin and sorbitol.

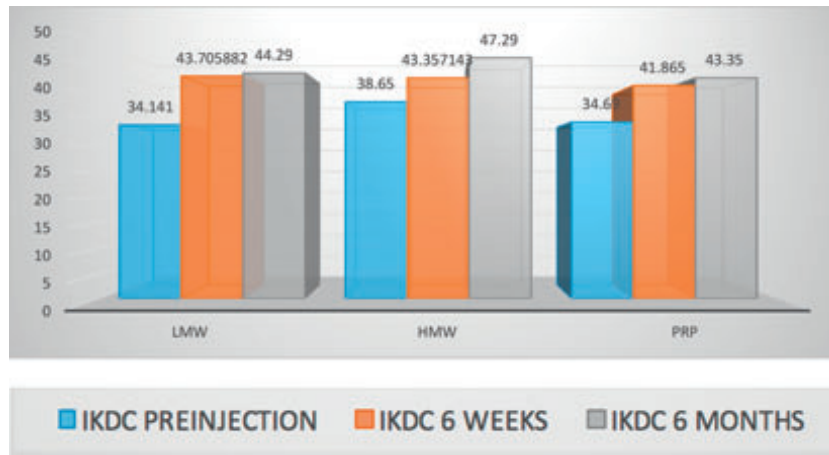
PRP has been used in orthopedics for almost two decades now showing varying outcomes and results. The purpose of the study is to determine whether PRP and viscosupplementation have any role in the treatment of early osteoarthritis of the knee joint. For this purpose, three groups; PRP, PRP+Low molecular weight (LMW) HA, PRP+High molecular weight (HMW) HA have been made. Subjective and functional scores pre and post injection will shed light on the effect this modality of treatment has on the disease and which group of injection is the most efficacious treatment. Joint replacement addresses final stages of the condition but earlier less symptomatic knees in early stages of the condition and do not warrant surgery need better effective treatment options. We aim to evaluate platelet rich plasma and visco-supplementation as a viable treatment option for early joint osteoarthritis of the knee joint.

## 2. Materials and methods

- Study type-comparative study
- Source- All the patients with early osteoarthritis of the knee joint, presenting to the Department of Orthopaedics K. S. Hegde Charitable hospital from February 2014 to February 2016 were included in the study after explaining the procedure and getting their consent.
- Consent: Institutional ethical committee clearance and patient consent
- Methodology: a patient has been diagnosed with early OA knee, he or she was added to one of three groups randomly.
  - Group 1: PRP group (20 patients)
  - Group 2: PRP with LMW HA (17 patients)
  - Group 3: PRP with HMW HA (14 patients)
- Inclusion criteria



**Graph 1.** VAS pre injection Vas 6 weeks and Vas 6 months.



**Graph 2.** Intra group International Knee Documentation Committee Score comparison.

**Table 1**  
Intragroup Comparison paired T test Platelet rich plasma.

PRP		Mean	N	Std. Deviation	Paired Differences		t	df	P VALUE
					Mean Difference	Std. Deviation			
Pair 1	IKDC PREINJECTION	34.69	20	10.11	-7.18	4.97	-6.45	19	<0.001
	IKDC 6 WEEKS	41.87	20	9.74					
Pair 2	IKDC PREINJECTION	34.69	20	10.11	-8.66	7.09	-5.47	19	<0.001
	IKDC 6 MONTHS	43.35	20	9.8					
Pair 3	IKDC 6 WEEKS	41.87	20	9.74	-1.49	3.76	-1.77	19	0.093
	IKDC 6 MONTHS	43.35	20	9.83					
Pair 4	VAS PREINJECTION	7.8	20	1.24	2.05	1.32	6.96	19	<0.001
	VAS 6 WEEKS	5.75	20	1.80					
Pair 5	VAS PREINJECTION	7.8	20	1.24	1.85	1.46	5.66	19	<0.001
	VAS 6 MONTHS	5.95	20	1.64					
Pair 6	VAS 6 WEEKS	5.75	20	1.80	-0.2	0.89	-1	19	0.33
	VAS 6 MONTHS	5.95	20	1.64					

**Table 2**  
Intragroup Comparison paired T test: Low Molecular Weight HA + PRP.

LMW		Mean	N	Std. Deviation	Paired Differences		t	df	P VALUE
					Mean Difference	Std. Deviation			
Pair 1	IKDC PREINJECTION	34.14	17	12.36	-9.56	8.082	-4.88	16	<0.001
	IKDC 6 WEEKS	43.70	17	10.68					
Pair 2	IKDC PREINJECTION	34.14	17	12.36	-10.15	8.29	-5.05	16	<0.001
	IKDC 6 MONTHS	44.29	17	10.95					
Pair 3	IKDC 6 WEEKS	43.71	17	10.68	-0.59	3.02	-0.80	16	0.434
	IKDC 6 MONTHS	44.29	17	10.95					
Pair 4	VAS PREINJECTION	7.65	17	1.41	2.06	1.56	5.44	16	<0.001
	VAS 6 WEEKS	5.59	17	1.77					
Pair 5	VAS PREINJECTION	7.65	17	1.41	1.94	1.44	5.58	16	<0.001
	VAS 6 MONTHS	5.71	17	1.72					
Pair 6	VAS 6 WEEKS	5.59	17	1.77	-0.12	0.78	-0.62	16	0.543
	VAS 6 MONTHS	5.71	17	1.72					

- Chronic pain or swelling of the knee for a minimum of 4 months
- Imaging findings of degenerative changes of the joint (Kellgren Lawrence 0 to III at X-ray evaluation)
- Exclusion criteria
  - Kellgren-Lawrence score > grade 3
  - Rheumatoid arthritis
  - Haematological diseases,
  - Severe cardiovascular diseases
  - Infections
  - Diabetes Mellitus
  - Patients in therapy with anticoagulants or anti aggregant

**Table 3**  
Intragroup Comparison paired T test: High Molecular Weight HA +.

HMW		Mean	N	Std. Deviation	Paired Differences		t	df	P VALUE
					Mean Difference	Std. Deviation			
Pair 1	IKDC PREINJECTION	38.65	14	19.16	-4.71	4.74	-3.718	13	<b>0.003</b>
	IKDC 6 WEEKS	43.36	14	16.10					
Pair 2	IKDC PREINJECTION	38.65	14	19.16	-8.64	14.65	-2.205	13	<b>0.046</b>
	IKDC 6 MONTHS	47.29	14	19.68					
Pair 3	IKDC 6 WEEKS	43.36	14	16.10	-3.93	14.12	-1.041	13	0.317
	IKDC 6 MONTHS	47.29	14	19.68					
Pair 4	VAS PREINJECTION	7.14	14	1.41	1.29	1.20	3.994	13	<b>0.002</b>
	VAS 6 WEEKS	5.86	14	1.29					
Pair 5	VAS PREINJECTION	7.14	14	1.41	1.57	1.91	3.078	13	<b>0.009</b>
	VAS 6 MONTHS	5.57	14	2.03					
Pair 6	VAS 6 WEEKS	5.86	14	1.29	0.29	2.27	0.471	13	0.645
	VAS 6 MONTHS	5.57	14	2.03					

### 2.1. Procedure

A 20 ml sample of venous blood was drawn from the patient's cubital vein under aseptic precautions and mixed with 5 ml of citrate phosphate dextrose solution. A 2 ml sample was collected here to assess the patient's baseline platelet counts. The mixture was then divided equally into 4 vacutainers. The sample were then placed in a centrifuge and spun at 3500 rpm for 7 minutes. Using a needle, the buffy coat supernatant layer was removed leaving behind the red and white cell components of the blood. The collected sample was divided equally into two more vacutainers and spun at 3000 rpm for another 5 minutes.

The sample was then collected using a 5 ml syringe and a 2.5 ml sample of PRP is then obtained. 2 ml of this sample was injected into the affected knee joint. 0.5 ml of the remaining collected sample of PRP was sent for platelet count assessment once again to determine whether an adequate concentration of platelet was achieved.

The patients were assessed with a VAS score, subjective and functional knee scoring systems before the injection, at 6 weeks and 6 months' post injection during review. Post injection the patient was only prescribed oral tramadol with paracetamol tablets for 5 days and told to ice the knee three times a day.

### 2.2. Statistical Analysis

Using paired T test for intra group comparison and One way Anova test with Posthoc test for inter group comparison. P value of 0.05 was taken as significant.

## 3. Results

### 3.1. Intragroup analysis

#### 3.1.1. PRP

IKDC scores between pre injection and 6 weeks show a mean difference in score of 7.18 which is a statistically significant increase in score where  $P < 0.001$

IKDC scores between pre injection and 6 months show a mean difference in score of 8.66 which is a statistically significant increase in score where  $P < 0.001$

Visual analogue scores (VAS) between pre injection and 6 weeks post injection show a mean difference of 2.05 which is a statistically significant reduction in VAS score where  $P < 0.001$

VAS scores between pre injection and 6 months shows a mean difference of 1.85 which is a statically significant reduction in VAS score where  $P < 0.001$

#### 3.1.2. LMW HA + PRP

IKDC scores between pre injection and 6 weeks show a mean difference in score of 9.56 which is a statistically significant increase in score where  $P < 0.001$

IKDC scores between pre injection and 6 months show a mean difference in score of 10.15 which is a statistically significant increase in score where  $P < 0.001$

VAS between pre injection and 6 weeks post injection show a mean difference of 2.06 which is a statistically significant reduction in VAS score where  $P < 0.001$

VAS scores between pre injection and 6 months shows a mean difference of 1.94 which is a statically significant reduction in VAS score where  $P < 0.001$

#### 3.1.3. HMW HA + PRP

IKDC scores between pre injection and 6 weeks show a mean difference in score of 4.71 which is a statistically significant increase in score where  $P = 0.003$

IKDC scores between pre injection and 6 months show a mean difference in score of 8.64 which is a statistically significant increase in score where  $P = 0.046$

VAS between pre injection and 6 weeks post injection show a mean difference of 1.29 which is a statistically significant reduction in VAS score where  $P = 0.002$

VAS scores between pre injection and 6 months shows a mean difference of 1.57 which is a statically significant reduction in VAS score where  $P = 0.009$

## 4. Intergroup analysis

### 4.1. VAS Score

At 6 weeks comparing the VAS scores between all three groups shows that LMW HA + PRP had the highest difference in scores and the HMW +PRP group had the least difference though this difference is **not** statistically significant.

At 6 months comparing the VAS scores between all three groups shows that LMW HA + PRP had the highest difference in scores and

**Table 4**  
Intergroup Comparison: One way Anova test.

	GROUPS	N	Mean	Std. Deviation	Statistics/mean squares	df2(welch)/F(Anova)	P VALUE
IKDC PREINJECTION	LMW	17	34.141	12.3588	91.487	0.48	0.622
	HMW	14	38.65	19.1551			
	PRP	20	34.69	10.1086			
	Total	51	35.594	13.6662			
IKDC 6 WEEKS	LMW	17	43.70588	10.6757	17.692	0.121	0.886
	HMW	14	43.35714	16.098			
	PRP	20	41.865	9.742272			
	Total	51	42.88824	11.85844			
IKDC 6 MONTHS	LMW	17	44.29	10.953	0.238	26.845	0.698
	HMW	14	47.29	19.68			
	PRP	20	43.35	9.832			
	Total	51	44.75	13.359			
	GROUPS	N	Mean	Std. Deviation	Statistics/mean squares	df2(welch)/F(Anova)	P VALUE
IKDC DIFFERENCE 6 WEEKS PREINJECTION	LMW	17	9.564706	8.082152	90.811	2.413	0.1
	HMW	14	4.707143	4.736514			
	PRP	20	7.175	4.972966			
	Total	51	7.294118	6.30601			
IKDC DIFFERENCE BASELINE 6 MONTHS	LMW	17	10.15294	8.288404	12.802	0.127	0.881
	HMW	14	8.635714	14.65079			
	PRP	20	8.66	7.086265			
	Total	51	9.15098	9.868381			
IKDC DIFFERENCE 6 WEEKS 6 MONTHS	LMW	17	0.588235	3.021978	45.107	0.72	0.492
	HMW	14	3.928571	14.12093			
	PRP	20	1.485	3.756997			
	Total	51	1.856863	7.869848			
	GROUPS	N	Mean	Std. Deviation	Statistics/mean squares	df2(welch)/F(Anova)	P VALUE
VAS PREINJECTION	LMW	17	7.65	1.412	1.857	1.027	0.366
	HMW	14	7.14	1.406			
	PRP	20	7.8	1.24			
	Total	51	7.57	1.345			
VAS 6 WEEKS	LMW	17	5.59	1.77	0.287	0.103	0.902
	HMW	14	5.86	1.292			
	PRP	20	5.75	1.803			
	Total	51	5.73	1.638			
VAS 6 MONTHS	LMW	17	5.71	1.724	0.634	0.2	0.819
	HMW	14	5.57	2.027			
	PRP	20	5.95	1.638			
	Total	51	5.76	1.75			
	GROUPS	N	Mean	Std. Deviation	Statistics/mean squares	df2(welch)/F(Anova)	P VALUE
VAS DIFFERENCE 6 WEEKS PREINJECTION	LMW	17	2.06	1.56	2.998	1.586	0.215
	HMW	14	1.29	1.204			
	PRP	20	2.05	1.317			
	Total	51	1.84	1.391			
VAS DIFFERENCE BASELINE 6 MONTHS	LMW	17	1.94	1.435	0.56	0.222	0.802
	HMW	14	1.57	1.91			
	PRP	20	1.85	1.461			
	Total	51	1.8	1.562			
VAS DIFFERENCE 6 WEEKS 6 MONTHS	LMW	17	-0.12	0.781	1.05	0.549	0.581
	HMW	14	0.29	2.268			
	PRP	20	-0.2	0.894			
	Total	51	-0.04	1.371			

the HMW+PRP group has the least difference though this difference is **not** statistically significant(Graphs 1 ).

#### 4.2. IKDC Score

At 6 weeks comparing the IKDC scores between all three groups shows that LMW HA +PRP had the highest difference in scores and the HMW +PRP group had the least difference though this difference is **not** statistically significant.

At 6 months comparing the IKDC scores between all three groups shows that LMW HA +PRP had the highest difference in scores and the HMW +PRP group has the least difference though this difference is **not** statistically significant(Graphs 2 ).

#### 5. Discussion

PRP and HA intra-articular injections are treatments that have been employed for over a decade in treatment of early knee OA and a final consensus has not been reached as to whether there is any benefit. As stated before studies have been ambiguous and there is also an element of industry funded studies showing more benefit than those privately funded.<sup>4</sup> Other studies have also stated that PRP and viscosupplementation are also effect treatments individually.<sup>5</sup> Our study has shed light on PRP and HA combined injections as well as an individual PRP injections (Tables 1–5, ).

In our study there were a total of 51 subjects of which 20 patients received intra-articular PRP, 17 received intra-articular

**Table 5**  
Intergroup comparison: Posthoc Test.

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	P VALUE
IKDC PREINJECTION	LMW	HMW	-4.5088	4.9843	0.64
		PRP	-0.5488	4.5559	0.992
IKDC 6 WEEKS	LMW	HMW	3.96	4.8125	0.691
		HMW	0.34874	4.357013	0.996
		PRP	1.840882	3.982519	0.889
IKDC 6 MONTHS	LMW	HMW	1.492143	4.206849	0.933
		HMW	-2.992	4.884	0.814
		PRP	0.944	4.464	0.976
IKDC DIFFERENCE 6 WEEKS PREINJECTION	LMW	HMW	3.936	4.716	0.684
		HMW	4.857563	2.214168	0.082
		PRP	2.389706	2.023856	0.47
IKDC DIFFERENCE BASELINE 6 MONTHS	LMW	HMW	-2.46786	2.137857	0.486
		HMW	1.517227	3.625416	0.908
		PRP	1.492941	3.313804	0.894
IKDC DIFFERENCE 6 WEEKS 6 MONTHS	LMW	HMW	-0.02429	3.500466	1
		HMW	-3.34034	2.856296	0.477
		PRP	-0.89676	2.610792	0.937
VAS PREINJECTION	LMW	HMW	2.443571	2.757854	0.652
		HMW	0.504	0.485	0.556
		PRP	-0.153	0.444	0.937
VAS 6 WEEKS	LMW	HMW	-0.657	0.469	0.348
		HMW	-0.269	0.602	0.896
		PRP	-0.162	0.55	0.954
VAS 6 MONTHS	LMW	HMW	0.107	0.581	0.981
		HMW	0.134	0.642	0.976
		PRP	-0.244	0.587	0.909
VAS DIFFERENCE 6 WEEKS PREINJECTION	LMW	HMW	-0.379	0.62	0.815
		HMW	0.773	0.496	0.274
		PRP	0.009	0.454	1
VAS DIFFERENCE BASELINE 6 MONTHS	LMW	HMW	-0.764	0.479	0.258
		HMW	0.37	0.573	0.796
		PRP	0.091	0.524	0.983
VAS DIFFERENCE 6 WEEKS 6 MONTHS	LMW	HMW	-0.279	0.553	0.87
		HMW	-0.403	0.499	0.7
		PRP	0.082	0.456	0.982
	LMW	PRP	0.486	0.482	0.576

LMW HA + PRP and 14 received intra-articular HMW HA + PRP. Assessing the effectiveness of the injections individually, all three groups showed a significant decrease in VAS score and a significant increase in IKDC score. When compared to pre-injection and follow up scores P is <0.05 in all of the three groups. This means that all three intra articular injections have a statistically significant effect on treatment of early osteoarthritis of the knee. Patients have better subjective pain scores as indicated by the decreasing VAS score and a better functional outcome as indicated by the increase in the IKDC score.

An intergroup comparison was done to answer the question as to which injection is most effective for treatment of early knee OA. The results of the intergroup comparison show that LMW HA + PRP had the greatest difference in VAS and IKDC score and HMW + PRP had the least difference in VAS and IKDC score. The difference in the comparison of the three groups was not statistically significant, indicating that in our study all three injection combinations were satisfactory modalities of treatment for early OA of the knee joint.

Our study indicates that there is a role for intra articular PRP injections as well as viscosupplementation in early OA of the knee joint. Of the three studied groups there is evidence to suggest that LMW HA + PRP was the most effective injection though the benefit is not statistically significant. A larger sample size may effect this result and prove a statistically significant difference.

Our results are in accordance with the study performed by Patel et al demonstrating PRP is more beneficial than placebo injections in early OA of the knee joint.<sup>6</sup> Another study done by Jang et al showed similar results where IKDC and VAS scores showed statistically significant improvement as in accordance with out

study.<sup>7</sup> Our study has shown that there are statistically significant positive effects of administering the studied intra articular injections in early knee OA patients, as seen in all of the three study groups.

As postulated HMW HA is said to have a more mechanical effect when given as an intra-articular injection and inhibits angiogenesis into the joint.<sup>8</sup> LMW HA having a lower molecular weight may allow for some biological response and therefore a better healing response within the articular joint cartilage.

HMW HA is a costly injection when compared to LMW HA and PRP. When taking into account the outcome scores of each group and also cost as a factor, LMW HA + PRP is the more appropriate injection for the treatment of early knee OA as it has the most benefit to cost ratio. HMW HA + PRP is high in cost and least effective.

## 6. Conclusion

From our study it is evident that intra articular injections of PRP, PRP + LMW HA and PRP + HMW HA are all effective treatments in early osteoarthritis of the knee joint, showing significant decreases in VAS scores and significant increases in IKDC scores. This indicates that all three studied treatment groups are effective and acceptable modalities of treatment for early osteoarthritis of the knee.

When comparing each injection with each other, it was found that there was no statistically significant difference in VAS and IKDC scores in all three groups. That being said, PRP + LMW HA

group did show the greatest difference in function and subjective outcome although not significant.

There were no significant complications observed during the duration of our study.

#### **Conflict of interest**

None.

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## Original article

# A 3DCT scan based assessment of femoral tunnel placement in arthroscopic ACL reconstruction by modified transtibial and anteromedial portal technique and its relation with the functional outcome: A retrospective comparative study



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## ABSTRACT

**Background:** The purpose of the study was to evaluate the accuracy of placement of femoral tunnels in an anatomical position with Modified Transtibial (TT) and Anteromedial portal (AMP) techniques during single bundle arthroscopic ACL reconstruction and the effect of the tunnel placement on functional outcome in young soldiers.

**Materials and methods:** A total of 92 patients operated for ACL tear between 01 Aug, 2012 and 31 Aug, 2014 were selected for the study of which 49 belonged to the TT and 43 belonged to the AMP group. They were subjected to a single 3DCT scan of knee to assess the femoral tunnel midpoint by quadrant method as described by Bernard and Hertel. These patients were also assessed subjectively for the functional outcomes using Lysholm, Tegner and IKDC scores.

**Results:** No statistical difference was noted in the femoral tunnel position or in the functional scores (Lysholm, Tegner and IKDC scores) between the groups. Our results showed that 61.22% of patients in TT group and 62.79% patients of AMP group could go back to the preinjury level of activity based on Tegner scores which is consistent with results in contemporary literature.

**Conclusion:** Both the modified TT and AMP techniques are capable of placing the femoral tunnel in a near anatomic position and also of producing comparable clinical results. With none of the techniques producing significantly superior results, it is up to the surgeon to choose from one of the techniques to produce consistent results.

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## 1. Introduction

Anterior cruciate ligament (ACL) tears are one of the commonest knee injuries sustained by a young soldier during sporting/athletic/Training activities or a traffic accident resulting in a clinically unstable knee. The aim of ACL reconstruction is to alleviate knee instability in order to facilitate return to previous activity level and to restore the normal kinematics of the knee which is important to prevent or delay the onset of osteoarthritis of

knee.<sup>1,2</sup> Several graft materials and fixation options are available for the same. Different methods of ACL reconstruction require drilling either single or double tunnels through proximal tibia and distal femur for graft passage and fixation. The tibial tunnels are commonly drilled using commercially available drill guides set at various angles as per surgeon preference. Femoral tunnels are drilled by either a trans-tibial (TT)/Anteromedial portal (AMP)/outside-in (OI) technique using femoral offset guides or freehand. Initially the TT technique of drilling the femoral tunnel was widely practiced owing to its simplicity in creating tunnels, ability to achieve parallel bone tunnels, avoiding screw divergence, shorter surgical time and good post op function.<sup>3,4</sup> However the popularity of TT method has been on a decline of late due to

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concerns that it places the graft in a non-anatomical (Vertical) position<sup>5–9</sup> and to overcome this limitation, use of anteromedial portal for drilling the femoral tunnel has been advocated<sup>10–13</sup> with the advantages of being able to place independent femoral and tibial tunnels, more accurate and anatomical tunnel placement, preservation of remaining ACL fibres to allow ACL augmentation and a good functional outcome.<sup>3,4</sup> Although double bundle reconstruction is considered to reproduce the kinematics of a normal knee, anatomical single bundle ACL reconstruction can produce similar results.<sup>3,4</sup> Hence anatomical Single bundle autograft reconstruction is considered ‘Gold standard’ for an ACL deficient unstable knee.<sup>14</sup>

As the frequent reason for graft failure is improper tunnel placement<sup>15–17</sup> appropriate placement of these tunnels, particularly on the intra articular side should be as close to the original ACL footprint as possible for a successful outcome in terms of kinematics and function.<sup>4,18–21</sup> The ill-effects of inaccurate tunnel placement can be graft impingement in the intercondylar notch, loss of either full extension or full flexion, graft rupture and failure of fixation resulting in a suboptimal clinical outcome or a failure of ACL reconstruction.<sup>22–24</sup>

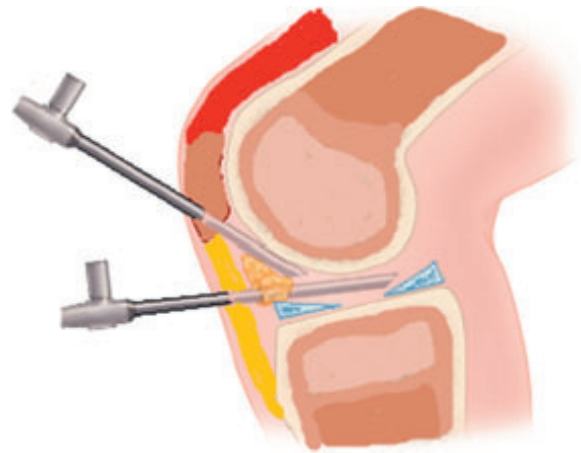
The purpose of this study was to determine the position of midpoint of femoral tunnel achievable by a modified transtibial (TT) and an anteromedial portal (AMP) technique so as to compare them and also determine the effect of the difference in the tunnel placement if any on the functional outcome after a single bundle arthroscopic ACL reconstruction using hamstring graft in high demand individuals like soldiers.

## 2. Methods

Between 01 Aug, 2012 and 31 Aug, 2014, a total of 164 arthroscopic single bundle ACL reconstructions were performed on soldiers using autologous hamstring graft at our centre, out of which 16 were multi-ligamentous injuries (ACL + PCL/ACL + PLC/ACL + LCL/ACL + MCL), 3 were revision ACL reconstructions, 13 had major meniscal injuries requiring Total/subtotal meniscectomy/repair and 13 were patients 45–50 years age, 1 patient had old distal femoral fracture and 4 proximal tibial fractures (Treated and healed) hence all of these were excluded and 114 patients remained. 32 of these had ‘minor’ meniscal injuries which required partial meniscectomy or balancing and we were able to retain most of the meniscus hence they were included in our study. Out of these 97 were available for Subjecting to CT scan as rest had moved out of station (being in a transferable job). Out of these only 92 consented for and underwent a CT scan of the knee. 49 belonged to TT and 43 to AM portal group. The demographic variables and other baseline parameters were as follows

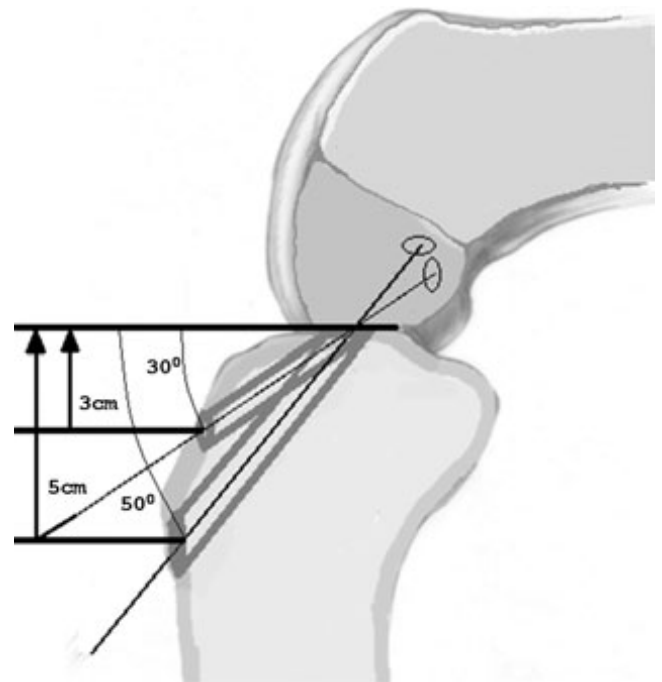
### 2.1. Surgical technique (TT group)

Under spinal anaesthesia, with tourniquet control, diagnostic arthroscopy of knee was done through high anterolateral and anteromedial portals created in order to avoid injuring the infrapatellar fat pad (Fig. 1). After confirming an ACL insufficiency, semitendinosus + Gracilis tendon was harvested (with an aim to have a final graft of minimum 8 mm diameter). The loose ends of the torn ACL from the femoral and tibial attachment sites intraarticularly were cleared preserving a little stump on either side. Wherever possible the intact AM/PL bundle was preserved. A modified technique to create Tibial tunnel was employed. The Guide wire was passed using a commercially available tibial guide (Karl storz/Arthrex) set at 50° but because of a high anteromedial portal the resultant angle of inclination of tibial tunnel was around 30–40°. Entry point of the tibial tunnel was kept at the anterior edge of MCL and intra articular opening at the anatomical tibial

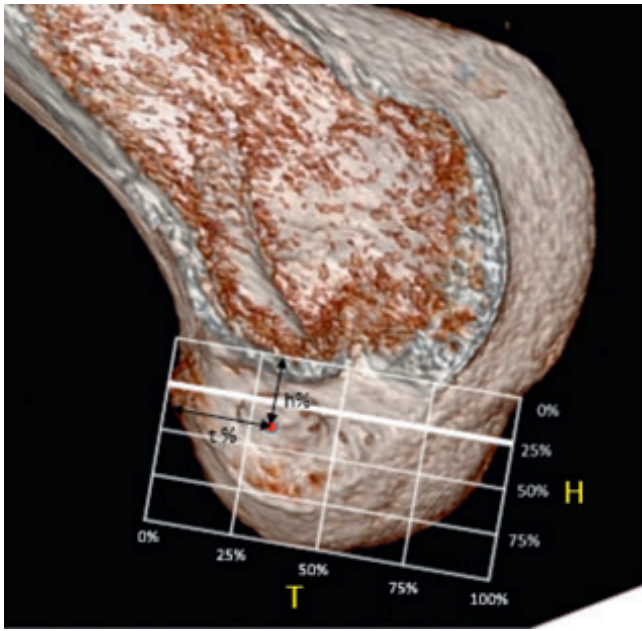


**Fig. 1.** Portal placement; high portal in TT Technique, low portal in AMP technique.

footprint of the native ACL. The final entry point obtained was closer to the articular surface (3–4 cm) resulting in a more horizontal tibial tunnel which makes it easier to reach the anatomical ACL femoral footprint (Figs. 2 and 3). Tibial tunnel was drilled over the guide wire to the requisite diameter as per graft size. Femoral offset guide (Arthrex/Karl Storz) chosen based on the size of prepared graft (1.5–2 mm more than the radius of the graft in order to have an intact posterior wall after drilling the tunnel) was passed through the prepared tibial tunnel onto the medial wall of the lateral femoral condyle with knee in 80–90° flexion. Guidewire passed at 2/10 O clock position depending on left or right knee respectively and femoral tunnel drilled to appropriate diameter and length. The prepared graft then inserted into the tunnels and fixed with a suspensory fixation method on femoral side (with ACL Tight rope RT, Arthrex or Endobutton CL, Smith and Nephew or Vanquish, Evolutis) and aperture fixation method on



**Fig. 2.** Proximal starting point producing a shorter, more horizontal tibial tunnel; Distal starting point producing a longer and more vertical tibial tunnel. A relatively



**Fig. 3.** Shows the method of estimating distance of midpoint of femoral tunnel from posterior to anterior (t%) and superior to inferior (h%).

the tibial side (with reverse cutting interference screw, Smith and Nephew).

### 2.2. Surgical technique (AMP group)

In case of AMP technique, standard anteromedial and anterolateral portals were created 1 cm above the joint line, 1 cm on either side of the edge of patellar tendon. The femoral tunnel was drilled first over a guidewire passed into the medial wall of lateral femoral condyle using a 6/7 mm femoral offset guide passed through the anteromedial arthroscopy portal with knee in 100–110° flexion. The tibial tunnel of appropriate size was drilled over a guidewire passed using commercially available tibial jigs inserted into the knee through the standard anteromedial portal and set at 50°. The intra articular reference point was the midpoint of anatomical tibial ACL footprint, approximately 7 mm anterior to the PCL. The method of fixation of the graft was same as in TT Group. None of the procedures in either group required a notchplasty.

All the ACL reconstructions by TT technique was performed by one surgeon and AMP technique by another surgeon.

### 2.3. Postoperative rehabilitation

We followed a standard institutional ACL reconstruction rehabilitation protocol for all patients. Patients were educated about Quadriceps and Hamstring strengthening exercises pre operatively. We encouraged active close chain ROM exercises and active SLR from the evening of surgery. We allowed partial weight bearing ambulation with crutch support as per tolerance and started on the Hamstring & Quadriceps strengthening exercises from first postoperative day. Full weight bearing ambulation without crutch or cane was allowed as soon as the patient could do active sustained SLR for at least 15–20s. Quadriceps, Hamstring and core strengthening exercises were continued. Till 6 months post op, only light jogging on a treadmill or a level jogging track and static cycling was allowed. Gradual return to preinjury sporting and activity levels was allowed over next 6 months.

After 1 year postoperatively, full and unrestricted return to desired level of activity was allowed.

### 3. Theory and calculations

The records of pre injury, preoperative and postoperative IKDC, Lysholm score and Tegner activity score being maintained in our centre for all Knee arthroscopy patients were retrieved for the purpose of the study. All patients at 24 months follow up were also asked if they were able to carry out all military training and duty related activities and the answer was recorded as either 'Yes' or 'No'. One independent orthopaedic surgeon blinded to the study analysed the clinical outcomes.

Institutional ethical committee clearance was obtained to subject volunteer patients to a single 3D CT scan of the operated knee. The quadrant method as described by Bernard-Hertel et al.<sup>25</sup> was utilised to assess the postoperative femoral tunnel position on the 3D-CT. A true lateral view subtracting the medial femoral condyle in middle of the intercondylar notch of the distal femur by 3D-CT was obtained. A rectangular Grid (4 × 4) was superimposed on the above image parallel to the Blumensaat line on Power Point ver. 2013 (Microsoft Corporation, Redmond, USA) as shown in Fig. 3. The t% calculated the posterior to anterior distances to the centre of the femoral tunnel parallel to the Blumensaat line, and h% calculated the proximal to distal distances to the centre of femoral tunnel perpendicular to the Blumensaat line. The assessment of the femoral tunnel midpoint on the CT scan was done by one orthopaedic surgeon and one radiologist blinded to the study at two different intervals at least 3 weeks apart. The interobserver intraclass correlation coefficients (ICCs) for evaluation of evenness of quantitative measurements were 0.789 and 0.795 and the intraobserver ICCs were 0.865 and 0.884.

### 3.1. Statistical analysis

The collected data was entered in Microsoft excel sheet. SPSS software (version 20) was used for carrying out statistical analysis. Fischer exact test was used to compare the distribution of gender in both the groups. Independent sample and Paired sample Student's *t*-tests were used to compare the difference between the continuous variables between the groups. Chi square test was used to compare groups in terms of preinjury level of activity. A *p* value equal to or less than 0.05 was considered to be statistically significant.

Single Tunnel position measured by an assessor at 3 weeks interval (intraobserver) and mean of tunnel positions measured by different assessors (Interobserver) were compared using intraclass correlation coefficients (ICC) and standard error of measurement (Table 1).

**Table 1**

Inclusion Exclusion criteria.

#### Inclusion Criteria

1. Unilateral ACL tears with 'minor' meniscal injuries.
2. Operated between 01 Aug 2012 to 31 Aug 2014.
3. Age 18 to 45 years.
4. Single bundle Arthroscopic ACL reconstruction using hamstring graft.

#### Exclusion Criteria

1. Multiligamentous injuries/rotatory instabilities.
2. Bucket Handle tear of meniscus.
3. Chondral injuries.
4. Revision ACL reconstructions.
5. Generalised ligamentous laxity patients.
6. Patients with proximal tibial/Distal femoral fractures.

#### 4. Results

The study included 92 cases with 4 females (AMP/TT: 2/2) and 88 males (AMP/TT: 41/47). The mean age of the study population was 30.25 years (AMP/TT: 31.16/29.35). Patient age and gender distribution between the two groups were comparable ( $p=0.27$  and  $0.641$  respectively). The two groups did not significantly differ with each other in terms of time from injury to surgery and BMI (Table 2).

The Femoral tunnel position assessed using quadrant technique showed a mean h% of  $35.94$  ( $SD \pm 1.796$ ) and  $35.26$  ( $SD \pm 1.840$ ) in TT/AMP group respectively and a mean t% of ( $30.20$   $SD \pm 2.746$ ) and  $31.30$  ( $SD \pm 4.723$ ) in TT/AMP group respectively. No statistically significant difference was found between the two groups either in the posterior to anterior distance (t%;  $p=0.170$ ) or the proximal to distal distance (h%;  $p=0.075$ ) from the midpoint of the tunnel (Table 3).

Functional assessment of the patients in both the groups showed that they were comparable in terms of functional scores (Lysholm score, Tegner activity level and IKDC scores) preoperatively as well as postoperatively at 6 months, 12 months and 24 months respectively (Tables 4 and 5). When asked if they were able to cope up with moderately tough requirements of routine training and duty,  $75.51\%$  and  $72.1\%$  of the patients in TT and AMP groups responded positively ('yes'), there was no significant difference between the groups ( $p=0.7117$ ).  $61.22\%$  and  $62.79\%$  of patients in TT and AMP groups reported activity levels equal to pre injury level based on Tegner scores and there was no significant difference between the groups ( $p=0.8785$ ).

#### 5. Discussion

Our clientele consisted of serving soldiers with a high demand physical activity profile in whom not only is the incidence of ACL injury high owing to the rigours of military life but also a need to recover fully after ACL reconstruction in order to regain preinjury activity levels. Though incidence of ACL tear is more common in females,<sup>26</sup> the present study shows a predominance of male subjects consistent with the relative gender distribution of a serving military population.

No statistical difference was found in femoral tunnel position achieved in the TT and AMP groups in our study (Table 2). The data on position of ACL femoral footprint from previous cadaveric studies<sup>24,41–46</sup> was analysed and mean t% and h% values were calculated for reference of ideal femoral tunnel position (Table 6). Most of these studies mention data for AM and PL bundle of ACL separately. However a mean value of AM/PL bundle in each study was taken as the femoral footprint position. The femoral tunnel position in TT (t% and h%:  $30.20$  and  $35.94$ ) and AMP (t% and h%:  $31.30$  and  $35.26$ ) groups of our study were found to be close to the femoral footprint of ACL obtained in various previous cadaveric studies (t% and h%:  $27.2$  and  $33.2$ ).<sup>24,41–46</sup>

**Table 2**  
Pre operative Demographic Profile.

	TT	AMP	p Value
Total (n=92)	n=49	n=43	–
Mean Age	29.35 ( $\pm 7.95$ )	31.16 ( $\pm 7.73$ )	0.271 Ind t-test
Sex (M:F)	47:2	41:2	0.641 Fischer
BMI	23.10 ( $\pm 2.33$ )	23.21 ( $\pm 2.435$ )	0.83 Ind t-test
Mean Duration to surgery from the time of injury	214.53 days ( $\pm 198.44$ )	297.37 days ( $\pm 232.93$ )	0.069 Ind t-test
Mean Pre injury Tegner scale	6.84 ( $+0.79$ )	6.67 ( $+0.78$ )	0.329 2 tailed ind sample t-test
Mean Pre op Lysholm	39.43 ( $+7.72$ )	39.65 ( $+7.24$ )	0.260
Mean Pre op Tegner score	2.04 ( $+0.40$ )	1.88 ( $+0.45$ )	0.669
Mean Pre op IKDC	43.43 ( $+7.73$ )	41.65 ( $+7.23$ )	0.081

**Table 3**  
Midpoint of Femoral tunnel positions in TT & AMP Groups.

	TT	AMP	p value
t%	30.20 $\pm 2.746$	31.30 $\pm 4.723$	0.170
h%	35.94 $\pm 1.796$	35.26 $\pm 1.840$	0.075

**Table 4**  
Lysholm and IKDC scores.

Lysholm scores	Pre op	6 m	12 m	24 m
AMP (n=43)	39.65 ( $\pm 7.24$ )	87.37 ( $\pm 2.64$ )	91.88 ( $\pm 2.57$ )	96.74 ( $\pm 1.14$ )
TT (n=49)	39.43 ( $\pm 7.72$ )	87.12 ( $\pm 2.89$ )	91.90 ( $\pm 2.36$ )	96.61 ( $\pm 1.11$ )
P value	0.260	0.271	0.978	0.579

IKDC Scores	Pre op	6 m	12 m	24 m
AMP (n=43)	41.65 ( $\pm 7.23$ )	80.37 ( $\pm 2.65$ )	90.88 ( $\pm 2.57$ )	91.67 ( $\pm 0.78$ )
TT (n=49)	43.43 ( $\pm 7.73$ )	81.12 ( $\pm 2.90$ )	89.90 ( $\pm 2.36$ )	91.61 ( $\pm 1.13$ )
P value	0.081	0.200	0.060	0.763

A traditional TT tunnel would place the femoral tunnel opening anterior and high as shown in Fig. 3 which is the main criticism of TT technique. In a cadaveric study designed by Piasecki et al.<sup>27</sup> it was concluded that femoral tunnels could be positioned in a highly anatomic manner using the TT technique but required careful choice of proximal tibial starting position. Youm et al.<sup>28</sup> concluded in their study that a simple alteration in technique of traditional transtibial passage of guide wire into femoral condyle by varus and internal rotation of tibia can achieve an anatomical femoral footprint. We modified the TT technique as described earlier resulting in a final tibial entry point that was closer to the articular surface (3–4 cm) with a more horizontal tunnel (angle  $30$ – $40^\circ$  to the tibial articular surface) which helped us reach the ideal femoral ACL footprint (more inferior and deep on the medial wall of lateral femoral condyle). Our study confirms findings of previous literature<sup>27–29</sup> that a modified TT technique can yield near anatomical femoral tunnels comparable with the ones obtained by AMP technique. We believe that a shorter tibial tunnel is not as much a critical limitation with use of hamstring graft fixed with interference screw as with Bone patellar tendon Bone graft which requires longer tunnels. We faced no problems with any of the cases in TT group due to the shorter tunnels or the tunnels that were closer to the articular surface of tibia.

Numerous studies have shown that a traditional TT technique for femoral tunnel placement often resulted in non-anatomic tunnel placement<sup>30,27,31</sup> with resultant suboptimal functional results as compared to the newer AM portal technique.<sup>5–9,32–36</sup> However high volume Danish registry based study by Rahr-Wagner et al.<sup>37</sup> on primary ACL reconstructions by TT/AMP technique found out that at an average time of follow-up of 22.2 months (95% CI: 21.8, 22.4) for the whole cohort and 16.2 (95% CI: 15.6, 16.8) and

**Table 5**

Tegner activity scale in both the groups.

	Pre injury	Pre op	6 m	12 m	24 m
AMP (n = 43)	6.67 ( $\pm 0.78$ )	1.88 ( $\pm 0.45$ )	3.86 ( $\pm 0.41$ )	5.30 ( $\pm 0.77$ )	6.41 ( $\pm 0.66$ )
TT (n = 49)	6.84 ( $\pm 0.79$ )	2.04 ( $\pm 0.40$ )	3.88 ( $\pm 0.39$ )	5.34 ( $\pm 0.75$ )	6.43 ( $\pm 0.89$ )
P value (two tailed test)	0.329	0.669	0.839	0.780	0.952

**Table 6**

Mean position of femoral tunnel midpoints in various cadaveric studies.

	t%			h%		
	AMB	PLB	Mean	AMB	PLB	Mean
Colombet et al. <sup>45</sup>	26.4	32.3	29.35	25.3	47.6	36.45
Zantop et al. <sup>43</sup>	18.5	29.3	23.9	22.3	53.6	37.95
Forsythe et al. <sup>42</sup>	21.7	35.1	28.4	33.2	55.3	44.25
Yamamoto et al. <sup>44</sup>	25	29	27	16	42	29
Bernard and Hertel <sup>24</sup>	–	–	24.8	–	–	28.5
Tsukada et al. <sup>41</sup>	25.9	34.8	30.35	17.8	42.1	29.95
Musahl V et al. <sup>46</sup>	–	–	26.6	–	–	26.3
Mean across Cadaveric studies	–	–	27.2	–	–	33.2
Our study	–	–	30.2	–	–	35.94
TT group	–	–	31.30	–	–	35.26
AMP group	–	–	–	–	–	–

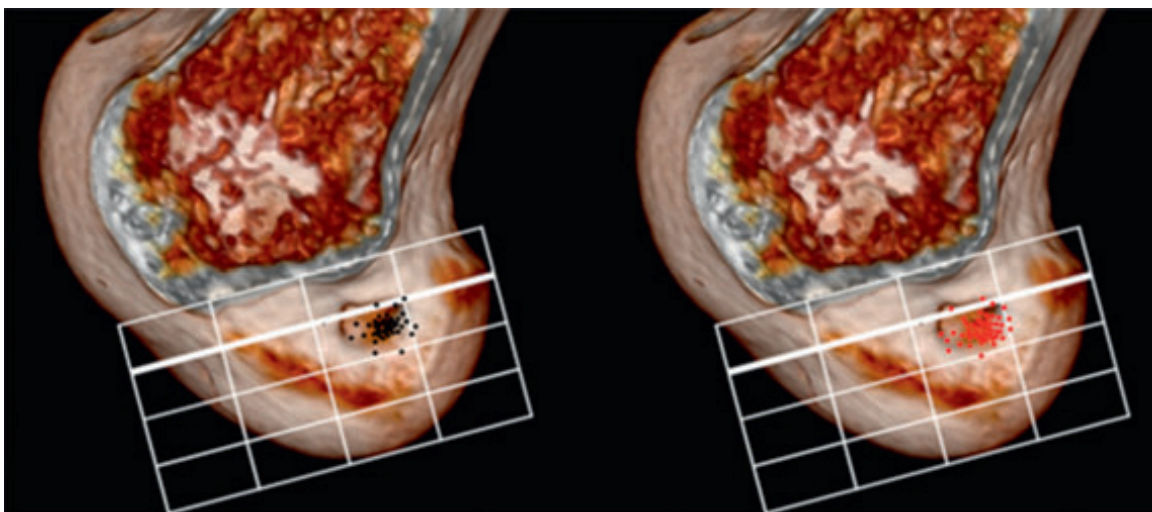
24.0 (95% CI: 23.6, 24.3) months for the AM and TT groups, respectively, The rates of revision were 5.16% (95% CI: 3.61%, 7.34%) and 3.20% (95% CI: 2.51%, 4.08%), respectively. They found the RR of 2.04 (95% CI: 1.39, 2.99) for revision surgery, 2.86 (95% CI: 2.40, 3.41) for positive pivot shift and 3.70 (95% CI: 3.09, 4.43) for sagittal instability in AM group compared to TT group. However this study did not compare the functional scores obtained in the two groups (Fig. 4).

Wang et al.<sup>38</sup> in their study to compare the efficacy of TT and AMP technique of femoral tunnel drilling in achieving normal knee kinematics during physiological loading conditions in ACL deficient knees concluded that the AMP technique restored the internal-external rotation and anterior-posterior translation more closely but there was significant extension loss (mean loss 5) of knees at flexion valley during the late stance phase compared with the controls. This may be due to posteriorly shifted femoral tunnel

resulting in graft tightness during extension. However the IKDC scores were equal in both groups.

In a meta-analysis of Clinical outcomes of TT versus AMP drilling techniques to prepare the femoral tunnel during ACL reconstruction by An Liu et al.,<sup>39</sup> the authors concluded that despite there being less than the minimal clinically important differences (MCID) in the Lysholm score, the IKDC score, and the VAS scores, the AM drilling technique was superior to the TT drilling technique based on the physical examination and scoring system results.

Chen et al.<sup>40</sup> in their systematic review of 10 articles and meta-analysis of 6 studies found that the AM technique yielded superior outcomes in terms of Lachman test, pivot-shift test, and IKDC scores and yielded comparable outcomes in terms of Lysholm scores. However they did not include articles involving modified TT technique and they excluded a study by Rahr-Wagner et al. because



**Fig. 4.** Shows the grouping of mid points of femoral tunnels obtained by AMP(Black dots) and TT(Orange dots) techniques. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

it was registry based with a different methodology, low follow up rate at 1 year but nevertheless had important findings of poorer results with AMP technique.

Our study found that 75.51% and 72.1% of the patients in TT and AMP groups were able to cope up with moderately tough physical requirements of military training and duty, there was no significant difference between the groups ( $p=0.7117$ ). However only 61.22% and 62.79% of patients in TT and AMP groups respectively could regain preinjury levels of activity based on Tegner scores and there was no significant difference between the groups ( $p=0.8785$ ). This was consistent with the previously reported outcomes in the contemporary literature.<sup>47–49</sup>

## 6. Strengths, weaknesses and conclusions

### 6.1. Strengths

This kind of Study in an Indian military population to our knowledge is the first of its kind.

### 6.2. Weakness

Retrospective study, small sample size, large number of patients not available for CT scan due to the transferable nature of their jobs, non-inclusion of objective measures for assessment of outcome.

### 6.3. Conclusions

We conclude by saying that both TT and AMP techniques of drilling the femoral tunnels can achieve near normal anatomical graft placement and produce excellent clinical outcomes essential in soldiers to cope with tough working conditions. The TT Technique cannot be discarded as an inferior technique as it has important advantages over AMP technique and as seen in our study, with slight modification in technique it can produce a near anatomical femoral tunnel similar to AMP technique resulting in a comparable clinical outcome. With none of the techniques producing significantly superior results, it is up to the surgeon to choose from one of the techniques to produce consistent results.

## Conflict of interest

None.

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## Research paper

# Study of neuroreceptors in native ACL stump and autologus hamstring tendon graft



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## ABSTRACT

**Background:** Anterior cruciate ligament (ACL) reconstruction is a very common arthroscopic surgery. All around the world the commonest autograft preferred is hamstring tendon. Present trend is more in favor of retaining the native ACL stump as the available neuroreceptors in the stump might help in early recovery of proprioception after ACL reconstruction.

**Methods:** This is a prospective study done on 56 cases. We took biopsy samples from knee joints of patients who had undergone arthroscopic ACL reconstruction at our hospital from native ACL stump as well as the graft (Semitendinosus) and sent them for immunohistological examination using S-100 Protein and NFP (Neural filament protein).

**Results:** Chronicity of ACL deficient knee's (injury to surgery more than 6 months) revealed poor positivity for neuroreceptors in sample A. After 3 months of injury there was a gradual decrease in positivity for neuroreceptors with persistence of these neural elements upto 6 months within remnant ACL stump.

**Conclusion:** The results suggest that complete or partial ACL tears should be addressed by early arthroscopic ACL reconstruction using remnant-preserving technique, as the number of mechanoreceptors gradually deteriorates with time following injury.

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## 1. Introduction

Palmer and Abbott described ACL as a double bundle structure, the anteromedial (AM) and the posterolateral (PL) bundle, which provide anterior and rotational stability of the knee.<sup>1,2</sup> The tibial footprint dictates the nomenclature of the two ACL bundles.<sup>3,4</sup> ACL reconstruction was first described by Hey Groves in 1917.<sup>5</sup> Single bundle (SB) ACL reconstruction has given good outcomes in restoration of anteroposterior knee stability in most patients.<sup>6,7</sup> Tashman et al. evaluated patients who had undergone single bundle ACL reconstruction and concluded that SB restored anteroposterior knee stability, but not rotational stability, of the knee joint.<sup>8</sup> Double bundle (DB) ACL reconstruction provides both anteroposterior knee stability and rotational stability. However, in literature there is no consensus on which technique is superior.<sup>10</sup>

Remnant preserving ACL reconstruction has been and topic of discussion and controversy. Several authors recommend shaving of ruptured stump of ACL for better accommodation and visualization

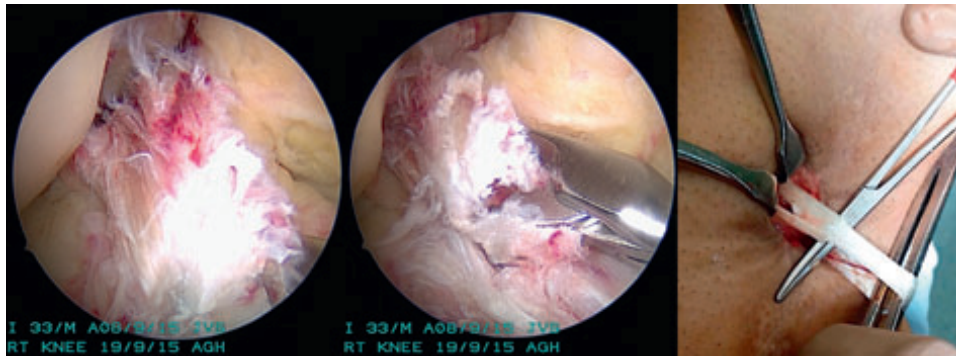
of a good-sized graft, especially a DB graft.<sup>9,11,12</sup> Whereas others feel that in remnant preserving technique the available neuroreceptors help in early recovery of proprioception.<sup>13–17</sup> There are three reasons to preserve the remnant stump: biomechanical advantage, better vascular and proprioceptive recovery.<sup>13–17</sup> Remnant ACL stump provides ingrowth of mechanoreceptors resulting in early proprioceptive recovery following ACL reconstruction.<sup>13–17</sup> Chronicity of ACL tear affects the availability of neuroreceptors.<sup>18</sup> Denti et al. demonstrated that the mechanoreceptors within ACL gradually decrease in number after 3 months of injury and could not be demonstrated after one year of injury.<sup>18</sup> Whereas, Dhillon et al. showed persistence of mechanoreceptors in one of the cases as late as 42 months after rupture.<sup>19</sup> Crain et al. classified ACL remnant stumps in to four types: Type 1 native ruptured ACL remnant adherent to PCL, Type 2 remnant tissue healed to roof of the notch, Type 3 healed to lateral wall and Type 4 complete resorption of stump ACL.<sup>20</sup>

### 1.1. The purpose of present study

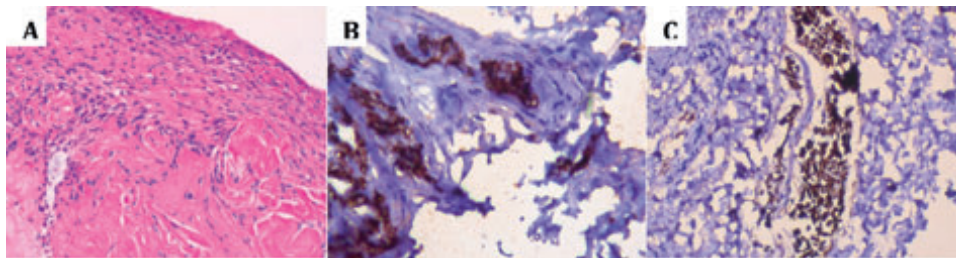
The purpose of this study was to find out the presence of neuroreceptors within ruptured native ACL stump and autologous hamstring graft (semitendinosus) (Fig. 1). This study used S-100

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**Fig. 1.** (A) Arthroscopic view of native ruptured ACL stump. (B) Biopsy taken using a 1.5 mm basket punch from native ACL stump (Sample A) close to its tibial attachment site. (C) During graft preparation biopsy Sample B (semitendinosus tendon) was taken close to its insertion.



**Fig. 2.** (A) Haematoxylin and eosin (H&E) stained section showing structure of native ruptured ACL stump H&E 200. (B) Grade III Neuroreceptors IHC with S-100 protein X 200. (C) Grade I Neuroreceptors IHC with Neurofilament protein (NFP) X 100.

Protein and NFP, immunohistological markers, to identify neural elements (Fig. 2).

## 2. Material and methods

The study is a prospective study comprising of 56 consecutive patients who presented to us with complete ACL tear for whom arthroscopic ACL reconstruction was done from January 2012 to July 2015. The study was approved by the ethics committee of our institution and all patients provided written informed consent to participate in this study.

**Inclusion criteria:** clinically unstable, ACL deficient knee, confirmed on MRI, with pivot shift positivity.

**Exclusion criteria:** Multiligamentous injuries, previously operated knees, severe Osteoarthritis, non-availability of ACL stump for biopsy.

Out of the 56 patients, 38 were male and the rest 18 were female. 34 patients had right knee injury and 22 patients had left knee injury. There were 26 patients within the age group 20–35 years, 24 patients in the age group 35–50 years and six patients belonged to more than 50 years of age. Patients were grouped based on the time of injury and the time ACL reconstruction was done within 6 months interval, 6 months to 1 year and more than 1 year time period.

The surgical technique was performed under spinal anesthesia; diagnostic arthroscopy was done using lateral and medial arthroscopic portals with a 30° fore oblique arthroscope. At arthroscopy, biopsy was taken from native ruptured ACL stump (Sample A) close to its tibial attachment site using a 1.5 mm basket punch (Fig. 1). Cases with chronic ACL rupture with no available stump, biopsy was not taken. They were excluded from the study. During graft preparation Sample B was taken from semitendinosus tendon (ST) close to its tibial attachment site (Fig. 1).

The samples were preserved in 10% formaldehyde solution. These Samples were processed routinely and paraffin embedded.

Sections were stained using haematoxylin and eosin (H&E), immunohistochemistry was done using S-100 protein and Neurofilament protein (NFP) antibodies (Fig. 2). The reason for using these IHC markers was their potency in identifying neuroreceptors. S-100 protein is located in Schwann cells and myelinated fibers whereas NFP is located in axon cytoskeleton.<sup>20</sup>

## 3. Results

A total of 56 cases of ACL reconstruction were taken up for the study. All specimens were stained by H&E and IHC markers. The patients were grouped based on the time of injury and when the ACL reconstruction was done. There were 45 patients within the time interval 6 months, six patients were in 6 months to 1 year and five patients were more than 1 year time period. The patients within the 6 months time interval of injury showed presence of neuroreceptors, whereas patients after 6 months did not show any neuroreceptors.

The area of the field was 0.65 mm and a subjective grading of number of positive areas/HPF was counted and reported. Presences of neuroreceptors were classified as follows: group I (+1/HPF), group II (+2/HPF) and group III (+3/HPF) (Table 2). Patients more than 6 months duration, showed negative grading for the presence of neuroreceptors. Whereas, patients who were within the 6

**Table 1**  
Results of Immunohistological analysis of Sample A (native ACL stump) and Sample B (Semitendinosus tendon graft) using S-100 protein and Neurofilament protein (NFP).

S-100 Protein	Positive for Neuroreceptors	Negative for Neuroreceptors
SAMPLE – A	38(67.86%)	18(32.14%)
SAMPLE – B	41(73.21%)	15(26.74%)
NFP		
SAMPLE – A	41(73.21%)	15(26.74%)
SAMPLE – B	44(78.57%)	12 (21.43%)



**Table 2**  
Results showing presence of neuroreceptors based on time of injury and surgery.

	Time elapsed between injury and surgery			
	0–3 months	3–6 months	6–9 months	Beyond 1 year
Neuroreceptors	+1	1 Patient		
	+2	10 Patients		
	+3	30 Patients		

months time interval showed presence of neuroreceptors. Immunohistological analysis revealed +3/HPF neuroreceptors for patients who were operated within 3 months from injury. After 3 months there was a gradual decline in the number of neuroreceptors (to +2/HPF), with +1/HPF seen in ten patients between the time interval of 4 and 6 months (Table 2). In the present study there were +3/HPF neuroreceptors upto 3 months in both sections stained using S-100 Protein and NFP. Although, after 3 months there was a gradual decline in the number of neuroreceptors/HPF within sections. From 3 months to 5 months period only +2/HPF neuroreceptors could be identified from immunohistological analysis. At sixth month +1/HPF neuroreceptors were detected within sections (Table 2).

Hence chronicity of the ACL deficient knee (injury to surgery more than 6 months) did not show any neural elements in Sample A. There were 38 patients (67.86%) with S-100 Protein and 41 patients (73.21%) with NFP positive which showed presence of neuroreceptors in Sample A. Sample B (ST tendon) showed +3/HPF neuroreceptors with S-100 Protein (73.21%) and NFP (78.57%) (Table 1).

S-100 protein and NFP were equally good identifying neural elements in tissue specimen. One was not found superior to the other. Sample A had increased amount of neural elements following rupture, but chronicity of ACL deficient knee (especially after a period of 6 months) may prove poor candidate for remnant preserving ACL reconstruction. Preserving native ruptured ACL stump in early ACL reconstruction will certainly help in recovery of proprioception, which may be critical for preventing graft ruptures following ACL reconstruction.

#### 4. Discussion

Mechanoreceptors are biological transducers, which convert stretch stimuli of ligaments into neural impulse that are transmitted through cortical and reflex pathway to the central nervous system for a protective feedback to the knee joint.<sup>21</sup> Scultz et al. was the first to describe the presence of mechanoreceptors in human ACL.<sup>22</sup> Mechanoreceptors were classified by Freeman and Wyke into four types based on their structure, functional characteristics and location within the knee.<sup>23–25</sup> The four types of neuroreceptors which were described in articular tissue of knee joint are as follows: 1) Ruffini, 2) Pacini 3) Golgi 4) Free nerve ending. The first three are encapsulated whereas as the latter is unencapsulated. All four types of neuroreceptors are present in human ACL and were found predominantly close to its tibial attachment site. Ruffini endings are low threshold and slowly adapting; Pacinian endings are low threshold, rapidly adapting; Golgi organs are high threshold, very slowly adapting mechanoreceptors; and free nerve ending are high threshold non adapting pain receptor. Out of the four neuroreceptors free nerve endings are not mechanoreceptor, but nociceptors and function to detect pain.<sup>23–25</sup>

Various authors have shown disappearance of mechanoreceptors from ruptured ACL stump with time in ACL deficient knees. Dent et al. showed that neuroreceptors were present upto 3

months from injury after which there was a gradual decrease of neuroreceptors in remnant ACL stump.<sup>18</sup>

Georgoulis et al. described persistence of neuroreceptors in stump ACL upto 3 years after injury.<sup>19</sup> Dhillon et al. used immunohistological assessment to detect neuroreceptors within native ACL stump in 63 consecutive patients undergoing arthroscopic ACL reconstruction. The samples were stained using H&E, S-100 Protein and NFP. In their study they showed persistence of neural elements in ruptured native ACL stump and concluded that preserving the ruptured ACL remnants may help in better functional outcome following ACL reconstruction because of better re-innervation and proprioception.<sup>26</sup> In our study there was presence for neuroreceptors, +3/HPF upto 3 months in both sections stained using S-100 Protein and NFP. Although, after 3 months there was a gradual decline in the number of neuroreceptors/HPF within sections, and from 3 months to 5 months period only +2/HPF neuroreceptors could be identified from immunohistological analysis. There was persistence of neuroreceptors within native ACL stump which showed +1/HPF in sections, upto 6 months from time of injury and surgery (Table 2).

Proprioception refers to the conscious perception of limb position in space.<sup>27</sup> Proprioception plays an important role in protecting knee from acute injury through a reflex arc. This protective reflex arc is initiated by neuroreceptors and occurs much more quickly than the reflex arc initiated by nociceptors (70–100 m/s vs 1 m/s). Also proprioceptive deficit in knees following ACL tear can predispose to further injury and degenerative changes of the joint.<sup>27</sup>

Ochi et al. in his study implies that electrical stimulation of injured, reconstructed, and normal ACL during arthroscopy under anesthesia induced a somatosensory-evoked potentials (SEPs) indicating that sensory neurons in the ligament provide sensory information about deformation of knee contributing to its stability.<sup>28</sup>

Krausp et al. demonstrated the presence of neurofilaments in ruptured ACL stump after injury and recommended preserving them while doing ACL reconstruction.<sup>29</sup>

Lee et al. was the first to describe remnant preserving arthroscopic ACL reconstruction using hamstring tendon graft and hypothesized that more the tibial remnant was retained better would be the preservation of proprioceptive function and functional outcomes of patients.<sup>13</sup> Kim et al. modified the ACL reconstruction using DB autogenous quadriceps tendon graft using remnant-preserving technique. He concluded that remnant preserving technique is a good alternative as it provides better proprioception and vascular recovery compared to remnant shaving technique.<sup>15</sup> Li et al. suggested that the persevered tendons could prevent tibial tunnel enlargement by avoiding joint fluid leakage. Although there is a possibility for the remnant to become Cyclops lesion resulting in impingement, but preservation of native ACL stump gives better clinical outcomes compared to sacrificing technique.<sup>17</sup>

After ACL reconstruction less than 50% of the patients return to their pre-injury level of activity and more than 90% of patients demonstrates degenerative changes.<sup>30</sup> The author suggest that chronic ACL deficient knee's with clinically marked instability and repeated re-injury can make the stump liable to degeneration and decrease in the availability of mechanoreceptors.

#### 5. Conclusion

Chronic ACL deficient knees have poor availability of neuroreceptors due to loss of these neural elements with time. ACL reconstruction using remnant preservation technique is best when done 6 months from time of injury, because after 6 months no neuroreceptors were found retained within the stump tissue.

Therefore complete or partial ACL tears should be addressed by early arthroscopic ACL reconstruction using remnant-preserving technique.

### Conflict of interest

None.

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## Research paper

## Role of posterior tibial slope in ACL deficient Indian population

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## ABSTRACT

**Purpose:** Posterior tibial slope (PTS) is a bony factor contributing to the anteroposterior stability of knee. It is believed that increased PTS has been associated with ACL injury. The aim of this study is to identify an increased posterior tibial slope as a possible risk factor for ACL injury in Indian population.

**Methods:** Prospective case control study was conducted in Bajaj orthopaedic sports clinic, Delhi. 55 patients were included, in which 27 patients with ACL tear were included in case group "A" and remaining 28 patients with intact ACL in control group "B". Inclusion criteria: Age – 15–55 years, group "A" – patient diagnosed with ACL tear clinically and radiologically on MRI knee and presented within 3 months of injury, group "B" – patient with intact ACL and got their MRI knee done for other knee pathologies. Exclusion criteria: Age >55 years, poor quality MRI, advanced osteoarthritis classified as >grade 2 in Outerbridge classification, multiple ligamentous instability, non-Indian and Patient with ACL tear presenting >3 months after injury. Using MRI, PTS was calculated and compared individually for medial and lateral tibial condyle.

**Results:** The average PTS in case group was 3.95 and 4.74 for medial and lateral tibial condyle respectively. PTS in control group was less than case group with mean value of 0.03 and –0.38 for medial and lateral condyle respectively with statistically significant outcomes (p value <0.05) both for medial and lateral slope.

**Conclusion:** In Indian population, increased PTS can be concluded as a significant risk factor in ACL injury. Though, posterior tibial slope cannot be considered as an isolated risk factor.

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## 1. Introduction

The incidence of anterior cruciate ligament (ACL) injuries has increased in last few decades.<sup>1,2</sup> Multiple predisposing factors have been quoted in the pathophysiology of ACL tear. Anatomical factors like inter-condylar notch index, body mass index, anatomic alignment etc. are included in intrinsic factors along with hormonal, neuromuscular and familial. Factors like playing surface, shoe type, weather condition, and type of sport are included in extrinsic risk factors.<sup>3–7</sup> Identifying the mechanism of injury and the risk factors involved may help prevent the occurrence of ACL injury.<sup>8–10</sup> Recently, posterior tibial slope (PTS) has been considered as an important risk factor. PTS is a bony factor which contributes to the anteroposterior stability of knee.<sup>11,12</sup> It is believed that the PTS directly affects the loading of the ACL during compressive axial force and therefore increased PTS has

been associated with increased strain on ACL which may contribute to the propensity of the ACL to rupture. The medial and lateral PTS are different with reported difference of as much as 27 degrees. A recent study found greater lateral plateau slope in patients with ACL rupture.<sup>13,14</sup> Yet, there is currently no published data investigating the relationship of medial and lateral posterior tibial slope and ACL tear in Indian population. The aim of this study is to identify an increased posterior tibial slope as a possible risk factor for ACL injury in Indian population.

## 2. Material and methods

A prospective case control study was conducted from January 2014 to December 2014. A total of 55 patients were included in this study, in which 27 patients with ACL tear were included in group "A" i.e. case group and remaining 28 patients with intact ACL were included in group "B" i.e. control group.

Inclusion criteria:-

1. Age – 15–55 years

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2. Group “A” – patient diagnosed with ACL tear clinically and radiologically on MRI knee and presented within 3 months of injury.
3. Group “B” – patient who got their MRI knee done for other knee pathologies but with intact ACL.

Exclusion criteria:-

1. Age > 55 years
2. Poor quality MRI scan
3. Advanced Osteoarthritis classified as > grade 2 on Outerbridge classification.
4. Multiple ligamentous instability
5. Patient with ACL tear presenting >3 months after injury
6. Non Indian (foreigners)

Informed written consent was taken from each patient regarding participation in this study and future publication of this study. Technique opted for measuring PTS was same as described by Hudek et al.<sup>15</sup> MRI knee of all patients were done using 1.5 Tesla MRI scan with slice thickness of 3 mm. All the MRI's were done at the same centre. Patient was placed in same position during MRI which was achieved by fixation of hip and determination of points on tibia. Intermediate weighted sagittal sections were used for each patient. The MRI sagittal slices were set manually by radiologist orthogonal to a line connecting the posterior femoral condyles. Measurement of bony PTS was done following 3 steps. In first step, central sagittal image was chosen, which was determined by the concave shape of tibial attachment of PCL, inter-condylar eminence and the anterior and the posterior

tibial cortex. Secondly, two circles were made, one cranial and one caudal in tibial head. The cranial circle was made such that it touches the anterior, posterior and cranial tibial cortex. The caudal circle had to touch the anterior and posterior cortex border. Moreover caudal circle was placed such that its circumference lied at the centre of cranial circle. Finally the longitudinal axis was drawn using two circles (Fig. 1). Orthogonal to the longitudinal axis was made; simultaneously the tangent was drawn to lateral and medial tibial plateau. Then, the posterior tibial slope of medial and lateral tibial plateau was measured independently by two observers twice (Fig. 2). Mean of their values were recorded as final readings. Results were analysed comparing posterior tibial slope between two groups i.e. ACL injured and ACL intact.

### 3. Results

SPSS SOFTWARE 20.0 was used to analyse the results, using independent student *t*-test as a statistics tool.

In group “A”, 17 patients were male out of 27. Mean age of males was 35.7 years (range 18–51 years). Ten patients were females with mean age of 35.8 years (range 16–51 years). The cause of ACL tear was road traffic accident in 8 patients, playing soccer in 10 patients, playing basketball in 5 patients and other causes in remaining 5 patients (Table 1). Mechanism of injury in 20 patients (except RTA) was non-contact type of ACL injury.

In group “B” also 13 patients were male with mean age of 36.6 years (range 24–52 years) and 15 were female patients with an average age of 39.1 years (range 19–50 years). They were either found to have isolated meniscal injuries, or no pathology (Table 2).

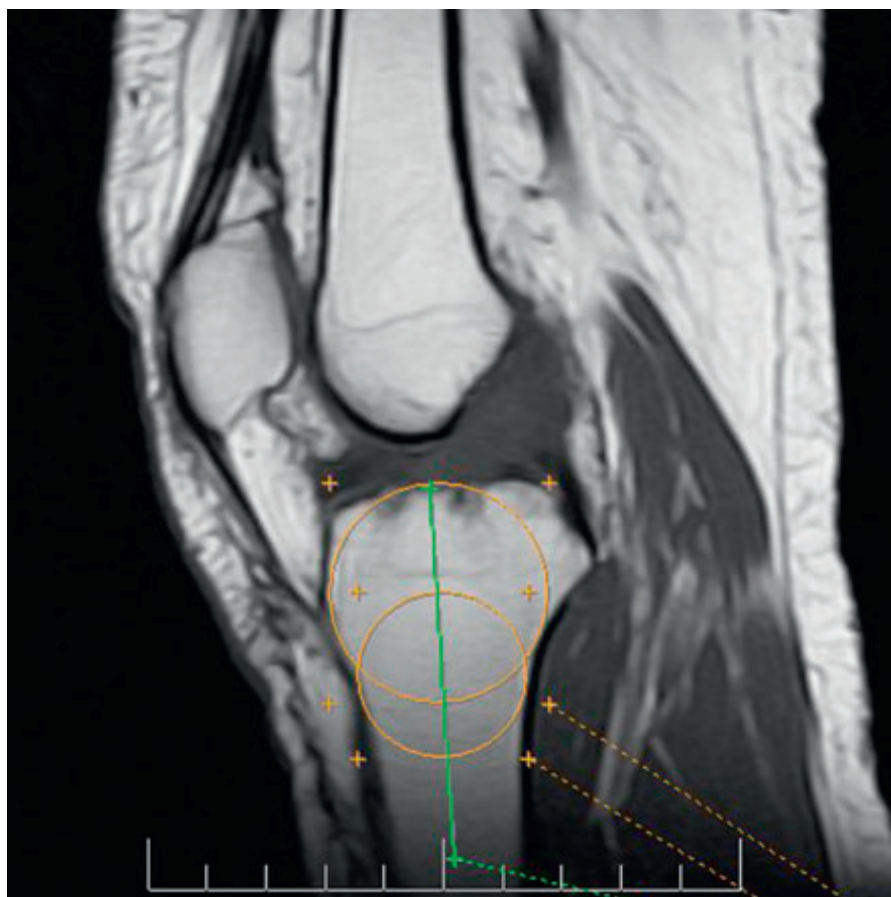


Fig. 1. Sagittal section of intermediate weighted image of MRI showing method of determining longitudinal axis of tibia.

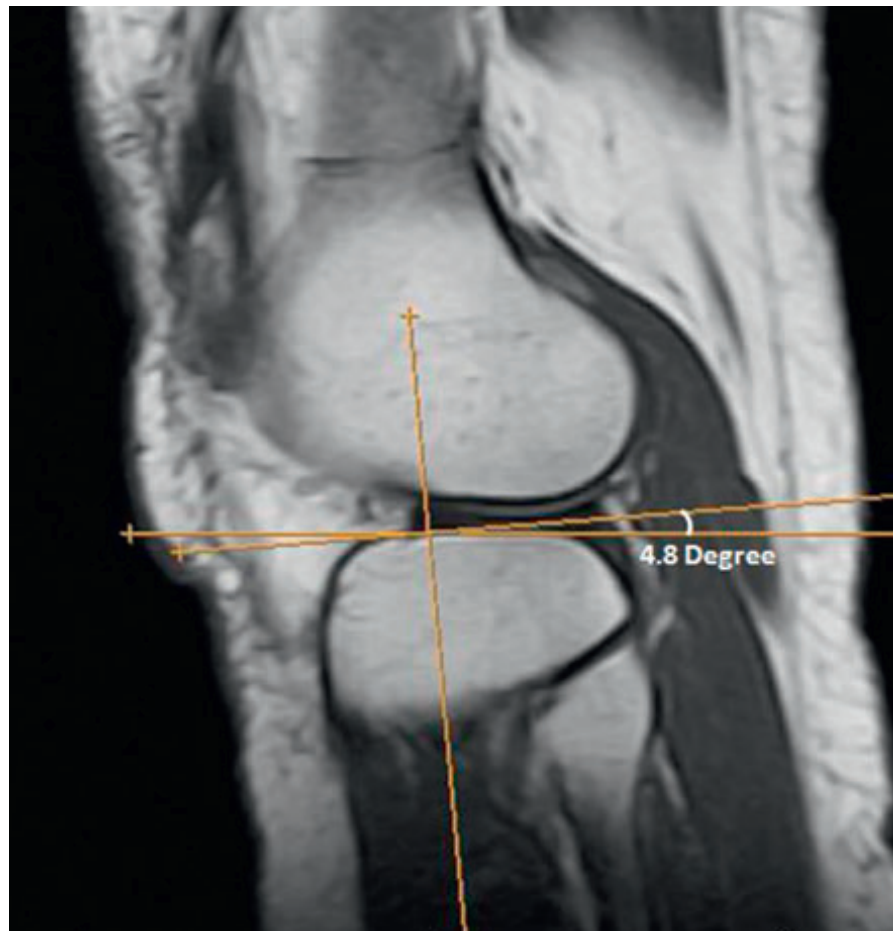


Fig. 2. Sagittal section of intermediate weighted image of MRI Method of measuring posterior tibial slope of lateral condyle.

**Table 1**  
Comparative studies.

Study/method of study	PTS medial			PTS Lateral		
	ACL Injured	ACL Intact	Significance (P value)	ACL Injured	ACL Intact	Significance (P value)
Meister et al. <sup>40</sup> 1998 (LR)	9.7 ± 1.8	9.9 ± 2.1	0.67	na	na	
Brandon et al. <sup>18</sup> 2006 (LR)	11.2 ± 3.8	8.5 ± 3.0	.001	na	na	
Stijak et al. <sup>33</sup> 2008 (LR + MRI)	5.2 ± 3.6	6.6 ± 3.2	0.066	7.5 ± 3.4	4.4 ± 2.3	0.001
Todd et al. <sup>35</sup> 2010 (LR)	9.4 ± 2.6	8.5 ± 2.7	0.003	na	na	
Hashemi et al. <sup>9</sup> 2010 (MRI)	6 (2–14)	5 (3–10)	.01	9 <sub>-</sub> (0–12)	6(0–14)	0.005
Hudek et al. <sup>38</sup> 2010 (MRI)	4.7 ± 2.7	4.1 ± 2.8	0.25	5.6 ± 2.9	4.9 ± 3.2	.292
Simon et al. <sup>29</sup> 2010 (MRI)	−1.8° ± 3.7°	−2.9° ± 2.8°	.20	1.8° ± 3.2°	−0.3° ± 3.6°	.02
Vyas et al. <sup>34</sup> 2011 (LR)	12.1 ± 3.3	8.9 ± 3.8	.009	na	na	
Ristic et al. <sup>37</sup> 2014 (MRI)	5.49 ± 2.77	4.67 ± 2.36	.227	6.68 ± 2.23	5.64 ± 1.90	.06
Current study	3.95 ± 2.94	0.03 ± 3.29	.0001	4.74 ± 2.59	−0.38 ± 4.53	.0001

On comparing the posterior tibial slope, the average angle of PTS in case group was 3.95 (standard deviation 2.94) and 4.74 (standard deviation 2.59) in medial and lateral tibial condyl respectively. PTS in control group was less than case group with mean value of 0.03 (standard deviation 3.29) and −0.38 (standard deviation 4.53) in medial and lateral condyl respectively. This difference between the groups was found to be statistically significant with p value <0.05 both for medial and lateral slope.

On comparing the medial and lateral tibial slope in males and females in ACL injured group, no significant difference was found. Mean of medial slope was 3.97 and 3.94 in males and females

respectively. Mean of lateral slope was 4.29 and 5.52 in males and females respectively (p value >.05)

#### 4. Discussion

Due to the frequent injury to the ACL and its subsequent cost in management, the importance of identifying the risk factors, in particular modifiable or reversible risk factors, is essential.<sup>16–20</sup>

Possible causative factors for the increased incidence may be extrinsic (body movement, muscle strength, shoe-surface interface, and skill level) or intrinsic (joint laxity, hormonal influences,

**Table 2**  
ACL injured.

CASE	Age (yrs)	Sex	Medial tibial Plateau slope (deg)	Lateral tibial Plateau slope (deg)
Case 1	51	F	5.2	3.6
Case 2	29	F	4.8	2.7
Case 3	37	F	5.5	4.5
Case 4	47	M	7	5.6
Case 5	34	M	1.2	5.8
Case 6	50	M	6.6	4.3
Case 7	30	M	5.2	5.1
Case 8	16	F	2.8	8.1
Case 9	40	F	8.1	5.9
Case 10	52	F	6.9	7
Case 11	53	F	5.8	10
Case 12	19	F	3.8	3.2
Case 13	51	M	4	3.7
Case 14	26	M	3.1	6.6
Case 15	43	M	2.5	5.8
Case 16	18	M	5	6.5
Case 17	28	M	7.8	8.3
Case 18	49	M	4.8	4.3
Case 19	26	M	10	7
Case 20	21	M	3.1	3.6
Case 21	20	M	3.7	3
Case 22	42	F	-2.8	8.5
Case 23	24	M	1.1	0
Case 24	45	F	-0.7	1.7
Case 25	51	M	2.1	1.9
Case 26	23	M	-0.5	-0.5
Case 27	37	M	0.8	2

limb alignment, notch dimensions, and ligament size). Aggressive contraction of quadriceps muscle during moderate knee flexion is also a relevant intrinsic factor for noncontact ACL injuries because it leads to increased anterior translation of tibia.<sup>21</sup> Women have 2–10 times higher risk for injury than men depending on the type of sport. One of the commonly studied anatomical parameter is notch width index. The non-contact anterior cruciate ligament injuries are more frequent in athletes who had a notch width index that was at least one standard deviation below the mean (normal intercondylar notch ratio is around  $0.23 \pm 0.04$ ).<sup>22–25</sup> Moreover, Female sex hormones (i.e. estrogen, progesterone, and relaxin) fluctuate radically during the menstrual cycle and are reported to increase ligamentous laxity and to decrease neuromuscular performance.

Posterior tibial slope is one of extensively debated and studied risk factor currently, because it comes under the group of modifiable factor. Even the high tibial osteotomy done for osteoarthritis of knee can make significant changes in posterior tibial slope which can ultimately alter the distribution of forces on ACL.<sup>26</sup> Normal value of posterior tibial angle is 7–10 degrees. A greater PTS with axial loading generates a greater anterior translation of tibia.<sup>27</sup> As the ACL is the main stabilizing structure of this movement, this results in its over-tightening which ultimately leads to the increased internal tibial rotation and greater force on ACL.<sup>28</sup> Chronic ACL injuries were excluded from our study due to a common finding of increased PTS in chronic ACL injury secondary to ACL injury rather as a causative factor in ACL injury.

Simon et al. used modified Hashemi's method with 3D reconstruction of tibial articular surface.<sup>29,30</sup> In our study we used the method described by Hudek et al. to measure the PTS. One of important advantages of MRI is the possibility for visualization of the articular cartilage that is not visible on lateral radiography.<sup>11,31</sup>

In our study, mean age of patient with ACL injury was found to be 35.7 years which corroborates with other studies where most of the patients belong to third decade.<sup>3,11,22,23,25,27,28</sup>

Dejour et al. used lateral radiography to assess the relationship of PTS with knee kinematics and has concluded that every 10 degrees of increase in PTS causes 6 mm increase in anterior tibial translation during single legged stance.<sup>10</sup> Fening et al. also experienced increased anterior tibial translation with increased PTS during his study.<sup>32</sup> He also concluded that less ACL tightening occurs after restoration of PTS by doing high tibial osteotomy. In their study, Simon et al found that the average slope of the medial tibial plateau for the injured subjects was  $-1.8^\circ$  and for the non-injured group was  $-2.9^\circ$ .<sup>29</sup> This difference between the two groups was not significant ( $p=0.20$ ). However, the difference between the lateral tibial plateau slopes was significantly different ( $p=0.02$ ), with the injured group ( $1.8^\circ$ ) having a steeper posterior slope than the non-injured group ( $-0.3^\circ$ ).

Stijak et al. concluded in their study that ACL injury is more closely related with the lateral tibial slope than medial tibial slope.<sup>33</sup> Vyas et al. conducted a study on paediatric population and emphasized on the relevance association of medial tibial slope and ACL injury with significant results.<sup>34</sup>

Todd et al and ŞENİŞİK S. et al. also concluded increased PTS in ACL injured subjects.<sup>35,36</sup> Todd et al. found in their study, subjects in the noncontact ACL group had significantly greater slope angles ( $9.39$  degrees  $\pm$   $2.58$  degrees) than did control subjects ( $8.50$  degrees  $\pm$   $2.67$  degrees) ( $P=.003$ ) with statistically significant results for the female subjects.<sup>35</sup>

RISTIĆ V. et al, one of the latest studies also found a statistically significant difference in the values of posterior tibial slope between the group with and without anterior cruciate ligament rupture with the slope on the lateral condyle greater than the medial one and lateral condyle slope being a more significant parameter.<sup>37</sup>

Contrary to the findings of maximum studies, Hudek et al. and Chung et al. found no obvious link between the medial or lateral PTS and ACL injury.<sup>38,39</sup> Meister et al., who studied the medial PTS on radiographs, also found no association to ACL injury (Table 3).<sup>40</sup>

Research done on patient belonging to different race and region had different interpretation, which strengthened our research idea in Indian population. Results in our study corroborates with the

**Table 3**  
ACL intact.

CONTROL	Age (yrs)	Sex	Medial tibial Plateau slope (deg)	Lateral tibial Plateau slope (deg)
CONTROL 1	30	F	0.8	0.6
CONTROL 2	55	F	0.9	1.2
CONTROL 3	52	F	2.9	1.3
CONTROL 4	42	M	-6.4	-4.9
CONTROL 5	44	M	2.5	1.7
CONTROL 6	27	M	1	0
CONTROL 7	32	M	-0.7	3.1
CONTROL 8	50	F	-0.8	-0.8
CONTROL 9	50	F	0	-1
CONTROL 10	42	F	-7.4	-16.2
CONTROL 11	39	M	0.5	-8.1
CONTROL 12	47	M	0	0.9
CONTROL 13	29	F	4.5	1.5
CONTROL 14	51	M	-5.9	-3.4
CONTROL 15	23	F	4.7	4.8
CONTROL 16	43	F	-0.7	-0.1
CONTROL 17	37	M	-3.5	-2.1
CONTROL 18	52	M	0	0
CONTROL 19	48	M	-2	-6.3
CONTROL 20	40	F	6	0
CONTROL 21	32	M	4.5	2.3
CONTROL 22	19	F	-1.2	3.6
CONTROL 23	23	M	1.8	2.5
CONTROL 24	42	F	-2.8	8.5
CONTROL 25	30	F	0.8	0.6
CONTROL 26	49	F	0.9	1.2
CONTROL 27	34	F	2.9	1.3
CONTROL 28	33	M	-2.4	-2.7

findings of most of the other studies i.e. the mean value of medial and lateral PTS was higher in ACL injured group than ACL intact group with statistically significant outcome. The average angle of PTS in ACL injured group was 3.95 (standard deviation 2.94) and 4.74 (standard deviation 2.59) in medial and lateral tibial condyle respectively. PTS in control group was less than case group with mean value of 0.03 (standard deviation 3.29) and -0.38 (standard deviation 4.53) in medial and lateral condyle respectively.

But, the small sample size of our study which included only 55 patients and the MRI slices which did not include the sections of whole tibia were the limitations of our study. As MRI slices of whole tibia can better delineate the tibial axis and can reduce the error. Furthermore study including all the patients with non-contact type of ACL injury only will be more relevant for conclusion. Hence, further studies are required with large sample size, MRI including whole tibia and a similar case group. Furthermore, optimization of PTS using surgical procedures like osteotomy should also be defined and needs further research to prevent ACL rupture on the contra-lateral normal knee and re-rupture.

## 5. Conclusion

In Indian population, increased posterior tibial slope is closely associated with ACL injury with statistically significant results; hence PTS can be concluded as a significant risk factor in ACL injury. Medial and lateral condyle slope, both are individually found to be significantly raised in patients with ACL injury in Indian population. Though, no significant difference was found in males and females PTS in ACL injured patients. Though, posterior tibial slope cannot be considered as an isolated risk factor.

## Conflict of interest

The authors have none to declare.

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## Research article

# Role of accelerated rehabilitation versus standard rehabilitation following anterior cruciate ligament reconstruction using hamstring graft



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## ABSTRACT

**Background:** There is no consensus regarding the optimal postoperative rehabilitation program after anterior cruciate ligament (ACL) reconstruction.

**Material and methods:** Forty patients who had a primary anterior cruciate ligament reconstruction (ACL-R) with a semitendinosus-gracilis (STG) autograft from a single orthopaedic surgeon were prospectively randomized into 2 groups. Twenty patients were randomized to the accelerated rehabilitation group (100% male, mean age  $26.45 \pm 4.696$  years) and 20 to the standard rehabilitation group (90% male, mean age  $28.90 \pm 6.307$  years). Patients were followed and knee laxity and Tegner activity level values were obtained at 6 weeks, 3 months and 6 months postoperatively. IKDC score and KOOS score was collected at 3 and 6 months postoperatively and functional score by single leg hop test was measured at 6 months.

**Results:** There were no differences between the groups for the baseline characteristics ( $P > .05$ ). There was no difference found between the groups in respect to A-P knee laxity, activity level, Patient satisfaction (KOOS score) and functional performance ( $P > .05$ ). There were significant differences in the IKDC scores between groups at 3 and 6 months and in the KOOS score at 3 months ( $P < .05$ ).

**Conclusions:** The current study indicate that an accelerated postoperative protocol is equivalent in terms of laxity, patient satisfaction, functional performance and activity level and better in terms of clinical outcome to a standard rehabilitation protocol after an isolated ACL-R using STG autografts.

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## 1. Introduction

Anterior cruciate ligament (ACL) rupture is one of the most common traumatic injuries that can result in significant functional disability.<sup>1</sup> Although ACL reconstruction (ACL-R) is the most widely practiced surgical intervention, controversy still exists in regard to graft selection and rehabilitation protocol, both of which are largely influenced by surgeon preference.<sup>2</sup>

Postoperative rehabilitation is a major factor contributing to the success of ACL-R and is an integral element in producing a favorable outcome after surgery. The goal of rehabilitation after ACL-R surgery is to restore normal joint range of motion (ROM),

strength, co-ordination and full function as soon as possible, without damaging the graft. In early days rehabilitation program included immobilization of the leg for 6 weeks or longer after an ACL-R procedure while inflammation diminished and the graft healed.<sup>3,4</sup> Postoperative immobilization of the knee results in to limited ROM, stiffness, muscular atrophy and inferior knee function, and prolonged recovery from procedure.<sup>5</sup> Advancements in surgical technique and fixation have warranted re-evaluation of the use of restrictions after ACL-R. Further studies has shown that restrictions may not be necessary, and early aggressive rehabilitation has shown no adverse effects with respect to future injury rate, A-P laxity, ROM deficits, or ability to return patients back to their previous level of function.<sup>6,7</sup>

This has led to interest in early rehabilitation programme. Current rehabilitation programs are aimed toward accelerated interventions with the aim of restoring the range of motion (ROM) to what it was before injury, encouraging weight bearing

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within the first week, reducing pain and swelling, and initiating and developing muscle strength.<sup>8,9</sup> Current evidence indicates that intensive rehabilitation can help prevent early arthrofibrosis and restore strength and function earlier. Although a significant body of literature has shown that aggressive rehabilitation is appropriate after ACL-R using BPTB grafts,<sup>7,10,11</sup> but conclusions are unclear when evaluating the effects on STG autografts. So we elected to evaluate post-operative recovery in ACL-R patient population using STG graft after accelerated rehabilitation and compared them with the outcome after standard rehabilitation.

The appropriate consent has been taken from all the patients in this study stating their wilfull participation and no objection in using/publishing their clinical and scientific data for publication in scientific journal without revealing their identity.

## 2. Material and methods

### 2.1. Patient selection and entry criteria

Patients who have complete ACL tear and clinically symptomatic for instability, of age between 18 years to 50 years of either sex between January 2014 to June 2015 have included in the study conducted at Sir Ganga Ram Hospital in department of orthopaedics. we excluded the patients who have history of previous injury or operation to knee, Simultaneous fracture or a concurrent injury to posterior cruciate ligament, posterior lateral corner, or lateral collateral ligament, Grade III medial collateral ligament tear, Evidence of osteoarthritis radiographically, Comorbidities such as diabetes or rheumatoid arthritis and have significant portion of anterior cruciate ligament found intact at the time of surgery. This study was approved by ethical committee of our hospital and all subjects signed informed-consent forms before participation.

### 2.2. Technique

Detailed history of all patients was taken and all patients were assessed and their age, sex, time since injury, involved side, X ray and MRI findings were noted. All the surgery was performed by the same surgeon by using the same technique. Arthroscopic ACL-R was done using single bundle quadruple hamstring (semitendinosus and gracilis) graft. After routine arthroscopic examination of joint followed by partial meniscectomy if needed, hamstring tendon graft was harvested from the ipsilateral knee. Anatomical landmarks were used to create the bone tunnels, then the graft with endobutton was passed from tibial to femoral tunnel using suture rail-road technique. Femoral fixation was done using endobutton. Then cycling of graft was done by passive flexion and extension before final tibial fixation with biodegradable interference screw. Postoperative on table examination was done by Lachman and Pivot shift test and their grading were noted.

### 2.3. Rehabilitation programme and follow up

After ACL-R patients was randomized to two types of rehabilitation programme and two groups of 20 cases each was made. One group followed the accelerated rehabilitation protocol<sup>20</sup> (Group A) for 19 weeks and other followed the standard rehabilitation protocol<sup>20</sup> (Group B) for 24 weeks. Common to the both programs were the limits of ROM, amount of weight bearing, restriction of movement. Use of brace, exercises and functional activities however, each program incorporated these activities over different time intervals. The cases were followed up regularly and we assessed:- anterior laxity of knee using clinical grading by

Lachman test and Pivot shift test<sup>12</sup> preoperatively, postoperatively on table, at 6 weeks, at 3 months and at 6 months, Knee injury and osteoarthritis outcome (KOOS) score<sup>13</sup> for patient satisfaction assessed preoperatively, at 3 months and at 6 months, International knee documentation committee (IKDC) score<sup>14</sup> for clinical assessment of patient assessed preoperatively, at 3 months and at 6 months, Tegner activity level (TAL) scale<sup>15</sup> for activity level of patient assessed preoperatively, at 6 weeks, at 3 months and at 6 months, and Functional scoring: using single leg hop test<sup>16</sup> assessed preoperatively, and at 6th month for functional performance of patient. On basis of above data a comparison was made between the two groups for anterior laxity of knee, patient satisfaction, clinical outcome, activity level, and functional performance.

### 2.4. Statistical methods

Statistical testing was conducted with the statistical package for the social science system version SPSS 17.0. Continuous variables were presented as mean  $\pm$  SD or median if the data is unevenly distributed. Categorical variables were expressed as frequencies and percentages. The comparison of normally distributed continuous variables between the groups was performed using Student's t test. Nominal categorical data between the groups was compared using Chi-squared test or Fisher's exact test as appropriate. For all statistical tests, a p value less than 0.05 was taken to indicate a significant difference. Sample size of 20 per group was calculated with reference to previous study, based on a mean difference of 4 weeks in duration of rehabilitation with a population variance of (4 wks.), a two-sided alpha of 0.05, and a power of 90%.

### 2.5. Observations and results

A total of 40 patients were enrolled in the study, 20 in accelerated rehabilitation group (A) with average age of 26.45 years, and 20 in the standard rehabilitation group (B) with average age of 28.90 years. Gender, age, side of the involved knee, intraoperative findings and concomitant injuries were equally distributed and similar between the patients in both groups. Similarly, the time interval between the injury and surgery was comparable between the accelerated (mean = 1.479 months) and standard (mean = 4.388 months) groups. The mean is higher in the group B, because of a single case which had the duration of time since injury 4 years. The median was 1.0 in both groups. There was no difference in the incidence of tears of the medial and lateral menisci between the treatment groups. These findings indicate that the randomization procedure established 2 groups of subjects with similar baseline characteristics.

Anterior laxity of knee was measured for all the participants using clinical grading by Lachman test and Pivot shift test preoperatively then after 6 weeks, then at 3 months and 6 months. Anterior laxity of knee was found negative (Grade 0) in all the participants in both groups at 6 weeks, at 3 months and at 6 months. There was no significant difference between both groups and both groups were comparable in anterior laxity of knee.

The clinical assesment of patients was done by IKDC score. Mean preoperative IKDC was 33.65 (SD  $\pm$  3.37) in group A and 35.32 (SD  $\pm$  3.95) in group B and was compairable. The IKDC at 3 months was 65.37 (SD  $\pm$  3.14) in group A and 62.11 (SD  $\pm$  3.01) in group B and at 6 months was 80.51 (SD  $\pm$  3.25) in group A and 78.15 (SD  $\pm$  3.22) in group B. The difference between the two groups was significant on statistical analysis at 3 months (p = 0.002) and at 6 months (p = 0.026) (Table 1).

**Table 1**  
Comparison of IKDC between group A and group B.

IKDC	GROUP A (n=20) Mean ± SD	GROUP B (n=20) Mean ± SD	P value
Pre-operative	33.65 ± 3.37	35.32 ± 3.95	0.158
3 Months	65.37 ± 3.14	62.11 ± 3.01	0.002
6 Months	80.51 ± 3.25	78.15 ± 3.22	0.026

Patient satisfaction was measured by KOOS score. The mean preoperative KOOS score was 49.54 (SD ± 2.71) in group A and 50.26 (SD ± 3.52) in group B and was comparable. The KOOS at 6 months was 82.39 (SD ± 3.14) in group A and 81.05 (SD ± 3.52) in group B. The difference between the two groups was non-significant ( $p=0.211$ ). It was significant at 3 months ( $p=0.007$ ) with KOOS score 75.24 (SD ± 3.06) in group A and 72.41 (SD ± 3.19) in group B (Table 2).

The mean preoperative Tegner activity level was 1.05 in group A and 1.35 in group B and was comparable. The mean TAL at 6 wks, 3 months and 6 months was 1.10, 4.15 and 5.95 in group A and 1.15, 3.85 and 5.55 in group B. The difference between the two groups was non-significant on statistical analysis at 6 wks, 3 months and at 6 months. ( $p$  value > .05) (Table 3). There was significant improvement in Tegner activity level within each group at 3 months and 6 months ( $p < 0.001$ ).

Functional performance of patient was measured by single leg hop test. The mean preoperative Limb symmetry index was 6.7 in group A and 10.9 in group B and was comparable. The LSI at 6 months was 81.8 in group a and 80.5 in group b. The difference between the two groups was non-significant on statistical analysis ( $p=0.254$ )

### 3. Discussion

Rehabilitation after ACL-R plays a major role in the functional outcome of the extremity. Protocols for rehabilitation programs focus on range of motion, weight bearing, strength recovery, and functional return to activities. The protocols that have been published vary as far as prescribed length of rehabilitation and expected rate of recovery. In 1981, the postoperative regimen was based on the principles of ACL reconstruction rehabilitation

described by Paulos et al.<sup>3</sup> Paulos released the patients after 9–12 months following surgery, to full unrestricted activity once they achieved full ROM and successfully completed the functional progression.

In 1988, the program of rigid immobilization was discarded in favor of study done by Tylar et al<sup>17</sup> which concluded that immediate weight bearing did not compromise knee joint stability and resulted in diminished knee pain. Then Ekstrand<sup>18</sup> evaluate the duration of entire programme, an extended 8-month rehabilitation program was compared to a 6-month rehabilitation program following ACL-R. No significant differences were found between the groups at 12 months after surgery based on the author's criteria (full ROM and 90% quadriceps muscle strength).

Shelbourne and nitz<sup>19</sup> in 1992 developed an accelerated strengthening programme that emphasizes full knee extension on the first postoperative day and immediate weight-bearing according to the patient's tolerance. They concluded that the accelerated rehabilitation program has been more effective in reducing limitations of motion (particularly knee extension) and loss of strength while maintaining stability and preventing anterior knee pain. These concepts have been applied, principally, to the BTB operation, and rehabilitation using the multi-strand technique has been less aggressive. Within the last several years, there has been a trend toward earlier range of motion and muscle strengthening exercises.

The studies have some evidence that accelerated rehabilitation may have better outcome. So we evaluate post-operative recovery in our patient population after accelerated rehabilitation and compared them with the outcome after standard rehabilitation.

Our study demonstrated that rehabilitation with either accelerated or standard programs after ACL reconstruction with

**Table 2**  
Comparison of KOOS between group A and group B.

KOOS	GROUP A (n=20) Mean ± SD	GROUP B (n=20) Mean ± SD	P value
Pre-operative	49.54 ± 2.71	50.26 ± 3.52	0.472
3 Months	75.24 ± 3.06	72.41 ± 3.19	0.007
6 months	82.39 ± 3.14	81.05 ± 3.52	0.211

**Table 3**  
Comparison of Tegner activity level between group A and group B.

Tegner activity level	GROUP A (n=20) Mean ± SD	GROUP B (n=20) Mean ± SD	P value
Pre-operative	1.05 ± 0.759	1.35 ± 0.813	0.235
6 Weeks	1.10 ± 0.308	1.15 ± 0.366	0.643
3 Months	4.15 ± 0.366	3.85 ± 0.587	0.06
6 months	5.95 ± 0.999	5.55 ± 0.759	0.162

a hamstring autograft produces the same effect on the primary outcome (the knee laxity) and a majority of the secondary outcomes patient satisfaction, functional performance and Tegner activity level. But clinical outcome measured by IKDC score shows significant improvement at 3 months ( $p$  value=0.002) and 6 months ( $p$  value=0.026) in accelerated rehabilitation group compared to standard group. KOOS score also shows significant improvement at 3 months ( $p$  value=0.007) follow up but at 6 months follow up there is no difference in patient satisfaction (KOOS score) between two groups. There is significant improvement in IKDC and KOOS within the same group at 3 months and 6 months follow up.

There is no difference found in anterior laxity of knee at the 6 weeks, 3 months and 6 months postoperatively in both rehabilitation programme as measured by clinical grading and both groups are comparable preoperatively in laxity of knee with  $P$  value of 0.127 for Lachman test and 0.058 for the Pivot shift test. Similarly there is no significant difference found in Tegner activity level and single leg hop test between two rehabilitation programme at 6 weeks, 3 months and at 6 months follow ups. However there is significant improvement in the Tegner activity level and functional outcome within the same group at 6 months follow up with  $P$  value < .001.

Our results of the study coincide with the previous study done by Beynnon et al.<sup>20</sup> in 2005 in which anterior cruciate ligament reconstruction with a BPTB graft followed by either accelerated or non-accelerated rehabilitation produces the same increase of anterior knee laxity. Both programs had the same effect in terms of clinical assessment, patient satisfaction, functional performance, and the biomarkers of articular cartilage metabolism. Previous studies have compared the effects of early aggressive rehabilitation protocols on outcomes after ACL-R using BPTB grafts, although the results of this study are congruent with the literature, we feel there is a lack of evidence addressing the effect of early aggressive rehabilitation on STG autografts.

Macdonald et al.<sup>21</sup> also shows early accelerated rehabilitation after anterior cruciate ligament reconstruction with semitendinosus and gracilis tendon autograft and a ligament augmentation device does not seem to affect the results adversely. Cristenson et al.<sup>22</sup> also found no differences between early aggressive and non aggressive rehabilitation after isolated ACL-R using STG autografts for the primary outcomes of A-P knee laxity and subjective IKDC score. In addition, no differences were observed for secondary outcomes between groups for differences in ROM and peak isometric force.

As surgical advancements with STG grafts improve, the rehabilitation model should adapt to the changes, and concepts of early aggressive rehabilitation. Early aggressive rehabilitation has been established for years, but there are discrepancies in the literature relative to overemphasis on BPTB grafts and lack of postoperative management on STG grafts. Our findings are clinically relevant since STG autografts have gained popularity in comparison with other graft choices, and limited research has been conducted evaluating the effects of early aggressive rehabilitation on functional outcomes. This evidence is important for guiding clinicians in making appropriate decisions on postoperative rehabilitation and restrictions after surgery.

#### 4. Conclusion

We found that there is no difference in anterior laxity of knee, patient satisfaction, activity level and functional performance in accelerated and standard rehabilitation group. Clinical outcome measured by IKDC score was found better in accelerated group and statistically significant. Patient satisfaction measured by KOOS score was also better at 3 months follow up in accelerated group.

The current study indicate that an accelerated postoperative protocol is equivalent in terms of laxity, patient satisfaction, functional performance and activity level and better in terms of clinical outcome to a standard rehabilitation protocol after an isolated ACL-R using STG graft.

#### Conflict of interest

None.

#### Author contribution

All the author contributed equally for the completion of the scientific work, data analysis and preparation of manuscript.

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None.

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## Research paper

## Trends in scientific publications of Indian arthroplasty surgeons over 15 years (2001–2015)



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## ABSTRACT

**Background:** The quality and number of scientific publications reflect the developmental status of research in a country. However, the contribution of Indian arthroplasty surgeons toward global research publications is unknown yet increasing. This study aims at determining the active role of Indian arthroplasty surgeons for scientific publications between 2000 and 2015.

**Materials and methods:** A literature search of the publications by Indian arthroplasty surgeons was performed using PUBMED. The search terms used were India and several joint related terminologies. The main information of the selected papers including the scientific journal, publication year, type of pathology, or Orthopedic study center, type of study, and the type of article was analyzed.

**Results:** A total of 20,485 Total Hip Arthroplasty articles; 17,151 Total Knee Arthroplasty articles; 400 Total shoulder arthroplasty articles; and 250 Total Elbow Arthroplasty articles were identified using PUBMED and after exclusion, 68 Total Hip Arthroplasty articles; 125 Total Knee Arthroplasty articles; 2 Total shoulder arthroplasty articles; and 3 Total Elbow Arthroplasty articles were analyzed. A growth of 250% in the number of publications in THR & 530% in the number of publications in TKR was observed in the period between 2011 and 2015, during which 35 of the articles in THR, 82 in TKR were published. The three most common pathologies studied for knee were (osteoarthritis, post-traumatic arthritis and complex fracture of a knee); for hip were (osteoarthritis, avascular necrosis, developmental dysplasia of the hip and post tubercular hip arthritis).

**Conclusion:** The current study concept reveals that publications in arthroplasty have been on growing rate in the last decade, although seems to be less. Further efforts such as research training of arthroplasty surgeons, international collaborations, and allocation of adequate funds, proper English tutorials are key factors to improve the scientific publications from India.

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## 1. Introduction

Research publications are one of the important indicators for the scientific growth of that profession. Strength of national research is directly proportional to the number of publications each country contributes toward the worldwide achievement. Developed countries such as the USA and the European Union Nations contribute to the greater part of the scientific publications of the world compared to the developing countries.<sup>1</sup> Adequate funding, competitive professional environment, and English expertise are some of the main reasons behind the major research contributions from developed nations.<sup>2</sup> Department of Science and

Technology (DST) reveals that in 2012 India ranks 9th in the world based on its relative share of worldwide publications.<sup>3</sup> Physics, Chemistry, Engineering, Material Science, and Clinical Medicine are the main areas of research products from India. In the field of clinical medicine, arthroplasty is a young introduced specialty in India and is practiced by orthopedicians. However, it is rapidly developing and has shown significant growth in the last decade. Though a large number of arthroplasty surgeries are performed every year, the contribution of arthroplasty surgeons toward the global literature is not known. Kyoung Min Lee et al concluded that the number of published orthopedic articles has been increasing over the last decade. The number of orthopedic articles, journals publication, and funding sources were dominated by research conducted in the United States; while share and growth of Asian countries including Japan, the Republic of Korea, and China were notable.<sup>4</sup> The present study was initiated to study the patterns of publications in the field of arthroplasty surgery in the last 15 years.

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This will help the surgeons to understand the need for more high-quality studies, the areas that require attention, improve the existing standards of research practices, and formulate steps to enhance research works.

## 2. Materials and methods

A Literature search of the publications by Indian arthroplasty surgeons regarding knee joint/hip joint/shoulder joint/elbow joint topics were made by us using an online database: Pubmed.gov (<http://www.ncbi.nlm.nih.gov/pubmed>).<sup>5</sup> Results were limited to articles published from January 2001 to December 2015. The search terms used were India and (“Total Knee Arthroplasty” or “Total hip Arthroplasty” or “Total shoulder Arthroplasty” or “Total elbow Arthroplasty” or “joint injuries” or “joint pathologies”). Initially, on the basis of heading and abstract, exclusion of published articles that did not involve arthroplasty/joint replacement surgery. The articles which were likely eligible again underwent analysis and the articles without Indian arthroplasty surgeons or authors, letters to the editor, articles not published between 2001 and 2015, and articles from the foreign country were also excluded [Fig. 1]. The Indian arthroplasty surgeons were defined as arthroplasty surgeons from the orthopedics specialty of India in which the paper was affiliated to an orthopedic service.

The main information on the selected papers, such as the scientific journal that published the papers, publication year, or Orthopedics study center, the type of study, the significant pathology studied, the Oxford classification, and the type of article was entered in a Microsoft Excel sheet. The pathologies studied in the articles were classified as: (1) Osteoarthritis; (2) Avascular necrosis; (3) Bone tumor; (4) Post infection arthritis; (5) Post-traumatic arthritis; (6) Joint malformation/deformity; (7) Assessment of outcome; (8) Degenerative disorders; (9) Complex

fractures with very poor fixation prognosis; (10) Surgical technique and; (11) Bone metabolism disorders.

Oxford classification was used to determine the Quality or Level of evidence (LOE) of the published articles. The articles were classified as Journal articles, Case reports, clinical studies, Experimental studies, Clinical trial, Reviews, Randomized control, and Observational studies. The Scopus web site (<http://www.scopus.com>) was used to obtain number of citations per published article.

Statistical analyses were conducted with IBM SPSS version 20.0 (Armonk, New York, IBM Corporation). In which categorical variables were presented as number and proportion. Chi-squared tests and ANOVA test were conducted to look at the progress in the quality of articles in the 15-year period.

## 3. Results

A total of 37,636 articles were identified by the PUBMED search. Only Abstracts of Full text article were assessed for eligibility. Reasons for exclusion of the articles are shown in Fig. 1. After exclusion, 198 articles, published in the PUBMED database by Indian arthroplasty surgeons from 2001 to 2015 were extensively analyzed.

The number of articles published according to the year of publication is shown in graph [Figs. 2 and 3]. An increasing number of publications have been observed. Total 68 articles published on Total Hip Arthroplasty between 2001 and 2015: 35(51.47%) articles were published between 2011 and 2015, 23 (38.23%) between 2006 and 2010, and 10 (10.29%) between 2001 and 2005; Total 125 articles published on Total knee Arthroplasty between 2001 and 2015: 82 (65.6%) articles were published,between 2011 and 2015, 30 (28%) between 2006 and 2010, and 13 (6.4%) between 2001 and 2005; Total 2 articles published on Total shoulder Arthroplasty between 2001 and 2015: 1each in year 2013 & 2009; Total 3 articles

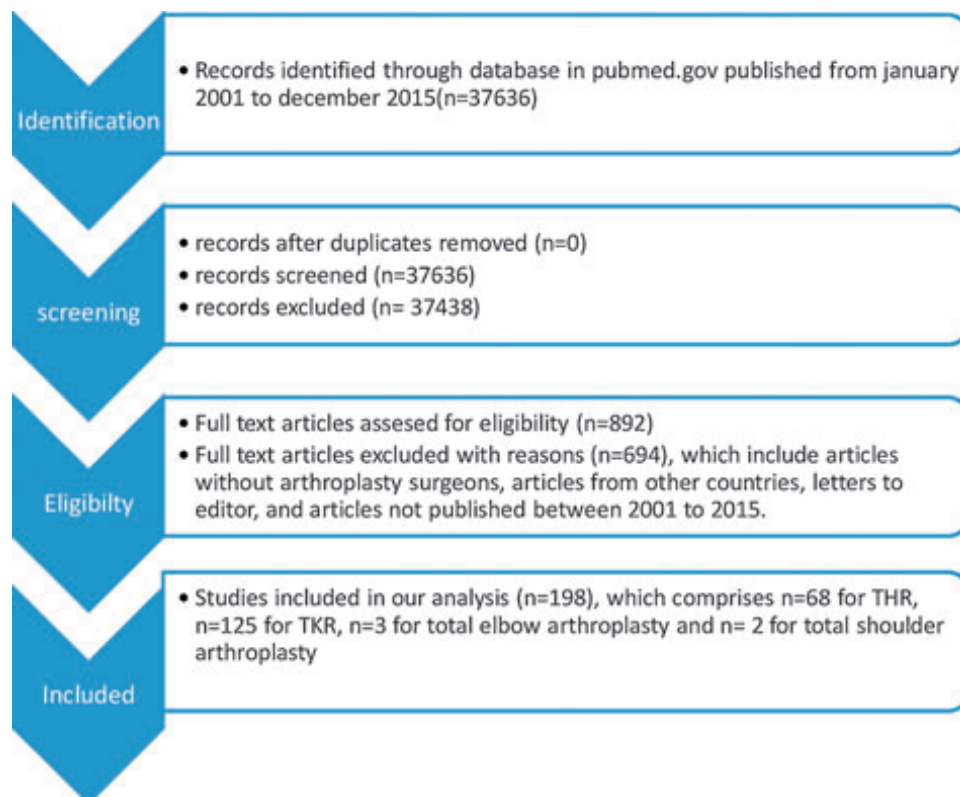


Fig. 1. Flow diagram showing selection of articles from pubmed search, based on inclusion criteria.

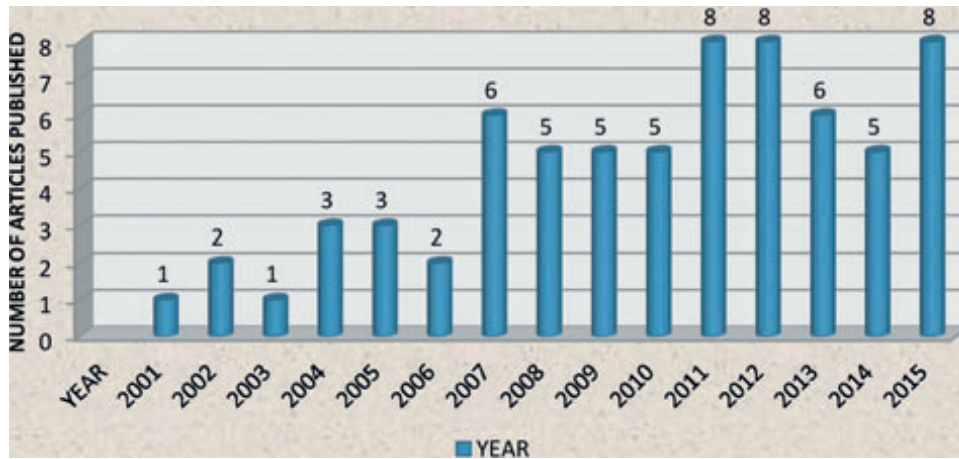


Fig. 2. A graph showing number of articles published for THR from 2001 to 2015.

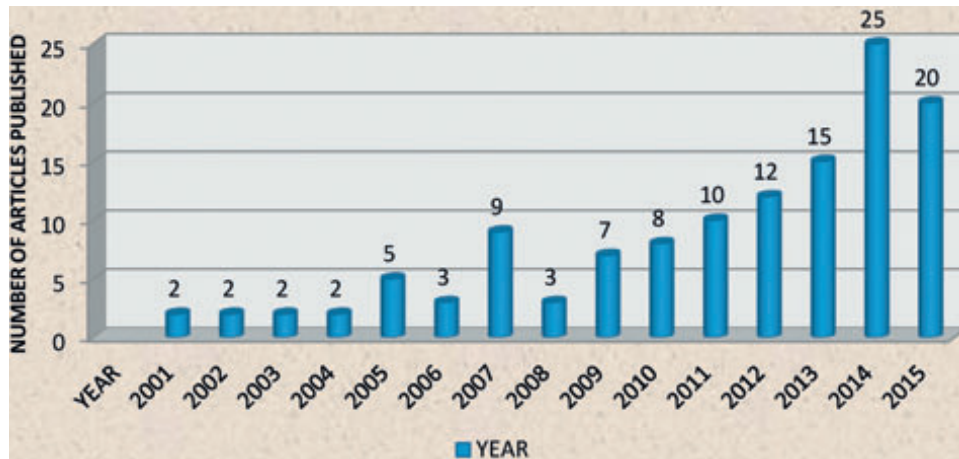


Fig. 3. A graph showing number of articles published for TKR from 2001 to 2015.

published on Total elbow Arthroplasty between 2000 and 2015: 2 in year 2014 and 1 in 2015. Compared to the period of 2001 and 2005, a growth of 250% in number of publications in THR and a growth of 530% in number of publications in TKR by Indian arthroplasty surgeons was observed between 2011 and 2015.

Journal articles 36 (53%) in THR and 67 (54%) in TKR were the most common types of articles, followed by comparative studies 8 (11.8%) in THR and 20 (16%) in TKR and other types of studies were 20 (35.2%) in THR and 38 (30%) in TKR (Figs. 4 and 5).

Figs. 6 and 7, shows the three most common pathologies studied for Knee and Hip which were (osteoarthritis, post traumatic arthritis and complex fracture of knee); for hip were (osteoarthritis, avascular necrosis, developmental dysplasia of hip and post tubercular hip arthritis) respectively.

Analysis of the Oxford classification demonstrated that most papers provided Level of Evidence(LOE) 5 (n = 38,55.8% for THR & n = 69,55.2% for TKR), followed by LOE 4(n = 21,30.8% for THR & n = 39,31.2% for TKR), LOE 3 (n = 7,10.29% for THR & n = 13,10.4% for TKR), LOE 2 (n = 1,1.4% for THR & n = 3,2.4% for TKR), and LOE 1

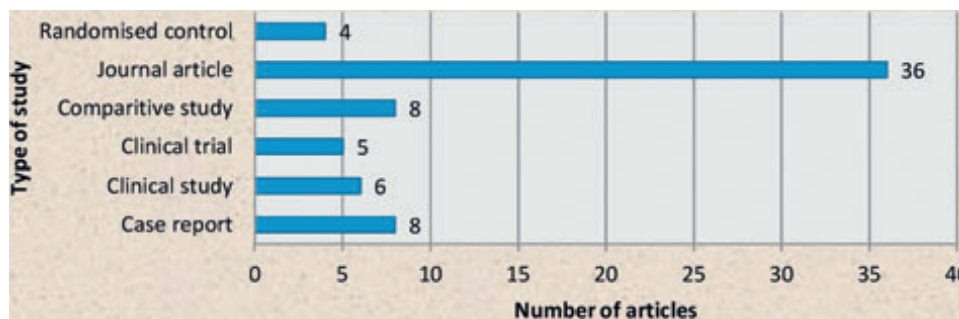


Fig. 4. Graph showing correlation between the Type of study and numer of articles published for THR between 2001 and 2015.



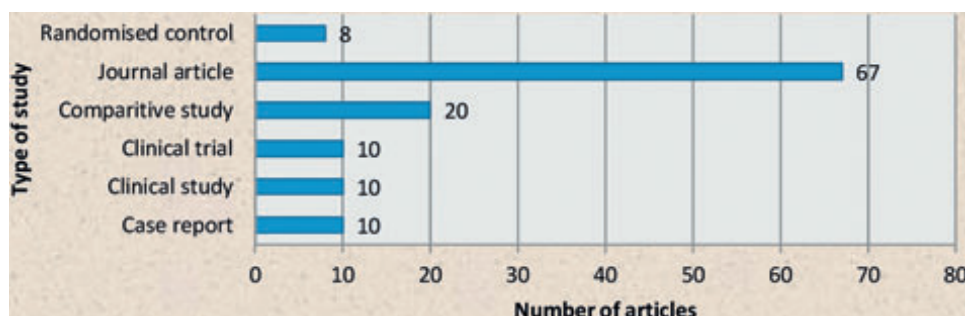


Fig. 5. Graph showing correlation between the Type of study and numer of articles published for TKR between 2001 and 2015.

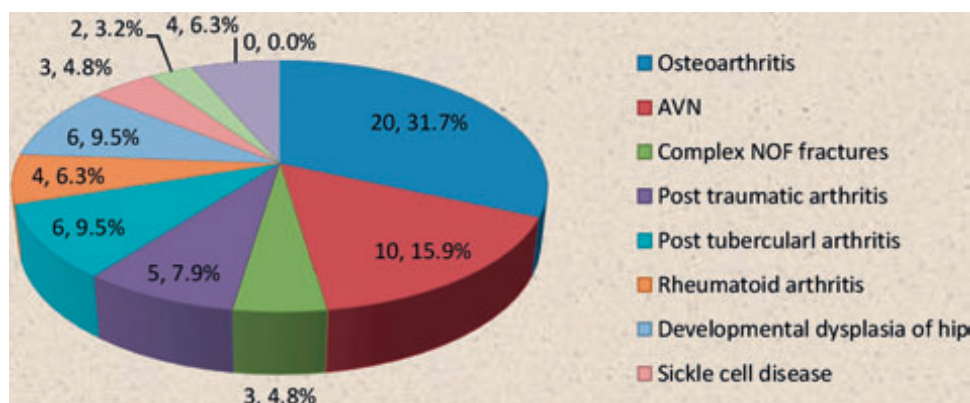


Fig. 6. Pie diagram showing classification of the articles based on main pathology studied for Thr.

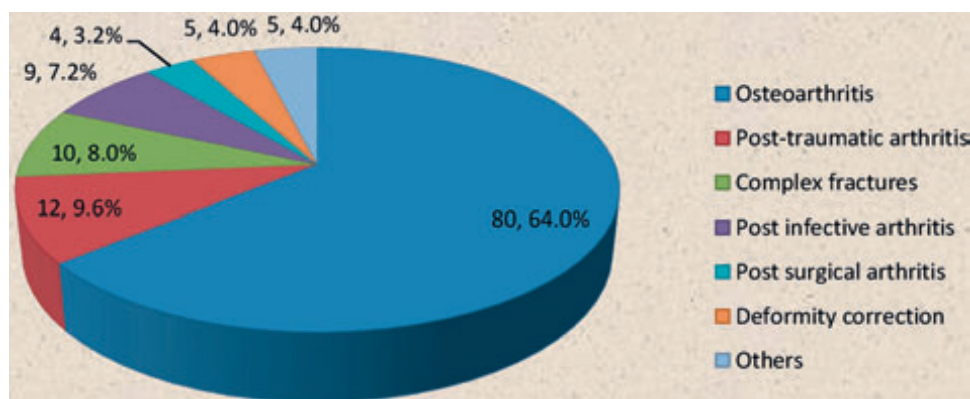


Fig. 7. Pie diagram showing classification of the articles based on main pathology studied for TKR.

(n = 1,1.4% for THR & n = 1,0.8% for TKR). Brian P. Cunningham et al studied that the number and proportion of Level I and II publications have increased. LOE can be graded reliably with high interobserver agreement. The number and proportion of high-level studies should continue to increase.<sup>6</sup> The Pearson r coefficient analysis showed a correlation between the number of publications and the papers classified at the Oxford LOE 1, 2, and 3 with significant results and positive association.

#### 4. Discussion

Nations evolution and lucrative progress depend on its development in the field of education, science, research and technology, which is determined by the strength of its scientific

publications. The number and quality of scientific publications from the different fields of science is an important marker of a salubrious scientific research environment.<sup>7</sup> Qualities and affordability of health care services in India is making rapid stalk in clinical medicine and is attracting medical tourism. Though, quality of health care needs to be constantly evaluated and appraised through diligent documentation work and fortnightly research, which are weak at present in India. Further, disease patterns and patient demands vary for each country. Hence, to improve Indian scientific strength there is a need for high quality research in the field of both the basic and clinical science level in high numbers to get specific solutions for its regional demands and improve its scientific strength.<sup>8</sup> DST reported, it was observed that India's share of world research output declined between 1981 and

1995. China was ranked 2nd after USA in 2010 in scientific publications.<sup>9</sup> Though worldwide share of publications started to increase after 2000 in India, rising to 3.5% by 2010.

Another bibliometric indicator which can be very useful in small datasets is the Evidence quality index. This indicator is calculated from the citation impact relative to the specific journal in which the paper is published. The USA was India's most frequent collaborating partner in Clinical Medicine, with 2437 publications coauthored between researchers in India and researchers in the USA in 2006–2010, representing 7.9% of India's total research output in Clinical Medicine.<sup>3</sup>

Arthroplasty surgery is a rapidly developing branch of clinical medicine and falls under the domain of orthopedics. The present study was initiated to study the patterns of publications in the field of arthroplasty surgery in the last 15 years. This will help the surgeons to understand the need for more high-quality studies, the areas that require attention, improve the existing standards of research practices, and formulate steps to enhance research works.

The number of articles which met the inclusion criteria for the present study was 198 over a 15-year period. Even though the number is low, an increasing number of publications has been observed from 2011 (51.47% of the articles were published between 2011 and 2015 for THR and 65.6% of the articles were published between 2011 and 2015 for TKR). This corresponds to a growth of 250% in number of publications in THR and in TKR a growth of 530% in number of publications in India in the field of arthroplasty, which is a very optimistic and motivational sign. Most of the publications are journal articles which were 53% in THR and 54% in TKR. This probably indicates lack of personnel, research funding, and expertise to perform basic research studies. It is necessary to note that basic science research is not chiefly laboratory based and it is actually a curtain-raiser to clinical research. The amalgamation of basic and applied research is climacteric to problem-solving and upheaval.<sup>10</sup>

The abnormalities or diseases studied in the articles shows frequently found in the Indian environment. The three most common pathologies studied were Osteoarthritis, Post traumatic arthritis and Complex fracture for Knee and Osteoarthritis, Avascular necrosis, Developmental Dysplasia of hip and Post tubercular hip arthritis for Hip. Surgical technique and infections also plays a major role. A limitation of the study is that we did not include a wide array of other search terms such as deformity, genu valgum/genu varum, coxa vara, specific tumors. This could cause selection bias due to loss of many related publications. However, we preferred to use more general keywords (e.g., knee/hip/shoulder/elbow joint/arthroplasty) just because they were linked to other more certain ones. We have not included peculiar keywords such as deformity of hip and knee; to avoid review of large number of papers unnecessarily.

As per the data there was 92% increment in the study scheme of publications in the field of medicine in India as a result of increase in the number of publications from 10,046 (2001–2005) to 19,273 (2005–2010). India only contributes 2% of worldwide publications in clinical medicine. Though there is a tremendous improvement in the number of publications, a cause of concern is the caliber of publications. Excellence of publications can be computed by three parameters: The number of publications in top 1% journals, Percentage of noncited articles, and the levels of evidence of the articles. Lukas A. Holzer et al This study shows that a variety of different journals is necessary to reflect the broad spectrum of orthopaedics in depth.<sup>11</sup> India shared only 0.5% publications in top 1% journals in 2001, though it had increased from 2610 (2001–2005) to 4273 (2005–2010).<sup>3</sup> approximately 25% degree of noncitedness of publications is from developed countries. Though in India, non cited publications is 47.3%.<sup>3</sup> In this study, it was observed that most of the studies published in arthroplasty surgery

provided a low quality of evidence, wherein only 6 articles provided level 1 or level 2 evidence. To improve the level of research in India high quality research providing grade 3 and above level of evidence are required. This would call for multifaceted viewpoint such as to stimulate submissions to high impact journals, discourage submissions to low impact factor journals, and to increase the citation profiles of national journals. Weak international bonding of India also leads to poor performance on the scientific research front. The Diagnostic Study Report (DSR) states that India's international partnership is less frequent than for many established economies. In 2001–2005, 18.8% of Indian research publications were internationally co authored and this increased minutely to 19.5% by 2006–2010.<sup>3</sup> In addition, the government's disbursements on scientific research accounts for only 1.2% of gross domestic product in 2012, which is much less than in developed nations.<sup>3</sup>

Sang Hwa Eom et al. concluded, Asian countries have contributed significantly to the TKA literature and its share has been increasing every year; both in terms of quantity and quality of research. However, there is a need to improve the quality of research to enhance the publishing power in high impact journals as well as the need for more basic research and epidemiological studies considering the unique differences among Asian patients undergoing TKA.<sup>12</sup>

For fewer numbers of publications and matchless quality of published studies there are many reasons. The lack of a contention in the field of scientific publications in India is a key factor. Among all the doctors Very few contributes in assembling and scrutinizing their clinical data. A contradictory problem for India is the stream of skilled researchers. Lack of impetus, Lack of research activities and publications, and shortage of consultant are important reasons for not having qualified researchers. Lack of English teaching; knowledge and proficiency is another factor toward failure in growth of research publications. The majority of indexed journals are in English and it has been shown in previous studies that language inadequacy is a remarkable factor for fewer numbers of researches from Asia. Man et al., studied that there was a notable correlation between national funding on research; English test scores and the publication out-turn of developed countries and found that these two factors revealed approx 71.5% of the variation in publication rate across developed nations globally. Rate of publications in highest ranked medical journal is directly proportional to English proficiency and research expenditure.<sup>2</sup> Disease transmission and control, healthcare requirements, patient's socioeconomic status are different for each country and India has specific healthcare needs. Currently, there is an extravagant province on scientific information obtained from studies in the Western countries, which barely can contribute solution to regional problems. India requires giving birth to its own scientific knowledge and education on the basis of local healthcare needs. Major scheme decisions to encourage health care research, proper funding, and counseling of research activists, inducements, and formulation of competitive environment of research are required to betterment of existing standards.

## 5. Conclusion

This study is designed to highlight that publications in the field of Arthroplasty are increasing in the last few years. A significant growth of 250% in number of publications in THR and in TKR a growth of 530% was observed in the period between 2009 and 2013, which is a good and motivating sign of improvement in the scientific research and publication environment in the field of Arthroplasty. Journal articles were the most common types of articles published, which indicates the need for more stress on basic science and experimental studies in the future. To contribute

markedly to the worldwide share of research publications, consequential endeavor are needed such as providing superior conditions for research training, recognizing areas of research, stimulating bonding, formulating multifaceted projects, promoting joint scientific hustle and bustle, and improving fund issuance for research.

#### Conflict of interest

There are no conflicts of interest.

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## Case report

## *Bacillus cereus*: A causative organism for deep soft tissue infection to forearm following trauma



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## ABSTRACT

*Bacillus cereus* is a Gram-positive, spore-forming rod, which is part of the *Bacillus* genus. Although, most commonly known to cause gastrointestinal infections, *B. cereus* infections can also result in osteomyelitis, meningitis, pneumonia, and endophthalmitis. Deep soft tissue infections caused by *Bacillus cereus* are uncommon and hence, rarely reported in the literature. Here we describe the case of young lady who presented with persistent soft tissue infection of her forearm following a traumatic injury despite treatment with empirical antibiotics. Soft tissue samples taken intra-operatively grew *Bacillus cereus*, which was treated successfully with intravenous vancomycin and oral ciprofloxacin. *Bacillus cereus* soft tissue infections should be considered as differential diagnosis for persistent inflammation following limb trauma. Soft tissue biopsies could play a vital role in accurate diagnosis and prompt management of such infections.

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### 1. Case report

A 26 year old female with past medical history of hypothyroidism presented to the closest Accident and Emergency after falling off her bicycle. She sustained a traumatic injury with extensive bruising, swelling and a small blistering wound to her left forearm. Plain radiographs did not show any fractures. Compartment syndrome was ruled out and she was discharged with a course of oral co-amoxiclav. A week later, she re-presented to the same hospital with on-going swelling and wound infection to her left forearm. Once again, compartment syndrome was excluded and patient was discharged with another course of oral antibiotics.

She subsequently presented to our trauma & orthopaedic department with persistent pain and swelling despite the two week course of co-amoxiclav. On admission she was afebrile, tachycardic and hypertensive. Clinical examination revealed a well healed superficial wound with marked tenderness and erythema on the dorsal aspect of her left forearm. There was no evidence of a fluctuant swelling. She was admitted for further investigations and

treatment. Initial blood tests showed a WCC of  $9.1 \times 10^9/L$  and CRP of 19 mg/L. After taking blood cultures, high dose intravenous flucloxacillin and oral sodium fusidate were commenced. MRI of her left forearm revealed generalised oedema of the subcutaneous tissues overlying the ulna with no evidence of a drainable collection, pyomyositis, osteomyelitis or joint effusion (Fig. 1). Blood cultures were negative. Marked reduction in pain and cellulitis of her forearm was noted after five days of intravenous antibiotics. She was discharged with a week of oral flucloxacillin and sodium fusidate.

### 2. What is your diagnosis?

Three weeks later, this patient was seen in outpatient clinic, where once again swelling to her forearm was noted. An urgent ultrasound scan (Fig. 2) was obtained, which showed marked thickening and induration of her forearm skin with appearances consistent with chronic cellulitis but no evidence of an abscess or drainable collection. After discussion with the Microbiologist, the patient was admitted for an urgent debridement and soft tissue biopsies of her forearm. Intra-operatively, multiple soft tissue samples were taken and sent for microbiological analysis. Soft tissue culture grew *Bacillus cereus* in the enrichment broth,

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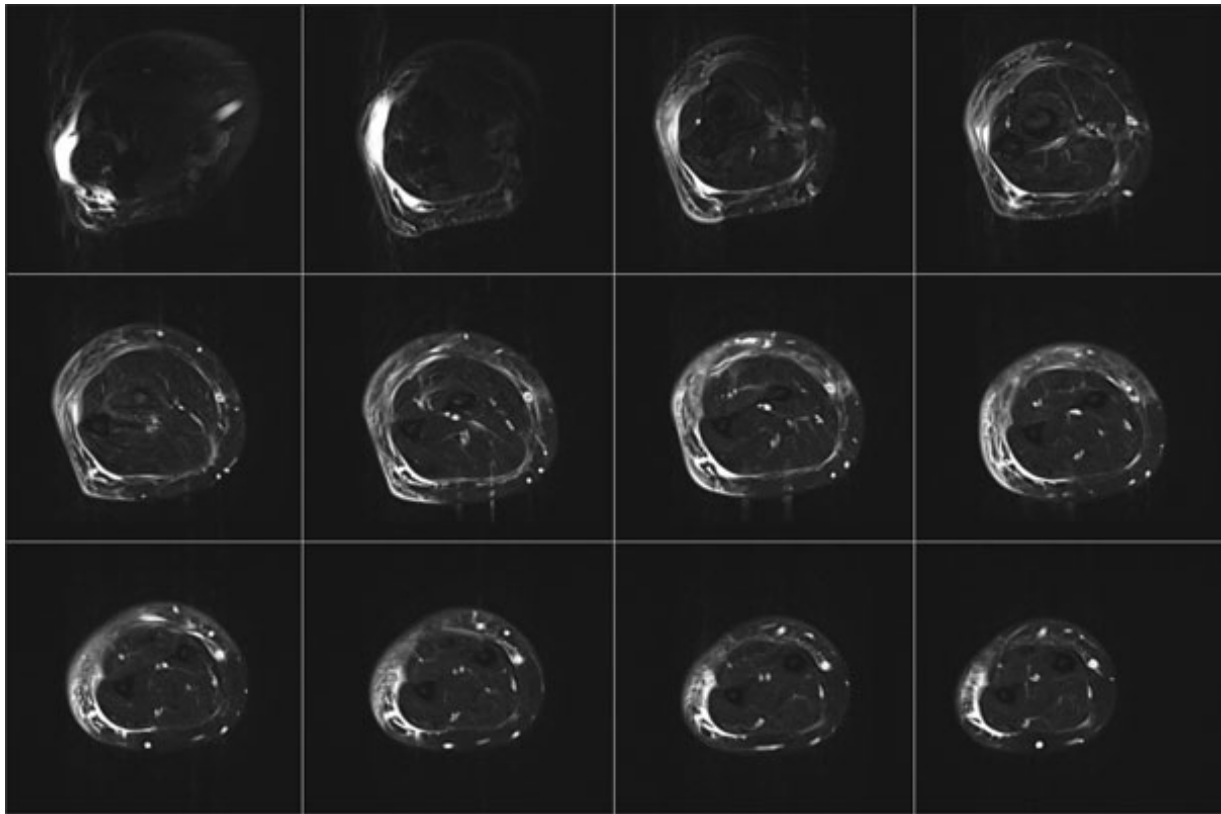


Fig. 1. T2 axial MR series showing generalised florid subcutaneous oedema of the left forearm.

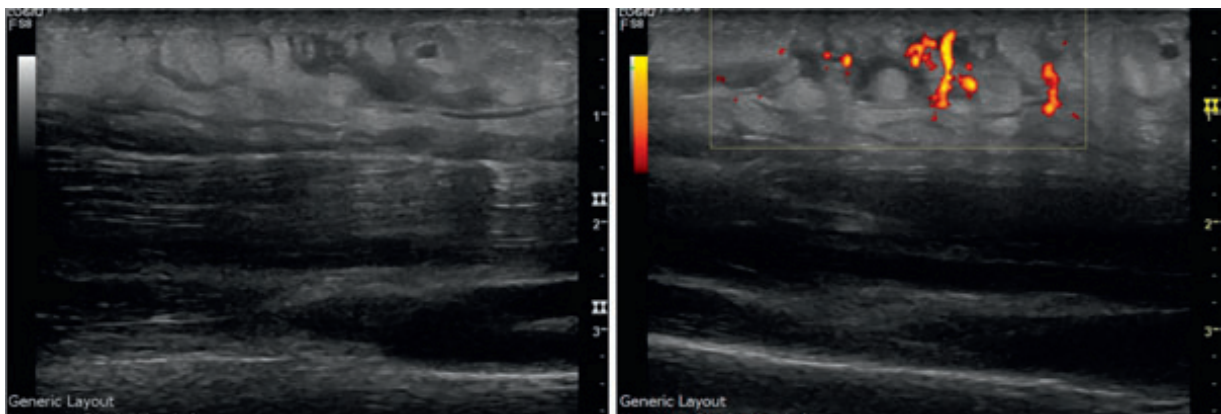


Fig. 2. Ultrasound imaging of the left forearm showing oedema and increased vascularity of the subcutaneous tissues.

susceptible to vancomycin and ciprofloxacin. Cultures were negative for *Actinomyces* and mycobacteria. The infection was treated with twelve days of intravenous vancomycin, resulting in improvement in her inflammatory markers and resolution of her symptoms. She was discharged with a further four week course of oral ciprofloxacin. Further follow up did not reveal recurrence of soft tissue infection to her forearm.

### 3. Discussion

*Bacillus cereus* is a rare cause of soft tissue infection and its ability to cause such infections is not widely appreciated.<sup>1</sup> In the

late 20th century *Bacillus cereus* was only considered to be a microbiological contaminant or non-pathogen, as cases of invasive disease were very rare.<sup>2</sup> We now know that *Bacillus cereus* has a number of virulence factors, and infections may cause serious complications such as osteomyelitis, myonecrosis, and gas gangrene and septicæmia.<sup>3</sup> Localised infection with *Bacillus cereus* tends to follow a mild course but necrosis and purulence can occur with deeper, more serious infections.<sup>2</sup> *Bacillus cereus* is often resistant to penicillin and other  $\beta$ -lactam antibiotics.<sup>5</sup> Bacteraemia due to *Bacillus cereus* has been known to be fatal in some cases, especially when there is a delay in prescribing the correct antibiotics.<sup>4</sup> Therefore deep tissue biopsy should be

considered at an early stage in such cases to avoid more serious complications of this infection. This unusual presentation represents successful treatment of a soft tissue infection secondary to *Bacillus cereus* in a previously unreported anatomical site

#### 4. Learning points

- *Bacillus cereus* infection must be considered in the differential diagnosis of soft tissue infection following limb trauma.
- *Bacillus cereus* may cause persistent low grade soft tissue infection that could be resistant to conventional antibiotic therapy.
- In order to guide targeted antibiotic therapy, soft tissue biopsy should be considered early in such cases.

#### Ethical approval

Informed written consent was obtained from the patient whose case is described in this study.

#### Conflicts of interest

All authors have none to declare.

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