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Tourniquet-less arthroscopic anterior cruciate ligament reconstruction: a technical guide & narrative review of the evidence

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Arthroscopic anterior cruciate ligament reconstruction (ACLR) is often performed with the use of a thigh tourniquet. Surgeons believe this helps improve visualisation and reduce operative time. However, tourniquet use has been associated with many complications including increased pain, neurovascular injury, venous thromboembolism, haematoma formation, and others.

In this article, we describe a method allowing comparable arthroscopic visualisation to be achieved without the aid of a tourniquet for ACLR procedures. The literature evidence relating to this technique as well as tourniquet use for ACLR is also reviewed.

Tourniquet-less ACLR can be achieved through the combined application of hypotensive anaesthesia, intravenous tranexamic acid, and use of adrenaline-supplemented irrigation fluid and local anaesthetic.

Performing ACLR without a tourniquet avoids the risks associated with its use and reduces the severity of post-operative haemarthrosis which may contribute to the patient's pain and limit their ability to perform their rehabilitation exercises.

Key words: knee, anterior cruciate ligament, anterior cruciate ligament reconstruction, arthroscopy, tourniquets..

INTRODUCTION

The anterior cruciate ligament (ACL) is one of the main stabilising structures, and also the most commonly injured ligament, of the knee. Rupture can lead to instability, pain, and loss of function as well as increasing the risk of secondary injury particularly the menisci[1]. In the non-acute setting, surgery remains the preferred treatment choice in active patients wishing to return to jumping, cutting, and pivoting activities[2]. Arthroscopic anterior cruciate ligament reconstruction (ACLR) is the gold standard for surgical management of ruptured ACL[3]. The incidence of ACLR has increased significantly over the last 20 years[4,5] with a particular rise in female and younger patients[6]. An estimated 400,000 ACLR procedures are currently performed each year worldwide, making it the third most frequent elective orthopaedic operation in developed countries[4,7-10]. Conventionally, during this procedure a thigh tourniquet is used by surgeons. It is believed this helps reduce intraoperative bleeding thereby improving arthroscopic visualisation and reducing operative duration[11,12]. However, the use of a tourniquet may undermine the benefits of performing ACLR arthroscopically such as reduced pain compared to open surgery[13,14] Also, intra-articular haemostasis is more likely to be achieved when ACLR is performed without a tourniquet, helping to reduce the size of any post-operative effusion that develops secondary to haematoma formation[15]. Several studies have reported on various other local and systemic complications associated with tourniquet use including venous thromboembolism, neurovascular injury, chemical burns, and many others[16-19]. In this article, we describe a technique enabling arthroscopic ACLR to be performed without the use of a tourniquet while still providing the surgeon with an excellent operative view.

TECHNIQUE

The arthroscopic irrigation system is set up without the use of an arthroscopic pump. This is believed to help reduce the risk of reported complications involving fluid extravasation into the surrounding soft tissues[20-23]. Irrigation fluid is supplemented with 1ml of 1:1000 adrenaline per three litre bag of normal saline for the first three bags. On the rare occasion that further bags of normal saline are needed during the procedure,

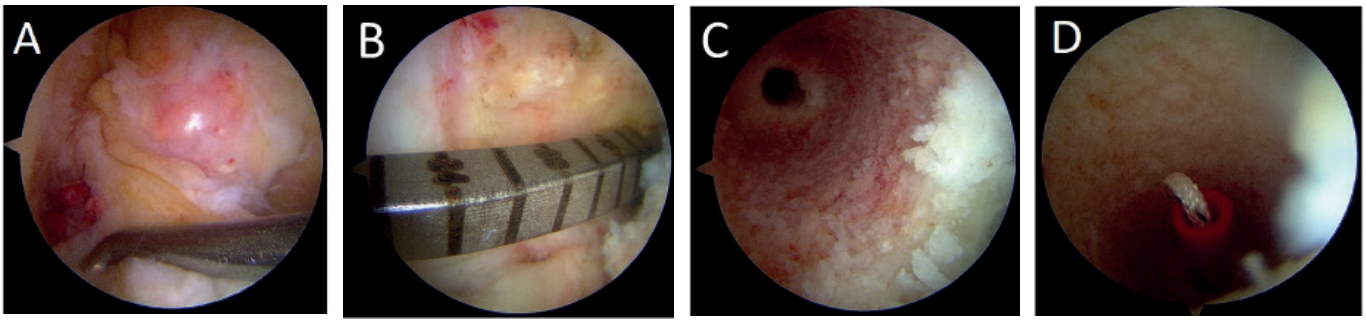

Figure 1 — Primary arthroscopic ACLR without tourniquet (A) ACL stump (B) measuring for location of femoral anatomic tunnel position (C) drilled femoral tunnel (D) drilled tibial tunnel.

these do not require supplementation with adrenaline as haemostasis is already achieved by this point. The irrigation bags are elevated above the level of the operated knee throughout the procedure to ensure gravity assisted flow.

After anaesthesia is performed and the patient is appropriately positioned, a dose of intravenous tranexamic acid is administered to the patient at a bolus dose of 15mg/kg of bodyweight. Controlled hypotension is then commenced by the anaesthetist. This reduces the patient's mean arterial pressure (MAP) by 30% from baseline. In normotensive individuals, this typically equates to MAP of 50-65 mmHg or systolic blood pressure of 80-90 mmHg[24].

The subcutaneous tissue around the locations of the planned arthroscopic portal sites are injected with low concentration high volume local anaesthetic of 100ml (e.g. 40ml of 0.25% levobupivacaine diluted with 60ml normal saline) mixed with 0.5ml of 1:1000 adrenaline. Agreement on these doses should be sought with anaesthetic team beforehand. This injected cocktail helps to minimise bleeding from the portal wound edges which can track into the knee joint. Prior to injection, key bony landmarks are drawn using a sterile pen to demarcate the surface anatomy since injecting the area can make these difficult to palpate.

Upon introducing the arthroscope, the prepared irrigation fluid is delivered into the knee joint and helps minimise bleeding from areas of performed interventions. If necessary, cauterisation of any bleeding points affecting arthroscopic visibility can also be performed using a standard radiofrequency arthroscopic wand.

The steps above enable adequate visualisation to be achieved throughout the entire procedure (Figures 1 and 2). Anterolateral and anteromedial portals were used in these cases. Proximal and close to midline (adjacent to the patellar tendon) allows for adequate visualisation in the notch and work on the ACL anatomic footprints

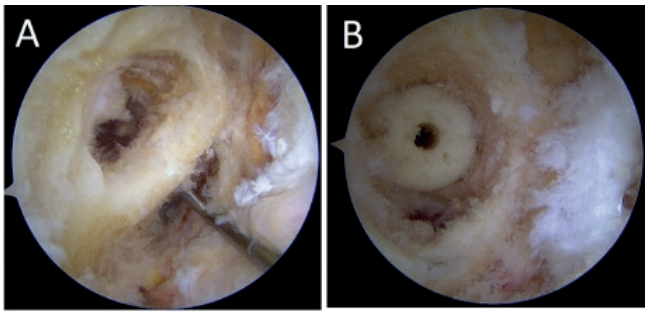

Figure 2 — First stage revision arthroscopic ACLR without tourniquet (A) femoral tunnel debridement (B) bone graft insertion.

without compromising visualisation of the rest of the knee. Care is also taken to infiltrate the graft harvest site pre-incision using the aforementioned cocktail of local anaesthetic supplemented with adrenaline. After the graft is obtained, the harvest site is further infiltrated with 0.25% levobupivacaine using a neonatal feeding tube (or equivalent). This is passed under direct vision deep to the sartorius fascia and along the graft harvest tract.

Table I summarises the pearls and pitfalls of this described technique.

DISCUSSION

There are no articles in the literature describing this specific method to assist soft tissue knee surgeons perform ACLR without a tourniquet. This method is routinely performed by the authors and consistently provides excellent arthroscopic visibility. Utilising this reliable method helps avoid the many complications associated with tourniquet use including increased pain, venous thromboembolism, neurovascular injury, chemical burns, and many others[16-18]. In the context of ACLR, there is some evidence that tourniquet use significantly increases the severity of pain experienced by patients at four and ten hours

Table I.— Pearls and pitfalls of tourniquet-less arthroscopic ACLR

Pearls	Pitfalls
Ensure it is clearly communicated to anaesthetic and theatre team that tourniquet is not planned to be inflated	Do not let the knee get dry. Keep subsequent bag of fluid supplemented with adrenaline ready to go
Do place a tourniquet around patient's thigh prior to starting procedure to eliminate the risk of field desterilisation should it become needed	Avoid using a mechanical pump without tourniquet
Do use adrenaline in the irrigation bags, and in combination with local anaesthetic infiltration for portal sites	Do not use the mechanical burst washout function
Do use gravity for fluid flow instead of a pump	If surgeons still prefer to use a mechanical pump, caution should be taken not to be tempted to increase pressures in order to control bleeding
Do use a handheld pump for the very occasional washout	Plan dose of local anaesthetic infiltration to be used for procedure in collaboration with anaesthetics. If maximum dose of local anaesthetic used (due to regional/epidural block) then consider diluted saline and adrenaline instead for portals and harvest incision
Achieve adequate haemostasis while progressing through the case	
Do infiltrate the graft harvest site with local anaesthetic to ensure optimum analgesia	

post-operatively (visual analogue scale 8.5±1.1 versus 4.9±0.9, p=0.011; and 5.7±1.3 versus 4.8±1.2, p=0.006, respectively). This coincided with doubling of intravenous opioid administration during the initial 24 hours post-operatively (8.8±3.7 mg versus 4.3±2.9 mg, p=0.001)[13]. Furthermore, patients who undergo ACLR with a tourniquet have a significantly increased risk of experiencing a more severe haemarthrosis post-operatively[14]. In a meta-analysis of RCTs on this topic by Kuo et al. there was a mean difference of 94.4 ml (95% CI 3.65 to 185.14; p=0.04) at 24 hours post-operatively in the surgical drains of patients who underwent ACLR with a tourniquet[15]. These finding are likely explained by rebound haemorrhage that occurs secondary to a combination of reactive hyperaemia and omitting to ensure haemostasis following tourniquet deflation. The presence of haemarthrosis likely contributes to patients overall discomfort and limits their ability to perform their rehabilitation exercises resulting in the significantly reduced knee range of motion observed at three weeks post-operatively[25]. It is also worth mentioning that hemarthroses have adverse effects on the articular cartilage, subchondral bone, and synovium[26,27].

The application of hypotensive anaesthesia during tourniquet-less ACLR aims to improve arthroscopic visibility by reducing the rate of intra-operative bleeding. Although there are relative and absolute contraindications to hypotensive anaesthesia including severe anaemia and cardiac disease[28,29], most patients undergoing ACLR are typically young, healthy patients[8,30] and therefore eligible for this intervention. While there are no studies investigating hypotensive anaesthesia in soft tissue knee surgery, a meta-analysis of randomised controlled trials (RCT) investigating this technique in various other orthopaedic procedures demonstrated significantly reduced intra-operative blood loss compared to controls and other blood conservation strategies. The pooled analysis of 36 comparisons (n=1398) revealed a mean difference of 376.7ml (95% CI 428.1 to 325.3 ml; $p < 0.001$) in favour of hypotensive anaesthesia. It is important to highlight that no serious adverse events (defined as severe cerebral, cardiac, renal, hepatic, and hematologic complications) occurred post-operatively in the six studies (n=286) reporting on this outcome. Also, a further 13 studies (n=634) did not find any differences in organ function and metabolic serum parameters between groups. Overall mortality was zero in the two studies (n=120) which investigated this outcome at 24 hours post-operatively and upon hospital discharge, and a further 17 studies (n=800) reported nil attrition during the follow up period suggesting nil mortality too[31]. Also, hypotensive anaesthesia is widely practiced in other settings including maxillofacial surgery where it is considered safe to implement subject to appropriate patient selection and other anaesthetic prerequisites[32,33].

The use of dilute adrenaline saline irrigation fluid (1mg/L) has been shown to effectively reduce intraoperative bleeding and improve visibility in an RCT of arthroscopic knee surgery. Compared to saline irrigation, the use of dilute adrenaline saline irrigation fluid halved the probability of converting to tourniquet use intraoperatively – 14/57 (25%) versus 24/48 (50%) patients; $p<0.008$[34]. Furthermore, no significant differences in the used volumes of

irrigation fluid were observed between the two patient groups. However, it may be important to mention that none of the patients in this trial underwent ligament reconstruction. RCTs involving shoulder arthroscopy have also shown significantly improved visibility, and reduced intraoperative bleeding and operating time when dilute adrenaline saline is used even at relatively lower concentrations of 0.33mg/L[35,36]. It is important to highlight that tourniquet use is not possible in shoulder arthroscopy however these procedures are performed safely and effectively. This raises the question as to why tourniquet use is necessary in knee arthroscopy.

Rare reports of complications and adverse events believed to be attributed to the use of adrenaline within irrigation fluids have been described. A scoping review on this topic identified seven case reports in the literature with a complication pattern consisting of severe hypertension, tachycardia (with or without evolving arrhythmia), and pulmonary oedema[37]. The authors concluded that causal association cannot be established in all reports due to many possible confounding factors. Nonetheless, it is important to be vigilant for this syndrome as well as ensure proper mixing of the adrenaline within the irrigation fluid. At a local level, the presence of adrenaline in irrigation fluid has been confirmed not to cause chondrotoxicity at concentrations ten-fold greater than that used in our technique[38].

Our described technique also involves the injection of adrenaline in combination with local anaesthetic at the planned arthroscopic portal sites. These wounds are believed to be the greatest source of bleeding affecting arthroscopic visibility[39]. In a multiple-arm RCT investigating the effectiveness of this technique, application of local anaesthetic containing adrenaline was shown to improve arthroscopic visibility compared to local anaesthetic alone when a tourniquet is not used. Of note, this mixture also achieved comparable visibility to the patient arm where a tourniquet was used[40].

While there is currently no RCT evidence investigating the use of intravenous tranexamic acid on arthroscopic visibility in knee surgery, its effectiveness has been demonstrated in shoulder arthroscopy[41,42]. It would be logical to infer similar findings would be observed in knee arthroscopy although future trials should investigate this. The benefits of administering tranexamic acid extend to reducing the severity of knee heamarthrosis. A meta-analysis of five RCTs investigating the effectiveness of tranexamic acid during arthroscopic ACLR found its use to be associated with significant reductions in drain output at 24 hours post-operatively, lower heamarthrosis grades, and improved Lysholm and pain scores extending to six weeks post-operatively. Furthermore, significantly fewer joint aspirations were performed for severe hemarthrosis (Coupens-Yates grades 3 and 4) and inadequate knee flexion (<90° by day 14 post-operatively) in the patient group which received tranexamic acid[43].

CONCLUSION

Applying this described technique during ACLR allows similar levels of arthroscopic visibility to be achieved without the use of a tourniquet. This approach can be considered relatively safer for patients as it avoids the risks associated with tourniquet use.

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