

## Review Article:

# Ultrasound-Guided Adductor Canal Block for Post-Operative Analgesia in Knee Arthroscopy

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### Abstract

The Adductor Canal Block (ACB) is a block of the saphenous nerve, which is a branch of the femoral nerve, performed at the level of lower third of the thigh so that the motor innervation of the quadriceps group is spared, the most significant advantage of the ACB over femoral nerve block and other techniques is that it is a pure sensory block provides postoperative analgesia that is at least as good as FNB while preserving quadriceps strength help early ambulation and rehabilitation and reduces the incidence of fall after knee surgeries.

**Key Words:** (ACB) Adductor Canal Block – Post-operative analgesia – Quadriceps strength – Knee arthroscopy – (FNB) Femoral Nerve Block – Ropivacaine (R).

### Introduction

ARTHROSCOPIC knee surgery refers to a large variety of surgical interventions in the knee, and numerous analgesic regimens have been investigated in order to find the best combination of analgesics for these procedures. The post-operative pain response depends on the type and duration of surgical intervention, and it can be challenging to predict which analgesic regimen will be the most appropriate for each patient until after surgery [1].

The post-operative pain of knee arthroscopy can affect early ambulation, a range of motion and duration of stay in the hospital. Unrelieved post operative pain may result in clinical and psychological changes that affect quality of life [2].

Adequate analgesia with motor preservation has become the goal after knee arthroscopies to enable shorter hospital stay, early physiotherapy, and faster recovery. So many options are available for the treatment of post-operative pain, including

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systemic (i.e., opioid and non opioid) analgesics and regional (i.e., neuraxial and peripheral) analgesic techniques, multimodal analgesia is achieved by combining different analgesics that act by different mechanisms and at different sites in the nervous system, resulting in synergistic analgesia with lowered adverse effects of administration of individual analgesics [3], epidural analgesia can produce adverse effects such as urinary retention and motor block, delayed early mobilization [4].

Femoral Nerve Block (FNB) is a well-established treatment for post-operative pain in knee arthroscopy but followed by reduced quadriceps muscle strength and associated with high risk of falling [5,6].

Adductor Canal Block (ACB) is a highly successful approach to the saphenous nerve, that was first described by Vander Wal [7]. Compared with FNB, ACB results in less reduction in the quadriceps muscle strength as only the motor nerve to the Vastus medialis of the quadriceps muscle traverses the adductor canal [8].

### Anatomy

The saphenous nerve, a terminal branch of the posterior division of the femoral nerve, provides sensory innervation to the medial, anteromedial, and posteromedial aspects of the lower extremity from the distal thigh to the medial malleolus. It travels along the lateral aspect of the superficial femoral artery in the proximal artery within the adductor canal (Hunter's canal). It then crosses over the superficial femoral artery anteriorly just proximal of the lower end of the Adductor Magnus muscle and runs medially alongside the superficial femoral artery until emerging from the canal with the saphenous branch of the descending genicular artery. After leaving the adductor canal, the saphenous

nous nerve divides into the infrapatellar branch, which provides a sensory branch to the peripatellar plexus of the knee, and the sartorial branch, which perforates the superficial fascia between the gracilis and sartorius muscles and emerges to lie in the

subcutaneous tissue below the knee fold. It then descends along the medial tibial border with the saphenous vein giving cutaneous branches to the medial aspect of the leg, ankle, and the forefoot [9].

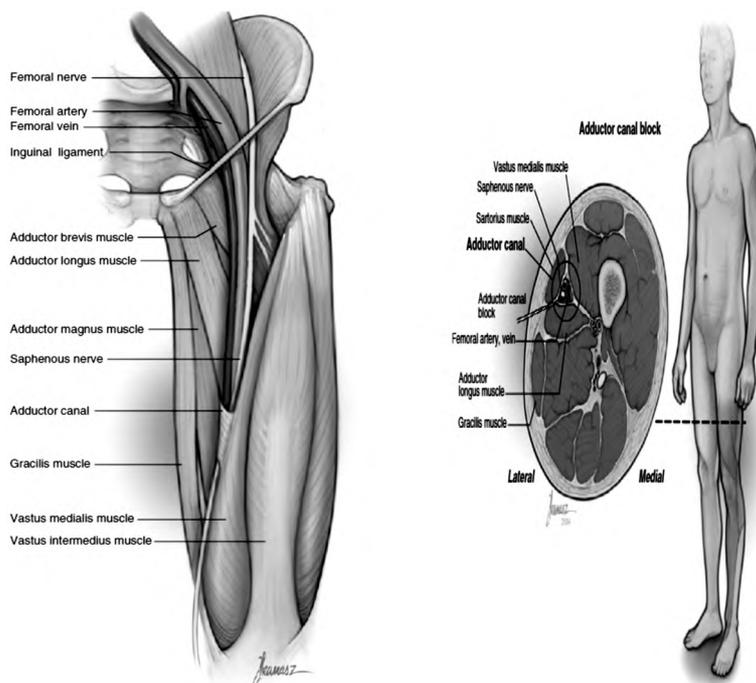


Fig. (1): Anatomy of adductor canal [9].

The nerve of the vastus medialis is also a branch of the posterior division of the femoral nerve. It travels laterally to the superficial femoral artery within the adductor canal and sends multiple branches to the vastus medialis and supplies the anteromedial portion of the knee capsule, the adductor canal is an aponeurotic tunnel in the middle third of the thigh. It courses between the anterior-medial compartment of the thigh and is covered by strong aponeurosis, the Vasto-adductor membrane. The canal contains the superficial femoral artery, vein, saphenous nerve, nerve to the vastus medialis, and the terminal nerve endings of the posterior branch of the obturator nerve [9].

Cadaver studies have shown that 15ml of LA are sufficient to fill the adductor canal although an MRI study supported the use of 30ml volume [10].

#### Adductor canal block technique:

##### General preparation:

After taking consent of the patient, the patient monitored and IV access obtained then appropriate assistance, equipment and resuscitation emergency drugs are available.

Specific equipment required: 22-gauge 100mm length, short-beveled regional block needle, skin antiseptic solution, sterile gloves, the portable ultrasound machine.

##### Procedure:

- Confirming operative site and side with patient; limb is marked and corresponds with information on consent form. Secure IV access, if required technique proceed with sedation/induction of general anesthesia/spinal anesthesia as per anesthetic plan, position patient supine with knee slightly flexed and leg externally rotated (frog-leg position) as shown in Fig. (2) [11].



Fig. (2): Patient positioning [11].

- Cleaning the area with Povidone-iodine 10% (Betadine), stand to the side of the patient to be blocked with the ultrasound machine on the opposite side and the screen facing, placing a high-frequency ultrasound probe on the anterior aspect of the patient's thigh, approximately mid-point between the inguinal crease and medial condyle, Identifying the femur (usually at a depth of 3-5cm although variable) and move probe medially until

the trapezoid/boat shaped Sartorius' muscle is visualized. The femoral artery lies just under this muscle within the adductor canal. Considering the saphenous nerve is almost always too small to be reliably imaged and the aim of the technique is, therefore, to deposit local anesthetic under Sartorius and around the femoral artery (i.e. within the adductor canal) [11].

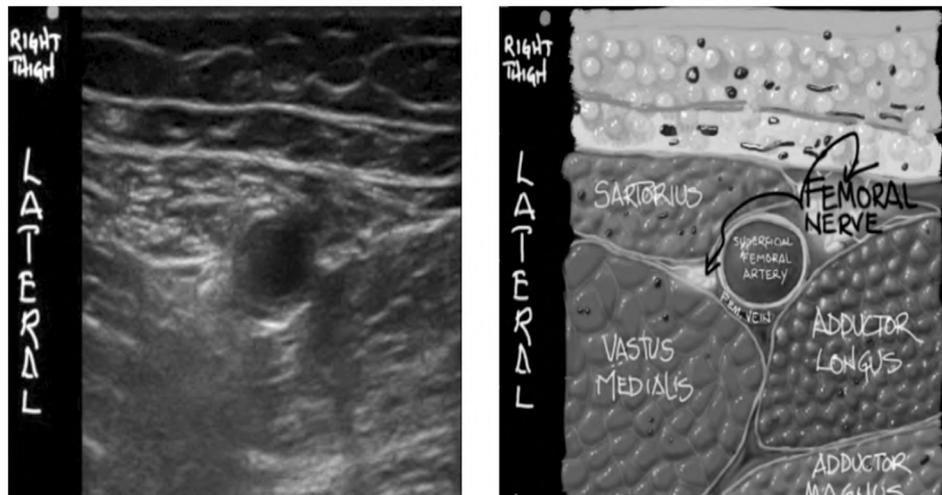


Fig. (3): Ultrasound view of the ACB [12].

- Optimizing image, adjusting depth, gain and frequency settings as required, the appropriate probe position is just proximal to where the femoral artery "dives" posteriorly and the probe should be positioned perpendicular to the artery. At this point the femoral artery should start to pass deeper to form the popliteal artery, the vastus medialis muscle lies anterolateral, the adductor magnus muscle posteromedial and the sartorius muscle medial. Use an in-plane approach from lateral to medial ensuring that your needle tip can be seen at all times, advance your needle into the adductor canal. This can be achieved by traversing Sartorius or Vastus Medialis, Aspirate and inject a test dose of 1 ml of the local anesthetic solution, observe the spread of the local anesthetic to ensure your needle tip is definitely within the adductor canal. If you cannot clearly see the spread of local anesthetic consider intravascular placement of needle and reposition, continue with the injection, aspirating every 5mls [11].

#### Post-procedure care:

Monitoring the patient carefully, looking particularly for signs of local anesthetic toxicity (perioral numbness, tinnitus, confusion, seizures), documentation of the side and site of injection, the needle used, volume and name of local anesthetic, and any associated problems (for example vascular

puncture). All patients should examine post-operatively to ensure that the block has been worn off completely [11].

#### Indications:

- Knee arthroscopy.
- Anterior Cruciate Ligament (ACL) reconstruction.
- Lower leg, foot and ankle surgery involving areas of skin supplied by the saphenous nerve.
- Total and uni-compartmental knee replacement.

#### Contraindications:

##### Absolute:

- Patient refusal.
- Inflammation or infection at the injection site.
- Allergy to local anesthetics.

##### Relative:

- Anticoagulation or bleeding disorders.
- Pre-existing peripheral neuropathies.

#### Complications:

*These are the same as for any regional anesthetic technique:*

- Block failure.
- Bleeding/Bruising.
- Infection.

- Local anesthetic toxicity.
- Nerve injury [13].

#### *Pharmacological considerations:*

Adductor canal block can be performed using the variety of local anesthetics in varying concentrations. In general, the duration of action is affected by the concentration of the local anesthetic and the volume injected. Duration of action can also be prolonged with additives, numerous adjuvant medications have been evaluated for their ability to hasten the onset of sensory or motor blockade, prolong the duration of the resulting nerve block, or slow the absorption of the local anesthetic administered, thus reducing the likelihood of local anesthetic toxicity. The many adjunct medications currently used do not share a unitary mechanism of action. Many adjunct medications are themselves analgesics (e.g., tramadol, buprenorphine, ketamine), and recent studies have compared the effect of the same adjuncts given perineurally versus intravenously or intramuscularly in an effort to elucidate whether giving the adjunctive agent peripherally might offer the same benefit while avoiding the risk of neurotoxicity [14] the adjuvants such as epinephrine or corticosteroid, typically dexamethasone [15]; although the mechanism of action of dexamethasone as an adjuvant to local anesthetics is still not completely understood but several mechanisms may be enrolled. Some authors suggest a local vaso-constrictive effect, resulting in reduced local anesthetic absorption [16].

Or a systemic anti-inflammatory effect following vascular uptake of the drug [17], may stem from decreased nociceptive C-fiber activity via a direct effect on glucocorticoid receptors and inhibitory potassium channels. The anti-inflammatory properties of dexamethasone as a direct effect on the nerve are probably responsible for the prolonged analgesia block [18]. Bupivacaine and Ropivacaine are most commonly used long-acting local anesthetic agents. Bupivacaine has the risk of cardiotoxicity causing hypotension, arrhythmias and even cardiac arrest [19]. Ropivacaine has very close pharmacodynamics profile to equipotent doses of bupivacaine. They have similar anesthetic and analgesic effects. The benefit of ropivacaine is its lower risk of cardiotoxicity in the event of inadvertent intravascular injection, significantly faster onset time and higher therapeutic index leading to an improved safety profile [20]. So, ropivacaine can be preferred over bupivacaine.

Differential sensory and motor block with ropivacaine is only apparent at low concentrations (0.2% and less). The 0.20% or higher doses pro-

vided satisfactory postoperative analgesia, but a significantly higher rate of the motor blockade is seen with concentrations above 0.50%, thus, for adductor canal block 15 to 30ml of 0.20-0.50%, ropivacaine is optimal for achieving adequate analgesia with preserved motor power [21].

Numerous studies compared adductor canal block with femoral nerve block in motor power and analgesia, Kwofie et al., [22] used 15ml of 3% chloroprocaine to compare ACB with FNB and found ACB results in significant quadriceps motor sparing and significantly preserved balance but they did not compare analgesia by above techniques. Patterson et al., [23] used 15-30ml bupivacaine and found adductor canal block provides equally effective analgesia when compared with a femoral nerve block and improves post-operative physical therapy performance. Kim et al., [24] used the same volume of 0.5% bupivacaine with epinephrine 5ug/ml and found analgesia and strength were both satisfactory. Sayed El-Ahl [25] also used 15ml of 0.5% ropivacaine and found that quadriceps strength is maintained with ACB but it provides inferior analgesia as compared to FNB.

Higher volumes have also been used by some authors like Jaeger et al., [26] used 30ml of 0.5% ropivacaine and found that adductor canal block preserved quadriceps muscle strength better than FNB, without a significant difference in post-operative pain. Jenstrup et al., [27] also used 30ml of 0.75% ropivacaine and found the reduction in morphine consumption and pain scores but this large dose if used in higher concentration can cause quadriceps weakness from the proximal spread.

#### *Limitations:*

The sensory innervations of the knee joint is not only from nerves passing through the adductor canal but also from articular filaments arising from the nerves to the vastus lateralis and intermedius, which both arise from the posterior division of the femoral nerve proximal to the adductor canal, and in fact only just distal to the inguinal ligament. Therefore, ACB may not provide post knee surgery analgesia as effective as that produced by a combined femoral and obturator block, being a compartment block, it is likely that intermittent boluses are required to block all nerves within the canal. This will necessitate either nurse administered boluses or a pump enabling relatively high bolus volumes. As the site of catheter placement is close to the knee, there is increased the risk of catheter displacement [28].

Table (1): Randomized controlled trials of adductor canal block.

Author/Year	Methodology	Primary outcome	Secondary outcomes
Jenstrup et al., 2012 [27]	71 patients. ACB placed in PACU. 30mL loading dose followed by intermittent boluses via AC catheters with either 15mL R 0.75% or NS every 6hr. at 6, 12, 18 and 24hr.	Morphine consumption significantly decreased with R vs. NS (40.21 vs. 56.21mg) for 1st 24hr $p=0.006$ .	Active VAS scores lower with $r$ ( $p=0.01$ ), but not at rest ( $p=0.06$ ). Ropivacaine group performed ambulation and TUG tests at 24hr.
Jæger et al., 2012 [35]	41 patients. ACB placed in PACU. Injected 30ml of R 0.75% or NS.	Active VAS score (45° active knee flexion) were not improved with $r=58$ (22) mm vs. NS 67 (29) mm, $p=0.23$ .	Significant difference of VAS scores between $r$ vs. NS from 1 to 6hr. ( $p=0.02$ ). No difference in resting VAS pain and morphine consumption.
Jæger et al., 2013 [26]	48 patients received both AC and FN catheters (one catheter with 30mL bolus Ropivacaine (R) 0.75%, followed by continuous R 0.2% 8mL/h for 24hr.	Quadriceps Maximum Voluntary Isometric Contractions (Q-MVICs). At 24hr was significantly higher with continuous ACB 52% (9%-92%) vs. FNB 18% (0-69%), $p=0.004$ .	No difference in post-operative resting or dynamic VAS scores, morphine consumption, or mobility testing.
Kwofie et al., 2013 [22]	16 patients. ACB performed in one leg and FNB in opposite leg. 15mL of 3% 2-chloroprocaine or NS was injected.	Q-MVICs were 95.1 ± 17.1% baseline in ACB group and 11.1 ± 14.0% baseline in FNB group ( $p<0.0001$ ) 30 minutes after block placement.	Berge balance scores were significantly impaired after FNB vs. no impairment after ACB.
Kim et al., 2014 [24]	93 patients. TKAs under combined spinal-epidural. ACB: Low adductor canal approach with 15mL bupivacaine 0.5%. FNB: 30mL bupivacaine 0.25%. Q-MVIC assessed baseline, 6 to 8, 24, 48hr. after surgery.	At 6 to 8hr. after surgery, ACB group had significantly higher median quadriceps strength versus FNB. ACB was not inferior to FNB in terms of either VAS scores or opioid consumption.	At 24 and 48hr., there was no difference in quadriceps strength, pain scores, or opioid consumption between ACB and FNB groups.
Hanson et al., 2014 [36]	76 patients. Received either AC catheters with 0.2% ropivacaine or sham infusion (in Sartorius muscle with NS). All patients received a pre-operative single-injection FNB (20mL R 0.5%).	48-hr cumulative IV morphine consumption significantly decreased with continuous ACB (46.7mg) vs. no ACB (63.4mg), $p=0.013$ .	Continuous ACB improved quadriceps strength ( $p=0.010$ ) and ambulation ( $p=0.034$ ).
Grevstad et al., 2014 [8]	50 patients with established severe dynamic pain after TKA on POD1 or POD2. Group A: AC injection with 30ml of R 0.75% after obtaining pre-block VAS score (T-0) followed by 30mL NS AC injection 45 minutes later (T-45). Group B: AC injection with NS at T-0 and 30mL of R 0.75% at T-45.	Dynamic VAS pain score significantly decreased (32mm difference) with ACB vs. no ACB ( $p<0.0001$ ) at T45.	Resting VAS pain score also significantly improved (15mm difference) with ACB vs. no ACB at T-45. No difference in VAS scores 45 minutes after second injection (T-90).
Shah et al., 2014 [37]	100 patients. Continuous AC catheters vs. continuous FN catheters. 30mL initial bolus dose R 0.75%, followed by intermittent repeat boluses of 30mL R 0.25% every 4hr.	Ambulation ability significantly better with CACB vs. CFNB (TUG test: 51 (7.9) vs. 180 (67); 10-m walk test: 67s (7.3) vs. 274s (103); and 30-sec chair test: 5.25 repetitions (0.7) vs. 1.5 repetitions (0.8).	Functional milestones also (straight leg raise, quad stick ambulation, staircase competency, and ambulation distance) all improved with CACB. No difference in maximal knee flexion, VAS scores, or rescue analgesic requirements with tramadol.
Jæger et al., 2014 [38]	30 patients. AC catheter with either 30mL of R 0.75% or NS bolus followed by an infusion of R 0.2% or NS beginning 6hrs after bolus.	Significant difference dynamic pain scores with knee flexion; 52 (22) mm with $r$ and 71 (25) mm with NS ( $p=0.04$ ) only at 4hr after initial block.	No significant difference in either resting or dynamic the area under the curve analgesia through 1st 24hr.
Shah et al., 2015 [39]	97 patients. Single-injection ACB vs. continuous ACB: Initial 30mL loading dose of R 0.75% via catheter followed by intermittent 30mL NS every 4hr. through morning POD2.	Post-operative resting and dynamic pain scores decreased in CACB (mean difference 4-7/100mm the difference at rest and 7-10/100 with activity)	No significant difference in ambulation ability (TUG test, 10-m walk test, 30-s chair test),
Abdallah et al., 2016 [40]	A total of 100 patients were randomized to receive ACB or FNB with 20ml ropivacaine 0.5% (with epinephrine). The authors sequentially tested the joint hypothesis that ACB is noninferior to FNB for cumulative oral morphine equivalent consumption and area under the curve for pain scores during the first 24h post-operatively and also superior to FNB for post block quadriceps maximal voluntary isometric contraction.	52 and 48 patients who received ACB and FNB, respectively. Compared with preset noninferiority margins, the ACB-FNB difference (95% CI) in morphine consumption and area under the curve for pain scores were -4.8mg (-12.3 to 2.7) ( $p=0.03$ ) and -71mm h (-148 to 6) ( $p<0.00001$ ), respectively, indicating noninferiority of ACB for both outcomes. The maximal voluntary isometric contraction for ACB and FNB at 45min were 26.6 pound-force (24.7-28.6) and 10.6 pound-force (8.3-13.0) ( $p<0.00001$ ), respectively, indicating the superiority of ACB.	The post-operative rest pain severity VAS scores were similar for both groups at all of the time points examined, the post-operative interval oral morphine equivalent consumption was also similar between the two groups at all of the time points examined. The degree of satisfaction with post-operative analgesia received was also similar between the two groups.
Mary F. Chisholm et al., 2017 [41]	One hundred ninety-five patients undergoing ACL reconstruction with BTB autograft (ages 16-65) were enrolled. Subjects received SSNB with 13ml of 0.5% bupivacaine (control group), 1mg preservative-free dexamethasone + 0.5% bupivacaine (treatment group I), or 4mg preservative-free dexamethasone + 0.5% bupivacaine (treatment group II)	Patient-perceived block duration was significantly increased in treatment group I [hazard ratio (95% Confidence Interval [CI]) 0.48 (0.31-0.75); $p=0.001$ ] and treatment group II (hazard ratio (95% CI): 0.52 (0.33-0.81); $p=0.004$ ) compared to control. The block was extended from a median (95% CI) of 33.1 (28.4-37.3) to 41.2 (32.4-50.9) and 46.5 (35.8-48.9) hours, respectively	Patients in treatment group II reported increased time that block provided pain relief, higher patient satisfaction, lower pain scores at rest, and decreased drowsiness and confusion.

The incidence of nerve injury with peripheral nerve blocks depends on the particular definition of injury. Reported frequency of permanent neuropathy ranged between 1.5/10,000 to 9/10,000, while this incidence was reported to be higher with continuous catheters [29]. Henningsen et al., followed 97 patients after ACB catheter and found no definitive saphenous nerve injury related to the block itself. But 84% of the patients had signs of injury to the infrapatellar branch in the anatomical distribution of the surgical incision [24], which may attribute to surgical injury. A unique effect to the ACB is the potential cephalad spread of local anesthetic within the adductor canal, with potential blockade of the more proximal femoral motor nerve branches within the femoral triangle. Such spread patterns were previously described in two reports of single injection [30], and continuous infusion [31]. This phenomenon has been well described in cadaveric dye studies [32]. Rarely, unrecognized cephalad spread of local anesthetic can lead to substantial quadriceps weakness. Gautier et al., reported a case where continuous ACB was performed with initial bolus of local anesthetic for anterior cruciate ligament repair and resulted in dorsiflexion weakness of the foot. Subsequently, a contrast was injected into the catheter and computer tomography revealed there was spread into the popliteal fossa and contacted the sciatic nerve [33]. However, Yuan et al., have demonstrated that contrast injection under controlled pressure did not routinely reach the lesser trochanter the location of the common femoral nerve [33]. In this study, sixty percent of subjects had contrast spread within either the same sector as the catheter tip or one sector distally. They found that there was limited catheter infusion spread within the adductor canal in both cephalad and caudex direction. However, the potential cephalad spread of local anesthetic within the adductor canal may place the patient at risk of quadriceps muscle weakness and fall [33]. Anatomically, much of the space in the adductor canal is occupied by the femoral vessels. Hence, there is a potential risk for unintended vascular puncture during the placement of ACB. Recent data showed that the risk of vascular puncture decreases with ultrasound guidance [34].

The following table showing some of latest randomized control trials on adductor canal block from 2014 to 2017 with focusing on primary and secondary results.

#### Conclusion:

Adductor canal block is a new golden technique for post-operative analgesia after Knee Arthroscopy

with promising results and fewer risk factors compared to other methods.

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## إحصار القناة المقربة باستخدام الموجات فوق الصوتية لتسكين ألم ما بعد عمليات مناظير الركبة

إحصار القناة المقربة بما فيه إحصار العصب الصافن، الذي هو فرع من العصب الفخذي، التي أجريت على مستوى الثلث السفلي من الفخذ بحيث لا يؤثر على القوة المحركة لمجموعة عضلات الفخذ، وأهم ميزة لإحصار القناة المقربة على إحصار العصب الفخذي وغيرها من التقنيات هو أنه إحصار للإحساس فقط يوفر تسكين بعد العملية الجراحية التي هي على الأقل جيدة مثل إحصار العصب الفخذي مع الحفاظ على حركة عضلات الفخذ تساعد على التماسك في وقت مبكر وإعادة التأهيل ويقلل من حدوث سقوط بعد الجراحة في الركبة.