Review Article

A comparative analysis of femoral nerve block with adductor canal block following total knee arthroplasty: A systematic literature review

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Abstract

Background: Patients undergoing total knee arthroplasty suffer from moderate-to-severe postoperative pain resulting in immobility-related complications and prolonged hospitalization. Femoral nerve block is associated with reduction in the quadriceps strength and increasing incidence of falls. Adductor canal block has been shown to be as effective as femoral nerve block without causing quadriceps weakness.

Objectives: To compare outcomes of studies comparing adductor canal block and femoral nerve block in patients undergoing primary total knee arthroplasty.

Data Sources: Original articles, published between July 2013 and April 2017, comparing the above interventions.

Study Eligibility Criteria, Participants, and Interventions: Comparison of outcome measures of all original articles shortlisted by the PUBMED and Google Scholar databases search using key words, "adductor canal block; femoral nerve block; total knee arthroplasty; total knee replacement."

Study Appraisal and Synthesis Methods: The primary outcome measures reviewed were: pain scores; interventional failure; post-operative opioid consumption; patient fall or near fall during postoperative rehabilitation; and length of stay.

Results: The opioid consumption was found to be comparable with both the interventions on the first and second postoperative day. Patients administered adductor canal block had better quadriceps power, longer ambulation distance, and shorter length of hospital stay.

Limitations: Of the studies reviewed five were retrospective and thus data quality amongst the studies may have been compromised.

Conclusions and Implications of Key Findings: Mobilization and ambulation, which are both important for recovery after total knee arthroplasty are both inhibited less by adductor canal block.

Keywords: Adductor canal block, femoral nerve block, peripheral nerve blockade, total knee arthroplasty

Introduction

Total knee arthroplasty (TKA) is regarded as an effective treatment for end-stage knee osteoarthritis. The increased life expectancy and better medical care have significantly escalated the number of TKA performed. In the last decade, TKA replaced coronary artery bypass graft surgery as the most common major surgery performed in the developed world. In the United States, more than 7,23,000 knee replacement surgeries were performed in 2014.[1] Cesarean section is the only surgery done more often than TKA.[1] TKA has been

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demonstrated to be a cost-effective procedure for degenerative diseases of the knee joint. It is one of the most common surgeries performed today, even in the Indian subcontinent.

TKA is associated with severe postoperative pain and effective postoperative analgesia after TKA remains a challenge. The incidence of moderate-to-severe pain after TKA is reported to be about 50%, and it can contribute to immobility-related complications, delay in hospital discharge, and may interfere with functional outcome.[2] Multiple and multimodal approaches to its relief have been tried, which include neuraxial blockade, systemic opioids, intrathecal opioids, systemic steroid/non-steroidal analgesics, local infiltration analgesia, and peripheral nerve blockade (PNB).[3]

Early mobilization is a challenge after TKA when a patient has severe pain and is receiving pain treatment. Despite a comprehensive multimodal analgesic regimen, TKA is often associated with intense postoperative pain.[4] Epidural analgesia being a viable alternative, however, faces a relatively high failure rate[5] and may result in side effects such as urinary retention and motor block,[6] with the latter potentially hindering mobilization.

PNBs are commonly used to relieve pain and to reduce opioid requirements and their adverse effects. PNB for TKA is associated with significantly lower hospital length of stay (LOS) and also with a lower risk of re-admission. Femoral nerve block (FNB) is one of the most commonly used nerve blockades and has been shown to be effective in reducing the usage rate of opioid painkiller and shortening hospital stays.[2] Nerve blocks involving the femoral nerve, however, lead to quadriceps muscle weakness.[7] Quadriceps weakness results in functional impairment and is associated with an increased risk of fall.[8,9] Attempt to overcome quadriceps involvement after FNB, without compromising analgesia, has failed.[7]

PNB with preserved muscle function and an adequate analgesic effect is desirable. Adductor canal block (ACB) blocks the largest sensory branch of the femoral nerve to the knee, the saphenous nerve, which is a component of the adductor canal.[10] ACB thus provides analgesia with only sensory blockade[11] and is as effective as FNB in reducing postoperative pain.[12] When compared with FNB, ACB has been reported to be associated with similar pain scores and better quadriceps strength postoperatively ensuring better ambulation after TKA.[12]

Considering anatomical evidence, ACB may be superior to FNB. However, studies comparing ACB with FNB have not entirely supported the above. Placebo-controlled trials have found the analgesia offered of the ACB comparable to the analgesia seen after FNB.[13,14] Although published studies have found similar pain relief outcomes with both the ACB and FNB, disputes over many aspects of the efficacy of the two techniques still exist.[15] Non-inferiority trials comparing the analgesic effects of the FNB and the ACB have not been conducted. A recent review recommended continuous ACB, supplement with multimodal analgesia, as the best analgesic protocol after TKA surgery under neuraxial anesthesia.[16]

We reviewed research published in the last 4 years, comparing FNB and ACB, to determine the comparative benefits and drawbacks of FNB *vis-a-vis* ACB in terms of pain relief and functional outcomes.

Material and Methods

We searched the PubMed and Google Scholar database with the keywords, "adductor canal block"; "femoral nerve block"; "total knee arthroplasty"; and "total knee replacement", in May 2018 with time limit set to 4 years (July 2013 and April 2017). Thirty-three publications were shortlisted based on these keywords. We reviewed only original articles comparing the ACB and FNB in patients who underwent primary TKA and excluded case reports; systematic review articles; and meta-analysis. Thirteen original articles were selected for the review. The methodology followed for the review was as per the PRISMA-based flow chart [Figure 1].

The demographic data were reviewed in terms of total number of patients studied; patients receiving FNB; and patients receiving ACB. The primary outcome targeted were pain scores measures; interventional failure; postoperative opioid consumption; patient fall or near fall (knee buckling) during postoperative rehabilitation; and LOS. The following secondary outcomes were evaluated: nerve injury or palsy; quadriceps strength in terms of maximum voluntary isometric contraction (MVIC); ambulation distance; and the Timed Up and Go test (TUG). The above data were extracted from the manuscript of the shortlisted studies and no authors were contacted for additional data.

Results

Table 1 displays a summary of the demographic and outcome results of the review. A total of 1279 patients, from 13 manuscripts reviewed, were included. Five of these publications were blinded randomized controlled trials (RCTs), three were non-blinded RCTs, and five of these were retrospective studies. Amongst these

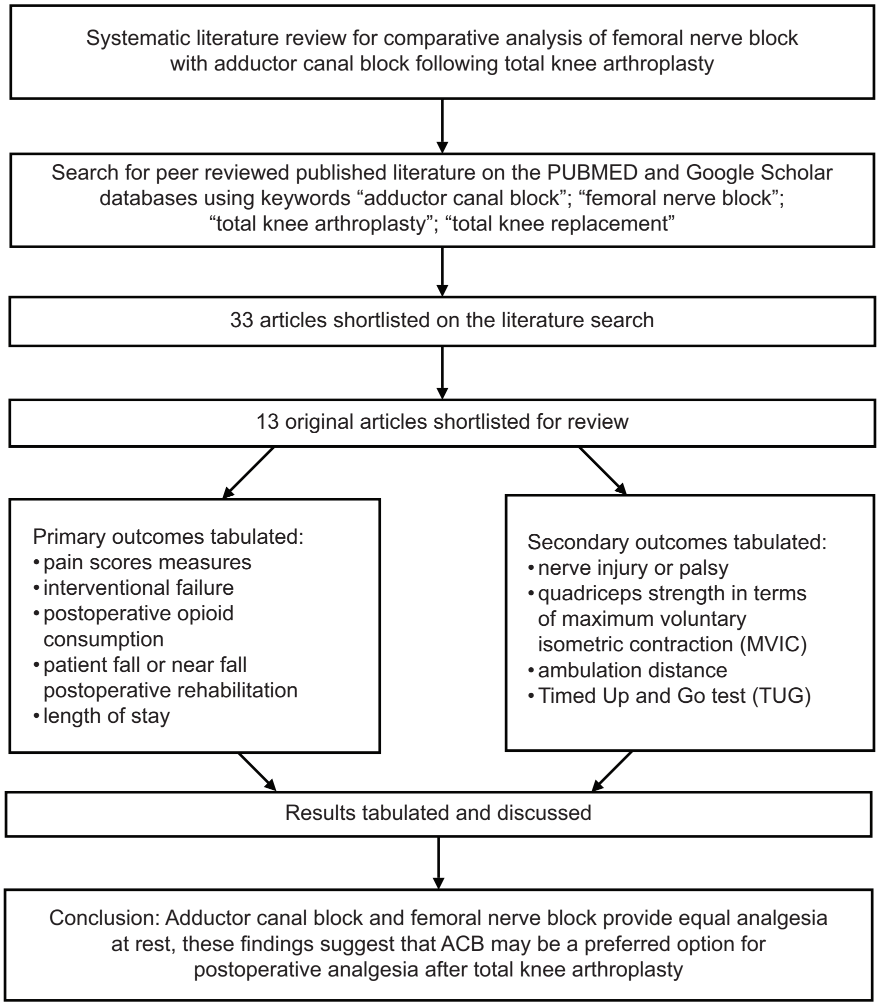

Figure 1: PRISMA flow chart for conduct of the systemic review

Table 1: Demographic and outcome data of studies reviewed to compare femoral nerve block and adductor canal block

Study	Type of study	Total patients (*n*)	Patient received FNB (*n*)	Patient received ACB (*n*)	Opioid usage	TUG test	Ambulation distance (10-m walk test)	Quadriceps strength (MVIC)	VAS score
Thacher *et al*. (2017)	Retrospective	279	129	150	∨/∧	–	–	–	Similar
Rasmussen *et al*. (2014)	Retrospective	45	22	23	Same	–	–	–	Similar
Patterson *et al*. (2015)	Retrospective	80	41	39	Same	–	∨/∧	∨/∧	–
Shah *et al*. (2014)	RCT	98	50	48	–	∨/∧	∨/∧	∨/∧	∧/∧ (NS)
Mudumbai *et al*. (2014)	Retrospective	168	102	66	Same	∨/∧	∨/∧	∨/∧	Similar
Memtsoudis *et al*. (2014)	RCT	59	32	27	–	–	∨/∧	Same	Similar
Macrinici *et al*. (2017)	Double-blind RCT	93	47	46	–	∨/∧	–	∨/∧	–
Ludwigson *et al*. (2015)	Retrospective	297	149	148	Same	∨/∧	∨/∧	–	Similar
Kwofie *et al*. (2013)	RCT	16	8	8	–	–	–	∨/∧	–
Kim *et al*. (2014)	Double-blind RCT	93	47	46	Same	–	–	∨/∧	Similar
Jaeger *et al*. (2013)	Double-blind RCT	48	26	22	Same	Equal	∨/∧	∨/∧	Similar
Grevstad *et al*. (2015)	Blind RCT	50	25	25	–	∨/∧	–	∨/∧	Similar
Elkassabany *et al*. (2016)	Double-blind RCT	62	31	31	Same	Same	Same	–	Similar

FNB=Femoral nerve block; ACB=Adductor canal block; MVIC=Maximum voluntary isometric contraction; RCT=Randomized control trial; TUG=Timed up and go; ∨=Inferior; ∧=Higher/superior; NS=Not significant; VAS=Visual analogue score

patients, 669 received FNB while 610 received ACB. All the patients reviewed underwent primary TKA. All comparisons were between single shot/continuous ACB and continuous FNB. The risk of postoperative fall and near fall was found to be significantly higher in the majority of patients administered FNB.

The requirement for opioids for pain management, on the first and second postoperative day (POD), was found to be comparable in both the groups. Only one study, by Thacher *et al.*,[17] suggested a decreased requirement of opioids in the FNB group. Pain scores, assessed by subjective Visual Analogue Score (VAS), were found to be similar in both the groups in all the patients reviewed, with good pain control with both the ACB and FNB. Shah *et al*.[11] and Ludwigson *et al*.[18] found LOS better with ACB, as compared to FNB, but Mudumbai *et al*.[19] found similar LOS in both the groups.

The TUG test measures the time a person takes to stand up from a chair, walk a distance of 3 m, and then return back to the chair. TUG time was reported as significantly lower in the ACB group, as compared to the FNB group, in all the studies except those by Jæger *et al*.[20] (which found no difference in time) and Grevstad *et al*.[21] (which reported a lower but not statistically significant difference in TUG time with ACB).

Ambulation distance was quantified by a 10-m walk test, which measures the time taken to walk 10 m as quickly as possible. Ambulation distance was significantly better in the ACB group, or the difference was not significantly longer, as compared to the FNB group in the studies reviewed. Ambulation distance was either significantly better in the ACB group in studies conducted by Shah *et al*.,[11] Mudumbai *et al*.,[19] Ludwigson *et al*.,[18] and Jæger *et al*.[20] or the difference was insignificantly better, as compared to the FNB group.

The 30-s chair stand test assesses how many times a person can rise from a chair and sit down again in 30 s, with the arms kept crossed over the chest. It was compared by Shah *et al*.[11] who reported it to be significantly better with the ACB.

Quadriceps strength was evaluated by the MVIC. MVIC was found to be significantly better in ACB group as compared to FNB group, at 6 h, 1 day, and 2 days postoperatively, in a majority of the patients. Ludwigson *et al*.[18] found the better mean knee flexion at POD 1 and 2 in the ACB group, while Jæger *et al*.[20] and Grevstad *et al*.[21] found no significant difference in the knee flexion in the ACB and FNB groups.

In the studies reviewed, no protocol reflected any evident bias in methodology. No nerve injury was reported in the studies. Interventional failure in terms of block failure was reported by Patterson *et al*.[22] in one patient and in four patients by Kim *et al*.[23]

Discussion

This systematic review was conducted to find the relative efficacy and advantages of two modalities of pain management following TKA in current practice. Pain management after TKA needs to be multimodal, intense, and proactive to make the patient pain free after this excruciatingly painful procedure.[24] Reducing opioid consumption helps prevent adverse effects associated with their use. Acute postoperative pain is associated with a risk of chronic post-surgery pain, and good effective analgesia reduces the risk.[25] Optimal pain management permits full range mobility of the joint facilitating appropriate physiotherapy and functional recovery. A large number of clinical trials comparing different modalities of pain management after TKA have been published and are also in process.

An ideal PNB must provide effective analgesia without motor blockade to facilitate early mobilization and associated with minimum opioid consumption.[26] FNB has been customarily used for postoperative pain relief after TKA. FNB, in comparison to other pain management modalities like epidural analgesia and opioids, has been shown to provide excellent postoperative analgesia with a lower incidence of opioid-related side effects. Despite the benefits associated with FNB, the adverse effects on quadriceps function hindering rehabilitation and the increased risk of falls or knee buckling, have been bugbears in its use.

Reports of patient fall due to quadriceps muscle weakness after FNB promoted research to find safer alternatives. The use of FNB has decreased significantly with the broader spread of ACB, due to the enthusiastic adoption of major functions sparing. In the last decade, free availability of ultrasound guidance also led to the more frequent use of ACB. The ACB offered a predominantly sensory neural blockade and thereby avoids the most significant adverse effect of motor blockade of the nerves. Recently, Thacher *et al*.[17] reported a statistically significant difference in episodes of near fall (knee buckling) with use of FNB *vis-a-vis* ACB [a total of 17 (13%) patients experienced knee buckling events in the FNB group during physiotherapy as compared to just 3 (2%) total patients in the ACB group]. Others have reported a 6–8% incidence of near fall.[11,19,23] Four of these studies demonstrated quadriceps weakness after FNB using a Lafayette Manual Muscle Test System, popularly called as Dynamometer (placed between the malleoli on the anterior aspect to the ankle and asking the patients to extend their legs three times with a 30 s pause between each attempt).[13,20,23,27] Kwofie *et al.*demonstrated a higher incidence of quadriceps muscle weakness and risk of falls after administration of FNB, as compared to ACB, in healthy volunteers using the Berg's Balance Scale.[15] Elkassabany *et al.* used the Tinetti Scale for gait and balance to assess the risk of fall after continuous FNB and ACB after TKA and reported a higher incidence of fall after 48 h in the FNB group.[28]

The greater preservation of quadriceps strength and ambulation activity in patients administered ACB, as compared to FNB, is an attribute of the anatomy of the block. The femoral nerve is encountered at or below the level of the inguinal ligament. Local anesthetic infiltration at this site causes neural blockade at the following sites: the entire front of the upper thigh down to and including the patella, and the medial side of the lower leg to nearly the medial malleolus of the femur.

ACB targets the saphenous nerve, articular branches of the obturator nerve, the medial retinacular nerve, and the nerve to the vastus medialis. The saphenous nerve and the nerve of the vastus medialis innervate the knee capsule, but the obturator nerve rarely innervates the capsule. The anatomical location for ACB is approximately halfway between the anterior superior iliac spine and the patella, at the mid-thigh level.[10] An ultrasound transducer is placed transverse to the longitudinal axis of the extremity to identify adductor canal underneath the sartorius muscle. The femoral artery is first identified as visible pulsations, with the vein just inferior and the saphenous nerve just lateral to the artery. The nerve is blocked at the location is so identified.

ACB results in sensory blockade of the anteromedial aspect of the knee.[29] The ACB spares most of the motor innervation of the quadriceps group. In all the studies reviewed, the pain relief concerning VAS score was equivalent with the use of both FNB and ACB. Opioids consumption was also similar for both the PNBs, suggesting comparable efficacy.

The importance of rehabilitation has recently become more apparent. A new composite outcome score "discharge readiness," specific to TKA, has been proposed. It includes four parameters: adequate analgesia, intravenous opioid dependence, ability to stand, walk 3 m and sit down, and ability to ambulate 30 m.[30] The "discharge readiness" is considered when a patient adequately meets all the four criteria. To determine "discharge readiness" we reviewed these parameters in all the studies.

The effective ambulation distance, for the 10-m walk test, was found to be significantly better with use of ACB and so was the 30-s chair stand test. Knee flexion test on first and second POD was better in the ACB group in comparison to the FNB group. The pain scores at or after knee flexion 24 h postoperatively in three RCTs also revealed insignificant differences between ACB and FNB.[14,17,19] These suggest a better and faster rehabilitation in patients receiving ACB for postoperative pain management. Machi *et al*.[30] reported "discharge readiness" after 55 h in patients who received continuous ACB versus 61 h in those who received continuous FNB, but the difference was not statistically significant.

Use of ACB is also associated with economic benefits. Rasmussen *et al*. reported a novel advantage with ACB use for patients undergoing TKA.[31] Despite a longer infusion period, ACB is associated with fewer provider interventions per patient when compared to FNB and thus decreases workload of healthcare workers. LOS was reported to be significantly less in patients who received ACB as compared to FNB by Shah *et al*.[11] and Ludwigson *et al*.[18]

This review has a few limitations. The studies reviewed were all done in patients for unilateral TKA and the findings cannot be extrapolated to bilateral TKA, where the pain load is higher and the motor involvement bilateral. Out of the studies reviewed five were retrospective and thus data quality amongst the studies may have been compromised. Study protocols had different comparisons, with some comparing single shot ACB with continuous FNB and others having different comparators. We thus considered both continuous/single shot ACB and FNB as one entity. Some secondary outcome parameters were not assessed by all studies. Large multicenter prospective RCTs, with similar protocols choosing either single shot or continuous blocks, need to be done to establish ACB as the preferred PNB for TKA.

Conclusion

The current review of literature elicits that both ACB and FNB have similar clinical efficacy concerning pain scores, opioid consumption, opioid-associated adverse effects, patient satisfaction, and success rate of the blockade. TKA patients who received ACB, however, have better quadriceps strength and consequently are less prone to falls. Patients receiving ACB can be mobilized early and have lower hospital LOS. Mobilization and ambulation, which are both critical for recovery after TKA, are both inhibited less by ACB. Although ACB and FNB provide equal analgesia at rest, these findings suggest that ACB may be a preferred option for postoperative analgesia after TKA.

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Conflicts of interest

There are no conflicts of interest.

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