Systematic Review and Meta-Analysis

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Is the proximal adductor canal block a better choice than the distal adductor canal block for primary total knee arthroplasty?

A meta-analysis of randomized controlled trials

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Abstract

Background: Total knee arthroplasty is accompanied by moderate to severe postoperative pain. Postoperative pain hampers the functional recovery and lowers patient satisfaction with the surgery. Recently, the adductor canal block (ACB) has been widely used in total knee arthroplasty. However, there is no definite answer as to the location of a continuous block within the ACBs.

Method: Randomized controlled trials about relevant studies were searched in PubMed (1996 to Oct 2019), Embase (1996 to Oct 2019), and Cochrane Library (CENTRAL, Oct 2019).

Results: Five studies involving 348 patients met the inclusion criteria. Pooled data indicated that the proximal ACB was as effective as the distal ACB in terms of total opioid consumption ($P=.54$), average visual analog scale (VAS) score ($P=.35$), worst VAS score ($P=.19$), block success rate ($P=.86$), and time of catheter insertion ($P=.54$).

Conclusions: Compared with the distal ACB, the proximal ACB showed similar analgesic efficacy for total opioid consumption, average VAS score, worst VAS score, block success rate, and time of catheter insertion. However, because of the limited number of involved studies, more high-quality studies are needed to further identify the optimal location of the ACB.

Abbreviations: ACB = adductor canal block, CIs = confidence intervals, MD = mean difference, RCTs = randomized controlled trials, TKA = total knee arthroplasty, VAS = visual analog scale.

Keywords: adductor canal block, distal, proximal, total knee arthroplasty

1. Introduction

Total knee arthroplasty (TKA) is 1 of the most important surgeries for patients with osteoarthritis.[1–3] It has been estimated that the number of primary TKA is expected to grow by 673% to 3.48 million in the United States by 2030.[4] The most common problem that concerns surgeons is postoperative pain following TKA.[5,6] Several pain relief methods are available for postoperative analgesia, including patient-controlled intravenous analgesia, intravenous opioids, femoral nerve block, local infiltration analgesia, and epidural.[7–10] However, the most suitable analgesic method remains controversial. Recently, published studies have reported that the adductor canal block (ACB) provides effective postoperative analgesia.[11–15] The adductor canal runs distally from the apex of the femoral triangle to the adductor hiatus distally. The proximal block is positioned caudally beyond the femoral triangle, and the distal block is placed between the inguinal crease and the top of the patella. However, the optimal location for ACB placement remains controversial.[16–20] Implementing the distal approach may be superior because of the decreased risk of femoral nerve injury, while adding a risk of contaminating the sterile surgical field.[21] In a study by Romano et al,[19] a better performance was seen in the proximal group. However, Mariano et al[17] reported that compared with the distal group, the proximal group offered a minor analgesic. Due to conflicting results, we were inspired to develop the first meta-analysis to compare the 2 techniques.

The hypothesis of the meta-analysis is as follows: Is the proximal ACB as effective as the distal ACB for analgesia?

2. Methods and materials

The study was approved by the Ethics Committee of the Xiaoshan Traditional Chinese Medical Hospital.

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LZ, CC, and WD contributed equally to this work.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are publicly available.

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2.1. Search strategy

We systematically searched PubMed (1996 to Oct 2019), Embase (1996 to Oct 2019), and Cochrane Library (CENTRAL, Oct 2019). We also searched related references and Google Scholar. Only randomized controlled trials (RCTs) were included in our study. "Total knee arthroplasty," "total knee replacement," "ACB," "adductor canal block," "proximal," and "distal" were used as keywords using Boolean operators "AND" or "OR." The search results are shown in Figure 1.

2.2. Inclusion criteria

Trials were included in our meta-analysis given that they met the PICOS criteria (patients, intervention, comparator, outcome, study design):

(1) patients, patients underwent TKA for the first time;
(2) intervention, proximal ACB technique;
(3) comparator, distal ACB approach;
(4) outcomes, total opioid consumption, average visual analog scale (VAS) score, worst VAS score, block success rate, and time of catheter insertion; and
(5) study design, RCT.

2.3. Data extraction and bias risk assessment

Two reviewers extracted available data from studies independently, and any disagreement was judged by a third reviewer. Basic characteristics included patients' age, sex, body mass index, American Society of Anesthesiologists physical status classification, and reference type. Total opioid consumption was the primary outcome in our meta-analysis. All painkillers were transformed into equivalent morphine consumption according to the standard formula[22] (Table 1). Secondary outcomes consisted of VAS score, block success rate, and time of catheter insertion. The VAS score contained 11 pain levels, with 0 being no pain and 10 representing the worst pain. We attempted to e-mail corresponding authors for incomplete data, or graphical data.

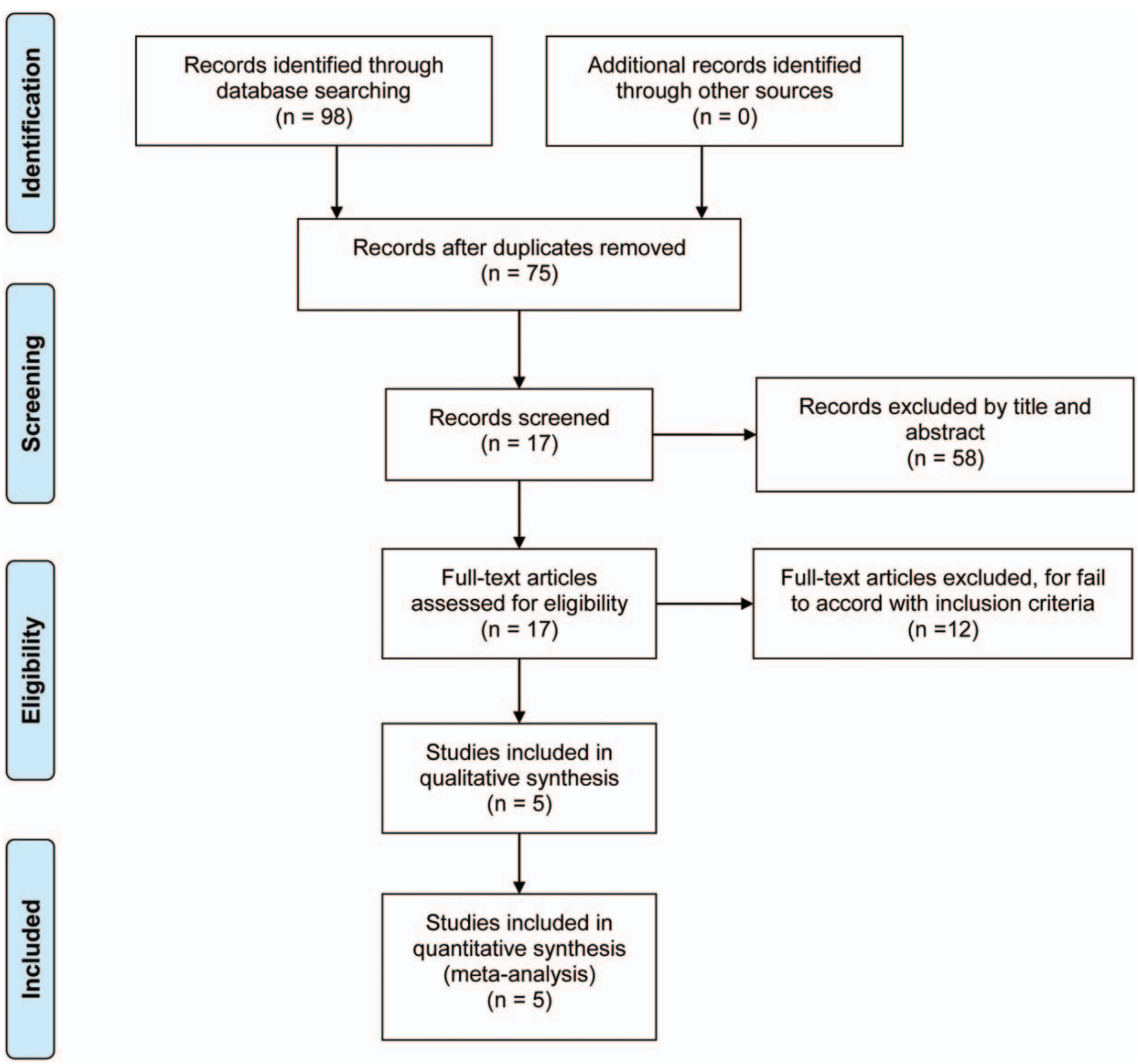

Figure 1. The search results and selection procedure.

Table 1

Conversion of analgesics use into equivalent morphine dosage.

Analgesics	Dosage of morphine equivalents (mg)
Morphine (subcutaneous or intramuscular)	10
Hydromorphone (subcutaneous or intramuscular/oral)	1.5/7.5
Codeine (subcutaneous or intramuscular/oral)	120/200
Oxycodone (oral)	20
Demerol (subcutaneous or intramuscular/oral)	80/300

The Cochrane Handbook for Systematic Reviews of Interventions (Review Manager 5.3) was used to evaluate the bias risk of included RCTs.[23]

2.4. Statistical analysis

Review Manager software 5.3 (Cochrane Collaboration, Copenhagen: The Nordic Cochrane Center) was used for this analysis. For continuous data, the mean difference (MD) with 95% confidence intervals (CIs) was used to weigh the effect interval. Differences were considered significant at $P<.05$. For discontinuous data, the risk ratio with 95% CI was used to calculate the effect interval. The values of P and I^2 were used to assess statistical heterogeneity among the included studies. We applied a fixed-effects model when $I^2<50\%$ and $P>.1$; otherwise, a random-effects model was applied.

3. Results

3.1. Search results

According to the search strategy, a total of 98 studies were retrieved, 23 studies were excluded by Endnote software, and 58 studies were removed upon reading the title and abstract. Finally, 5 RCTs[16–20] were included in our meta-analysis. The basic characteristics and interventions are summarized in Tables 2 and 3. The primary and secondary end points of the single studies are presented in Table 4.

3.2. Risk of bias of assessment

The risk of assessment bias is presented in Figures 2 and 3. Among the 5 RCTs, 3 RCTs[16,19,20] reported using computer-generated randomization. Two RCTs[17,18] described allocation concealment via sealed envelopes or other methods. A double-blind method was carried out in 2 studies.[17,18] Three studies[16–18] reported the implementation of blinding of outcomes. Publication bias was assessed by the funnel plot diagram (Fig. 4). The funnel plot diagram indicated that there were no obvious risks of publication bias of opioid consumption, average VAS score, worst VAS score, and block success. Only 2 RCTs were assessed in the funnel plot of catheter insertion. Thus, we were unable to determine the risk of publication bias.

3.3. Results of the meta-analysis

3.3.1. Total opioid consumption. Four studies,[17–20] including 228 patients, reported total opioid consumption, and no significant differences were found between the 2 groups (MD=-0.77; 95% CI, [-3.22, 1.69]; $P=.54$; Fig. 5). There was no significant heterogeneity between the 2 groups ($x^2=1.42$; df=3; $P=.7$; $I^2=0\%$; Fig. 5). Thus, a fixed-effects model was used.

3.3.2. Average VAS score. The average VAS score was recorded in 4 studies[17–20] containing 228 patients. Pooled data indicated that there were no significant differences between the 2 groups (MD=-0.28; 95% CI, [-0.87, 0.30]; $P=.35$; Fig. 6). We used a fixed-effects model because there was no heterogeneity between the studies ($x^2=1.92$; df=3; $P=.59$; $I^2=0\%$; Fig. 6).

3.3.3. Worst VAS score. The worst VAS score was reported in 3 studies[17,18,20] including 172 patients. No significant differences

Table 2

The characteristics of included studies.

Studies (year)	The proximal Group/ The distal Group					Reference Type
	Patients (n)	Ages (yr)	Female Gender (%)	BMI	ASA (I/II/III/IV)	
Romano et al 2018	28/28	60.8/62.9	78.6/67.9	34.6/35.0	0/13/15/0 vs0/15/13/0	RCT
Meier et al 2018	36/37	67.7/66.2	63/84	32/29	0/33/3/0vs/3/29/5/0	RCT
Sztain et al 2018	24/26	69/69	32/54	28.4/29.9	N/A	RCT
Marian et al 2015	58/62	45.2/47.1	44.8/71	31.3/30.2	18/34/6/0vs/12/43/7/0	RCT
Mariano et al 2014	25/24	66/65	N/A	33/20	11/7/0/0vs/9/8/1/0	RCT

ASA=American society of anesthesiologists, BMI=body mass index, N/A=not applicable, RCT=randomized controlled trial.

Table 3

Characteristics of the included studies showing general intervention information.

Studies (year)	Analgesics and Dosage	surgical approach	Anesthesia	Pneumatic tourniquet
Romano et al 2018	20 mL of 5 mg/mL ropivacaine	N/A	Spinal anesthesia	Use
Meier et al 2018	8 mL/h of 0.2% ropivacaine	Hospital standard practice	Spinal anesthesia	N/A
Sztain et al 2018	30 mL of lidocaine 2% with 5 μg/mL epinephrine. Ropivacaine 0.2% was initiated via the perineural catheter at 8 mL/with total of 30 minutes	Parapatellar approach	Spinal anesthesia	Use
Marian et al 2015	10 mL of 0.5% ropivacaine	N/A	Spinal anesthesia	N/A
Mariano et al 2014	15 mL of 2%mepivacaine with epinephrine, 2.5 μg/mL	N/A	Regional anesthesia	N/A

N/A=not applicable.

Table 4

Primary and secondary endpoints of the single studies.

Studies (year)	Primary endpoints	secondary endpoints
Romano et al 2018	Postoperative opioids consumption	TUG test, LOS, VAS
Meier et al 2018	Postoperative opioids consumption	Quadriceps strength, VAS, Patient satisfaction, Distance ambulated, LOS, Complications
Sztain et al 2018	NRS	Opioid consumption, Time for catheter insertion, Operation time,
Marian et al 2015	Block success	Time to success, Time to perform block, Ultrasound image of nerve
Mariano et al 2014	Time to success	Patient satisfaction, Fluid leakage at site, NRS,

LOS=length of stay, NRS=numeric rating scale, TUG test=time up and go test, VAS=visual analog scale.

were found between the proximal and distal groups (MD=-0.22; 95% CI, [-0.56, 0.11]; P=0.19; Fig. 7). A fixed-effects model was used because no heterogeneity was found between the 2 groups (x^2=1.47; df=2; P=.48; I^2=0%; Fig. 7).

3.3.4. Block success rate. Block success was reported in 3 studies[16,17,19] including 225 patients. No significant differences were found between the proximal and distal groups (relative risk=0.98; 95% CI, [0.80, 1.22]; P=0.88; Fig. 8). We used a random-effects model because of the heterogeneity between the studies (x^2=9.76; df=2; P < .01; I^2=80%; Fig. 8).

3.3.5. Time of catheter insertion. The time of catheter insertion was reported in 2 studies[17,20] with 99 patients. Pooled data indicated no significant differences between the proximal and distal groups (MD=0.34; 95% CI, [-0.74, 1.42]; P=.54; Fig. 9).

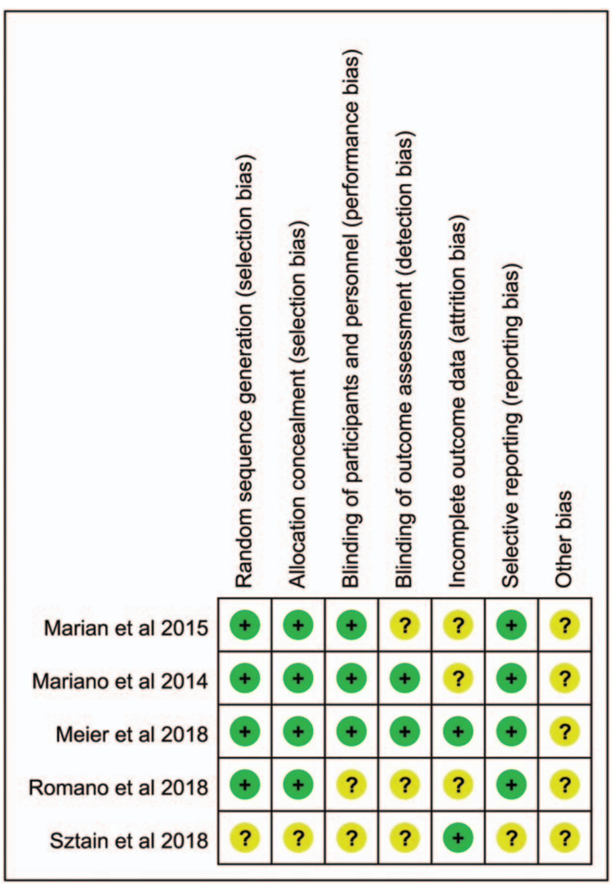

Figure 2. The risk of bias summary: review authors' judgement of each risk of bias items for each included studies.

A fixed-effects model was used because no heterogeneity was found between the 2 groups (x^2=0.18; df=1; P=.67; I^2=0%; Fig. 9).

4. Discussion

The most important finding of the meta-analysis was that compared with the distal ACB, the proximal ACB showed similar analgesic efficacy in total opioid consumption, average VAS score, worst VAS score, block success rate, and time of catheter insertion.

The ACB is 1 of most commonly used analgesic methods and has been widely used to relieve postoperative pain in TKA.[24–26] The proximal block was positioned caudally beyond the femoral triangle, and the distal block was placed between the inguinal crease and the top of the patella. The femoral triangle (proximal location) can spread local anesthetic to the vastus medialis nerve, while a distal location could reach the posterior plexus.

Total opioid consumption was the primary outcome in our meta-analysis. Total opioid consumption is 1 of the most important indexes for estimating the efficacy of analgesic methods. An RCT conducted by Mariano et al[17] reported that there were no significant differences in total morphine consumption between the proximal and distal groups. An RCT conducted by Romano et al[19] found no significant differences between the proximal and distal groups related to mean opioid consumption at 24 hour postoperatively. Similar findings were reported by Meier et al and Sztain et al[18,20] Our meta-analysis also found no differences between the proximal and distal groups.

In our meta-analysis, we used the average and worst VAS scores to weigh analgesia effects. We found that the proximal group was equal to the distal group, not only the average but also the worst VAS score. Recently, Romano et al[19] reported that there were no significant differences in postoperative pain scores between the distal and proximal groups. Sztain et al[20] also demonstrated that the median and maximum numerical rating scales (NRSs) were lower in the proximal group at all other time points compared to the distal group. Similar findings were reported by Mariano et al[17] and Meier et al[18] Taking these results into consideration, we concluded that the proximal ACB group had similar analgesic effects to that in the distal group.

Data for block success rate and time of catheter insertion were used to evaluate the feasibility. Marian et al[16] reported that the proximal ACB group showed a similar success rate compared to the distal ACB group. A high-quality RCT conducted by Mariano et al[17] reported that the proximal and distal groups acquired similar block success rates (91.7% and 95.8%, respectively). Similar findings were reported by Romano et al[19] Regarding time of catheter insertion, both Mariano et al[17] and Sztain et al[20] reported that there were no significant differences

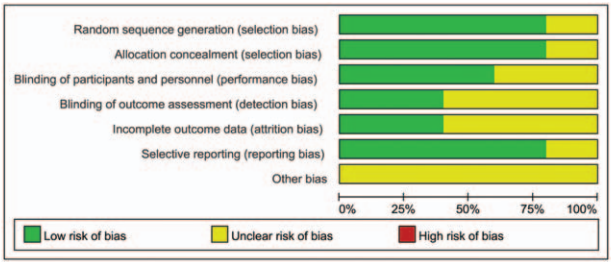

Figure 3. The risk of bias graph of the included studies.

between the proximal and distal groups. These results were consistent with our findings. Hence, we conclude that both the proximal and the distal ACB had equivalent difficulty upon catheter insertion.

Our systematic review and meta-analysis has several limitations:

(1) Only 5 RCTs were included in the study. Pooled data would be more accurate and reliable if more studies and patients had been included.
(2) Different categories and dosages of analgesics among the included studies may create potential bias.
(3) Outcomes such as patient satisfaction and length of hospital stay failed to be analyzed due to insufficient data.

Finally, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and Cochrane Handbook were used to ensure the quality of our meta-analysis.[23]

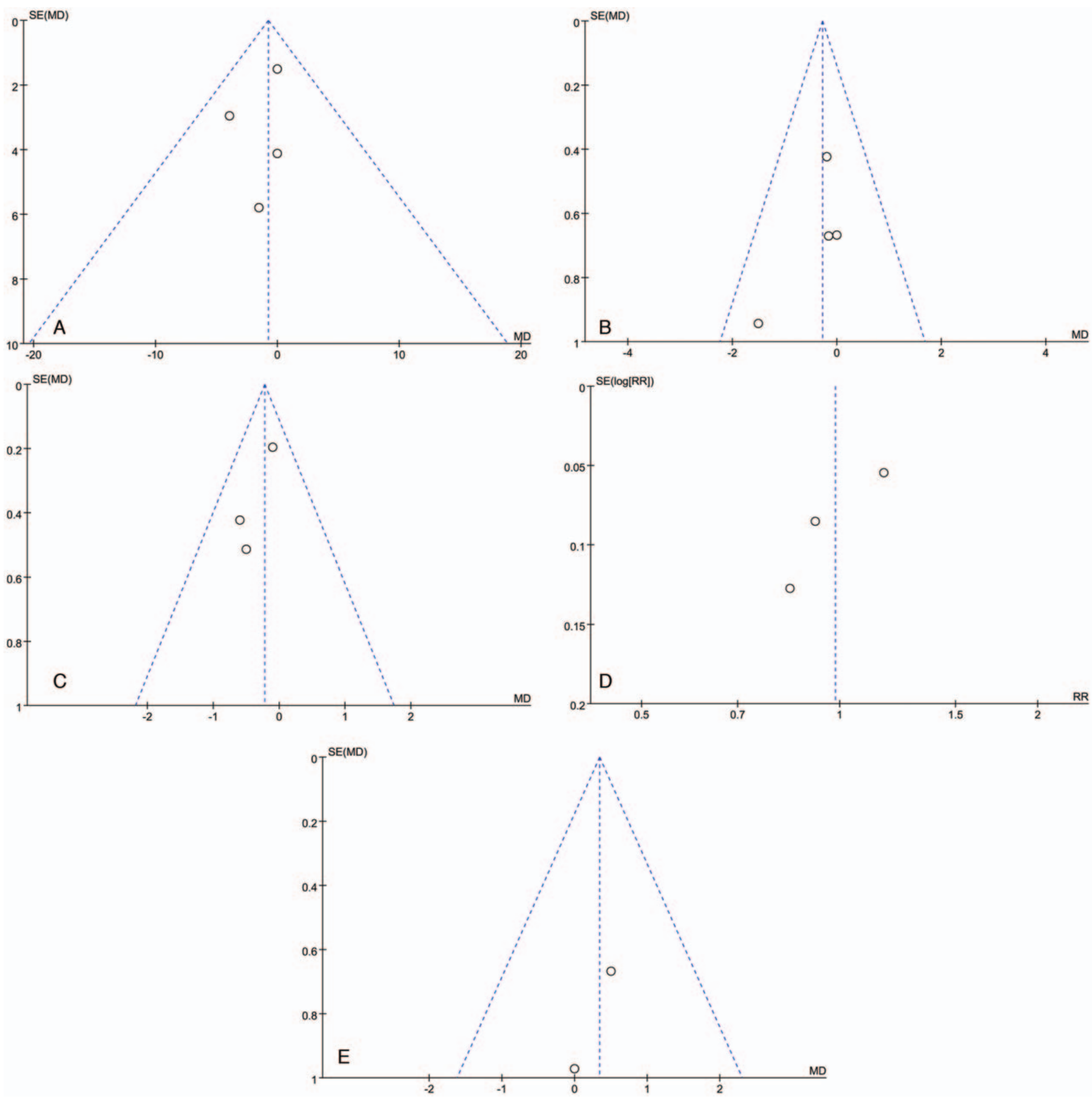

Figure 4. (A) A funnel plot of total opioid consumption; (B) A funnel plot of average VAS score; (C) A funnel plot of worst VAS score; (D) A funnel plot of block success rate; (E) A funnel plot of time for catheter insertion. VAS = visual analog scale.

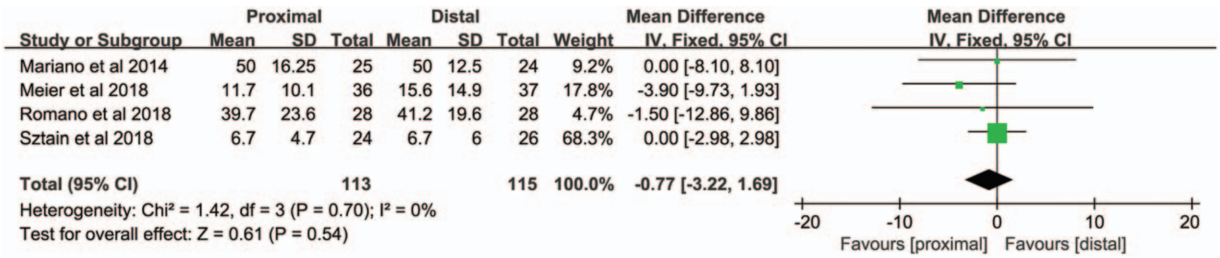

Figure 5. A forest plot diagram showing the total opioid consumption.

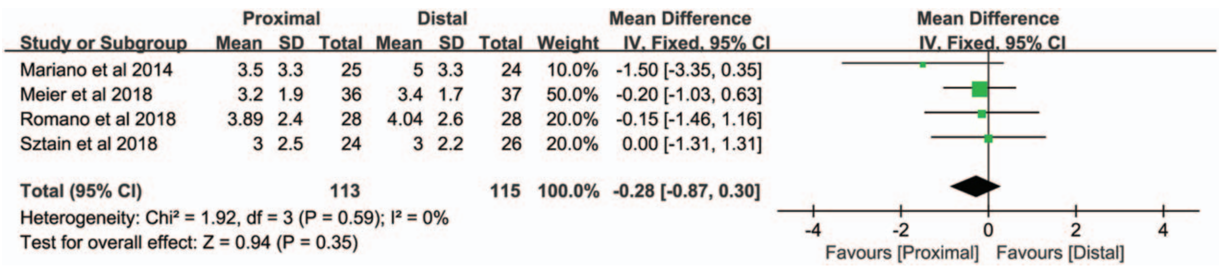

Figure 6. A forest plot diagram showing the average VAS score. VAS = visual analog scale.

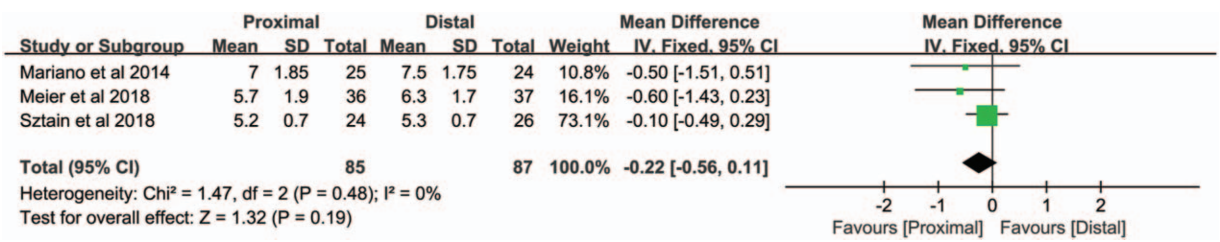

Figure 7. A forest plot diagram showing the worst VAS score. VAS = visual analog scale.

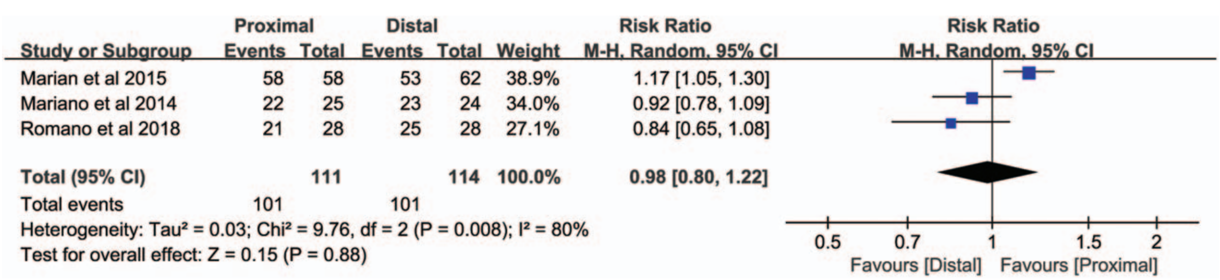

Figure 8. A forest plot diagram showing the block success rate.

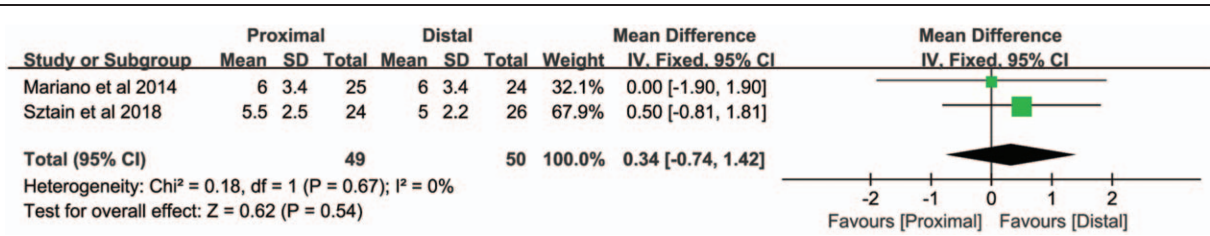

Figure 9. A forest plot diagram showing the time for catheter insertion. Credit: All figures can be printed by *Medicine*.

5. Conclusion

Conclusively, no difference was found between the proximal and distal groups in terms of total opioid consumption, VAS score, block success rate, and catheter insertion. Taking these into consideration, we conclude that proximal ACB is a feasible analgesic method.

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Writing – review & editing: Ren-Fu Quan.

References

[1] Delanois RE, Mistry JB, Gwam CU, et al. Current epidemiology of revision total knee arthroplasty in the United States. J Arthroplasty 2017;32:2663–8.
[2] Pollock M, Somerville L, Firth A, et al. Outpatient total hip arthroplasty, total knee arthroplasty, and unicompartmental knee arthroplasty: a protocol for systematic review of the literature. JBJS reviews 2016;4(12.):
[3] Ethgen O, Bruyere O, Richy F, et al. Health-related quality of life in total hip and total knee arthroplasty. a qualitative and systematic review of the literature. J Bone Joint Surg Am 2004;86-a:963–74.
[4] Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007;89:780–5.
[5] Elmallah RK, Chughtai M, Khlopas A, et al. Pain control in total knee arthroplasty. J Knee Surg 2018;31:504–13.
[6] Gaffney CJ, Pelt CE, Gililland JM, et al. Perioperative pain management in hip and knee arthroplasty. Orthop Clin North Am 2017;48:407–19.
[7] Yu S, Eftekhary N, Wiznia D, et al. Evolution of an opioid sparse pain management program for total knee arthroplasty with the addition of intravenous acetaminophen. J Arthroplasty 2019;35:89–94.
[8] Jules-Elysee KM, Tseng A, Sculco TP, et al. Comparison of topical and intravenous tranexamic acid for total knee replacement: a randomized double-blinded controlled study of effects on tranexamic acid levels and thrombogenic and inflammatory marker levels. J Bone Joint Surg Am 2019;101:2120–8.
[9] Henson KS, Thomley JE, Lowrie LJ, et al. Comparison of selected outcomes associated with two postoperative analgesic approaches in patients undergoing total knee arthroplasty. AANA J 2019;87:51–7.
[10] Borys M, Domagala M, Wenclaw K, et al. Continuous femoral nerve block is more effective than continuous adductor canal block for treating pain after total knee arthroplasty: a randomized, double-blind, controlled trial. Medicine 2019;98:e17358.
[11] Turner JD, Dobson SW, Henshaw DS, et al. Single-injection adductor canal block with multiple adjuvants provides equivalent analgesia when compared with continuous adductor canal blockade for primary total knee arthroplasty: a double-blinded, randomized, controlled, equivalency trial. J Arthroplasty 2018;33:3160–6. e3161.
[12] Masaracchia MM, Herrick MD, Barrington MJ, et al. Adductor canal blocks: changing practice patterns and associated quality profile. Acta anaesthesiologica Scandinavica 2017;61:224–31.
[13] Rousseau-Saine N, Williams SR, Girard F, et al. The effect of adductor canal block on knee extensor muscle strength 6 weeks after total knee arthroplasty: a randomized, controlled trial. Anesth Analg 2018;126:1019–27.
[14] Thacher RR, Hickernell TR, Grosso MJ, et al. Decreased risk of knee buckling with adductor canal block versus femoral nerve block in total knee arthroplasty: a retrospective cohort study. Arthroplast Today 2017;3:281–5.
[15] Lee S, Rooban N, Vaghadia H, et al. A randomized non-inferiority trial of adductor canal block for analgesia after total knee arthroplasty: single injection versus catheter technique. J Arthroplasty 2018;33:1045–51.
[16] Marian AA, Ranganath Y, Bayman EO, et al. A comparison of 2 ultrasound-guided approaches to the saphenous nerve block: adductor canal versus distal transsartorial: a prospective, randomized, blinded, noninferiority trial. Reg Anesth Pain Med 2015;40:623–30.
[17] Mariano ER, Kim TE, Wagner MJ, et al. A randomized comparison of proximal and distal ultrasound-guided adductor canal catheter insertion sites for knee arthroplasty. J Ultrasound Med 2014;33:1653–62.
[18] Meier AW, Auyong DB, Yuan SC, et al. Comparison of continuous proximal versus distal adductor canal blocks for total knee arthroplasty: a randomized, double-blind, noninferiority trial. Reg Anesth Pain Med 2018;43:36–42.
[19] Romano C, Lloyd A, Nair S, et al. A randomized comparison of pain control and functional mobility between proximal and distal adductor canal blocks for total knee replacement. Anesth Essays Res 2018;12:452–8.
[20] Sztain JF, Khatibi B, Monahan AM, et al. Proximal versus distal continuous adductor canal blocks: does varying perineural catheter location influence analgesia? A randomized, subject-masked, controlled clinical trial. Anesth Analg 2018;127:240–6.
[21] Burckett-St Laurant D, Peng P, Giron Arango L, et al. The nerves of the adductor canal and the innervation of the knee: an anatomic study. Reg Anesth Pain Med 2016;41:321–7.
[22] Chaumeron A, Audy D, Drolet P, et al. Periarticular injection in knee arthroplasty improves quadriceps function. Clin Orthop Relat Res 2013;471:2284–95.
[23] Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions. Cochrane database of systematic reviews (Online). 2011;2011
[24] Kim MK, Moon HY, Ryu CG, et al. The analgesic efficacy of the continuous adductor canal block compared to continuous intravenous fentanyl infusion with a single-shot adductor canal block in total knee arthroplasty: a randomized controlled trial. Korean J Pain 2019;32:30–8.
[25] Koniuch KL, Buys MJ, Campbell B, et al. Serum ropivacaine levels after local infiltration analgesia during total knee arthroplasty with and without adductor canal block. Reg Anesth Pain Med 2019.
[26] Swenson JD, Pollard JE, Peters CL, et al. Randomized controlled trial of a simplified adductor canal block performed for analgesia following total knee arthroplasty. Reg Anesth Pain Med 2019.