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KNEE ARTHROPLASTY

Local infiltration analgesia with additional intraarticular catheter provide better pain relief compared to single-shot local infiltration analgesia in TKA

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Abstract

Purpose Local infiltration analgesia (LIA) has been proven to be efficient in total knee arthroplasty (TKA). However, the effect of single-shot LIA is temporarily limited. The objective of this prospective trial was to investigate if the potential benefits resulting from LIA can be prolonged by a continuous intra-articular perfusion of LIA. The hypothesis of the present study was that the use of an additional continuous intra-articular perfusion delivering LIA would result in less pain and better function compared to single-shot LIA in the immediate post-operative period.

Methods 50 consecutively selected patients undergoing TKA received either a single-shot LIA (S-LIA group, 25 knees) or single-shot LIA combined with a continuous post-operative intra-articular perfusion for three post-operative days (CP-LIA group, 25 knees). VAS (visual analogue scale) for pain, pain medication consumption and flexion ability were recorded postoperatively for 6 days. All patients had the same implant, surgeon and intra- as well as post-operative setting.

Results The VAS score was significantly better for CP-LIA 6 h after surgery and on post-operative day 1, 2 and 6. There was no significant difference with regard to additional opioid consumption or flexion ability of the knee. However, there was a trend of the CP-LIA group requiring less additional opioids over the complete post-operative period compared to the S-LIA group. There were no complications or revisions.

Conclusion LIA combined with an additional intra-articular catheter provides better short-term pain control compared to single-shot LIA. However, no significant differences in terms of knee flexion were observed. This limited benefit should be balanced against the additional costs and the possible higher risk of infection.

Level of evidence Level II.

Keywords Local infiltration analgesia · LIA · TKA · TKR · Perioperative pain management

Abbreviations

TKA	Total knee arthroplasty
LIA	Local infiltration analgesia
CP-LIA	Continuous-perfusion local infiltration analgesia
S-LIA	Single-shot local infiltration analgesia
ROM	Range of motion
VAS	Visual analogue scale
LMWH	Low-molecular-weight heparins

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Introduction

Total knee arthroplasty (TKA) represents a standard procedure but still constitutes a major surgery with associated risks and pain [1–4]. Generally, current peri-operative pain management strives to achieve immediate rehabilitation and limited doses of narcotics. Management of post-operative pain is one of the most critical aspects in allowing fast recovery and in reducing the risk of post-operative complications. Ideal analgesia allows immediate mobilization, immediate good knee flexion with minimal pain and no motor impairment to enable successful mobilization [5]. Over the recent years, peri-articular infiltration of local anesthetics or so-called local infiltration analgesia (LIA), has attracted growing interest because the analgesia effects are confined to almost only the surgical area with limited systemical interference. Further, it has been proven to be efficient and even superior to other techniques, such as nerve blocks or spinal anesthesia [6, 7], which are associated with substantial side effects, such as impaired post-operative mobility and sensibility, urinary retention and hypotension. Further, LIA seems to reduce the requirement for post-operative opioids [8, 9], which cause sedation, nausea and vomiting and are, therefore, limited in their application in daily clinical practice. So far, mainly single-shot techniques are described [13–16] with varying anesthetic techniques [10–12]. A major disadvantage, nonetheless, is that the duration of single-shot analgesia is significantly short and insufficient for the entire post-operative pain therapy [17]. The idea underlying a continuous intra-articular analgesia is to prolong the positive effects of single-shot LIA. However, literature shows contradictory results in this respect. Zhang et al. who compared the effect of single-shot LIA to continuous LIA after total knee arthroplasty reported that the use of a continuous local infiltration analgesia provided better pain relief, better functional recovery and patient satisfaction compared to single-shot LIA [18]. On the contrary, Ali et al. reported that the use of continuous intra-articular analgesia did not show any clinically relevant effects with regard to post-operative pain, length of hospital stay or range of motion. In addition, they observed that more infections occurred, which is why they discontinued the use of continuous intra-articular analgesia [19].

The objective of this prospective trial was to investigate if the potential benefits deriving from LIA can be prolonged by a continuous intra-articular perfusion of LIA. The hypothesis of the present study was that the use of an additional intra-articular catheter delivering LIA would result in less pain and better function compared to single-shot LIA only in the immediate post-operative period.

Materials and methods

This prospective cohort study was approved by the ethic committee of the local state medical council (Approv. No. F-2017-024). 50 patients with end-stage osteoarthritis who were scheduled for TKA were selected consecutively over a period of 4 months and included after informed consent was obtained. Exclusion criteria were as follows: age under 18/over 85 years, neuropathy and polyneuropathy, paralysis, diabetes mellitus, non-compliance, cognitive or verbal restrictions or relevant allergies (to local anesthetics or metal). Information about study cohort is displayed in Table 1.

The first 25 patients were assigned to receive single-shot LIA only (S-LIA, $n=25$), which consisted of 150 ml ropivacaine 0.2% and 20 mg morphine. It was applied before every incision into soft tissues and into the capsule. Before implant positioning, LIA was applied into the posterior capsule and after implant positioning into the anterior capsule as well as soft tissues. The following 25 patients were assigned to receive the same single-shot LIA, but in combination with a continuous intra-articular catheter (CP-LIA, $n=25$), delivering 350 ml ropivacaine 0.2% and 20 mg morphine with 8 ml/h. The catheter (Pajunk, Geisingen, Germany) was inserted from superolateral into the medial gutter. To minimize the risk of infection, the catheter was placed in an inside-out technique and securely fixed and draped. Drape and catheter were not touched until removal on day 3 postoperatively.

The catheter has a diameter of 19 G, a length of 60 cm and comprises 45 perforations in a spiral-shaped arrangement at equal intervals, which guarantees a steady distribution of the local anesthetic in a 360° radius.

The mean age (64.7 in the S-LIA group and 69.4 in the CP-LIA group, n.s.) and gender distribution (female to male ratio was 17:13 in the S-LIA-group and 16:14 in the CP-LIA group, n.s.) were comparable between both groups. There were not any other differences in the post-operative treatment. All patients underwent surgery under general anesthesia with laryngeal mask and received a cruciate retaining TKA (PFC Sigma, CR, Depuy, Warsaw, IN, USA) and tranexamic acid. All surgeries were performed by the senior author (JB) through a medial parapatellar approach. No drains or tourniquet were used and all patients received the

Table 1 Information about study cohort

	Mean age	Gender ratio female:male
S-LIA	64.7	17.13
CP-LIA	69.4	16.14

same post-operative treatment protocol. Full weight-bearing with crutches as needed as well as flexion according to pain was allowed. Physiotherapy was started immediately and continued for several weeks if needed. Low-Molecular-Weight Heparins (LMWH) were given for 2 weeks postoperatively. The intra-articular catheter was removed on post-operative day 3.

Outcome measures

For data acquisition, several clinical parameters were recorded for each patient preoperatively, 6 h after surgery, and then every 24 h for six post-operative days. The parameters included pain, which was quantified by VAS (0–10), additional pain medication and function of the knee i.e., flexion (tested three times using a goniometer and the highest value was recorded). VAS score and additional pain medication were collected by the same investigator. Flexion ability was tested by the same physiotherapist.

Statistical analysis

A power analysis prior to trial based on a VAS score computed a group size of 23 patients with a power of 0.95 (14 with a power of 0.8), an effect size of 1.25 and an alpha level of 0.05. Due to possible drop-outs, group size was raised to 25. Shapiro–Wilk test was performed to test for normal distribution. Mann–Whitney *U* test was performed to reveal differences between the groups. A Fisher's exact test was performed for nominal distributed data. A value of $p < 0.05$ was specified for significance. SPSS for Windows (version 12.0) was used for statistical calculation.

Results

There were no post-operative complications, such as deep vein thrombosis, embolism, hematoma or infection, in both groups.

Pre-operatively, the CP-LIA group had a significant higher VAS score than the S-LIA group (Table 2). There were not any significant differences between groups with regard to pain medication (Table 3) or flexion ability (Table 4).

6 h after surgery and further on post-operative days 1, 2 and 6, the CP-LIA group showed a significant less VAS score than the S-LIA group (Table 2). A pain "rebound" occurred after 24 h with an increase of 1.6 in the VAS score in both groups (Fig. 1). No further significant rebound could be observed after removing of the catheter in the CP-LIA group (Fig. 1).

There was a trend of the S-LIA group requiring more pain medication compared to the CP-LIA group (Fig. 2), however, the difference was not significant (Table 3).

Any significant difference in terms of knee flexion was not observed (Table 4).

Results are presented in detail in Figs. 1, 2, 3 and Tables 2, 3, 4.

Table 2 Average (SD) VAS score

	Pre-OP	OP-day	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
S-LIA	3.4 (1.6)	1.9 (0.8)	3.5 (0.8)	2.9 (0.7)	2.8 (0.8)	2.9 (0.8)	2.7 (0.7)	2.7 (0.7)
CP-LIA	4.1 (1.1.7)	1.1 (0.7)	2.7 (1.1)	2.4 (0.7)	2.5 (0.7)	2.6 (0.7)	2.5 (1.0)	2.2 (0.7)
p value	0.023*	0.002*	0.0004*	0.030*	0.097	0.153	0.197	0.013*

* indicates $p < 0.05$

Table 3 Average (SD) of additional pain medication (morphine equivalents)

	Pre-OP	OP-day	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
S-LIA	15.4 (16.6)	12.1 (15.4)	36.4 (19.2)	39.1 (26.2)	32.6 (13.6)	29.4 (13.5)	28.6 (11.8)	27.4 (11.8)
CP-LIA	13.2 (3.7)	17.8 (6.5)	33.3 (9.5)	33.2 (8.4)	32.1 (10.5)	28.8 (10.4)	27.0 (8.4)	23.4 (8.4)
p value	0.968	0.497	0.674	0.236	0.459	0.596	0.503	0.184

Table 4 Average (SD) Flexion ability

	Pre-OP	OP-day	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
S-LIA	111,6 (10.3)	84.8 (11.2)	50.6 (16.4)	73.0 (12.7)	78.6 (13.4)	82.2 (12.2)	86.4 (10.6)	88.6 (4.0)
CP-LIA	113.2 (10.7)	90.0 (7.6)	59.0 (18.9)	69.6 (15.1)	74.8 (13.3)	79.8 (9.7)	84.0 (6.9)	87.0 (5.6)
p value	0.459	0.077	0.129	0.406	0.242	0.180	0.052	0.254

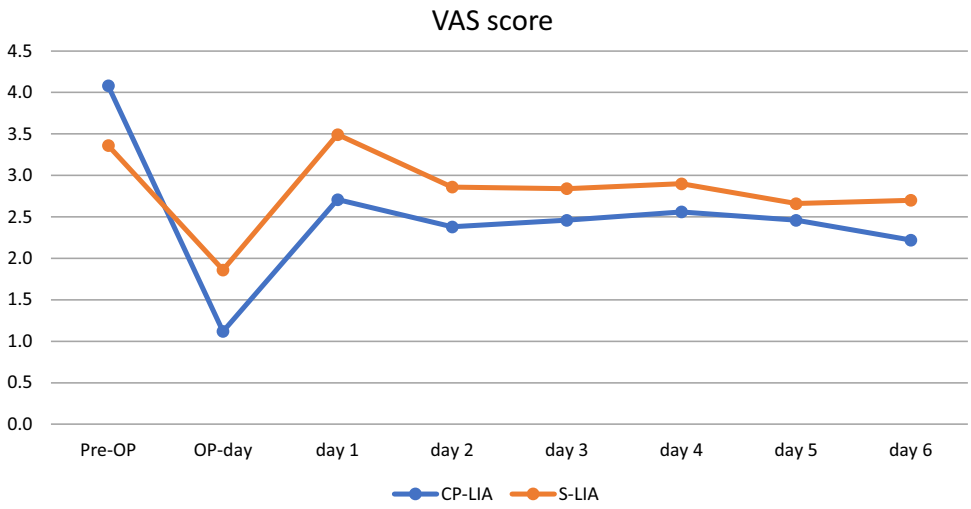


Fig. 1 Average VAS score

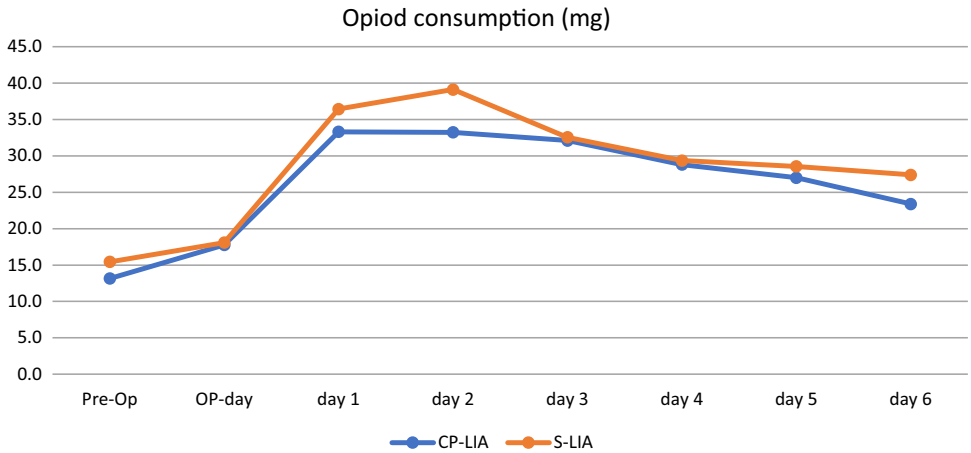


Fig. 2 Average of additional pain medication (morphine equivalents)

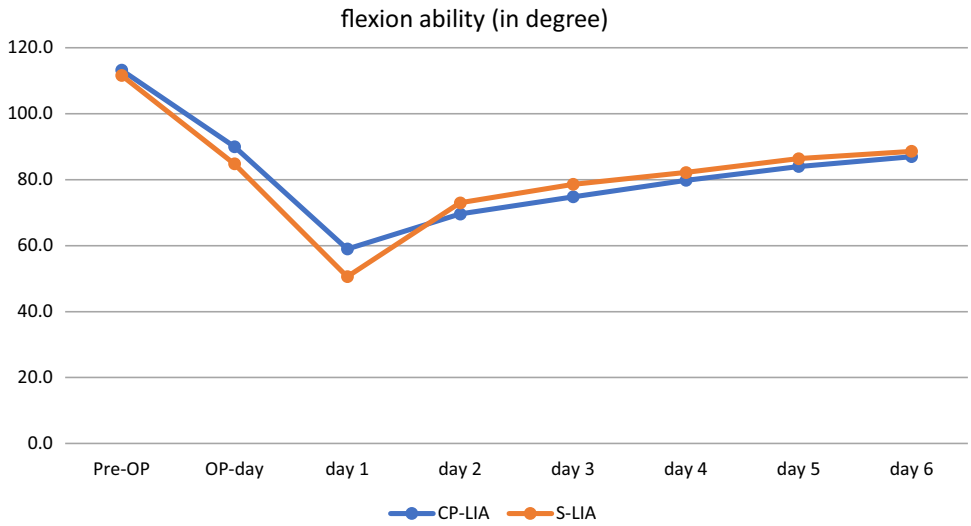


Fig. 3 Average Flexion ability in degree

Discussion

The most important finding of the study was that patients with LIA in combination with an intra-articular pain catheter had less post-operative pain compared to patients with LIA only. However, any significant differences in terms of knee flexion were not observed. Therefore, the hypothesis can be confirmed in part only.

The primary objective in post-operative pain management is to relieve pain without having to accept adverse side effects. However, current modalities for post-operative pain management, such as nerve blocks or epidural analgesia, are associated with substantial side effects, such as impairment of the post-operative sensibility, muscular weakness, hypotension and urinary retention. Additional opioids, which are often required postoperatively, are accompanied by several side effects too. Incidentally, the United States is facing an opioid epidemic [20–22], and a study revealed that patients undergoing TKA tend to receive the highest amount of opioid medication among the major elective orthopedic surgeries [23]. Further, a high prevalence of prolonged opioid use after total joint arthroplasty was reported [24]. With this in mind, the need for an effective non-opioid pain management in TKA becomes evident and has resulted in the development of new techniques. Peri- and intra-capsular medications have attracted growing interest recently, because they act locally, block afferent nerve fibers and, therefore, the pain at its origin and simultaneously modify the local surgical inflammatory cascade. Another advantage of LIA, which becomes obvious especially in comparison with nerve blocks, is that the muscle function remains unimpaired [25]. However, the main limitation in single-shot LIA lies in the short duration of effect. Several studies report on short-term findings concerning single-shot analgesia [15, 16, 26–29] or removal of the intra-articular catheters within two days or even after 12 h postoperatively [6]. Higher pain scores are published after loss of response to the single-shot application (rebound pain) [13, 29, 30], which shortens the low pain time interval and increases post-operative pain levels [17].Therefore, prolonging the positive effects of LIA by an intra-articular catheter seems to be a logical and promising solution.

In the present study, patients of the CP-LIA group showed significant lower VAS scores 6 h after surgery and further on post-operative days 1, 2 and 6. However, both groups showed a pain rebound with an increase of 1.6 in the VAS score after 24 h. These results show, that the use of an additional intra-articular catheter has beneficial effects concerning pain in the immediate post-operative period; however, these benefits need to be balanced against higher costs and a possibly higher risk of infection. In the present study, any infection was not observed. Even more, there are indications that local anesthetics have a bactericidal and/or bacteriostatic effect [31], thereby reducing the risk of infection [9, 32]. This is one reason why Ali et al. who reported a higher risk of wound healing complications including deep infections, discussed the latter finding to be difficult to explain and possibly to be coincidental [19].

Our results are in line with Zhang et al. who reported superior analgesia of continuous LIA compared to single-shot LIA [18]. In contrast, Nechleba et al., who assessed the efficacy of local continuous bupivacaine in comparison to normal saline, concluded that continuous LIA did not provide significant improvements in pain relief or pain medication use [33]. However, the patients in this study received drainages, through which the LIA could have been lost before it was fully effective. Another study with a study design similar to the present study refers to the efficacy of continuous LIA in unicondylar knee arthroplasty and reported only minor benefits from the use of continuous LIA [34]. However, due to the potential chondrotoxicity of the LIA, the catheter was placed peri-articular, which could limit the effect of the applied LIA.

Limitations of the present study are the short follow-up and that any data concerning mid- or long-term knee function are not available by now. Future studies are needed to state if the use of an additional intra-articular catheter has impact on mid- or long-term outcome of TKA. Although the preoperative VAS score of the CP-LIA group was significantly higher than the respective score of the S-LIA group, the CP-LIA group reported less pain 6 h after surgery and on post-operative day 1, 2 and 6. However, it remains unknown whether the higher preoperative VAS score in the CP group led to greater post-operative satisfaction or comprise a greater perception of pain in this group. Despite the limitations, findings of the present study demonstrated that an intra-articular catheter providing LIA can be used in daily practice to prolong the the positive effects associated with single-shot LIA.

Conclusion

LIA combined with an additional intra-articular catheter provides better short-term pain control compared to single-shot LIA. However, no significant differences in terms of knee flexion were observed. This limited benefit should be balanced against the additional costs and the possible higher risk of infection.

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Compliance with ethical standards

Conflict of interest The authors MM, SS, JH, CB declare that they have no conflict of interest. The author ET declares that he is providing consultancies for Convatec, KCI, LIMA, Medacta and Zimmer Biomet. He also declares that he receives royalties from LIMA, Medacta and Zimmer Biomet. He further declares that he is part of the euopean knee society board. The author JB declares that he has no conflict of interest, receives honoraria from DePuy, Conformis, Pajunk and Smith and Nephew.

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the ethic committee of the local state medical council (Approv.No. F-2017-024).

Informed consent Informed consent was obtained from all individual participants included in this study.

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