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Posterior cruciate ligament reconstruction without tourniquet use reduces joint swelling without compromising surgical outcomes: a retrospective study

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The objective of this study was to determine the efficacy and safety of the employment of a tourniquet in the management of a posterior cruciate ligament reconstruction (PCLR) surgery. We hypothesized that PCLR without tourniquet use would reduce postoperative joint swelling and tourniquet-related complications while maintaining comparable surgical outcomes. We retrospectively reviewed 108 consecutive patients who underwent PCLR surgery between March 2016 and July 2022. Exclusion criteria included osteoarthritis, meniscus injury requiring repair, history of peripheral neuropathy, pregnancy, lumbar radiculopathy, or prior knee surgery on the affected or contralateral knee. Patients were categorized into tourniquet and non-tourniquet groups according to their surgery dates. The outcomes were evaluated by quantifying pain levels using the visual analog scale (VAS) and assessing the range of motion. Duration of operation, arthroscopic visibility, complications, consumption of analgesic, and total bleeding from suction and drainage were recorded. Of the 108 patients, 55 patients received PCLR with the tourniquet between March 2016 and October 2019, and 53 patients received PCLR without a tourniquet between November 2019 and July 2022. No significant difference was found in sex, age, or body mass index (BMI). There was no significant difference between the two groups with respect to intraoperatively arthroscopic visualization, operation time, total bleeding, pain score, consumption of analgesic, and range of motion. Both groups exhibited no instances of infection, wound complication, or venous thromboembolism (VTE). The rate of joint swelling was significantly higher in the tourniquet group than in the non-tourniquet group ($p = 0.01$). The tourniquet group also experienced a few instances of bruising and blister in the mid-thigh, while none occurred in the non-tourniquet group. Given the comparable outcomes in terms of arthroscopic visualization, operation time, bleeding, pain, function, and less joint swelling, we advocate discontinuing routine tourniquet use in PCL reconstruction. This approach significantly reduces swelling and local complications while maintaining surgical efficacy, aligning with modern minimally invasive principles.

Keywords Tourniquet, Posterior cruciate ligament, Posterior cruciate ligament reconstruction, Knee, Arthroscopy

Posterior cruciate ligament (PCL) reconstruction is associated with a higher complication rate (20.1%) compared to other knee procedures, along with specific risks such as popliteal artery injury[1,2]. In knee arthroscopy, surgeons commonly utilize a tourniquet to mitigate blood loss, enhance visibility, and decrease operative time[3,4]. Many surgeons assert that tourniquet usage has no discernible impact on complication rates or postoperative rehabilitation. Moreover, they believe it enhances the surgical view, resulting in reduced operative times, and leading to an increased frequency of tourniquet application[4]. Recently, studies reported that tourniquet use during arthroscopic ACL reconstruction is associated with adverse postoperative outcomes, including thigh muscle injury, increased postoperative pain and drain output, and tourniquet-related complications[5–7]. However, no studies have specifically evaluated tourniquet use in PCL reconstruction, and the recent expert consensus and systematic review on management of posterior cruciate ligament injuries also does not specify the effectiveness

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and risks of using tourniquets in PCL reconstruction[8,9]. Consequently, we aimed to determine the necessity of tourniquet use in PCL reconstruction procedures, hypothesizing that non-tourniquet PCL reconstruction would provide comparable surgical efficiency while reducing postoperative joint swelling and tourniquet-related complications.

Materials and methods

Patients

This study received approval from the ethics review committee of The Second Xiangya Hospital, and written informed consent was acquired from all participants. Participants were selected using the following inclusion criteria: (1) aged older than 18 years; (2) underwent unilateral isolated PCL reconstruction in the day-surgery unit under general anesthesia between March 2016 and July 2022; (3) complete clinical records available for analysis. Exclusion criteria included osteoarthritis, meniscus injury requiring repair, history of peripheral neuropathy, pregnancy, lumbar radiculopathy, or prior knee surgery on the affected or contralateral knee. Patients were systematically categorized into tourniquet and non-tourniquet groups according to their surgery dates. A flow diagram illustrating patient selection and grouping is presented as Fig. 1. Nonsteroidal anti-inflammatory drugs were avoided for the initial two weeks post-surgery, and patients were typically mobilized and discharged on the fourth postoperative day.

Surgeries

All cases were isolated PCL reconstructions (PCLRs) without concomitant surgeries. All PCLRs were performed by the same experienced surgeon (Dr. Wu, > 10 years of PCL reconstruction experience), with the patients under general anesthesia. Patients utilizing a tourniquet were categorized into the tourniquet group, where a thigh tourniquet inflated to 300 mmHg was applied to the operated leg. In cases exceeding 90 min, the tourniquet was deflated and reinflated as necessary after a 10-minute interval. Routine arthroscopy was performed, and all patients received multi-modal analgesia, including an intra-articular cocktail injection (20 ml ropivacaine 0.25% and 1 ml Diprospan) and a femoral nerve block with 20 ml ropivacaine 0.25%. The procedure was done in the standard anatomical single-bundle PCL reconstruction technique, preserving the native PCL remnants, using autologous tendons (semitendinosus and gracilis tendons) and fixed with two biodegradable interference screws. The operative time was recorded for all patients. Considering that there was minimal bleeding throughout and subsequent to the operation and it would not affect the recovery of joint function, no drainage tube was inserted after the surgery. Postoperative analgesia began immediately after skin closure, consisting of a daily 50 mg flurbiprofen axetil injection for three days.

Clinical evaluation

Patient information, including age, BMI, sex, operative time, arthroscopy view, and complications (infection, VTE, wound complications, bruising, or blister in the mid-thigh) were assessed, along with total bleeding from suction and drainage. The arthroscopy view was classified as satisfactory (excellent) or unsatisfactory (good, fair, or poor) based on a combined score for visibility and ease of procedure throughout the operation, following criteria established by David et al. [10], which are shown in Supplementary Table 1. The same surgeon graded the operative view. Knee swelling was assessed with the change of the knee girth (measured at the mid patella) and patella floating test at 24 h postoperatively. Postoperative parameters included pain, range of motion, and analgesia consumption were recorded. VAS pain scores, ranging from "No pain at all" (0) to "Worst pain imaginable" (10), were measured post-surgery. The assessment of VAS was conducted without knowledge of tourniquet inflation status, and additional analgesia was recorded as needed.

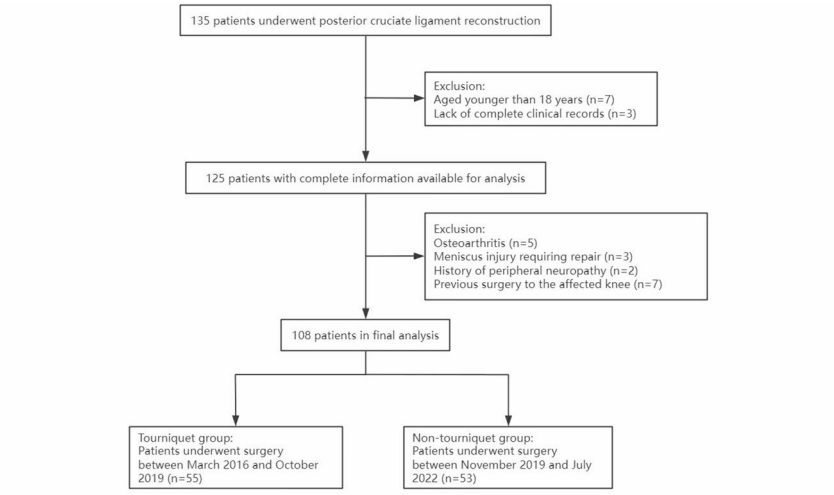

Fig. 1. Flowchart illustrating patient selection, exclusion, and grouping process for the study.

Characteristics	Tourniquet	Non-tourniquet	P value
Number	55	53	0.93
Age, y	32	28	0.78
BMI, kg/m^2	28	26	0.87
Sex			0.56
Men(n)	27	28	
Women(n)	28	25	
Duration of operation, min	73 ± 18	74 ± 20	0.87
Bleeding, ml	10 ± 4	15 ± 10	0.57

Table 1. Clinical characteristics of the patients with or without tourniquet.

	Tourniquet	Non-tourniquet	*P* value
Excellent	54	49	0.66
Good	1	4	0.32
Fair	0	0	NA
Poor	0	0	NA

Table 2. Assessment of arthroscopic visibility.

Postoperative rehabilitation

Both groups adhered to an identical rehabilitation program, focusing on quadriceps function restoration and complete extension. Accelerated rehabilitation commenced immediately post-operation, with full weight-bearing encouraged after two weeks. Compression and cooling systems were employed until visible swelling reduction. A brace facilitated full extension in the initial two weeks, followed by gradual flexion to 90 degrees in four weeks. Unrestricted physical activity, including pivotal sports like skiing or football, was recommended after at least six months.

Statistical methodology

Statistical analyses were conducted with SPSS version 24 software (IBM Corp., Armonk, NY, USA). Descriptive statistics for clinical and demographic features were presented as the mean and standard deviation for continuous variables. The Student's t-test was used to compare continuous variables that followed a normal distribution, whereas the Wilcoxon rank-sum test evaluated differences in non-normally distributed variables. Fisher's exact test and Pearson's Chi-Squared test determined correlations between categorical variables. P-values < 0.05 were considered significant.

Ethics approval

The study was conducted in compliance with the principles outlined in the Declaration of Helsinki and received approval from the Human Ethics Committee for Medical Research at The Second Xiangya Hospital of Central South University. The clinical trial number is not applicable. Due to the retrospective nature of this study, the formal ethics approval ID was not required by our institutional policy at the time of data collection. However, all data were anonymized and handled in compliance with the Declaration of Helsinki. All procedures adhered to pertinent guidelines and regulations. Informed consent was obtained from all participants.

Results

Out of the 108 patients, 55 patients underwent tourniquet inflation between March 2016 and October 2019, while the remaining 53 patients did not between November 2019 and July 2022. The baseline characteristics, duration of operation, and bleeding for these patients are listed in Table 1. Demographic profiles revealed no significant differences between the two groups. The operative time averaged 73 ± 18 min in the tourniquet group and 74 ± 20 min in the non-tourniquet group, with no statistically significant difference observed ($p = 0.87$). In terms of bleeding volume, the tourniquet group showed 10 ± 4 ml, compared to 15 ± 10 ml in the non-tourniquet group. However, no significant difference in total bleeding between the two groups was found ($p = 0.57$) The detailed characteristics of the patients are shown in Table 1.

Regarding the operative view, the tourniquet group had 54 cases rated as excellent and 1 as good, while the non-tourniquet group had 49 excellent and 4 good cases. No significant difference was found between the two groups in this regard ($p = 0.66$). The detailed results are shown in Table 2. VAS pain scores, measured on three occasions, did not reveal any significant differences between the groups (Fig. 2). Postoperative analgesic consumption analysis indicated no analgesic requirements other than the routine 50 mg flurbiprofen axetil injection (data not presented).

Concerning the range of motion, the average postoperative flexion in the second week was 30 degrees in the tourniquet group and 28 degrees in the non-tourniquet group, with no significant difference between the two groups (Fig. 3). Both groups experienced no wound complications, VTE, or postoperative infections. However,

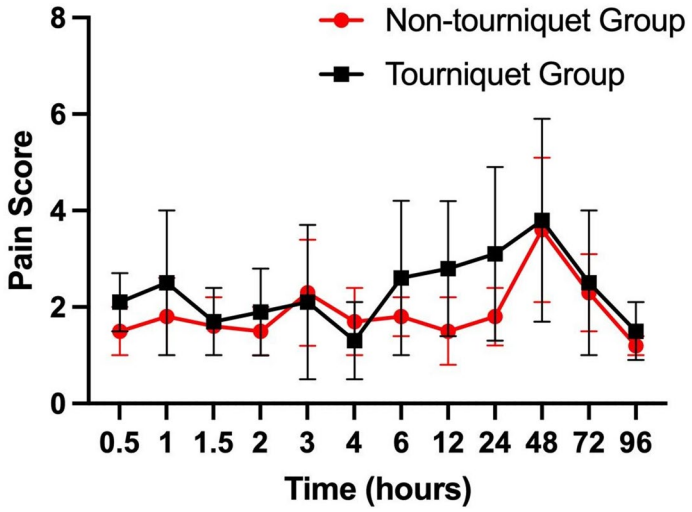

Fig. 2. Pain score of tourniquet and non-tourniquet group postoperatively.

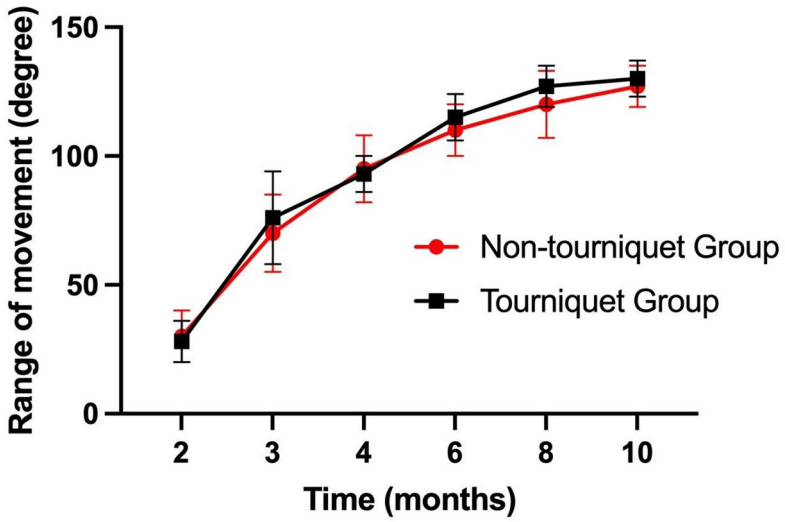

Fig. 3. Range of motion for tourniquet and non-tourniquet group postoperatively.

the rate of joint swelling was increased in the tourniquet group (9.1%) compared with the non-tourniquet group (0%) ($p = 0.01$). The increase of the knee girth at 24 h postoperatively averaged 2.24 ± 0.60 cm in the tourniquet group and 1.33 ± 0.39 cm in the non-tourniquet group, with a statistically significant difference observed ($p < 0.001$). We conducted post hoc power analyses to confirm ample statistical power. For increase in the knee girth, power > 99.9% (d = 1.79). For knee swelling incidence, Power = 85.7%. This exceeds the 80% threshold recommended by Cohen, ensuring reliable detection of clinically meaningful effects. We also estimate the required sample size. Increase in the knee girth was used as the primary outcome measure. With a significance level of $\alpha = 0.05$ and power $(1 - \beta) = 0.90$, the results indicated that a minimum of 6 patients per group (12 total) would be sufficient to achieve statistical power greater than 0.90.

There were three cases of bruising in the mid-thigh and two cases of blistering in the mid-thigh in the tourniquet group, compared to none in the non-tourniquet group. The detailed results are shown in Table 3. At a mean follow-up time of 1 year, no patients in either group required repeat arthroscopy or further imaging.

Discussion

Our study demonstrates that PCL reconstruction without tourniquet use significantly reduces postoperative joint swelling and thigh complications while maintaining equivalent operative times, visibility, and functional outcomes. To our knowledge, this is the first study specifically evaluating tourniquet use in isolated PCL reconstruction. Our findings challenge the routine use of tourniquets in complex knee procedures and provide evidence that omitting tourniquets reduces joint swelling without compromising surgery. This directly impacts clinical practice by improving early rehabilitation comfort.

	Tourniquet	Non-tourniquet	P value
Knee swelling	9.1%	0	0.01
Increase of the knee girth (cm)	2.24 ± 0.60	1.33 ± 0.39	< 0.001
Infection	0	0	NA
Wound complication	0	0	NA
VTE	0	0	NA
Bruising in the mid-thigh	3	0	0.23
Blister in the mid-thigh	2	0	0.44

Table 3. Complications of the patients with or without tourniquet.

As arthroscopic techniques have evolved into the preferred approach for PCLR, the ongoing debate regarding the necessity of tourniquet use in these intricate and more time-consuming procedures persists. The tourniquet has been commonly used in knee arthroscopic surgery to minimize intraoperative bleeding within the joint, thereby creating a bloodless surgical field, enhancing visualization during the operation, and reducing the overall duration of the surgery[3,4]. However, using tourniquets is related to possible complications, including vascular damage, neuropathies, muscle weakness and atrophy, delayed recovery of function postoperatively, abnormalities in electromyogram (EMG), and an elevated risk of deep vein thrombosis[10–12]. Additionally, alterations in acid-base balance, acute pulmonary edema, and cardiac arrest have been reported[13,14]. Despite longer operation times and an increased demand for tourniquet application, the complication rate increases[15]. Studies report a 21.9% incidence of deep vein thrombosis (DVT) after arthroscopic PCL reconstruction without the use of anticoagulant drugs, a deviation from the standard practice in arthroscopic surgery[2]. In China, there seems to be a prevailing reluctance to perform certain orthopedic procedures, including arthroscopy, without a tourniquet. This enduring practice is fueled by the desire for a clear operative view, reduced bleeding, and the misconception that tourniquets are harmless. Many previous studies concerning tourniquet use in arthroscopic knee surgery have evaluated its effects following meniscectomy and ACL reconstruction. However, there are few studies focusing on the effects of tourniquet use during PCL reconstruction[16]. Recent meta-analyses discourage tourniquet use in knee arthroscopic surgery, although not specifically addressing PCL reconstruction[17]. Consequently, our study was to assess the efficacy and safety of the employment of a tourniquet in PCL reconstruction surgery.

Results from our study reveal no significant differences between the groups in terms of operation time, intraoperative bleeding, visibility, pain scores, range of motion, and wound complications. This indicates that PCL arthroscopy can be performed with equal effectiveness whether or not a tourniquet is used. Similar to other studies, Johnson[18] found that operative visualization was not significantly compromised without the use of a tourniquet in the majority of arthroscopic surgeries (mostly meniscal surgeries). Reda[19] indicated that the operative view was rated as excellent for all participants, regardless of whether they were in the tourniquet or non-tourniquet group, and highlighted that there was no significant difference in the average operative time between the two groups. Additionally, a previous meta-analysis indicated that there was no notable difference in both visualization quality and operative time between the two groups[17]. Interestingly, certain procedures, such as synovial biopsy and meniscal repair, are reported to be better executed without a tourniquet, indicating potential advantages for non-tourniquet surgery, especially in cases involving concurrent PCL injury and meniscal tear[20].

Our study explored the complex relationship between tourniquet application and pain. Although no postoperative pain score differences were observed between the groups, the tourniquet group experienced slightly higher scores at 6, 12, and 24 h postoperatively, with a notable increase in both groups at 48 h. The mechanism of tourniquet pain is still unclear, possibly resulting from local pressure, ischemic or reperfusion injuries to muscular and neural tissues[21,22], as well as the activation of small, unmyelinated C-fibers[23,24]. In contrast to our results, several studies[25–27] found that individuals who underwent surgery without the tourniquet experienced less postoperative pain and less use of analgesics, which may be attributed to the relatively short duration of tourniquet application in our study (73 ± 18 min) and the multimodal analgesic approach, including femoral nerve block and intra-articular injection of ropivacaine and diprospan. Interestingly, the pain in the tourniquet group was localized in the upper thigh, possibly attributable to tourniquet application. To address postoperative pain, we routinely administered flurbiprofen axetil for three days.

The knee swelling rate was 9.1% in the tourniquet group as we observed and it is higher than the tourniquet group. The increase in knee circumference at 24 h postoperatively in the tourniquet group was significantly greater than in the non-tourniquet group. Such results are consistent with a previous study which indicates that the extent of joint swelling in the non-tourniquet group was decreased compared with the tourniquet group in knee surgery[17]. Knee swelling might be attributed to blood loss postoperatively, reactive hyperemia, and postanoxic edema. Some studies indicated that using a tourniquet may increase the postoperative hidden blood loss and drainage volume[28–30].

In the tourniquet group, due to squeezing the thigh, a few cases exhibited bruising and blisters in the mid-thigh, coinciding with reported pain cases. While both groups demonstrated pain relief within 96 h, skin injuries can adversely affect the patient experience and increase the risk of infection. Despite no significant difference in the range of motion, intraoperative bleeding in the non-tourniquet group appeared slightly more, primarily from hamstring harvest procedures. However, this minimal bleeding is unlikely to impede patient recovery.

This study has some limitations. First, there is an inaccuracy in the evaluation of total perioperative blood loss and postoperative blood loss in our study. In the study of tourniquets in ACL reconstructions (ACLRs), Masaki Nagashima calculated the total perioperative blood loss from the change in hemoglobin between that preoperatively and on postoperative day (POD) 1. Masaki Nagashima found total blood loss was significantly higher in the non-tourniquet group(339 ± 216 mL)than in the tourniquet group (258 ± 199 mL)[31]. Since the patient was discharged early after surgery and hemoglobin was not reexamined timely, we could not accurately assess the total perioperative blood loss. Hiroshi Nakayama[15] assessed the total postoperative blood loss by the fluid collected via the suction drain and the total postoperative blood loss averaged 133.6 ± 62.4 ml (range60-250 ml) and 85.3 ± 47.3 ml (range20-190 ml) in the tourniquet and non-tourniquet groups. There are few studies on whether using drains after PCLRs is necessary. However, there is still debate over the use of drains following other knee surgery. Some previous studies suggested not using a drain following anterior cruciate ligament reconstruction[32]. Kęska R showed that primary ACLRs without using drainage did not adversely affect the recovery of patients[33]. Also, some studies reported increased pain in the drained group after ACLRs and removal of the drain is uncomfortable and carries theoretical and avoidable risks[34]. Some studies have shown that it is feasible to forgo wound drainage in simple, primary, tourniquet-free total knee arthroplasty (TKA)[35,36]. Primary TKA without using drainage could reduce local inflammation, make recovery faster, and improve early knee function[37]. With the increased cost, time, and need for drain removal, using the drain after TKA is likely an unnecessary intervention[38]. Considering the above research results, economic cost, and clinical experience, we decided not to use drains following PCLRs.

Second, due to its retrospective design and a relatively low level of evidence resulting from the limited number of PCL reconstruction cases. Third, the single-center design may affect generalizability, and long-term functional outcomes (> 1 year) were not assessed. While we posit that PCL reconstruction without a tourniquet is advantageous, larger-scale, multicenter, and high-quality randomized controlled studies are warranted to confirm our results.

In conclusion, considering equivalent operation times, bleeding, arthroscopic visibility, pain scores, range of motion, and less knee swelling, we advocate discontinuing routine tourniquet use in PCL reconstruction. This approach significantly reduces swelling and local complications while maintaining surgical efficacy, aligning with modern minimally invasive principles.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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References

1. Exercise + massage beat steroids for tennis elbow. *Duke Med. Health News* **12**, 4 (2006).
2. Chen, D. et al. Incidence and risk factors of deep venous thrombosis following arthroscopic posterior cruciate ligament reconstruction. *Medicine* **96**, e7074. https://doi.org/10.1097/MD.0000000000007074 (2017).
3. Hoogeslag, R. A. G., Brouwer, R. W., van Raay, J. & J. A. M. The value of tourniquet use for visibility during arthroscopy of the knee: a double-blind, randomized controlled trial. *Arthroscopy: J. Arthroscopic Relat. Surg.* **26**, S67–S72. https://doi.org/10.1016/j.arthro.2009.12.008 (2010). Official Publication of the Arthroscopy Association of North America and the International Arthroscopy Association.
4. Zaid, H. H. G. et al. Tourniquet use improves intraoperative Parameters, leading to similar postoperative outcomes compared with no tourniquet use in anterior cruciate ligament reconstruction: A Prospective, Double-Blind, randomized clinical trial. *Arthroscopy* **39**, 626–637e623. https://doi.org/10.1016/j.arthro.2022.10.033 (2023).
5. Yang, Y. et al. Tourniquet use in anterior cruciate ligament reconstruction May decrease operative time but is associated with muscular injury and postoperative pain: A systematic review and Meta-analysis of randomized controlled trials. *Arthroscopy* **41**, 2568–2579. https://doi.org/10.1016/j.arthro.2024.11.082 (2025).
6. Samei, M. et al. Arthroscopic anterior cruciate ligament reconstruction with and without tourniquet use: an updated systematic review and meta-analysis on clinical outcomes. *BMC Musculoskelet. Disord.* **25**, 994. https://doi.org/10.1186/s12891-024-08101-w (2024).
7. D'Ambrosi, R., Valli, F., Di Feo, F., Marchetti, P. & Ursino, N. Use of tourniquet in anterior cruciate ligament reconstruction: is it truly necessary? A prospective randomized clinical trial. *J. Orthop. Surg. (Hong Kong)*. **32**, 10225536241293538. https://doi.org/10.1177/10225536241293538 (2024).
8. Gao, S. et al. Management of posterior cruciate ligament injuries: an expert consensus from 17 countries. *Int. J. Surg.* **111**, 4080–4085. https://doi.org/10.1097/js9.0000000000002416 (2025).
9. D'Ambrosi, R., Hallé, A. & Hardy, A. Good clinical and radiological results following remnant-preserving posterior cruciate ligament reconstruction: a systematic review. *Knee Surg. Sports Traumatol. Arthrosc.* **31**, 2418–2432. https://doi.org/10.1007/s00167-022-07192-z (2023).
10. Flevas, D. A., Sarantis, M., Tsakotos, G., Sasalos, G. G. & Tokis, A. V. Arthroscopic anterior cuciate ligament reconstruction using neither a tourniquet nor drainage: A perioperative case series report. *Life (Basel)*. **15** https://doi.org/10.3390/life15040619 (2025).
11. Williams, M. G. et al. The 'vulnerable nerve'; surgically acquired neuropathy in distal humeral surgery patients and the role of a tourniquet. *Shoulder Elb.* 17585732241284255 https://doi.org/10.1177/17585732241284255 (2024).
12. Zhang, L., Ning, Y., Yang, C. & He, T. Limiting tourniquet use during total knee arthroplasty improves short-term postoperative outcomes in patients with hypertension. *Front. Surg.* **12**, 1535662. https://doi.org/10.3389/fsurg.2025.1535662 (2025).
13. Santhosh, M. C. B., Pai, R. B. & Rao, R. P. Acute pulmonary edema following inflation of arterial tourniquet. *Rev. Esp. Anestesiol Reanim.* **61**, 451–453. https://doi.org/10.1016/j.redar.2013.09.006 (2014).
14. Ding, W., Li, Y., Feng, Y. & Tian, X. Cardiac arrest caused by tourniquet releasing: A case report. *Asian J. Surg.* https://doi.org/10.1016/j.asjsur.2024.10.220 (2024).
15. Nakayama, H. & Yoshiya, S. The effect of tourniquet use on operative performance and early postoperative results of anatomic double-bundle anterior cruciate ligament reconstruction. *J. Orthop. Sci.* **18**, 586–591. https://doi.org/10.1007/s00776-013-0405-2 (2013).

16. Choudhary, A., Kanodia, N., Agrawal, S., Bhasin, V. B. & Singh, A. Tourniquet use in arthroscopic ACL reconstruction: A blinded randomized trial. *Indian J. Orthop.* **55**, 384–391. https://doi.org/10.1007/s43465-020-00250-z (2021).
17. Wang, J., Xu, W. & Lv, J. Is it better to routinely use tourniquet for knee arthroscopic surgery: A systematic review and Meta-analysis. *J. Knee Surg.* **33**, 866–874. https://doi.org/10.1055/s-0039-1688555 (2020).
18. Johnson, D. S., Stewart, H., Hirst, P. & Harper, N. J. Is tourniquet use necessary for knee arthroscopy? *Arthroscopy: J. Arthroscopic Relat. Surg. : Official Publication Arthrosc. Association North. Am. Int. Arthrosc. Association.* **16**, 648–651 (2000).
19. Reda, W., ElGuindy, A. M. F., Zahry, G., Faggal, M. S. & Karim, M. A. Anterior cruciate ligament reconstruction; is a tourniquet necessary? A randomized controlled trial. *Knee Surg. Sports Traumatol. Arthrosc.* **24**, 2948–2952. https://doi.org/10.1007/s00167-015-3582-z (2016).
20. Yaghmour, K. M. & Al-Khateeb, H. Anterior cruciate ligament reconstruction without the use of a tourniquet. *Ann. R. Coll. Surg. Engl.* **101**, 123–125. https://doi.org/10.1308/rcsann.2018.0197 (2019).
21. Tai, T. W. et al. Tourniquet use in total knee arthroplasty: a meta-analysis. *Knee Surg. Sports Traumatol. Arthrosc.* **19**, 1121–1130. https://doi.org/10.1007/s00167-010-1342-7 (2011).
22. Alcelik, I. et al. A comparison of outcomes with and without a tourniquet in total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. *J. Arthroplasty*. **27**, 331–340. https://doi.org/10.1016/j.arth.2011.04.046 (2012).
23. MacIver, M. B. & Tanelian, D. L. Activation of C fibers by metabolic perturbations associated with tourniquet ischemia. *Anesthesiology* **76**, 617–623 (1992).
24. Crews, J. C., Cahall, M. & Behbehani, M. M. The neurophysiologic mechanisms of tourniquet pain. The activity of neurons in the rostroventral medulla in the rat. *Anesthesiology* **81**, 730–736 (1994).
25. Liu, Y. et al. More pain and slower functional recovery when a tourniquet is used during total knee arthroplasty. *Knee Surg. Sports Traumatol. Arthrosc.* **28**, 1842–1860. https://doi.org/10.1007/s00167-019-05617-w (2020).
26. Lin, Z., Chen, T., Chen, G., Pan, W. & Xu, W. Effects of tourniquet on surgical site wound infection and pain after total knee arthroplasty: A meta-analysis. *Int. Wound J.* **21** https://doi.org/10.1111/iwj.14414 (2023).
27. Albayrak, M. & Ugur, F. With or without a tourniquet? A comparative study on total knee replacement surgery in patients without comorbidities. *Med. (Kaunas)*. **59** https://doi.org/10.3390/medicina59071196 (2023).
28. Zhou, K. et al. Influence of tourniquet use in primary total knee arthroplasty with drainage: a prospective randomised controlled trial. *J. Orthop. Surg. Res.* **12**, 172. https://doi.org/10.1186/s13018-017-0683-z (2017).
29. Li, Z. et al. Association of tourniquet utilization with blood loss, rehabilitation, and complications in Chinese obese patients undergoing total knee arthroplasty: A retrospective study. *Medicine* **96**, e9030. https://doi.org/10.1097/MD.0000000000009030 (2017).
30. Mutlu, S. et al. Tourniquet use during total knee arthroplasty does not offer significant benefit: A retrospective cohort study. *Int. J. Surg.* **18**, 123–127. https://doi.org/10.1016/j.ijsu.2015.04.054 (2015).
31. Nagashima, M., Sasaki, R., Tanaka, K. & Takeshima, K. The use of tourniquet is useful in terms of blood loss and soft tissue damage in arthroscopic anterior cruciate ligament reconstruction: a retrospective study. *Sci. Rep.* **13**, 17798. https://doi.org/10.1038/s41598-023-45159-3 (2023).
32. Clifton, R., Haleem, S., McKee, A. & Parker, M. J. Closed Suction surgical wound drainage after anterior cruciate ligament reconstruction: a systematic review of randomised controlled trials. *Knee* **14**, 348–351 (2007).
33. Witoński, D., Kęska, R., Cyranowski, R. & Paradowski, P. T. Arthroscopically assisted anterior cruciate ligament reconstruction with bone-patellar tendon-bone autograft without wound drainage: short- to middle-term outcome. *Wideochir Inne Tech. Maloinwazyjne.* **11**, 76–82. https://doi.org/10.5114/wiitm.2016.60044 (2016).
34. Straw, R., Colclough, K. & Geutjens, G. G. Arthroscopically assisted ACL reconstruction. Is a drain necessary? *Knee* **10**, 283–285 (2003).
35. Zhou, K. et al. Non-drainage versus drainage in tourniquet-free knee arthroplasty: a prospective trial. *ANZ J. Surg.* **87**, 1048–1052. https://doi.org/10.1111/ans.14183 (2017).
36. Migliorini, F. et al. Closed Suction drainages in lower limb joint arthroplasty: A level I evidence based meta-analysis. *Surgeon* **20**, e51–e60. https://doi.org/10.1016/j.surge.2021.02.014 (2022).
37. Wang, D. et al. Closed Suction drainage is not associated with faster recovery after total knee arthroplasty: A prospective randomized controlled study of 80 patients. *Orthop. Surg.* **8**, 226–233. https://doi.org/10.1111/os.12247 (2016).
38. Lachance, A. et al. Suction drain usage has no benefit following revision total hip and knee arthroplasty. *Arch. Orthop. Trauma Surg.* **144**, 3565–3571. https://doi.org/10.1007/s00402-024-05474-4 (2024).

Author contributions

Yuchen Du and Zhengxiao Ouyang wrote the main manuscript text. Zhengxiao Ouyang and Ren Wu prepared Tables 1, 2 and 3. All authors reviewed the manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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