Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology 32 (2023) 7–11

Contents lists available at ScienceDirect

Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology

journal homepage: www.ap-smart.com

Original Article

# Non-use of intra-articular drain after anterior cruciate ligament reconstruction does not affect postoperative knee pain and muscle strength on early period

Kengo Shimozaki, Junsuke Nakase*, Rikuto Yoshimizu, Tomoyuki Kanayama, Yusuke Yanatori, Takuya Sengoku, Hiroyuki Tsuchiya

*Department of Orthopaedic Surgery, Graduate School of Medical Sciences, Kanazawa University, 13-1 Takara-machi, Kanazawa-shi, Ishikawa-ken, 920-8641, Japan*

ARTICLE INFO

*Article history:*
Received 28 November 2022
Accepted 6 April 2023
Available online 3 May 2023

*Keywords:*
Anterior cruciate ligament reconstruction
Intra-articular drain
Postoperative pain
Muscle strength

ABSTRACT

*Introduction:* This study aimed to determine the effect of using an intra-articular drain after anterior cruciate ligament (ACL) reconstruction on early postoperative pain, range of motion (ROM), muscle strength, and complications.

*Materials and methods:* Between 2017 and 2020, of the 200 consecutive patients who underwent anatomical single-bundle ACL reconstruction, 128 patients underwent primary ACL reconstruction with hamstring tendons and were evaluated for postoperative pain and muscle strength at 3 months postoperatively. Sixty-eight patients who received intra-articular drain before April 2019 were classified as group D and 60 patients without an intra-articular drain after ACL reconstruction after May 2019 were classified as group N. Patient background, operative time, postoperative pain, number of additional analgesics used, presence of intra-articular hematoma, ROM at 2, 4, and 12 weeks postoperatively, extensor and flexor muscle strength at 12 weeks postoperatively, and perioperative complications were compared between the two groups.

*Results:* The postoperative pain at 4 h after surgery was significantly greater in group D than in group N although no significant difference was found in the pain felt in the immediate postoperative period and at 1 day and 2 days postoperatively and in the number of additional analgesics used. No significant difference in the postoperative ROM and muscle strength was noted between the two groups. Six patients with intra-articular hematomas in group D and four patients in group N needed puncture by 2 weeks postoperatively, and no significant difference was found between the two groups.

*Conclusion:* Postoperative pain was greater at 4 h postoperatively in group D. Furthermore, the intra-articular drain did not affect muscle strength, ROM, and complications on the early postoperative period. The usefulness of intra-articular drain after ACL reconstruction was considered low.

*Level of Evidence:* Level IV.



## Introduction

Drain placement after orthopedic surgery to prevent hematoma and decrease pain and swelling has been the standard practice for many years. In addition, drains are expected to hasten the return of motion, shorten the hospital day, speed up rehabilitation, and decrease the risk of infection.[1,2] However, in recent years, some studies have suggested that drain placement in joint arthroplasty included in revision case or trauma surgery does not affect postoperative clinical outcomes and hospital stay.[3–6] In anterior cruciate ligament (ACL) reconstruction, only two randomized prospective clinical trials have followed up with patients over 8 weeks about the necessity of intra-articular drain placement. In 2003, Straw et al.[7] reported that intra-articular drain placement after ACL reconstruction with bone–tendon–bone (BTB) graft for pain did not affect knee range of motion (ROM) and muscle

* Corresponding author. 13-1 Takara-machi, Kanazawa-shi, Ishikawa-ken, 920-8641, Japan.
*E-mail address:* nakase1007@yahoo.co.jp (J. Nakase).

https://doi.org/10.1016/j.asmart.2023.04.002

strength at 4 weeks after surgery, although less swelling and better ROM were observed in the drain group at 2 weeks after surgery. Moreover, McCormack et al.[8] reported that intra-articular drain placement after ACL reconstruction using BTB and hamstring graft did not affect postoperative pain and knee ROM on the early postoperative period. They concluded that their results do not support the use of intra-articular drain after ACL reconstruction. Furthermore, in the evaluation of the long-term effect of a drain replacement, no significant difference was found in the clinical outcomes at 6 months, including ROM and pain, due to drain placement after ACL reconstruction.[9] However, few studies have investigated the influence of utilizing intra-articular closed drain after ACL reconstruction using hamstring tendon on the early postoperative period, that is, from a few hours to 3 months. Hence, it does not provide a clear reason for surgeons to stop placing intra-articular drains. Drains are still used for ACL reconstruction in many institutions. However, the use of an intra-articular closed drain is still controversial; thus, more evidence is needed.

This study aimed to determine the influence of using an intra-articular closed drain after ACL reconstruction on the early postoperative pain, ROM, muscle strength, and complications. The hypothesis was that the use of an intra-articular drain after ACL reconstruction did not affect early postoperative clinical outcomes.

## Materials and methods

This prospective, nonrandomized trial compared the use and non-use of an intra-articular drain after arthroscopic ACL reconstruction. This study was approved by the medical ethics review committee of our institute (Approval no. 1842–3). Written informed consent was obtained from all patients included in this study.

### *Study population*

Between February 2017 and October 2021, of the 200 consecutive patients who underwent anatomical single-bundle ACL reconstruction at our institution, 128 underwent primary ACL reconstruction with hamstring tendons from the ipsilateral knee and were evaluated for postoperative pain and muscle strength at 3 months postoperatively. The exclusion criteria were as follows: ACL reinjury or contralateral ACL injury, use of patella tendon or quadriceps tendon as a graft, need for postoperative fixation for more than 2 weeks, and unavailable data on postoperative pain and muscle strength.

Sixty-eight patients with drain placement before April 2019 were classified as group D and 60 patients without drain placement after May 2019 were classified as group N. Patient's background, operative time, postoperative visual analog scale (VAS) score (immediately after surgery, 4 h, day 1, and day 2), number of additional analgesics used, intra-articular hematoma that needed puncture by 2 weeks postoperatively, knee joint ROM at 2, 4, and 12 weeks postoperatively, extension and flexion muscle strength at 12 weeks postoperatively, and perioperative complications were compared between the two groups.

### *Surgical techniques for ACL reconstruction, postoperative pain control, and rehabilitation*

An experienced orthopedic surgeon who had >15 years of experience in ACL reconstruction performed all the operations at our institution. General anesthesia was used, and ultrasound-guided femoral nerve block using 20 mL of 0.75% ropivacaine was administered in all patients. A tourniquet was inflated from the initiation of the operation until its completion. All 128 patients underwent anatomical, single-bundle ACL reconstruction using four-folds of semitendinosus tendon with or without two-folds of the gracilis tendon. For tibial side grafts with diameters <8.0 mm or femoral side graft size with <6 × 9 mm, the gracilis tendon was use.[10] First, an initial diagnostic arthroscopic examination was performed, with the management of the meniscus and articular cartilage as necessary. If patients had any meniscus tears, all meniscus tears were repaired by an all-inside or inside-out technique. After minimal synovectomy necessary to secure the surgical view, a rounded rectangular tunnel was created at the anatomical insertion of the ACL femoral footprint from the anteromedial portal.[11] The femoral tunnel ranged from 6 × 10 mm or 6 × 11 mm depending on the graft diameter. Subsequently, a round tibial tunnel was created at the anteromedial position in the anatomical tibial insertion of the ACL. The tibial tunnel ranged from 8.0 to 9.5 mm, with increments of 0.5 mm, depending on the graft diameter. The graft was inserted via the tibial tunnel, and it was looped over a TightRope (Arthrex, Naples, FL, USA) for femoral fixation. The other end of the graft was fixed using a Tensionloc (Arthrex, Naples, FL, USA), and the initial graft tension was set to 20–30 N at 0° of knee flexion. In group D, a closed drain with a diameter of 3.5 mm was placed in the joint and aspirated at full pressure immediately after surgery. The drain was removed the next morning after surgery regardless of the amount of bleeding.

Postoperative pain control consisted of regular morning and evening oral administration of non-steroidal anti-inflammatory drugs (NSAIDs) for 1 week in all patients, and additional analgesics, such as acetaminophen suppositories or NSAIDs, were used according to the patient's level of pain and requirements. The patients wore a knee brace for 1 week postoperatively to promote the initial healing of the graft and alleviate pain. Knee ROM and full weight-bearing were permitted 1 week after ACL reconstruction, according to the degree of knee pain. Running was permitted after 3–4 months, depending on muscle strength recovery. In this patient series, the postoperative therapy plan was common with and without meniscus injury.

The knee ROM at 2, 4, and 12 weeks postoperatively were measured by goniometer (ANIMA, Tokyo, Japan). In knee extension, the full extension was set at 0°, and hyperextension and limitation of the extension were set as plus and minus, respectively. Muscle strength measurements at 12 weeks postoperatively were performed using an isokinetic dynamometer (BIODEX System 4; Biodex Medical Systems, Inc., NY, USA), and both knee extensor and flexor muscle strengths were measured at angular velocities of 60°/s and 180°/s, respectively. A 5-min exercise using an ergometer was included as a warm-up before the muscle strength measurement. Patients performed three flexion–extension exercises per set, and three sets were performed. The first two sets were practice sets, and the third set was the production test. The measurement ranged from 0° to 100° for the knee joint, and the lower leg was gravity-corrected. The knee flexor and extensor strengths were calculated by averaging the production tests over the three reported tests. The methods used to compare muscle strength were peak torque, limb symmetry index (LSI), and body weight (BW) ratio. We calculated LSI as follows: LSI = (at 3 months after ACL reconstruction, involved limb muscle strength/uninvolved limb muscle strength) × 100. BW ratio was defined as follows: BW = (involved limb muscle strength/body weight).[12]

### *Statistical analyses*

Data were analyzed using the IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., NY, USA). The assessment items were analyzed between the two groups using the chi-squared test for the presence of meniscus tear and hematoma that puncture and the

**Table 1**
Patients' demographic data and operative time. No significant difference was found between the two groups.

| Patients' demographic data and operative time | Group D (n = 68) | Group N (n = 60) | P Value |
|---|---|---|---|
| Age (years) | 24.2 ± 12.6 | 22.6 ± 10.8 | 0.97 |
| Sex (women: men) | 32: 36 | 29: 39 | 0.72 |
| BMI (kg/m$^2$) | 22.7 ± 3.1 | 23.0 ± 3.5 | 0.77 |
| Medial meniscus tear (cases, %) | 22 (32%) | 25 (41%) | 0.27 |
| Lateral meniscus tear (cases, %) | 35 (51%) | 26 (43%) | 0.29 |
| Operative time | 108.0 ± 22.3 | 104.8 ± 24.3 | 0.43 |

BMI: body mass index.

Mann–Whitney *U* test for other assessment items. The level of significance was set at $\alpha = 0.05$. An a priori power analysis for the sample size was performed: for an effect size of 0.6, a power of 0.95, and an $\alpha$ level of 0.05, 120 individuals were required.

## Results

No significant difference was found in the demographic data (i.e., age, sex, body mass index, and presence of meniscus tear) and operative time between the two groups (Table 1). In postoperative pain evaluation, the VAS score at 4 h after surgery was significantly larger in group D than in group N (P = 0.033), although no significant difference was found in the VAS score immediately and at day 1 and day 2 after surgery. The number of additional analgesics used was also not significantly different between the two groups (Table 2). Regarding the postoperative ROM, no significant difference was noted between the two groups at 2, 4, and 12 weeks after surgery, although the range of knee extension and flexion at 4 weeks tended to be smaller in group D (Table 3). Similarly, for extensor and flexor muscle strength, no significant difference in the peak torque, LSI, and BW ratio was found between the two groups at 12 weeks after surgery (Table 4). Although no significant difference was noted between the two groups, six patients in group D and four patients in group N with intra-articular hematomas needed puncture by 2 weeks postoperatively. One postoperative case of deep vein thrombosis was observed in group N, but no additional treatment was required, and no other perioperative complications such as infection were observed. The average drainage volume in group D was 72.5 ± 25.3 mL.

## Discussion

The most important finding of this study was that intra-articular drain placement after ACL reconstruction did not affect postoperative pain, knee ROM, muscle strength 3 months after surgery, and complications. Additionally, the level of pain 4 h after surgery was lower in group N than in group D. These results revealed that -articular drain placement after ACL reconstruction has fewer benefits.

The primary aim of using intra-articular drain after knee joint surgery is to decrease postoperative hematoma, and its effectiveness has been reported to reduce complications such as infection.[2] Similarly, a randomized clinical trial about using intra-articular drain after ACL reconstruction did not find a difference in the early postoperative clinical outcomes, but an average of 152 mL of fluid was drained in the drainage group, which suppressed hematoma formation in the first postoperative week.[8] However, in this study, patients with hematomas had patellar ballottement and required puncture by the second postoperative week, and no significant difference was found between the two groups. This may be attributed to the low drainage volume in group D, averaging 72 mL because we used radiofrequency devices during synovectomy to secure the surgical field. In other words, it is important to use radiofrequency devices during synovectomy to reduce postoperative blood loss even if a tourniquet was used.

Regarding postoperative pain in the early postoperative period, there is no consensus in previous randomized trials.[13,14] In this study, the pain level at 4 h after surgery was higher in group D than in group N. The results supported many previous studies with the same conclusions.[8,15] The result was considered affected by the intra-articular drain itself. That is, improper placement of the intra-articular drain or placement for an inappropriate length will dislodge the drain in the suprapatellar pouch, resulting in trapping symptoms and pain due to suction irritation to the synovial tissue caused by minor knee movement that pinches the patellofemoral joint. Thus, it is important to ensure that the appropriate length of the drain is placed in the suprapatellar pouch even if the surgeon uses the intra-articular drain.

As in previous reports of ACL reconstruction and total knee arthroplasty,[3,8] in the present study, the ROM and muscle strength at 12 weeks postoperatively showed a good clinical course with and without intra-articular drain. This may be because in these studies, including the present study, the intra-articular drain was placed for only 1–2 days, and there was no difference in the timing of initiation of joint ROM training and muscle strength training between patients with and without drains. Therefore, even if a drain is used, it should be removed to the extent that it does not affect rehabilitation.

The current studies, included in this study, suggest that the use of intra-articular drains after ACL reconstruction has no obvious advantages over non-drain use in terms of pain, ROM, or muscle strength in the early postoperative period, and there is reluctance to use drains given the cost and risk of retrograde infection.[8,16] This is also true for total knee arthroplasty, in which intra-articular

**Table 2**
The results of postoperative pain and the number of additional analgesics between two the groups. The VAS score at 4 h after surgery was significantly larger in group D than in group N (P = 0.033).

| The results of postoperative pain and the number of additional analgesics between two the groups | Group D (n = 68) | Group N (n = 60) | P Value |
|---|---|---|---|
| VAS score at immediately | 6.4 ± 2.8 | 5.8 ± 3.1 | 0.32 |
| VAS score at 4 h | 5.4 ± 2.7 | 4.3 ± 2.2 | 0.033* |
| VAS score at 1 day | 4.4 ± 2.4 | 4.5 ± 2.2 | 0.59 |
| VAS score at 2 days | 2.1 ± 2.0 | 2.4 ± 1.9 | 0.26 |
| The number of additional analgesics | 1.3 ± 1.2 | 1.4 ± 1.3 | 0.85 |

VAS: visual analog scale, * Significant difference.

**Table 3**
The results of knee ROM at 2, 4, 12 weeks after ACL reconstruction between two the groups. No significant difference was noted between the two groups at 2, 4, and 12 weeks after surgery.

| The results of knee ROM at 2, 4, 12 weeks after ACL reconstruction between two the groups | Group D (n = 68) | Group N (n = 60) | P Value |
|---|---|---|---|
| Knee extension at 2 weeks | −8.9 ± 6.6 | −8.3 ± 7.2 | 0.31 |
| Knee flexion at 2 weeks | 88.6 ± 19.7 | 94.7 ± 21.4 | 0.13 |
| Knee extension at 4 weeks | −3.9 ± 3.8 | −2.7 ± 3.8 | 0.09 |
| Knee flexion at 4 weeks | 111.6 ± 18.2 | 117.9 ± 18.1 | 0.06 |
| Knee extension at 12 weeks | 0.4 ± 2.8 | 0.7 ± 2.7 | 0.44 |
| Knee flexion at 12 weeks | 140.7 ± 5.2 | 140.9 ± 6.6 | 0.48 |

**Table 4**
The results of extensor and flexor muscle strength at 12 weeks after ACL reconstruction between two the groups in peak torque, LSI and BW ratio. No significant difference in the peak torque, LSI, and BW ratio was found between the two groups at 12 weeks after surgery.

| The results of extensor and flexor muscle strength at 12 weeks after ACL reconstruction between two the groups in peak torque, LSI and BW ratio | Group D (n = 68) | Group N (n = 60) | P value |
|---|---|---|---|
| Extension 60°/s (Nm) | 100.2 ± 37.2 | 102.7 ± 38.1 | 0.66 |
| Extension 180°/s (Nm) | 71.6 ± 27.1 | 75.7 ± 27.3 | 0.45 |
| Flexion 60°/s (Nm) | 49.3 ± 19.7 | 53.4 ± 18.2 | 0.16 |
| Flexion 180°/s (Nm) | 44.1 ± 18.1 | 48.6 ± 17.8 | 0.14 |
| LSI ext60° (%) | 77.4 ± 18.5 | 73.1 ± 16.2 | 0.21 |
| LSI ext180° (%) | 81.7 ± 17.6 | 82.1 ± 22.2 | 0.77 |
| LSI flex60° (%) | 87.8 ± 18.8 | 87.2 ± 17.5 | 0.93 |
| LSI flex180° (%) | 90.8 ± 22.1 | 93.8 ± 28.6 | 0.72 |
| BW ratio ext 60° (Nm/kg) | 1.6 ± 0.5 | 1.6 ± 0.6 | 0.79 |
| BW ratio ext180° (Nm/kg) | 0.8 ± 0.3 | 0.9 ± 0.3 | 0.54 |
| BW ratio flex60° (Nm/kg) | 1.2 ± 0.3 | 1.2 ± 0.4 | 0.25 |
| BW ratio flex180° (Nm/kg) | 0.7 ± 0.3 | 0.8 ± 0.3 | 0.18 |

LSI: limb symmetry index, BW: body weight, ext: extension, flex: flexion.

drains have been used traditionally, and recent reports have shown only the disadvantages of increased blood loss and transfusions, leading to being doubtful about the use of the intra-articular drain.[5,17,18] Although we cannot consider it in the same league as TKA because ACL reconstruction rarely requires blood transfusions, evidence is accumulating regarding its use during ACL reconstruction and the use of intra-articular drain is expected to decrease in the future.

Although we have made several efforts to minimize methodological limitations in this study, some limitations should be acknowledged. First, this study was not a randomized trial. The two groups were divided by the period when they received surgery, which may have resulted in bias in terms of surgeon proficiency and proficiency in hospitalization management. Fortunately, there were no differences in patient background or operative time in this study, but more large randomized prospective studies are needed. Second, the effect of meniscal repair on meniscus injury concomitant with ACL injury was not ruled out. Meniscal repair may prolong the operative time and worsen pain due to the use of a tourniquet and meniscal repair site pain. These may contribute to early postoperative pain and ROM limitation. We still believe that a randomized trial with standardized conditions is needed in the future.

## Conclusions

Postoperative pain was greater at 4 h postoperatively in group D. Furthermore, the intra-articular drain did not affect muscle strength, ROM, and complications in the early postoperative period. The usefulness of an intra-articular drain after ACL reconstruction was considered low.

## Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

## Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the medical ethics review committee of our institute (approval No. 1842−3).

## Informed consent

The authors certify that they have obtained the required patient consent in writing. In the consent form, the patients provided consent for their images and other clinical information to be reported in the journal. However, consent was not applicable because the patients' personal information is not reported in this paper.

## Authors' contributions

All authors made a significant contribution to the research concept, design, data collection, analysis and interpretation of data, critical correction of important intellectual content. All authors have read and approved the final submitted version of the manuscript.

Specific contributions are.

(1) Conception and design of research: KS, JN
(2) Data acquisition: KS, RY, TS,
(3) Data analysis and interpretation: KS, RT, TK, YY
(4) Draft article: KS, JN, HT
(5) Final approval of submitted version: KS, JN, HT

## Availability of data and materials

The datasets used and/or analyzed during the current study are

available from the corresponding author and first author on reasonable request.

## Declaration of competing interest

No conflict of interests is declared.

We attest these authors have not received or will not receive benefits for personal or professional use from a commercial party directly or indirectly to the subject of this article.

## Acknowledgments

Not applicable.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.asmart.2023.04.002.

## Abbreviations

| | |
|---|---|
| ACL | anterior cruciate ligament |
| BTB | bone-tendon-bone |
| ROM | range of motion |
| VAS | visual analog scale |
| NSAID | non-steroidal anti-inflammatory drugs |
| LSI | limb symmetry index |
| BW | body weight |

## References

1. Coupens SD, Yates CK. The effect of tourniquet use and hemovac drainage on postoperative hemarthrosis. *Arthroscopy*. 1991;7:278–282.
2. Holt BT, Parks NL, Engh GA, Lawrence JM. Comparison of closed-suction drainage and no drainage after primary total knee arthroplasty. *Orthopedics*. 1997;20:1121–1125.
3. Jenny JY, Boeri C, Lafare S. No drainage does not increase complication risk after total knee prosthesis implantation: a prospective, comparative, randomized study. *Knee Surg Sports Traumatol Arthrosc*. 2001;9:299–301.
4. Abolghasemian M, Huether TW, Soever LJ, Drexler M, MacDonald MP, Backstein DJ. The use of a closed-suction drain in revision knee arthroplasty may not Be necessary: a prospective randomized study. *J Arthroplasty*. 2016;31:1544–1548.
5. Chen JY, Lee WC, Chan HY, Chang PCC, Lo NN, Yeo SJ. Drain use in total knee arthroplasty is neither associated with a greater transfusion rate nor a longer hospital stay. *Int Orthop*. 2016;40:2505–2509.
6. Lang GJ, Richardson M, Bosse MJ, et al. Efficacy of surgical wound drainage in orthopaedic trauma patients: a randomized prospective trial. *J Orthop Trauma*. 1998;12:348–350.
7. Straw R, Colclough K, Geutjens GG. Arthroscopically assisted ACL reconstruction. Is a drain necessary? *Knee*. 2003;10:283–285.
8. McCormack RG, Greenhow RJ, Fogagnolo F, Shrier I. Intra-articular drain versus no drain after arthroscopic anterior cruciate ligament reconstruction: a randomized, prospective clinical trial. *Arthroscopy*. 2006;22:889–893.
9. Shamim S, Kushwaha SS, Shantanu K, Maurya G, Arshad I. Assessment of an intra-articular drain in arthroscopy-assisted anterior cruciate ligament reconstruction. *Cureus*. 2021;3, e16928.
10. Park SY, Oh H, Park S, Lee JH, Lee SH, Yoon KH. Factors predicting hamstring tendon autograft diameters and resulting failure rates after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2013;21:1111–1118.
11. Nakase J, Toratani T, Kosaka M, et al. Technique of anatomical single bundle ACL reconstruction with rounded rectangle femoral dilator. *Knee*. 2016;23:91–96.
12. Wellsandt E, Failla MJ, Snyder-Mackler L. Limb symmetry indexes can overestimate knee function after anterior cruciate ligament injury. *J Orthop Sports Phys Ther*. 2017;47:334–338.
13. Clifton R, Haleem S, McKee A, Parker MJ. Closed suction surgical wound drainage after anterior cruciate ligament reconstruction: a systematic review of randomised controlled trials. *Knee*. 2007;14:348–351.
14. Maniar RN, Pradhan P, Bhatnagar N, Maniar A, Bidwai R, Bindal P. Role of suction drain after knee arthroplasty in the tranexamic acid era: a randomized controlled study. *Clin Orthop Surg*. 2019;11:73–81.
15. Dhawan A, Doukas WC, Papazis JA, Scoville CR. Effect of drain use in the early postoperative period after arthroscopically assisted anterior cruciate ligament reconstruction with bone-patellar tendon-bone graft. *Am J Sports Med*. 2003;31:419–424.
16. Yin D, Delisle J, Banica A, et al. Tourniquet and closed-suction drains in total knee arthroplasty. No beneficial effects on bleeding management and knee function at a higher cost. *Orthop Traumatol Surh Res*. 2017;103:583–589.
17. Zhang Q, Guo W, Zhang Q, Liu Z, Cheng L, Li Z. Comparison between closed suction drainage and nondrainage in total knee arthroplasty: a meta-analysis. *J Arthroplasty*. 2011;26:1265–1272.
18. Watanabe T, Muneta T, Yagishita K, Hara K, Koga H, Sekiya I. Closed suction drainage is not necessary for total knee arthroplasty: a prospective study on simultaneous bilateral surgeries of a mean follow-up of 5.5 years. *J Arthroplasty*. 2016;1:641–646.