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RESEARCH

Tourniquet-less total knee arthroplasty does not negatively affect cement penetration: a double-blinded randomized controlled trial

Seyed Mohammad Javad Mortazavi[1,2] · Hesan Rezaee[1,2] · Seyed Mohammad Milad Seyedtabaei[1,2] · Maziar Nafisi[1,2] · Parva Javan Shayani[3] · Mohammadreza Razzaghof[1,2] · Mohammad Ayati Firoozabadi[1,2]

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Abstract

Background The use of tourniquets in total knee arthroplasty (TKA) remains controversial, with growing interest in tourniquet-less techniques to improve patient outcomes. However, concerns persist regarding the adequacy of cement penetration and long-term implant stability. This study evaluated whether tourniquet-less TKA compromises cement penetration compared to conventional tourniquet-assisted procedures.

Methods A double-blind randomized controlled trial included 120 patients with end-stage osteoarthritis undergoing cemented TKA. Patients were randomized into two groups: tourniquet ($n=60$) and tourniquet-less ($n=60$). All patients received standardized protocols including tranexamic acid, spinal anaesthesia with controlled hypotension, and identical cementing techniques. The primary outcome was cement penetration depth measured on standardized radiographs at 60 days. Secondary analysis assessed the impact of bone mineral density on cement penetration.

Results Both groups achieved optimal cement penetration (2–3 mm) across the measured zones, with no clinically significant differences in average penetration depth. Bone mineral density did not affect penetration in either group, with 28.9% of patients having osteoporosis. Statistically significant differences in select zones (0.06–0.5 mm) were not clinically meaningful.

Conclusions Tourniquet-less TKA achieves equivalent cement penetration to tourniquet-assisted procedures when performed with modern standardized techniques. These findings support surgical decision-making for tourniquet-less approaches without compromising implant fixation quality, potentially enabling improved patient-centered outcomes.

Keywords Total knee arthroplasty · Tourniquet · Cement penetration · Bone mineral density · Randomized controlled trial

✉ Seyed Mohammad Javad Mortazavi
smjmort@yahoo.com

Hesan Rezaee
hesan.rezaee@gmail.com

Seyed Mohammad Milad Seyedtabaei
miladst94@gmail.com

Maziar Nafisi
maziarnafisi@gmail.com

Parva Javan Shayani
mrs.parva.shayani@gmail.com

Mohammadreza Razzaghof
m.razzaghof@gmail.com

Mohammad Ayati Firoozabadi
dr.mohammad.ayati@gmail.com

1 Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Islamic Republic of Iran

2 Department of Orthopedic Surgery, Imam Khomeini Hospital Complex, Tehran, Islamic Republic of Iran

3 Shohadaye Tajrish Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Islamic Republic of Iran

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Introduction

Tourniquet use has long been a common practice in total knee arthroplasty (TKA) to enhance surgical visibility, minimize blood loss, and improve cement penetration during component fixation [1]. Despite these potential advantages, the routine use of tourniquets in TKA has recently been questioned due to concerns about complications, including quadriceps muscle ischemia, reduced early range of motion, increased postoperative pain, limb swelling, and potential damage to local blood vessels and nerves [2–6]. Additionally, recent studies have highlighted specific considerations for patients with sickle cell trait and sickle cell disease, where tourniquet use may be associated with increased complications [7, 8].

Cemented primary TKA has demonstrated excellent long-term clinical results. However, aseptic loosening of the tibial component remains a major reason for revision surgeries, making up more than 28% of revision arthroplasties following primary procedures [9–11]. This issue places a considerable financial strain on both patients and healthcare systems. Of the various causes of aseptic loosening, inadequate cement penetration and the strength of the cement-bone interface are especially important [12]. To ensure effective engagement of the first transverse trabeculae, optimal cement fixation necessitates a penetration depth of 2–3 mm [13, 14].

While tourniquet use has been shown to increase cement penetration during component placement [15–17], it is still uncertain whether tourniquet-less TKA can reach similar cement penetration levels. Several studies, including randomized clinical trials, have examined the link between tourniquet use and cement penetration, but their results continue to vary [10, 15, 18–22]. Some studies have demonstrated that tourniquet application increases cement mantle thickness [15–19], while others report no significant difference between tourniquet and tourniquet-less groups [10, 21–25]. These discrepancies likely arise from methodological differences and insufficient control over potential confounders. For example, some studies labeled procedures as "tourniquet-less" even when a tourniquet was used during cementation. Furthermore, variability in anesthesia protocols, inconsistent tranexamic acid use, unreported mean arterial pressures, and the lack of osteoporosis evaluation may have also played a role in the conflicting results [18, 19, 22–24].

To address these limitations, we designed a randomized controlled trial (RCT) to evaluate the impact of tourniquet use on cement penetration in TKA, accounting for confounding variables. We hypothesize that tourniquet-less TKA does not compromise cement penetration and may yield outcomes similar to tourniquet-assisted procedures.

Methods

Ethics approval

A randomized controlled trial was conducted from December 2022 to August 2023 at Imam Khomeini Hospital Complex in Tehran, Iran, a tertiary referral hospital. The study received ethics approval with the code IR.TUMS.IKHC.REC.1401.113. Additionally, the trial protocol was registered with the Iranian Registry for Clinical Trials under the identifier IRCT20221116056519N1.

Patients

During the study, 167 patients with end-stage osteoarthritis undergoing unilateral TKA were screened. Inclusion criteria: aged 55–85, BMI < 40 kg/m², ASA I or II, Kellgren and Lawrence score III-IV, and signed consent. Exclusions: knee fractures or surgeries, malignancies, cardiovascular disease, rheumatoid arthritis, neuromuscular disorders, liver failure, coagulation disorders, infectious diseases, glucocorticoids, warfarin, heparin, thromboembolism history, unwillingness, or follow-up under 60 days.

After eligibility assessment and consent, 30 patients were excluded, and 17 declined. 120 patients were randomly assigned to the tourniquet (60) or tourniquet-less (60) groups. During follow-up, six patients from the tourniquet group were lost: two relocated, four missed follow-up. (Fig. 1). Patient Demographics and Baseline Characteristics: In the tourniquet group, 32 participants (59.2%) were women, with a mean age of 66.4 years (SD = 8.7). In the tourniquet-less group, 37 participants (61.6%) were women, with a mean age of 66.7 years (SD = 7.9). Detailed baseline characteristics are summarized in Table 1.

Randomization and blinding

Patient randomization was performed by a trained secretary using permuted block randomization with two blocks via the site randomization website. This double-blinded RCT ensured patients and evaluators were unaware of group assignments. The surgeon had no role in data curation or analysis, which was performed blindly. Interventions and controls were labeled 'A' and 'B' during analysis, with codes revealed only after completion.

Surgical technique

Two senior Orthopaedic surgeons specializing in joint reconstruction performed all surgeries. A universal medial parapatellar approach was utilized for all procedures. The

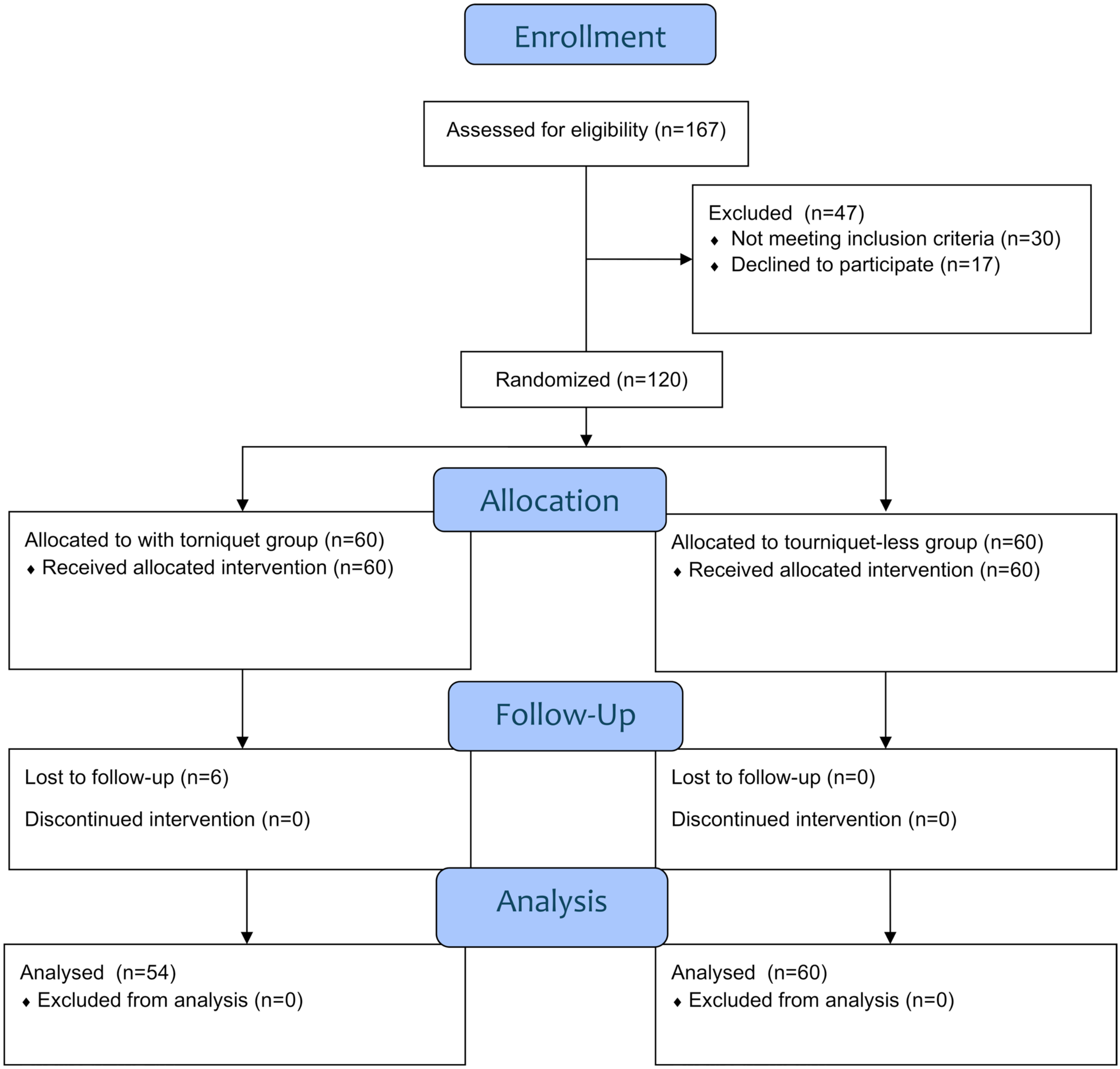

Fig. 1 Flow diagram illustrating patient enrolment, allocation, follow-up, and analysis

Table 1 Basic and demographic characteristics of participants

Variable	Tourniquet	Tourniquet-less	*P*-value
Gender; *n* (%)			
Female	32 (59.2)	37 (61.6)	0.94
Male	22 (40.7)	23 (38.3)	
Age (years); Mean (SD)	66.4 (8.7)	66.7 (7.9)	0.84
Mean Arterial Pressure (mmHg); Mean (SD)	92.7 (13.7)	89.5 (13.6)	0.23
Body Mass Index (kg/m²); Mean (SD)	29.2 (3.5)	29.7 (4.5)	0.46
Bone Mineral Density (BMD)			0.087
Normal	43 (79.6)	38 (63.3)	
Osteoporosis	11 (20.3)	22 (36.6)	

prosthesis used was the NexGen LPS-Flex (Zimmer Biomet Inc., Warsaw, IN) without patellar resurfacing, and BonOs R Genta cement (40 mg, OSARTIS GmbH, Münster, Germany) was applied in all cases. In the tourniquet group, the tourniquet was inflated to 250 mmHg and remained in place from incision until final closure. In the tourniquet-less group, no tourniquet was used, nor was it applied in a deflated state at any point during the procedure.

All patients received 10 mg/kg of intravenous tranexamic acid right before surgery, along with 2 g of intravenous cefazolin for prophylaxis. Before implant placement, a cocktail containing 400 mg of ropivacaine, 5 mg of morphine, 30 mg of ketorolac, 3 g of tranexamic acid, and 3 mg of epinephrine (1:10000 vial) was injected periarticularly [26]. The controlled hypotension technique was used in all surgeries, maintaining systolic pressure at 90–100 mmHg, diastolic at 50–60 mmHg, and mean arterial pressure between 85 and 95 mmHg.

Detailed cementing technique: Cementing began with bone surface preparation using pulse lavage as per Stronach et al. [27]. The tibial plateau was first exposed, cleaned, and thoroughly dried. A single batch of cement was mixed and applied to both the tibial bone surface and the tibial canal simultaneously. The tibial implant's undersurface was then coated with PMMA cement, inserted, and impacted into position. Following tibial component insertion, the femoral bone surfaces were prepared in a similar fashion - cleaned, dried, and cement was applied to both the anterior and posterior femoral condylar surfaces as well as the intercondylar notch area. The femoral component's undersurface was coated with cement and then inserted and impacted. The polyethylene insert was placed, and the knee was maintained in full extension throughout the entire cement curing process for both components. This sequential approach allowed for optimal cement penetration while maintaining proper component alignment.

Patellar management: As specified in our methodology, patellar resurfacing was not performed in any patient in this study. This decision was made to maintain consistency across all procedures and eliminate any potential confounding variables related to patellar cement penetration. All `.

Radiographic cement penetration measurements

Standardized digital X-ray images were obtained 60 days post-surgery to assess cement penetration. Radiographs included AP and lateral views of the tibial plateau, plus a lateral view of the femoral component. The average cement penetration depth was measured using the Knee Society Radiographic Evaluation System [28]. A reference sphere (25 mm diameter) was used in all images. Measurements were made with a calibrated digital ruler according to the zones described by the Knee Society system, split into thirds for tibial and femoral measurements. For each zone, the average penetration depth was calculated [29]. Independent measurements by two evaluators were averaged, resolving differences > 1.0 mm with repeated evaluations until agreement. The secondary outcome assessed BMD's impact on cement penetration, with preoperative BMD measured by DXA, recording T-scores from the femoral neck, total hip, and vertebral regions.

Table 2 Comparison of cement penetration between groups

Variable	Tourniquet	Tourniquet-less	*P*-value
Cement Penetration in Lateral View of the Femur (mm)			
Average (all zones)	2.65 (1.17)	2.56 (1.07)	0.311
1	2.05 (0.53)	1.78 (0.47)	0.038
2	2.19 (0.57)	2.25 (0.62)	0.64
3-Anterior	3.25 (1.02)	3.03 (0.80)	0.208
4	3.39 (1.17)	3.15 (0.94)	0.22
5	2.36 (1.05)	2.58 (1.30)	0.27
Cement Penetration in Anterior-Posterior View of Tibia (mm)			
Average (all zones)	2.51(0.27)	2.3(0.37)	0.15
1	2.67 (1.1)	2.45 (0.7)	0.21
2	2.76 (1.1)	2.19 (0.52)	0.001
3-Medial	2.44 (0.5)	2.43 (1.03)	0.95
3-Lateral	2.35 (0.5)	2.38 (1.04)	0.86
Cement Penetration in Lateral View of Tibia (mm)			
Average (all zones)	2.56(0.29)	2.44(0.36)	0.24
1	2.6 (0.9)	2.16 (0.47)	0.005
2	2.64 (0.5)	2.68 (1.2)	0.84
3-Anterior	2.35 (0.81)	2.00 (0.50)	0.024
3-Posterior	2.69 (1.06)	2.91 (1.02)	0.25

Data analyses

An a priori power analysis calculated a sample size of $n = 60$ to detect a 1 mm difference between two groups with 0.80 power and $\alpha = 0.05$. An overall sample size of $n = 120$ accounted for possible dropout. In presenting our data, mean and standard deviation (SD) were reported for continuous variables, while the number and percentage were used for categorical variables. The Chi-square or Fisher's exact test was employed to compare categorical variables between groups. An independent T-test or Analysis of Variance (ANOVA) was applied to compare normally distributed variables between groups, whereas the Mann-Whitney

Table 3 Mean (SD) cement penetration (millimeter) based on the bone mass densitometry results in the tourniquet-less group based on T-score

View	Femur neck				Spine				Total Hip			
	Osteoporotic ($n = 8$)	Osteopenic ($n = 30$)	Normal ($n = 16$)	*P*-value	Osteoporotic ($n = 6$)	Osteopenic ($n = 34$)	Normal ($n = 14$)	*P*-value	Osteoporotic ($n = 4$)	Osteopenic ($n = 27$)	Normal ($n = 23$)	*P*-value
Lat Femur	2.6 (0.83)	2.55 (0.56)	2.2 (0.77)	0.224	2.08 (0.26)	2.47 (0.77)	2.58 (0.54)	0.338	1.89 (0.35)	2.48 (0.69)	2.52 (0.69)	0.241
AP Tibia	2.54(0.7)	2.41 (0.66)	2.1 (0.59)	0.226	2.21 (0.53)	2.36 (0.74)	2.33 (0.49)	0.88	2.1 (0.65)	2.38 (0.66)	2.33(0.67)	0.081
Lat Tibia	2.5 (0.37)	2.37 (0.63)	2.1 (0.54)	0.206	2.5 (0.39)	2.24 (0.63)	2.4 (0.52)	0.45	2.2 (0.17)	2.18 (0.48)	2.49 (0.7)	0.193

Table 4 Mean (SD) Cement penetration (millimeter) based on the bone mass densitometry results in the tourniquet-less group based on T-score

View	Femur neck				Spine				Total Hip			
	Osteoporotic (n=16)	Osteopenic (n=33)	Normal (n=11)	*P*-value	Osteoporotic (n=16)	Osteopenic (n=26)	Normal (n=18)	*P*-value	Osteoporotic (n=9)	Osteopenic (n=26)	Normal (n=25)	*P*-value
Lat Femur	2.4 (0.4)	2.57 (0.49)	2.56 (0.39)	0.811	2.66 (0.4)	2.34 (0.4)	2.74 (0.46)	0.01	2.35 (0.27)	2.56 (0.44)	2.6 (0.52)	0.371
AP Tibia	2.76 (0.63)	2.47 (0.45)	2.59 (0.79)	0.27	2.67 (0.7)	2.48 (0.32)	2.6 (0.72)	0.58	3 (0.69)	2.4 (0.38)	2.51 (0.66)	0.06
Lat Tibia	2.54 (0.35)	2.6 (0.51)	2.7 (0.57)	0.51	2.7 (0.51)	2.5 (0.41)	2.6 (0.57)	0.55	2.6 (0.33)	2.6 (0.47)	2.6 (0.56)	0.93

or Kruskal-Wallis tests were utilized for ordinal variables and those with a non-normal distribution. All analyses were conducted using SPSS version 26, and a p-value of less than 0.05 was considered statistically significant.

Result

Primary outcome: Both groups demonstrated cement penetration ranging from 2 to 3 mm across all measured zones, except in femoral zone 1. The average cement penetration was similar between groups in the anterior-posterior (AP) and lateral tibial zones and the lateral femoral zones. Statistically significant differences were observed in femoral zone 1, AP tibial zone 2, and lateral tibial zones 1 and 3-anterior (Table 2). However, these differences ranged from only 0.06 to 0.5 mm, and the literature does not consistently define a meaningful clinically cemented depth (MCID).

Secondary Outcome: To evaluate the impact of bone mineral density (BMD) on cement penetration, patients were classified into three subgroups according to their bone densitometry results: femoral neck, spine, and total hip. Cement penetration was assessed separately for both tourniquet and tourniquet-less groups. In both groups, cement penetration ranged from 2 to 3 mm across all views. In the tourniquet group, no significant differences were observed in average cement penetration among osteoporotic, osteopenic, and normal patients across the AP and lateral tibial and lateral femoral views (Table 3). In contrast, the tourniquet-less group showed significant differences in cement penetration only in the lateral femoral view for the spine subgroup, while all other views demonstrated similar results (Table 4). Furthermore, a comparison between patients with osteoporosis (33 patients) and those with normal or osteopenic bone density (81 patients) revealed no significant differences in cement penetration (Table 5).

Discussion

This study aimed to assess whether performing TKA without a tourniquet adversely affects cement penetration. Our results show that tourniquet-less TKA does not significantly alter the depth of cement penetration, with both the tourniquet and tourniquet-less groups reaching similar penetration levels (2–3 mm) in most measured zones.

Previous studies have reported conflicting findings regarding the impact of tourniquet application on cement penetration during TKA. Yao et al. [30] conducted a meta-analysis of seven studies involving 675 patients and found that tourniquet use did not significantly influence cement penetration in primary TKA—conversely, Lu et al. [31] conducted a meta-analysis of eight randomized controlled trials (RCTs) involving 677 knees, concluding that tourniquet application increased the thickness of the bone cement around the prosthesis, potentially improving the stability and durability of the implant. Recognizing these inconsistencies, we critically analyzed previous studies and identified several methodological limitations that may have influenced their findings [1, 10, 15–17, 21–23, 25]. (Table 6)

The limitations of previous studies on tourniquet use in TKA include small sample sizes, inconsistent tourniquet protocols, and variability in implant types, making comparisons difficult. Many studies failed to control for key confounding factors such as bone mineral density (BMD), intraoperative blood pressure, and anaesthesia type, which can influence cement penetration. Additionally, the use of tranexamic acid (TXA) was either absent or inconsistently reported. Some studies also applied the tourniquet only

Table 5 Mean (SD) cement penetration based on bone mass densitometry results in osteoporotic vs. other patients

	Lat femur		AP Tibia		LAT Tibia	
Osteoporosis 33(28.9%)	2.5(0.61)	P-Value=0.63	2.64(0.64)	P-Value=0.051	2.56(0.46)	P-Value=0.27
Normal or osteopenic 81(71%)	2.4(0.57)		2.38(0.62)		2.43(0.59)	

Table 6 Comparative analysis of studies on tourniquet use and cement penetration in TKA

Author	Conclusion	Study Design	Tourniquet Protocol	Implant Type	TXA Use	Anesthesia Type	Intraoperative Blood Pressure	BMD Measurement	Femoral Side Measurement
Pfitzner et al. (2016)	Tourniquet use increased tibial cement mantle thickness.	RCT, 2 arms (n=45)	350 mmHg in T group; not specified in T-less group.	NexGen LPS Flex, Zimmer, fixed-bearing design.	Not used	Not mentioned	Not mentioned	Not measured	Not measured
Vertullo et al. (2017)	Tourniquet inflation during cementation does not improve tibial cement penetration.	RCT, 2 arms (n=20)	Limited tourniquet use in T group.	NexGen Posterior Stabilized LPS Mobile Bearing.	Not used	Not mentioned	Hypotensive anesthesia (not compared).	Not measured	Not measured
Ozkunt et al. (2018)	No significant difference in cement penetration among three groups.	RCT, 3 arms (n=25)	Tourniquet use: full procedure, limited, or none.	Posterior Cruciate Retaining Genesis II.	Not used	General anesthesia (consistent).	Not mentioned	Not measured	Not measured
Jawhar et al. (2019)	Tourniquet application did not significantly influence cement penetration.	RCT (n=43)	360 mmHg in T group; not specified in T-less group.	Cemented PFC SIGMA prosthesis.	Not used	Spinal anesthesia (consistent).	Not mentioned (hypotensive anesthesia not used).	Not measured	Not measured
Yi et al. (2021)	No significant difference in cement mantle thickness across three groups.	RCT, 3 arms (n=50)	Tourniquet use: full procedure, limited, or none.	Posterior-Stabilized Fixed-Bearing P.F.C.	Not used	Not mentioned	Controlled hypotension (not compared).	Not measured	Not measured
Touzopoulos et al. (2019)	Tourniquet use increased tibial cement mantle thickness and influenced radiolucent line (RLL) occurrence.	Retrospective Case-Control (n=50)	360 mmHg in T group; not specified in T-less group.	MultiGen Plus CR, Lima Corporate.	Not used	Not mentioned	Not mentioned	Not measured	Not measured
Herndon et al. (2019)	Cement penetration was similar between tourniquet and non-tourniquet groups when TXA was used.	Retrospective Case-Control (n=70)	250 mmHg in T group; no tourniquet in T-less group.	Zimmer Persona, ConforMIS iTotal, Smith & Nephew Journey II.	TXA used (standard protocol).	Not mentioned	Not mentioned	Not measured	Not measured
Hegde et al. (2020)	Tourniquet use improved cement penetration and reduced RLL progression.	Retrospective Case-Control (n=60)	250 mmHg (>30 min).	Triathlon, Stryker.	Not used	Not mentioned	Controlled hypotensive anesthesia.	Not measured	Not measured
Zak et al. (2021)	Tourniquet use does not affect average penetration depth but increases the likelihood of optimal cement penetration.	Multicenter retrospective review of previous RCTs (168vs 189)	Not mentioned; different cementing protocols used.	Smith & Nephew Journey II, Smith & Nephew Legion, Zimmer Persona.	Not mentioned	Not mentioned	Not mentioned	Not measured	Not measured

during cementation in tourniquet groups, further complicating interpretations. These methodological inconsistencies undermine the reliability of existing findings and highlight the need for more rigorously controlled trials. To address these concerns, we designed a rigorous randomized controlled trial, incorporating measures to minimize potential biases and enhance the reliability of our results.

The routine administration of tranexamic acid (TXA) in total knee arthroplasty (TKA) is widely regarded as an effective measure for minimizing blood loss and reducing the need for blood transfusions. Both intravenous and topical applications of TXA have demonstrated benefits in this regard [32]. Two studies specifically examine the impact of TXA on cement penetration during TKA. Herndon et al. found that when using modern TXA protocols, there was no significant difference in cement penetration between the tourniquet and non-tourniquet groups. However, the use of a tourniquet did result in reduced blood loss [25]. Dincel et al. examined the effects of tranexamic acid (TXA) and tourniquet use on tibial cement penetration in primary TKA. The authors compared cement penetration levels among patients receiving TXA without a tourniquet and those using a tourniquet without receiving TXA. They concluded that the use of TXA instead of a tourniquet does not reduce the depth of cement penetration in TKA [33]. A notable limitation in many prior randomized controlled trials (RCTs) is the lack of clarity regarding TXA administration. Our study addressed this limitation by routinely administering TXA in both the tourniquet and non-tourniquet groups.

No specific studies investigate the role of intraoperative blood pressure on cement penetration in total knee arthroplasty (TKA). However, some previous research considers intraoperative blood pressure as a significant factor and notes whether hypotensive anesthesia was used [10, 16, 22, 23]. It is well established that regional anaesthesia, particularly spinal anaesthesia, is increasingly preferred over general anaesthesia due to potentially lower rates of complications, including venous thromboembolism and perioperative bleeding, shorter hospital stays, and improved recovery [34]. The reduced intraoperative bleeding associated with regional anaesthesia could theoretically affect bone surface cleaning before cementation, especially in tourniquetless TKA. Additionally, the design of implants might influence the thickness of cement penetration, particularly around the tibial component keel, as keels vary in design. We aimed to address all these potential confounders by using spinal anesthesia and controlled hypotension in all patients. Furthermore, we utilized only one type of implant for all patients.

Notably, the majority of previous studies have concentrated primarily on tibial cement penetration, with only one study also evaluating femoral cement penetration [13]. That study found that tourniquet use did not significantly impact femoral cement penetration. Our findings support these conclusions, as we observed no effect of tourniquet use on femoral-side cement penetration within our cohort.

It is well established that bone density plays a critical role in influencing the morphological pattern of cement penetration, with areas of higher bone density exhibiting greater horizontal interdigitation and reduced penetration depths [35]. However, before this study, no randomized controlled trial (RCT) had specifically examined the relationship between bone mineral density (BMD) and cement penetration in total knee arthroplasty (TKA). Our study is the first to investigate cement penetration while stratifying patients based on their BMD values. The results indicate that bone density had no significant impact on cement penetration, as both tourniquet and tourniquet-less groups achieved optimal penetration levels, irrespective of osteoporosis status. We acknowledge that this finding may be subject to a type B error, as the number of osteoporotic patients may not have been large enough to detect a significant difference. Nevertheless, we believe that our finding of adequate cement penetration in non-osteoporotic patients, even in the tourniquet-less group, is noteworthy.

The prevalence of osteoporosis in our cohort was 28.9%, which contrasts with earlier reports, such as that by James et al., who observed a relatively low prevalence of DEXA-confirmed hip osteoporosis (2.8%) and spinal osteoporosis (6.9%) among arthroplasty patients [36]. Another study by Ishii et al. [37] identified osteoporosis in 22% of women and 5% of men undergoing TKA, emphasizing the importance of preoperative bone health assessment, especially in older women. [37] Our findings support the notion that while osteoporosis may be relatively common among TKA candidates, it does not significantly affect cement penetration when contemporary cementing techniques are employed.

Our study's strengths include a randomized controlled design, control of confounding factors, standardized surgical protocols, and bone mineral density assessment, enhancing its reliability. Limitations include being conducted at a single tertiary center, which may introduce bias and limit generalizability. The sample size was adequate for detecting cement penetration differences, but the short sixty-day follow-up might not reflect long-term outcomes. We did not use vacuum mixing or cement gun, part of fourth-generation techniques. The study mainly assesses cement mantle depth and doesn't address TKA implant survivorship or longevity.

Conclusion

This study demonstrates that performing tourniquet-less TKA does not compromise cement penetration and can be considered a safe alternative to conventional tourniquet-assisted techniques. Avoiding tourniquet use may reduce postoperative pain, improve functional recovery, and decrease intraoperative complications without sacrificing implant stability. Furthermore, our findings indicate that BMD does not significantly affect cement penetration, suggesting that modern cementing techniques are effective regardless of bone density. Further research is warranted to assess long-term outcomes and the potential benefits of tourniquet-less TKA in diverse patient populations.

Author contributions Mortazavi. MJ: Study concept and design. Ayati.M: supervision, Project Administration. Rezaee. H: Writing - Original Draft. Seyed tabaei. MM: Investigation and Validation. Nafisi. M: Data Gathering. Javan Shayani. P: Data Analysis. Razzaghof. M: Review & Editing.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

References

1. Zak SG, Yeroushalmi D, Long WJ, Meftah M, Schnaser E, Schwarzkopf R (2021) Does the use of a tourniquet influence outcomes in total knee arthroplasty: a randomized controlled trial. J Arthroplast 36:2492–2496
2. Grigoras M, Boughton O, Cleary M, McKenna P, Rowan FE (2021) Short-term outcomes of total knee arthroplasty performed with and without a tourniquet. Sicot-j 7:15. https://doi.org/10.1051/sicotj/2021019
3. Tai T-W, Chang C-W, Lai K-A, Lin C-J, Yang C-Y (2012) Effects of tourniquet use on blood loss and soft-tissue damage in total knee arthroplasty: a randomized controlled trial. JBJS 94:2209–2215
4. Mayer C, Franz A, Harmsen JF, Queitsch F, Behringer M, Beckmann J, Krauspe R, Zilkens C (2017) Soft-tissue damage during total knee arthroplasty: focus on tourniquet-induced metabolic and ionic muscle impairment. J Orthop 14:347–353. https://doi.org/10.1016/j.jor.2017.06.015
5. Leurcharusmee P, Sawaddiruk P, Punjasawadwong Y, Chattipakorn N, Chattipakorn SC (2018) The possible pathophysiological outcomes and mechanisms of Tourniquet-Induced Ischemia-Reperfusion injury during total knee arthroplasty. Oxidative medicine and. https://doi.org/10.1155/2018/8087598. cellular longevity 2018:8087598
6. Radulovic A, Cerovac S (2024) The history of tourniquet use in limb surgery. Int Orthop 48:603–609. https://doi.org/10.1007/s00264-023-06018-y
7. Hernigou P, Vedrenne P, Karam S, Flouzat-Lachaniette CH (2025) Tourniquet use in patients with sickle cell trait (SCT): mediterranean or African ancestry influences complications, demonstrating a higher prevalence than control patients: matched study of nine hundred and Forty SCT versus one thousand, two hundred and Sixty three non-SCT patients. Int Orthop 49:1607–1614. https://doi.org/10.1007/s00264-025-06555-8
8. Hernigou P (2025) Procedures under tourniquet in sickle cell disease: safety evaluated in two hundred and Thirty three sickle-cell disease anaemia adult patients in comparison with outcomes in five hundred and Seventy four sickle cell anaemia patients with procedures without tourniquet. Int Orthop 49:1319–1329. https://doi.org/10.1007/s00264-025-06510-7
9. Feng B, Weng X, Lin J, Jin J, Wang W, Qiu G (2013) Long-term follow-up of cemented fixed-bearing total knee arthroplasty in a Chinese population: a survival analysis of more than 10 years. J Arthroplast 28:1701–1706
10. Jawhar A, Stetzelberger V, Kollowa K, Obertacke U (2019) Tourniquet application does not affect the periprosthetic bone cement penetration in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 27:2071–2081
11. Etkin CD, Springer BD (2017) The American joint replacement Registry-the first 5 years. Arthroplasty Today 3:67–69. https://doi.org/10.1016/j.artd.2017.02.002
12. Vanlommel J, Luyckx JP, Labey L, Innocenti B, De Corte R, Bellemans J (2011) Cementing the tibial component in total knee arthroplasty: which technique is the best? J Arthroplasty 26:492–496. https://doi.org/10.1016/j.arth.2010.01.107
13. Zak SG, Tang A, Pivec R, Meftah M, Austin MS, Schnaser E, Schwarzkopf R (2023) The effects of tourniquet on cement penetration in total knee arthroplasty. Arch Orthop Trauma Surg 143:2877–2884
14. Lutz MJ, Pincus PF, Whitehouse SL, Halliday BR (2009) The effect of cement gun and cement syringe use on the tibial cement mantle in total knee arthroplasty. J Arthroplast 24:461–467
15. Pfitzner T, von Roth P, Voerkelius N, Mayr H, Perka C, Hube R (2016) Influence of the tourniquet on tibial cement mantle thickness in primary total knee arthroplasty. Knee Surgery, Sports Traumatology, Arthroscopy 24:96–101
16. Hegde V, Bracey DN, Johnson RM, Dennis DA, Jennings JM (2021) Tourniquet use improves cement penetration and reduces radiolucent line progression at 5 years after total knee arthroplasty. J Arthroplast 36:S209–S214
17. Touzopoulos P, Ververidis A, Mpogiatzis C, Chatzigiannakis A, Drosos GI (2019) The use of tourniquet May influence the cement mantle thickness under the tibial implant during total knee arthroplasty. Eur J Orthop Surg Traumatol 29:869–875. https://doi.org/10.1007/s00590-019-02369-8
18. Zhou J, Dou W, Oouyang H, Chu W (2018) The effect of not using tourniquet in total knee arthroplasty. Chin Rural Med 25:10–11
19. Xie X, Yue C, Huang Z, Kang P, Zhou Z, Yang J, Shen B, Pei F (2017) Total knee arthroplasty with or without tourniquet: a randomized controlled trial. Orthop J China 25:1572–1576
20. Zhao HY, Yeersheng R, Kang XW, Xia YY, Kang PD, Wang WJ (2020) The effect of tourniquet uses on total blood loss, early function, and pain after primary total knee arthroplasty: a prospective, randomized controlled trial. Bone Joint Res 9:322–332. https://doi.org/10.1302/2046-3758.96.bjr-2019-0180.r3
21. Ozkunt O, Sariyilmaz K, Gemalmaz HC, Dikici F (2018) The effect of tourniquet usage on cement penetration in total knee arthroplasty: a prospective randomized study of 3 methods. Medicine 97:e9668
22. Yi Z, Yan L, Haibo S, Yuangang W, Mingyang L, Yuan L, Bin S (2021) Effects of tourniquet use on clinical outcomes and cement penetration in TKA when Tranexamic acid administrated: a randomized controlled trial. BMC Musculoskelet Disord 22:1–9
23. Vertullo CJ, Nagarajan M (2017) Is cement penetration in TKR reduced by not using a tourniquet during cementation? A single blinded, randomized trial. J Orthop Surg 25:2309499016684323
24. Yang J, Wei L, Zhang J, Huang X (2017) The effect of the tourniquet on cement mantle thickness in total knee arthroplasty. Chongqing Med 36:782–785
25. Herndon CL, Grosso MJ, Sarpong NO, Shah RP, Geller JA, Cooper HJ (2020) Tibial cement mantle thickness is not affected by tourniquetless total knee arthroplasty when performed with Tranexamic acid. Knee Surg Sports Traumatol Arthrosc 28:1526–1531. https://doi.org/10.1007/s00167-019-05559-3
26. Mortazavi SMJ, Vosoughi F, Yekaninejad M, Ghadimi E, Kaseb MH, Firoozabadi MA, Fallah E, Toofan H, Pestehei SK (2022) Comparison of the effect of Intra-Articular, periarticular, and combined injection of analgesic on pain following total knee

arthroplasty: A Double-Blinded randomized clinical trial. https://doi.org/10.2106/JBJS.OA.22.00074. JB JS Open Access 7
27. Stronach BM, Jones RE, Meneghini RM (2021) Tourniquetless total knee arthroplasty: history, controversies, and technique. JAAOS-Journal Am Acad Orthop Surg 29:17–23
28. Meneghini RM, Mont MA, Backstein DB, Bourne RB, Dennis DA, Scuderi GR (2015) Development of a modern knee society radiographic evaluation system and methodology for total knee arthroplasty. J Arthroplasty 30:2311–2314. https://doi.org/10.1016/j.arth.2015.05.049
29. Gapinski ZA, Yee EJ, Kraus KR, Deckard ER, Meneghini RM (2019) The effect of tourniquet use and sterile carbon dioxide gas bone Preparation on cement penetration in primary total knee arthroplasty. J Arthroplast 34:1634–1639
30. Yao S, Zhang W, Ma J, Wang J (2021) Effect of tourniquet application on cement penetration in primary total knee arthroplasty: a meta-analysis. Arthroplasty 3:1–9
31. Lu C, Song M, Chen J, Li C, Lin W, Ye G, Wu G, Li A, Cai Y, Wu H (2020) Does tourniquet use affect the periprosthetic bone cement penetration in total knee arthroplasty? A meta-analysis. J Orthop Surg Res 15:1–7
32. Fillingham YA, Ramkumar DB, Jevsevar DS, Yates AJ, Bini SA, Clarke HD, Schemitsch E, Johnson RL, Memtsoudis SG, Sayeed SA, Sah AP, Della Valle CJ (2019) Tranexamic acid in total joint arthroplasty: the endorsed clinical practice guides of the American association of hip and knee surgeons, American society of regional anesthesia and pain medicine, American academy of orthopaedic surgeons, hip society, and knee society. Reg Anesth Pain Med 44:7–11. https://doi.org/10.1136/rapm-2018-000024
33. Dincel YM, Sarı A, Çetin MÜ, Günaydın B, Agca E, Dogan AH, Varol R (2020) The effect of Tranexamic acid and tourniquet use on tibial cement penetration in primary total knee arthroplasties. Arthroplasty Today 6:422–426
34. Rodriguez-Patarroyo FA, Cuello N, Molloy R, Krebs V, Turan A, Piuzzi NS (2021) A guide to regional analgesia for total knee arthroplasty. EFORT Open Rev 6:1181–1192. https://doi.org/10.1302/2058-5241.6.210045
35. Scheele CB, Pietschmann MF, Schröder C, Lazic I, Grupp TM, Müller PE (2019) Influence of bone density on morphologic cement penetration in minimally invasive tibial unicompartmental knee arthroplasty: an in vitro cadaver study. J Orthop Surg Res 14:331. https://doi.org/10.1186/s13018-019-1376-6
36. James S, Mirza S, Culliford D, Taylor P, Carr A, Arden N (2014) Baseline bone mineral density and bone turnover in pre-operative hip and knee arthroplasty patients. Bone Joint Res 3:14–19
37. Ishii Y, Noguchi H, Sato J, Takahashi I, Ishii H, Ishii R, Ishii K, Toyabe S-i (2021) Preoperative bone assessment by bone mineral density and bone turnover in patients undergoing total knee arthroplasty. J Orthop 28:121–125