

# Tourniquet Effect on Cement Penetration in Total Knee Arthroplasty: A Systematic Review and Meta-Analysis

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## INTRODUCTION:

Aseptic loosening is a leading cause of prosthesis failure in total knee arthroplasty (TKA) and can arise from factors such as wear, implant malalignment, suboptimal prosthetic design, and inadequate bonding at the bone-cement interface. Since bone cement lacks adhesive properties, sufficient penetration into the trabecular bone is critical for mechanical interlock and implant stability. Deeper cement penetration has been associated with improved implant longevity and strength. One intraoperative factor that may affect cementation quality is the use of a tourniquet, which creates a bloodless field, potentially enhancing bone surface preparation and cement penetration. However, literature reports remain conflicting regarding the impact of tourniquet use on cement mantle thickness. To resolve this controversy, we performed a meta-analysis of randomized controlled trials and non-randomized studies assessing the effect of tourniquet application on tibial cement mantle thickness during TKA. This study aims to determine whether tourniquet use significantly improves cement penetration and, consequently, prosthetic fixation.

## METHODS:

This systematic review and meta-analysis followed the PRISMA guidelines. A comprehensive search was conducted across MEDLINE (PubMed), Web of Science, Embase, and Scopus from inception through February 2024. The search combined MeSH terms and keywords such as "total knee arthroplasty," "TKA," and "tourniquet" using Boolean operators. We included randomized controlled trials (RCTs) and non-randomized studies of interventions (NRSIs) comparing tourniquet use versus no tourniquet during primary TKA, specifically reporting tibial bone cement penetration.

Studies were included if they involved adult patients undergoing primary TKA, with cement mantle thickness as the primary outcome. Exclusion criteria were studies on revision TKAs, non-comparative designs, insufficient data, and non-original articles (e.g., reviews, case reports, cadaveric or in vitro studies). Data extraction covered study design, patient demographics, tourniquet parameters, cement brand, and cementing technique. Cement penetration was measured in tibial zones defined by the Knee Society Scoring System (KSS) on anteroposterior and lateral radiographs, with values aggregated using PACS.

Secondary outcomes included surgery duration, hemoglobin changes, transfusion rates, postoperative pain (VAS), and complications such as infections or DVT. Risk of bias was assessed using RoB2 for RCTs and the Newcastle-Ottawa Scale for NRSIs. Meta-analyses were conducted in R, using standardized mean differences for continuous outcomes. Heterogeneity was assessed via the  $I^2$  statistic, and random-effects models were applied. Publication bias was evaluated using Egger's test and funnel plots, with additional outlier detection performed via GOSH analysis and unsupervised learning algorithms. A  $p$ -value  $< 0.05$  was considered statistically significant.

## RESULTS:

The literature search and study selection process identified 425 studies after removing duplicates. Screening titles and abstracts excluded 388 irrelevant studies, and full-text review of 37 articles led to the exclusion of 21 additional studies due to lack of comparative groups or insufficient data. Ultimately, 16 studies published between 2014 and 2024 were included, consisting of 10 randomized controlled trials and 6 non-randomized studies, with a total of 1,516 patients.

Meta-analysis of these studies (1,516 patients; tourniquet = 764, control = 752) showed that tourniquet use significantly improved tibial bone cement penetration (standardized mean difference [SMD] = 0.619; 95% confidence interval [CI], 0.186 to 1.052;  $p = 0.005$ ). When considering only studies reporting average cement penetration (8 studies; 811 patients), the improvement remained significant but modest (SMD = 0.144; 95% CI, 0.003 to 0.284;  $p = 0.045$ ). Analysis of cumulated cement penetration from 8 studies (705 patients) also showed significant benefit with tourniquet use (SMD = 1.099; 95% CI, 0.326 to 1.872;  $p = 0.005$ ).

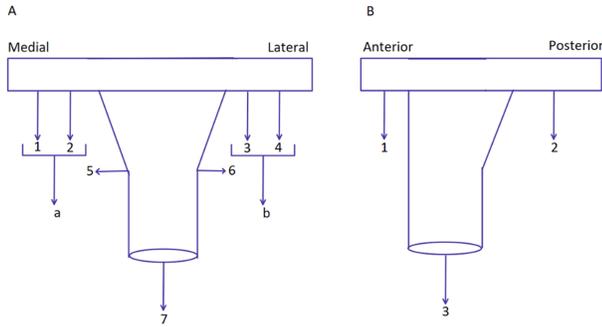
Subgroup analysis by tourniquet pressure ( $\leq 300$  mmHg vs.  $> 300$  mmHg) revealed no significant differences in cement penetration. Zone-specific analyses indicated moderate effects in some anteroposterior zones, whereas lateral zones showed minimal or no significant effects.

For secondary outcomes, the meta-analysis showed a significant reduction in blood transfusion rates under the common effect model (odds ratio [OR] = 0.45; 95% CI, 0.22 to 0.91), but this was not confirmed with the random-effects model (OR = 0.48; 95% CI, 0.17 to 1.36). There were no significant differences between tourniquet and control groups regarding operation duration (7 studies; 725 patients; SMD = -0.261; 95% CI, -0.586 to 0.063;  $p = 0.115$ ) or postoperative pain scores (5 studies; 397 patients; SMD = 1.939; 95% CI, -0.918 to 4.796;  $p = 0.184$ ).

## DISCUSSION AND CONCLUSION:

This meta-analysis suggests that tourniquet use during total knee arthroplasty is associated with improved bone cement penetration, which may enhance prosthesis fixation. No significant differences were found in surgical duration or postoperative pain between tourniquet and non-tourniquet groups. Although a reduction in transfusion rates was noted,

these results should be interpreted cautiously due to heterogeneity among studies and the secondary nature of this outcome. Further high-quality research is needed to confirm these findings and clarify the clinical implications of tourniquet use in TKA.



**Figure 2.** illustrates the distribution of the tibial cement mantle in various zones based on the Knee Society Score (KSS) classification in both anteroposterior (AP) and lateral views. In the AP view, the medial side is divided into Zone 1 and Zone 2, while the lateral side comprises Zone 3 and Zone 4. When the article refers to the medial side without specifying Zone 1 or Zone 2, it is classified as Zone a. Similarly, if only the lateral side is mentioned without specifying Zone 3 or Zone 4, it is classified as Zone B. Additionally, the AP view includes Zone 5, Zone 6, and Zone 7. In the lateral view, the classification consists of Zone 1, Zone 2, and Zone 3. This approach ensures a standardized interpretation when specific zone details are not provided.