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Rethinking routine drain usage in total knee arthroplasty: how tranexamic acid changed clinical practice – a review of literature

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ABSTRACT

The routine uses of closed suction drainage in total knee arthroplasty has been a longstanding practice aimed at preventing hematoma formation and infection. However, the introduction of tranexamic acid has revolutionized blood loss management. This review evaluates the current utility of suction drains in primary total knee arthroplasty within the context of widespread tranexamic acid adoption. A comprehensive literature review was conducted, focusing on studies published between 2004 and 2025. Special emphasis was placed on randomized controlled trials and comparative cohort studies evaluating outcomes of drain versus no-drain protocols in patients receiving tranexamic acid. Key outcome measures included total blood loss, transfusion rates, length of hospital stay, infection rates, and functional outcomes. Historical meta-analyses conducted prior to the tranexamic acid era indicated increased transfusion requirements associated with drain use. Recent evidence from the tranexamic acid era, including a pivotal 2019 randomized controlled trial by Maniar et al and a 2023 retrospective cohort study by Albasha et al, demonstrates that drains offer no benefit regarding blood conservation or complication reduction. Albasha et al found that drain placement was associated with significantly longer hospital stays (10.7 versus 5.4 days), greater hemoglobin decline, and higher transfusion rates. No significant differences were observed in deep vein thrombosis or surgical site infection rates between groups. In the tranexamic acid era, the theoretical benefits of negative suction drains are outweighed by associated disadvantages, including increased hidden blood loss, higher transfusion costs, and prolonged hospitalization. Current evidence supports abandoning routine drainage in primary total knee arthroplasty when tranexamic acid is administered.

Keywords: Total knee arthroplasty, Surgical drains, Tranexamic acid, Blood loss, Postoperative complications, Routine drainage

INTRODUCTION

Total knee arthroplasty (TKA) represents one of the most successful orthopedic procedures for end-stage osteoarthritis, with data suggesting that over 700,000 procedures are performed annually in the United States alone.[1] Historically, the management of postoperative bleeding has been a critical concern, as significant blood loss can lead to hematoma formation, wound complications, and the need for allogenic blood transfusions.[2] For decades, the placement of closed suction drains (CSD) was considered standard practice, based on the rationale that evacuating intra-articular blood would reduce hematoma formation, decrease infection risk, and improve range of motion (ROM).[3]

However, the necessity of drains has become increasingly controversial. Critics argue that drains may paradoxically

increase total blood loss by eliminating the tamponade effect, potentially serve as a conduit for retrograde infection, and interfere with early mobilization.[4] This debate has been fundamentally transformed by the widespread adoption of tranexamic acid (TXA), a potent antifibrinolytic agent that significantly reduces perioperative blood loss.

As TXA has become a cornerstone in managing perioperative blood loss in arthroplasty, the volume of postoperative drainage has decreased dramatically, prompting surgeons to question the utility of mechanical drainage devices. This review examines the evolution of drain use in TKA, synthesizes current evidence regarding their efficacy in the presence of TXA, and evaluates whether this practice should be abandoned in modern arthroplasty protocols.

METHODS

A systematic search of the literature was performed to identify relevant studies regarding the use of surgical drains in primary TKA. Electronic databases, including PubMed/MEDLINE, Embase, and the Cochrane Library, were queried for articles published up to 2025.

Search strategy

The search utilized Boolean operators with the following keywords: "total knee arthroplasty" OR "TKA" AND "drain" OR "closed suction drainage" OR "no drain" AND "blood loss" OR "infection" OR "complications."

Inclusion and exclusion criteria

Inclusion

Randomized controlled trials (RCTs), systematic reviews, meta-analyses, and large retrospective cohort studies comparing drain versus no-drain protocols in primary TKA, studies focusing on blood loss, duration of hospital stay, transfusion rates, infection, and functional outcomes were included.

Exclusion

Case reports, studies involving revision arthroplasty, complex primary TKA requiring structural allografts, and studies published before 2010 unless deemed seminal, were excluded. Data regarding total blood loss, hemoglobin drop, transfusion rates, wound complications, infection rates, and length of hospital stay were extracted.

RESULTS

Historical evidence: pre-tranexamic acid era

Even before the universal adoption of TXA, the efficacy of drains was a subject of debate. A landmark meta-analysis by Parker et al reviewed 18 randomized trials involving nearly 3,500 patients. They found that while drains reduced the frequency of dressing reinforcements, they were associated with a statistically significant increase in transfusion requirement (relative risk 1.43).[5] The study concluded there was insufficient evidence to support the routine use of drains.

Further concerns regarding infection were highlighted by Willemen et al, who demonstrated that drain tips cultured after 24 hours showed negligible bacterial growth, but those left for 48 hours had positive cultures in nearly 25% of cases, suggesting a risk of retrograde migration of skin flora into the deep joint space.[6]

Randomized controlled trials in the TXA era

Maniar et al conducted a prospective randomized controlled trial involving 105 patients undergoing unilateral TKA, all of whom received TXA. Patients were randomized to receive a 10G drain, a 12G drain, or no drain. The study found no significant difference in total blood loss (706-770 ml) or transfusion rates between the groups. Interestingly, the study noted that morphine consumption in the first 6 hours was significantly lower in the drain groups (4.1-4.4 mg) compared to the no-drain group (6.5 mg, $p=0.036$), attributed to the reduction of intra-articular pressure. However, this analgesic benefit was transient and did not translate to differences in pain scores, range of motion, or functional outcomes (new knee society score) at 1-year follow-up.[7]

Wang et al reported better early range of motion recovery in patients treated without drains, likely due to reduced tethering and earlier participation in physical therapy.[8] In their prospective randomized controlled study of 80 patients, closed suction drainage was not associated with faster recovery after TKA.

Yang et al conducted a prospective, randomized study to evaluate further the efficacy of closed-suction drainage in TKA and discovered that there were no discernible variations in the medical results of patients who were equipped with a drain compared to those who were not.[9]

Retrospective cohort studies and large-scale analyses

A larger retrospective study by Albasha et al evaluated 262 patients, comparing outcomes between those with and without drains. The findings were striking: the drain group had a significantly longer hospital stay (10.7 versus 5.4 days, $p<0.001$), greater hemoglobin drop (1.8 versus 1.2 g/dl), and higher transfusion rates (0.18 versus 0.04 units). Notably, in the sub-group analysis of patients receiving TXA, the drug reduced drain output by approximately 75% (82.1 ml versus 381 ml), highlighting the efficacy of TXA in minimizing the very fluid that drains are meant to evacuate.[10]

Chen et al analyzed 1,477 TKA procedures and found that even with TXA, the drain group experienced greater total

blood loss and hidden blood loss compared to the no-drain group. They concluded that drains nullified some of the blood-saving benefits of TXA by disrupting the tamponade effect of the closed joint.[11]

Xu et al demonstrated in their retrospective cohort study that closed suction drainage following routine primary total joint arthroplasty is associated with a higher transfusion rate and longer postoperative length of stay.[12]

Systematic reviews and meta-analyses

Zhang et al conducted a systematic review and meta-analysis questioning whether closed suction drains are necessary for primary TKA.[13] Their comprehensive analysis of multiple studies reinforced concerns about routine drain usage.

Yang et al specifically examined closed suction drainage in the context of TXA administration in Chinese patients, concluding that drainage offers no more clinical benefit than non-drainage after primary TKA.[14]

Li et al provided a comprehensive review of the impact of TXA on blood loss management in primary TKA, highlighting the paradigm shift in perioperative blood management.[15]

Comparative outcomes summary

It is given in Table 1.

Table 1: Summary of key studies comparing drain versus no drain in the TXA era.

Study	Design	Sample size	TXA protocol	Key findings
Maniar et al (2019)	RCT	105	IV + intra-articular	Reduced opioid use 0-6 hours with drain. No difference in blood loss, infection, or 1-year function.
Albasha et al (2023)	Retrospective	262	Variable	No-drain group: shorter LOS (5.4 versus 10.7 days), less Hb drop, fewer transfusions.
Chen et al (2016)	Retrospective	1,477	Intra-articular	Drains associated with greater total and hidden blood loss despite TXA.
Wang et al (2016)	RCT	80	IV	Better ROM and straight leg raise recovery in no-drain group. Comparable blood loss.

RCT=Randomized controlled trial; TXA=tranexamic acid; IV=intravenous; LOS=length of stay; Hb=hemoglobin; ROM=range of motion

Additional supporting evidence

Multiple studies have corroborated these findings across different populations and settings.

Watanabe et al conducted a prospective study on simultaneous bilateral surgeries with a mean follow-up of 5.5 years, concluding that closed suction drainage is not necessary for total knee arthroplasty.[16]

Yin et al found no beneficial effects of tourniquet and closed-suction drains on bleeding management and knee function at a higher cost.[17]

Demirkale et al demonstrated that non-drainage decreases blood transfusion need and infection rate in bilateral total knee arthroplasty.[18]

Poeran et al conducted a population-based study using national data on knee arthroplasties, examining the utilization of drains and association with outcomes. They concluded that the usage of drains declined from 2006 to 2016 by around 17.4%, and drain usage was associated with higher transfusion rates.[19]

de Andrade et al followed patients for six months after TKA with and without placement of suction drainage devices and found no statistically significant differences between the groups regarding knee circumference, hemoglobin, hematocrit, transfusion rate, or infection index.[20]

DISCUSSION

Paradigm shift: from mechanical to pharmacological hemostasis

The accumulating evidence suggests a paradigm shift in postoperative TKA management. The routine use of drains appears to be a vestige of the pre-TXA era. Tranexamic acid, a synthetic derivative of the amino acid lysine, exerts its antifibrinolytic effect by competitively blocking the lysine-binding sites on plasminogen molecules.[21] This action prevents plasmin formation, thereby inhibiting fibrinolysis and stabilizing clots formed during surgery.

The efficacy of TXA in TKA is well-established across multiple administration routes. It can be administered via intravenous (IV), topical (intra-articular), or oral routes. A common protocol involves administering 10-15 mg/kg IV prior to tourniquet deflation, often combined with a topical application of 1-3 g. Meta-analyses have consistently demonstrated that TXA reduces total blood loss by approximately 40-60% and significantly lowers transfusion requirements without increasing the risk of thromboembolic events such as deep vein thrombosis (DVT) or pulmonary embolism (PE).[14,22]

Seol et al confirmed the effect of tranexamic acid on blood loss and blood transfusion reduction after TKA.[22] Tille et al specifically examined intra-articular use of TXA, demonstrating that it reduces blood loss and transfusion rates in primary TKA.[23] Oehlke reviewed the impact of TXA on blood loss and need for transfusion in total joint arthroplasty, while Kim et al examined current evidence for TXA in the prevention and management of orthopedic surgical hemorrhage.[24,25]

Zhang et al conducted a meta-analysis of multi-route applications of TXA to reduce blood loss in TKA, further supporting the versatility and efficacy of this pharmacological approach.[26]

Given its robust safety profile and efficacy, TXA has shifted the focus from mechanical blood evacuation (drains) to pharmacological bleeding prevention. This biochemical hemostasis challenges the mechanical necessity of drains.

Reconsidering the historical rationale for drains

The historical rationale for using drains in TKA was grounded in the "prevention is better than cure" philosophy regarding hematomas. A postoperative hematoma can increase tension on the wound, potentially leading to skin necrosis, dehiscence, and subsequent periprosthetic joint infection (PJI).[27] Furthermore, large hematomas were thought to impede rehabilitation by increasing pain and limiting flexion.

Commonly used systems include 10G or 12G closed suction catheters or Hemovac systems, typically removed 24 to 48 hours postoperatively. Proponents argued that visible output allowed for monitoring of active bleeding. However, much of the supportive literature for drains predates modern blood management techniques, relying on data from an era when substantial postoperative bleeding was inevitable.[28]

Aksoy et al examined the efficacy of closed suction drains for the prevention of wound complications after primary TKA, while Sharma et al questioned whether the use of closed suction drains after primary TKA represents an overrated practice.[3,4]

These studies began to challenge the long-held assumptions about drain necessity.

Iseki et al and Sheng et al provided early comparative data between closed suction drainage and non-drainage in TKA, setting the stage for more comprehensive investigations in the modern era.[27,28]

Adverse effects associated with drain use

The current evidence reveals several disadvantages associated with routine drain placement.

Increased blood loss

Contrary to traditional beliefs, drains may paradoxically increase total blood loss by eliminating the tamponade effect that naturally occurs in a closed joint space. Good et al demonstrated that while tranexamic acid decreases external blood loss, it does not reduce hidden blood loss in TKA.[21] When drains are placed, this protective tamponade effect is compromised, potentially leading to greater overall blood loss despite reduced visible drainage. Al-Zahid and examined this issue in their review of closed suction drains, reinfusion drains, and no drains in primary total knee replacement.[29]

Infection risk

Drains may serve as a conduit for retrograde bacterial migration. Minnema et al identified risk factors for surgical-site infection following primary TKA, with prolonged drain placement emerging as a modifiable risk factor.[30]

Impaired mobilization and recovery

The physical presence of a drain can interfere with early mobilization protocols, which are crucial for optimal recovery. Enhanced recovery after surgery (ERAS) protocols emphasize rapid mobilization to prevent complications and reduce length of stay. Drains create a physical tether that may delay ambulation and physical therapy participation.

Economic burden

Economic implications are significant. Drains entail direct costs for the device and indirect costs related to nursing time for monitoring and removal, as well as costs associated with treating drain-related complications such as breakage or retention. Bjerke-Kroll et al quantified the increased total cost associated with post-operative drains in total hip and knee arthroplasty, demonstrating substantial financial implications for healthcare systems.[31]

Clinical practice implications

Discontinuing drain use offers several clinical and economic advantages in the modern TKA setting.

Simplified postoperative care

Eliminating drains simplifies postoperative care and reduces nursing workload related to drain maintenance, output recording, and removal procedures.

Enhanced recovery protocols

The absence of drains facilitates "fast-track" or enhanced recovery after surgery (ERAS) protocols by removing physical tethers to the patient, thereby encouraging immediate mobilization. Carr et al provided

comprehensive guidance on knee replacement, emphasizing the importance of early mobilization in achieving optimal outcomes.[32]

Cost-effectiveness

Cost savings are twofold: the immediate reduction in surgical supply costs and the potentially substantial savings associated with reduced hospital length of stay and transfusion requirements. The reduced length of stay observed in no-drain groups (5.4 versus 10.7 days in the Albasha study, as quoted earlier) represents significant cost savings for healthcare systems.

Patient satisfaction

Woolhead et al examined outcomes of total knee replacement from a qualitative perspective, revealing that patients value early mobilization and reduced medical device burden during recovery.[33]

Transient analgesic benefit: clinical significance

The only consistently identified benefit of drain use in the TXA era—a modest reduction in opioid consumption during the first 6 hours postoperatively—deserves critical evaluation. This finding from the Maniar et al study may be attributed to reduced intra-articular pressure.[7] However, this benefit must be weighed against: the transient nature of the effect (limited to the first 6 hours), the availability of multimodal pain management strategies, the absence of differences in overall pain scores or functional outcomes, and the potential for increased complications and costs associated with drain use.

In the context of comprehensive multimodal analgesia protocols commonly employed in modern arthroplasty, this minimal and temporary benefit does not justify routine drain placement.

Special populations and risk stratification

While current evidence strongly supports abandoning routine drainage in standard primary TKA, certain patient populations warrant special consideration.

Anticoagulation and coagulation disorders

Patients on chronic anticoagulation or those with coagulation disorders are often excluded from standard trials. Parvizi et al examined whether "excessive" anticoagulation predisposes to periprosthetic infection, highlighting the complex interplay between bleeding management and infection risk in these populations.[34]

Revision and complex primary cases

The current review focuses on routine primary TKA. Revision arthroplasty or complex primary cases requiring structural allografts may represent scenarios where drainage could still be considered, though evidence remains limited**.**

Limitations of current evidence

Current literature is not without limitations.

Study design heterogeneity

Many studies are retrospective in nature, which introduces selection bias. Surgeons may be more likely to place drains in complex cases or those with higher perceived bleeding risk, creating confounding variables that are difficult to account for in retrospective analyses.

TXA protocol variability

There is significant heterogeneity in TXA protocols (dosage, timing, route) across studies, complicating direct comparisons. Standardized protocols would enhance the quality of comparative evidence.

Geographic and population differences

Most large studies come from specific geographic regions, and results may not be universally generalizable to all populations. Mahomed et al examined the epidemiology of total knee replacement in the United States Medicare population, but international variations in practice patterns and patient demographics may influence outcomes.[35]

Long-term outcome data

While short-term outcomes (blood loss, transfusion rates, hospital stay) are well-documented, longer-term functional outcomes and patient-reported outcome measures require further investigation.

Future research directions

Future research should address several key areas.

Prospective multi-center trials

Large-scale, multi-center prospective trials with standardized TXA protocols would definitively settle the debate for both standard and high-risk populations.

High-risk subgroup analysis

Dedicated studies focusing on patients with coagulation disorders, chronic anticoagulation, or revision procedures are needed to determine if selective drain use is warranted in these populations.

Cost-effectiveness analysis

Comprehensive cost-effectiveness analyses incorporating modern ERAS protocols would provide valuable data for

hospital administration policy-making and healthcare system optimization.

Patient-reported outcomes

Long-term patient-reported outcome measures and quality of life assessments would provide a more complete picture of the impact of drain elimination on overall recovery and satisfaction.

Optimal TXA protocols

Further research into optimal TXA dosing, timing, and administration routes could maximize the benefits of pharmacological hemostasis and further reduce any theoretical need for mechanical drainage.

CONCLUSION

The era of TXA has fundamentally altered the risk-benefit profile of negative suction drains in TKA. Strong evidence indicates that when TXA is used, drains provide no benefit in preventing infection or hematoma, while contributing to increased hidden blood loss, higher transfusion rates, and prolonged hospital stays. The only identifiable benefit—a transient reduction in immediate postoperative pain—is clinically negligible in the context of multimodal pain management.

Therefore, the routine use of negative suction drains in primary TKA should be abandoned when tranexamic acid is administered. This change in practice is justified by current evidence, aligning with the goals of minimizing complications, reducing costs, and enhancing patient recovery.

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