Original Article

Comparison of Pulsed Lavage Versus Manual Pressurised Lavage in Preventing Postoperative Infection Rate in Total Knee Arthroplasty

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ABSTRACT

Objective: To compare the effectiveness of pulsed lavage versus manual pressurized lavage in preventing postoperative infection, as measured by CRP levels and clinical outcomes, in patients undergoing TKA.

Study Design: Prospective observational cohort study

Place and Duration of Study: This study was conducted at the Shifa International Hospital Islamabad during August 2024 till January 2025.

Methods: A total of 173 patients undergoing TKA were included and divided into two groups based on the type of lavage used: pulsed lavage (n = 87) and manual pressurized lavage (n = 86). Data were collected using validated questionnaires during hospitalization and follow-up visits. CRP levels were recorded on postoperative Day 3, Week 2, and Week 6. Clinical signs of infection and recovery parameters were also assessed.

Results: CRP elevations were observed in 6 patients (3 in each group), with no significant differences in mean CRP levels at any time point ($p > 0.05$). No clinical infections were reported in either group. Healing time, pain scores, and patient satisfaction were comparable between groups. There were no statistically significant differences in postoperative outcomes or infection-related markers.

Conclusion: It is concluded that pulsed lavage and manual pressurized lavage are equally effective in preventing postoperative infections in TKA. Both techniques demonstrated similar inflammatory responses and recovery outcomes. Therefore, the choice of lavage method may be guided by availability, cost, and surgeon preference rather than clinical advantage.

Key Words: Total knee arthroplasty, pulsed lavage, manual pressurized lavage, postoperative infections, C-reactive protein, infection prevention.

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INTRODUCTION

Total Knee Arthroplasty is a definitive treatment procedure for restoring complete function in patients with advanced knee osteoarthritis. There has been an increased demand for surgeries preserving mobility in an aging population[1].

Total knee arthroplasty delivers important benefits yet patients face major difficulties from postoperative complications particularly infections which result in extended hospitalization and the requirement of implant revisions or potentially lead to implant failure[2]. Total knee arthroplasty stands as a common surgical intervention which treats end-stage knee pain and functional limitations that stem from osteoarthritis disease. The combination of innovative surgical approaches together with advanced prosthetic development and improved operative management has enhanced the outcomes of total knee arthroplasty[3]. Among total knee arthroplasty-related complications periprosthetic joint infection stands as the most feared and damaging outcome[4]. The low rates of 0.5 to 2 percent do not eliminate the severe consequences of these infections since they extend hospital time and necessitate revision operations and higher healthcare expenses while decreasing patient life quality. The prevention of infections in total knee arthroplasty represents both an essential clinical obligation and a vital health system reliability mandate[5]. Intraoperative conditions provide surgeons with their main chance to reduce infection risks. Among many operative factors surgical site irrigation serves as a key mechanism for mechanical removal of blood and bone debris combined

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with microbial contamination[6]. Through proper irrigation, the microbial load decreases and stops bacterial biofilms from forming while these biofilms demonstrate resistance to antibiotics and the body's immune cleanup mechanisms. Two standard irrigation techniques exist for orthopedic surgical procedures. Two common surgical site irrigation techniques include pulsed lavage and manually pressurized lavage. Operating devices produce intermittent bursts of high-pressure fluid delivery for pulsed lavage procedures[7]. Deep tissue purifications benefit from this method which combines efficient contaminant removal with minimization of tissue-damaging pulsatile flow effects. The controlled pressure settings on pulsed lavage systems produce uniform debridement output that potentially improves the surgical area's cleanliness.

Patients receive irrigation solutions through syringes and gravity-assisted bags as components of manually pressurised lavage. Although affordable and easy to use the manual pressurised lavage system faces problems with inconsistent surgical practices and unpredictable pressure delivery and operator fatigue[8]. Manual lavage is favored by surgeons because the procedures minimize soft tissue damage and generates no mechanical sounds that might disturb the operating room[9]. Although orthopedic centers utilize these methods persistently for total knee arthroplasty infection prevention the available evidence fails to demonstrate clear superiority of one technique over the other[10]. Laboratory studies and revision arthroplasty research show mechanical cleaning benefits from pulsed lavage while primary knee arthroplasty clinical outcomes remain poorly documented in this area. The available research faces critical limitations through its small sample sizes as well as retrospective designs and insufficient long-term follow-ups which compromises its general clinical use[11].

METHODS

This Prospective observational cohort study was conducted at Shifa International Hospital Islamabad during August 2024 till January 2025.

Inclusion criteria

- Patients undergoing total knee arthroplasty (TKA) for osteoarthritis, rheumatoid arthritis, or other joint-degenerative conditions
- Patients must receive either pulsed lavage or manual pressurized lavage during surgery as the primary irrigation technique
- Patients with complete postoperative records post-surgery to monitor infection status.

Exclusion criteria

- Patients with a pre-existing infection in or around the knee joint before surgery.
- Patients with known immunodeficiencies, such as HIV/AIDS, active chemotherapy, or other conditions affecting immune function.
- Patients with missing or incomplete postoperative records, making it impossible to assess infection outcomes accurately.
- Patients with known allergies to solutions used in either lavage method.

Data collection: Data were collected using a structured, pre-validated questionnaire administered to patients during hospitalization and at follow-up visits. The questionnaire included both objective clinical outcomes and patient-reported measures. Demographic information, comorbidities, and the type of lavage used were recorded at baseline. Participants were divided into two groups based on the type of intraoperative irrigation method used:

- Group A (n = 87): Underwent intraoperative pulsed lavage.
- Group B (n = 86): Received manual pressurised lavage.

All procedures were carried out by the Orthopedic Department at Shifa International Hospital Islamabad. One surgical team used pulse lavage, while the other used manual pressurized lavage, both following the same standard protocols to minimize variability. Although the same surgical approach—a standard medial parapatellar approach—was used in all cases, the type of anesthesia varied. Most procedures were performed under spinal anesthesia, but some patients received spinal combined with general anesthesia, spinal with epidural, or other combinations as clinically indicated. Cemented, posterior-stabilized prostheses were used in all cases. Both groups received prophylactic intravenous antibiotics (Zinacef 1.5g) administered preoperatively and continued for 24 hours postoperatively. Postoperatively, the questionnaire captured signs and symptoms of surgical site infection, such as redness, warmth, discharge, and fever, as reported by the patient and corroborated by clinical examination. Data on pain levels, wound healing time, satisfaction, complications, and any subsequent interventions or readmissions were also collected.

Statistical Analysis: Data were analyzed using SPSS v26. Categorical data such as infection rates and complication frequencies were compared using the Chi-square test. Continuous variables including pain scores and healing times were compared using independent t-tests. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Data were collected from 173 patients. The mean age in the pulsed lavage group was 66.4 ± 7.8 years, while in the manual lavage group it was 67.1 ± 8.1 years ($p = 0.51$). Gender distribution was balanced, with males comprising 48.3% (n = 42) and females 51.7% (n = 45) in the pulsed lavage group, compared to 47.7% (n = 41) males and 52.3% (n = 45) females in the manual lavage

group (p = 0.88). The prevalence of diabetes was 23.0% (n = 20) in the pulsed group and 24.4% (n = 21) in the manual group (p = 0.72), while hypertension was present in 45.9% (n = 40) and 44.2% (n = 38) of patients, respectively (p = 0.79).

Table No.1: Baseline Demographic and Clinical Characteristics

Characteristic	Pulsed Lavage (n = 87)	Manual Lavage (n = 86)	p-value
Mean age (years)	66.4	67.1	0.51
Male, n (%)	42 (48.3%)	41 (47.7%)	0.88
Female, n (%)	45 (51.7%)	45 (52.3%)	0.88
Diabetes, n (%)	20 (23.0%)	21 (24.4%)	0.72
Hypertension, n (%)	40 (45.9%)	38 (44.2%)	0.79

Table No.2: Postoperative CRP Levels in Pulsed Lavage vs. Manual Lavage Groups

Time Point	Pulsed Lavage (Mean ± SD)	Manual Lavage (Mean ± SD)	p-value
Day 3	47.8 ± 11.9	48.1 ± 12.3	0.89
Week 2	21.3 ± 7.6	21.7 ± 8.0	0.83
Week 6	7.1 ± 3.0	7.4 ± 3.5	0.77

On Day 3, the mean CRP level was 47.8 ± 11.9 mg/L in the pulsed lavage group and 48.1 ± 12.3 mg/L in the manual lavage group (p = 0.89). At Week 2, levels declined to 21.3 ± 7.6 mg/L and 21.7 ± 8.0 mg/L, respectively (p = 0.83). By Week 6, CRP levels further decreased to 7.1 ± 3.0 mg/L in the pulsed group and 7.4 ± 3.5 mg/L in the manual group (p = 0.77).

Out of 173 patients, only six exhibited elevated CRP levels postoperatively, with three cases (3.4%) in the pulsed lavage group and three cases (3.5%) in the manual lavage group. Importantly, no clinical infections were observed in either group during the follow-up period.

Table No.3: Patients with Elevated CRP and Clinical Infection Incidence

Group	Patients with Elevated CRP (n, %)	Clinical Infections Observed (n, %)
Pulsed Lavage	3 (3.4%)	0 (0.0%)
Manual Lavage	3 (3.5%)	0 (0.0%)

The mean healing time was 14.6 ± 2.9 days in the pulsed lavage group and 14.9 ± 3.1 days in the manual lavage group. Pain scores at Week 6 were also similar, with averages of 2.3 ± 1.1 and 2.5 ± 1.2, respectively. Patient satisfaction scores were high in both groups, measured at 8.9 ± 0.6 for pulsed lavage and 8.7 ± 0.7 for manual lavage (Figure 1).

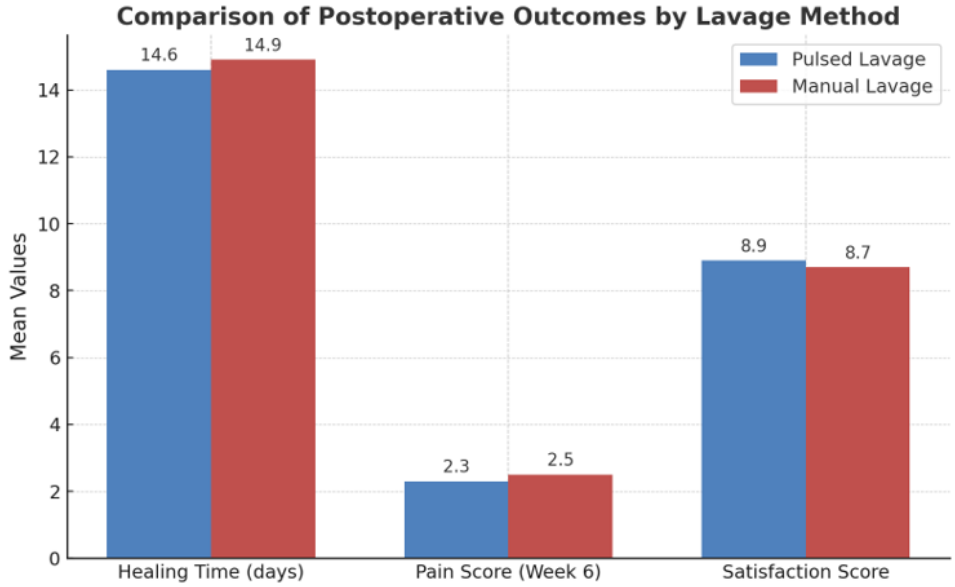

Figure No.1: Postoperative Outcomes and Patient Recovery

DISCUSSION

The present study aimed to compare the efficacy of pulsed lavage and manual pressurized lavage in reducing postoperative inflammatory markers and infection rates among patients undergoing total knee arthroplasty. Postoperative CRP measurements revealed minimal elevations in a subgroup of patients from each group with no significance detected between lavage

methods for CRP assessments or clinical recovery metrics. Clinical measurements of systemic inflammatory response through CRP values remain similar between patients in Day 3, Week 2 and Week 6 assessments regardless of irrigation method. Pulsed lavage did not demonstrate superior debris removal or lower bacterial levels when compared to manual lavage according to research from previous laboratory and animal model studies[12]. The theoretical advantages identified from experimental studies did not lead to corresponding differences in infection rates or change inflammatory markers such as CRP when tested on clinical patients. Elevations in CRP cannot be used to determine clinical infection because findings from six patients showed clinical infection did not develop despite elevated CRP[13]. Thus, mild CRP elevations postoperatively require interpretation with additional clinical indicators. Both techniques showed comparable results related to patient satisfaction and healing times and postoperative pain scores for the patients undergoing these procedures. This indicates that TAL nicely matches PL for surgical wound management. Multiple recent clinical trials have shown identical outcomes regarding periprosthetic joint infection prevention between different lavage techniques and our study aligns with this clinical evidence[14]. Aljaafri et al. (2021) and Bottner et al. (2020) conducted studies where pulsed lavage proved equally effective to manual irrigation for orthopedic procedure infection prevention. The usefulness of these research results supports decisions about surgical organization and budget management[15]. While pulsatile lavage is widely used for wound irrigation, especially in orthopedic and trauma settings, several concerns have been raised regarding its safety in soft tissue management. High-pressure pulsatile lavage has been shown in vitro to cause significant bone damage and intramedullary bacterial dissemination in contaminated tibial fractures[13]. Reports also document the risk of air embolism during pulsed saline lavage of pelvic fractures, and inadvertent air introduction into muscle tissue can lead to perioperative complications. Moreover, recent studies suggest that high-pressure lavage may drive bacteria deeper into soft tissues, potentially increasing the risk of infection. Although the extent of bacterial penetration into deeper layers remains unclear, the mechanical force of lavage at pressures as low as 0.14 N/mm² has been associated with irreversible tissue injury, including myonecrosis and dystrophic calcification in animal models[16]. The limitations of this study include its non-randomized design, which may introduce selection bias as group allocation depends on the operating surgeon's standard practice. Additionally, while CRP is a useful marker of inflammation, it is non-specific and may not fully reflect localized infection risks.

CONCLUSION

It is concluded that there is no significant difference between pulsed lavage and manual pressurized lavage in terms of reducing postoperative infection rates and CRP levels in patients undergoing total knee arthroplasty. Both irrigation techniques demonstrated similar clinical outcomes, including comparable healing times, pain levels, and patient satisfaction scores. Although pulsed lavage has been suggested to offer theoretical advantages in surgical decontamination, this study did not find any clinical superiority over manual lavage within the observed follow-up period.

Author's Contribution:

Concept & Design or acquisition of analysis or interpretation of data:	Raja Ehtesham Ul Haq Khan, Zohaib Nadeem, Sajjad Hassan Orakzai
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Final Approval of version:	All the above authors
Agreement to accountable for all aspects of work:	All the above authors

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