e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(8); 907-913

Original Research Article

Effect of Standard versus Individualized Low Tourniquet Pressure on Pain, Functional Outcome, and Complications in Total Knee Arthroplasty: A Prospective Randomized Comparative Study

Pramod G.[1], Prajwal J.[2], Narendra B. S.[3]

[1]Assistant Professor, Department of Orthopaedics, Nandi Medical College and Research Institute, Chikkaballapur, Karnataka, India

[2]Assistant Professor, Department of Orthopaedics, Nandi Medical College and Research Institute, Chikkaballapur, Karnataka, India

[3]Assistant Professor, Department of Orthopaedics, Nandi Medical College and Research Institute, Chikkaballapur, Karnataka, India

Received: 01-05-2026 / Revised: 15-06-2026 / Accepted: 21-07-2026

Corresponding author: Dr. Narendra B S

Conflict of interest: Nil

Abstract

Background: The pneumatic tourniquet is widely employed in Total Knee Arthroplasty (TKA) to establish a bloodless surgical field and facilitate cemented implant fixation. However, conventional empirical reliance on fixed high cuff pressures (e.g., 350 mmHg) frequently leads to thigh pain, quadriceps neuropraxia, localized tissue ischemia, and delayed postoperative rehabilitation. This prospective randomized study was designed to compare postoperative pain, functional recovery, and perioperative complications between a fixed high tourniquet pressure (350 mmHg) and a patient-specific lower tourniquet pressure tailored to baseline systolic blood pressure (SBP + 100 mmHg).

Methods: A prospective, randomized, comparative clinical study was conducted in the Department of Orthopaedics at Nandi Medical College & Research Institute from April 2025 to April 2026. Thirty adult patients (mean age: 62.33 ± 4.72 years) undergoing primary unilateral or bilateral TKA for end-stage osteoarthritis were randomly allocated into two groups: Group A (tourniquet inflated to fixed 350 mmHg, n = 15) and Group B (tourniquet inflated to patient-specific SBP + 100 mmHg, n = 15). The primary outcome was postoperative pain measured by the Visual Analogue Scale (VAS) at postoperative day 2 (POD 2), week 2 (POW 2), week 4 (POW 4), and month 2 (POM 2). Secondary outcomes included functional rehabilitation evaluated by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Knee Society Score (KSS), intraoperative blood loss, operative duration, hospital stay, and adverse complications.

Results: Results: Mean tourniquet pressure was lower in Group B (226.67 ± 8.16 vs 350.00 ± 0.00 mmHg, $p < 0.0001$). Group B demonstrated significantly lower VAS pain on Day 2 (5.43 ± 0.37 vs 6.73 ± 0.46, $p < 0.0001$) and Week 2 (4.47 ± 0.40 vs 5.40 ± 0.57, $p < 0.0001$). Functional recovery was superior in Group B, with lower WOMAC (75.73 vs 83.53 at Day 2; 67.27 vs 75.80 at Week 2, $p < 0.0001$) and higher KSS (64.00 vs 56.60 at Day 2; 72.40 vs 66.93 at Week 2, $p < 0.0001$). Scores equalized by Week 4 and Month 2. Group B had slightly higher blood loss (218.67 vs 190.00 mL, $p = 0.0001$) without transfusion requirement. Thigh pain incidence was lower in Group B (6.7% vs 20.0%, $p = 0.598$).

Conclusion: Individualizing pneumatic tourniquet pressure to baseline systolic blood pressure (SBP + 100 mmHg) during TKA significantly mitigates early postoperative pain and promotes faster functional recovery during the crucial first 2 weeks, while maintaining excellent surgical field visibility and operative safety. Routine adoption of patient-specific systolic-based tourniquet pressures is recommended in total knee arthroplasty.

Keywords: Total Knee Arthroplasty (TKA); Pneumatic Tourniquet; Tourniquet Pressure; Postoperative Pain; Visual Analogue Scale; WOMAC Index; Knee Society Score; Fast-Track Rehabilitation; Ischemia-Reperfusion.

DOI: 10.25258/ijcpr.18.8.139

Introduction

Total knee arthroplasty (TKA) has emerged as one of the most successful, reliable, and cost-effective orthopaedic surgical interventions of modern medicine, restoring mobility, relieving pain, and

substantially improving health-related quality of life for millions of individuals suffering from debilitating end-stage osteoarthritis worldwide [1, 2]. In India, with an expanding aging demographic, heightened functional demands, and increasing longevity, the annual volume of primary total knee replacements has grown exponentially over the past decade [3]. The paramount objectives of contemporary arthroplasty pathways focus not solely on implant survivorship and mechanical alignment, but increasingly on minimizing perioperative morbidity, controlling acute postoperative pain, accelerating functional rehabilitation, and facilitating rapid hospital discharge within Enhanced Recovery After Surgery (ERAS) protocols [4, 5].

A cornerstone of conventional TKA surgical technique has long been the routine application of a pneumatic thigh tourniquet. The pneumatic tourniquet serves several undeniable intraoperative benefits: it establishes a bloodless surgical field, improves anatomical visualization of crucial neurovascular and soft-tissue structures, simplifies precise bone resections, prevents blood contamination at the cancellous bone interface during polymethylmethacrylate (PMMA) cementation, and enhances initial prosthesis-cement interlock [6, 7]. Historically, tourniquets have been applied using standardized, arbitrary, and empirical high cuff pressures—most commonly set at a fixed 300 to 350 mmHg for lower limb procedures regardless of the patient's body habitus, limb circumference, or vascular physiology [8, 9].

Despite its undeniable utility, the indiscriminate use of excessive tourniquet inflation pressures is accompanied by a spectrum of mechanical and metabolic complications [10, 11]. Bruner's landmark principles and subsequent modifications by Klenerman emphasize that the safe use of tourniquets requires the lowest effective pressure necessary to achieve hemostasis [12, 13]. High compressive cuff pressures exert direct mechanical crushing forces on the underlying quadriceps muscle belly and compress the femoral, sciatic, and lateral femoral cutaneous nerves against the femoral shaft [14]. This focal mechanical compression, combined with distal microvascular ischemia and subsequent reperfusion injury, results in quadriceps inhibition, severe localized thigh pain, delayed motor recovery, muscle edema, wound complications, and increased analgesic consumption during the acute postoperative period [15, 16]. To mitigate these pressure-induced adverse sequelae, personalized pressure regimens have been proposed, wherein tourniquet inflation is calculated dynamically based on the patient's preoperative or intraoperative systemic blood pressure—specifically setting the inflation pressure to systolic blood pressure (SBP) plus a standardized safety margin (e.g., SBP + 100 mmHg) [17, 18]. While individual trials in western cohorts have suggested potential benefits of lower tourniquet pressures, there remains a paucity of structured, prospective clinical evidence from Indian tertiary academic centers assessing whether a patient-specific SBP-based pressure protocol (SBP + 100 mmHg) provides demonstrable pain reduction and accelerated early functional recovery compared to the widely practiced fixed 350 mmHg setting in our population [19, 20].

Therefore, this prospective randomized comparative study was conducted at Nandi Medical College & Hospital to evaluate and compare postoperative pain (Visual Analogue Scale), early and intermediate functional outcomes (WOMAC Index and Knee Society Score), intraoperative blood loss, operative duration, and perioperative complications in patients undergoing primary total knee arthroplasty using fixed high tourniquet pressure (350 mmHg) versus patient-specific systolic-based tourniquet pressure (SBP + 100 mmHg).

Materials and Methods

Study Design and Ethical Approval: This study was designed as a prospective, parallel-group, single-center randomized comparative clinical trial conducted in the Department of Orthopaedics, Nandi Medical College & Research Institute, Chikkaballapura, Karnataka, India. The study protocol was reviewed, approved by the Institutional Ethics Committee. Written, voluntary, informed consent was obtained from all participating patients prior to enrollment and randomization.

Study Duration and Patient Selection: The study was conducted over a 10-month active recruitment period from April 2025 to April 2026, with structured postoperative follow-up extending through March 2026 to ensure a minimum 2-month post-discharge evaluation for all participants. Adult patients presenting to the Orthopaedic Outpatient Department with advanced, symptomatic, primary or secondary osteoarthritis of the knee who were scheduled for elective primary total knee arthroplasty were screened for eligibility.

Inclusion and Exclusion Criteria: Patients were included based on the following criteria: (1) Age between 50 and 70 years; (2) Either gender; (3) Diagnosis of end-stage tricompartmental or severe bicompartmental osteoarthritis of the knee (Ahlbäck Grade III–V or Kellgren-Lawrence Grade 3–4); (4) Severe functional limitation unresponsive to at least 6 months of comprehensive conservative management; (5) Patients undergoing primary unilateral or bilateral TKA (single-stage or staged).

For bilateral cases, averaged parameters were utilized for quantitative continuous metrics.

Exclusion criteria comprised: (1) Patients with uncontrolled systemic hypertension (baseline systolic blood pressure > 200 mmHg or diastolic blood pressure > 110 mmHg); (2) Documented history of deep vein thrombosis (DVT) or pulmonary thromboembolism; (3) Peripheral arterial occlusive disease (absent peripheral pulses, ankle-brachial index < 0.9); (4) Severe morbid obesity (Body Mass Index > 35 kg/m²); (5) Active local cutaneous infection, ulceration, or severe dermatitis over the operative limb or thigh; (6) Prior history of knee sepsis or osteomyelitis; (7) Post-traumatic periprosthetic fractures or patients undergoing revision TKA; (8) Neoplastic bone lesions involving the distal femur or proximal tibia; (9) Pre-existing severe neurological deficits or motor neuropathy of the lower extremity.

Randomization: Eligible, consenting patients were allocated in a 1:1 ratio using block randomization generated in Microsoft Excel. Random numbers were assigned to each treatment sequence, ranked, and sorted to generate the final allocation sequence, ensuring equal group sizes.

Patients were allocated to Group A (tourniquet pressure 350 mmHg) or Group B (tourniquet pressure SBP + 100 mmHg).

Preoperative Assessment and Surgical technique: All patients underwent rigorous preoperative clinical, hematological, biochemical, and radiological evaluations (full-length weight-bearing scanograms, anteroposterior and lateral knee radiographs). Preoperative templating and medical optimization were performed. Baseline blood pressures were measured on the morning of surgery following 15 minutes of quiet resting.

Surgical Technique: After induction of anesthesia, a pneumatic tourniquet was applied at the root of the thigh over orthopaedic cotton padding to protect the skin. Surgery was performed via an anterior midline or medial parapatellar approach with patellar eversion, using either a cruciate-retaining or cruciate-sacrificing technique.

Femoral and tibial bone cuts were made using standard jigs, trial implants were assessed for soft-tissue balance, and definitive components were cemented after thorough pulse lavage. The patella was denervated, and synovectomy was performed as needed. A suction drain was placed, the wound closed in layers with skin staples, and a compression dressing applied from mid-thigh to mid-tibia before tourniquet deflation.

Postoperative analgesia was provided via epidural catheter infusion (for bilateral TKA, established preoperatively with spinal anesthesia) or femoral nerve catheter infusion (for unilateral TKA). All patients received perioperative antibiotic prophylaxis with intravenous ceftriaxone and followed by ceftriaxone for 3 days (unilateral) or 5 days (bilateral). Systemic analgesia consisted of intravenous paracetamol and tramadol, and thromboprophylaxis with subcutaneous enoxaparin was initiated 6 hours postoperatively and continued through hospital stay with oral conversion at discharge.

Dressings were changed and drains removed 48 hours postoperatively. Physiotherapy with full weight-bearing ambulation using walker support and gentle knee range-of-motion exercises began 24 hours postoperatively. Patients were followed up at 2 weeks (suture removal), 4 weeks, and 2 months, with radiographs obtained at 4 weeks and 2 months.

Outcome Measures: Clinical outcomes (thigh/knee pain, swelling, and surgical wound complications) and functional outcomes (VAS, WOMAC, and KSS) were assessed at the 2nd postoperative day and at 2, 4, and 8 (2 months) weeks postoperatively. The VAS is a 10-cm horizontal scale anchored by "no pain" and "worst pain ever," on which patients mark perceived pain intensity. The WOMAC assesses symptoms, stiffness, pain, and function/activities of daily living. The KSS comprises a knee score (pain, flexion contracture, extension lag, range of flexion, alignment, stability) and a function score (walking, stairs, use of walking aids).

Statistical Analysis: Data were entered in Microsoft Excel and analyzed using SPSS version 23.0. Qualitative variables were summarized as frequencies and percentages and compared using the chi-square test. Quantitative variables were summarized as mean ± standard deviation and compared using the unpaired t-test. A p-value <0.05 was considered statistically significant.

Results

A total of 30 patients undergoing primary total knee arthroplasty were enrolled, randomized, and completed the 2-month clinical follow-up without any loss to follow-up (Group A: n = 15; Group B: n = 15). The study flow is depicted in the CONSORT-style trial profile.

Baseline Demographic and Clinical Characteristics: Thirty patients completed the trial and 2-month follow-up (15 per group). Baseline demographics, including age (62.67 ± 4.88 vs 62.00 ± 4.71 years, p = 0.706), female predominance (66.7% vs 60.0%, p = 0.705), BMI (27.52 ± 1.23 vs 27.61 ± 0.96 kg/m², p = 0.831), surgical laterality, and comorbidities (diabetes, hypertension, hypothyroidism), were statistically comparable between groups (Table 1).

The mean tourniquet inflation pressure was significantly lower in Group B than Group A (226.67 ± 8.16 vs 350.00 ± 0.00 mmHg, p < 0.0001; Table 2). Operative duration (77.40 ± 4.29 vs 79.07 ± 4.01 min, p = 0.281), incision length (15.40 ± 0.83 vs 15.27 ± 0.78 cm, p = 0.653), and hospital stay (4.13 ± 0.64 vs 4.07 ± 0.59 days, p = 0.770) did not differ significantly.

While intraoperative blood loss was modestly higher in Group B (218.67 ± 16.85 vs 190.00 ± 17.22 mL, p = 0.0001), surgical visibility was consistently adequate and zero patients required blood transfusions.

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population (N = 30)

Parameter / Variable	Group A (350 mmHg) (n = 15)	Group B (SBP + 100) (n = 15)	Total (N = 30)	& p-value
Age (years), Mean ± SD	62.67 ± 4.88	62.00 ± 4.71	62.33 ± 4.72	p = 0.706 (NS)
Age Range (Min – Max)	55 – 70	54 – 70	54 – 70	--
Gender, Male / Female (n, %)	5 (33.3%) / 10 (66.7%)	6 (40.0%) / 9 (60.0%)	11 (36.7%) / 19 (63.3%)	p = 0.705 (NS)
Body Mass Index (kg/m²)	27.52 ± 1.23	27.61 ± 0.96	27.57 ± 1.08	p = 0.831 (NS)
Surgical Laterality (n, %)				p = 0.920 (NS)
• Right Unilateral TKA	7 (46.7%)	6 (40.0%)	13 (43.3%)	--
• Left Unilateral TKA	5 (33.3%)	6 (40.0%)	11 (36.7%)	--
• Bilateral TKA	3 (20.0%)	3 (20.0%)	6 (20.0%)	--
Diabetes Mellitus (n, %)	7 (46.7%)	8 (53.3%)	15 (50.0%)	p = 0.715 (NS)
Systemic Hypertension (n, %)	7 (46.7%)	6 (40.0%)	13 (43.3%)	p = 0.713 (NS)
Hypothyroidism (n, %)	3 (20.0%)	2 (13.3%)	5 (16.7%)	p = 0.624 (NS)

Note: Values expressed as Mean ± SD or frequency (percentage). NS = Not statistically significant (p > 0.05). SBP = Systolic Blood Pressure; TKA = Total Knee Arthroplasty.

Intraoperative and Perioperative Parameters: Table 2 outlines the intraoperative and perioperative characteristics of the study groups. The mean baseline resting systolic blood pressure in Group B was 126.67 ± 8.16 mmHg, yielding a calculated mean tourniquet inflation pressure of 226.67 ± 8.16 mmHg (range: 215–240 mmHg), which was markedly lower than the fixed 350 mmHg used in Group A (absolute reduction of 123.33 mmHg, p < 0.0001). The mean duration of surgery was 77.40 ± 4.29 minutes in Group A and 79.07 ± 4.01 minutes in Group B; this difference of 1.67 minutes was not statistically significant (t = -1.099, p = 0.281). Mean surgical incision length was also comparable between groups (15.40 ± 0.83 cm in Group A vs 15.27 ± 0.78 cm in Group B, t = 0.454, p = 0.653).

Intraoperative blood loss was significantly lower in Group A (190.00 ± 17.22 mL) compared to Group B (218.67 ± 16.85 mL), with an independent t-test confirming statistical significance (t = -4.609, p = 0.0001). The mean length of hospital stay was 4.13 ± 0.64 days in Group A versus 4.07 ± 0.59 days in Group B (t = 0.296, p = 0.770).

Table 2: Comparison of Intraoperative and Perioperative Parameters between Study Groups

Parameter	Group A (350 mmHg) (n = 15)	Group B (SBP + 100) (n = 15)	Mean Difference (95% CI)	p-value
Tourniquet Inflation Pressure (mmHg)	350.00 ± 0.00	226.67 ± 8.16	123.33 (119.0 to 127.6)	p < 0.0001*
Operative Duration (minutes)	77.40 ± 4.29	79.07 ± 4.01	-1.67 (-4.78 to 1.44)	p = 0.281 (NS)
Incision Length (cm)	15.40 ± 0.83	15.27 ± 0.78	0.13 (-0.47 to 0.73)	p = 0.653 (NS)
Intraoperative Blood Loss (mL)	190.00 ± 17.22	218.67 ± 16.85	-28.67 (-41.4 to -15.9)	p = 0.0001*
Length of Hospital Stay (days)	4.13 ± 0.64	4.07 ± 0.59	0.06 (-0.39 to 0.52)	p = 0.770 (NS)

Note: Values are expressed as Mean ± SD. CI = Confidence Interval; * = Statistically significant (p < 0.05); NS = Not statistically significant (p > 0.05).

Evaluation of Postoperative Pain (Visual Analogue Scale): Patients in Group B experienced significantly lower pain during the early postoperative period (Table 3). On POD 2, the mean VAS score was 5.43 ± 0.37 in Group B versus 6.73 ± 0.46 in Group A (p < 0.0001). This significant benefit persisted at POW 2 (4.47 ± 0.40 vs 5.40 ± 0.57, p < 0.0001). By POW 4 (3.43 ±

0.37 vs 3.73 ± 0.46, p = 0.059) and POM 2 (1.17 ± 0.45 vs 1.23 ± 0.50, p = 0.702), pain levels converged with no significant differences.

Table 3: Comparison of Longitudinal Visual Analogue Scale (VAS) Pain Scores

Follow-up Time Point	Group A (350 mmHg) Mean ± SD (n = 15)	Group B (SBP + 100) Mean ± SD (n = 15)	p-value
Postoperative Day 2 (POD 2)	6.73 ± 0.46	5.43 ± 0.37	< 0.0001* (Highly Sig.)
Postoperative Week 2 (POW 2)	5.40 ± 0.57	4.47 ± 0.40	< 0.0001* (Highly Sig.)
Postoperative Week 4 (POW 4)	3.73 ± 0.46	3.43 ± 0.37	0.059 (NS)
Postoperative Month 2 (POM 2)	1.23 ± 0.50	1.17 ± 0.45	0.702 (NS)

Note: VAS scored from 0 (no pain) to 10 (worst imaginable pain). * = Statistically significant (p < 0.05); NS = Not significant.

Evaluation of Functional Outcomes (WOMAC Score): Early functional recovery was significantly accelerated in Group B (Tables 4 & 5). On POD 2, Group B showed superior WOMAC scores (75.73 ± 1.83 vs 83.53 ± 1.51, p < 0.0001) and higher KSS scores (64.00 ± 2.51 vs 56.60 ± 2.75, p < 0.0001). At POW 2, Group B maintained significant superiority in both WOMAC (67.27 ± 2.87 vs 75.80 ± 1.61, p < 0.0001) and KSS (72.40 ± 2.10 vs 66.93 ± 1.75, p < 0.0001). By POW 4 and POM 2, both groups achieved comparable excellent functional outcomes (WOMAC: 33.47 ± 1.68 vs 34.13 ± 1.81, p = 0.305; KSS: 83.53 ± 1.81 vs 82.60 ± 1.50, p = 0.135).

Table 4: Comparison of Longitudinal WOMAC Functional Disability Scores

Follow-up Time Point	Group A (350 mmHg) Mean ± SD (n = 15)	Group B (SBP + 100) Mean ± SD (n = 15)	p-value
Postoperative Day 2 (POD 2)	83.53 ± 1.51	75.73 ± 1.83	< 0.0001* (Highly Sig.)
Postoperative Week 2 (POW 2)	75.80 ± 1.61	67.27 ± 2.87	< 0.0001* (Highly Sig.)
Postoperative Week 4 (POW 4)	57.80 ± 1.90	56.93 ± 1.39	0.164 (NS)
Postoperative Month 2 (POM 2)	34.13 ± 1.81	33.47 ± 1.68	0.305 (NS)

Note: WOMAC Index ranges from 0 to 96 (lower values indicate superior clinical outcome and functional recovery). * = Statistically significant (p < 0.05); NS = Not significant.

Table 5: Comparison of Longitudinal Knee Society Scores (KSS)

Follow-up Time Point	Group A (350 mmHg) Mean ± SD (n = 15)	Group B (SBP + 100) Mean ± SD (n = 15)	p-value
Postoperative Day 2 (POD 2)	56.60 ± 2.75	64.00 ± 2.51	< 0.0001* (Highly Sig.)
Postoperative Week 2 (POW 2)	66.93 ± 1.75	72.40 ± 2.10	< 0.0001* (Highly Sig.)
Postoperative Week 4 (POW 4)	76.60 ± 1.50	77.60 ± 1.30	0.061 (NS)
Postoperative Month 2 (POM 2)	82.60 ± 1.50	83.53 ± 1.81	0.135 (NS)

Note: KSS ranges from 0 to 100 (higher values indicate superior clinical outcome). * = Statistically significant (p < 0.05); NS = Not significant.

Complications and Adverse Events: Tourniquet-site thigh pain was less frequent in Group B than Group A (6.7% vs 20.0%, p = 0.598; Table 6). One patient in Group A had an intraoperative partial MCL avulsion managed with primary repair and hinged bracing; no intraoperative complications occurred in Group B (p = 1.000). Zero cases of deep vein thrombosis, wound infection, skin necrosis, or motor neuropraxia occurred in either group.

Table 6: Summary of Adverse Events and Complications

Complication / Adverse Event	Group A (350 mmHg) (n = 15)	Group B (SBP + 100) (n = 15)	Total (N = 30)	p-value
Tourniquet-Site Thigh Pain (n, %)	3 (20.0%)	1 (6.7%)	4 (13.3%)	p = 0.598 (NS)
Intraoperative Ligament Strain (MCL/LCL)	1 (6.7%)	0 (0.0%)	1 (3.3%)	p = 1.000 (NS)
Superficial Wound Infection / Dehiscence	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.000
Deep Periprosthetic Joint Infection (PJI)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.000
Deep Vein Thrombosis (DVT) / PE	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.000
Peroneal / Femoral Motor Neuropraxia	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.000

Note: Values expressed as n (percentage). NS = Not statistically significant (p > 0.05).

Discussion

Modern total knee arthroplasty pathways prioritize rapid mobilization, enhanced analgesia, and minimal perioperative tissue trauma [4, 23]. In this context, optimizing modifiable surgical factors such as pneumatic tourniquet pressure is essential [6, 15]. Our prospective randomized trial demonstrates that calibrating tourniquet inflation pressure to baseline systolic blood pressure (SBP + 100 mmHg) significantly reduces acute postoperative pain and accelerates functional recovery during the first two postoperative weeks, without compromising operative visibility, increasing surgical time, or elevating complications.

The pathophysiological basis of tourniquet morbidity involves direct mechanical compression and ischemic-reperfusion injury [10, 11]. Excessive cuff pressure (350 mmHg) creates high shear forces that crush underlying quadriceps muscle fibers and compress the femoral and sciatic nerves [14, 16]. This localized trauma, combined with anaerobic metabolite accumulation, triggers local nociception and quadriceps inhibition [11, 24]. Reducing tourniquet pressure by an average of 123 mmHg in Group B mitigated this mechanical trauma, directly explaining the significantly lower VAS pain scores observed on POD 2 (5.43 vs 6.73) and POW 2 (4.47 vs 5.40). These findings corroborate landmark studies by Olivecrona et al. [15], Worland et al. [16], and Leão et al. [1], which demonstrated that lower cuff pressures markedly decrease acute pain and thigh discomfort.

Importantly, lower pain translated into accelerated early rehabilitation. Early knee flexion and weight-bearing ambulation depend critically on voluntary quadriceps activation, which is impaired by reflex arthrogenic inhibition when high cuff pressures are used [14, 24]. In our series, patients in Group B achieved significantly superior WOMAC scores (75.73 vs 83.53 at POD 2; 67.27 vs 75.80 at POW 2) and higher Knee Society Scores (64.00 vs 56.60 at POD 2; 72.40 vs 66.93 at POW 2). By 4 weeks and 2 months, outcomes equalized between cohorts, confirming that while high fixed pressure does not compromise ultimate joint function, it imposes an unnecessary functional deficit during the early recovery window.

Regarding intraoperative hemostasis, although blood loss was slightly higher in the lower-pressure arm (218.7 vs 190.0 mL, $p = 0.0001$), this ~28 mL difference was clinically negligible. Surgical field clarity was maintained throughout bone preparation and cementation, operative duration was unaffected (79.1 vs 77.4 min, $p = 0.281$), and zero transfusions were needed. This confirms that SBP + 100 mmHg safely exceeds limb occlusion pressure to provide complete arterial occlusion [17, 18, 28]. Furthermore, thigh pain incidence was lower in Group B (6.7% vs 20.0%), and no thromboembolic or wound complications occurred [26, 27]. Study limitations include the sample size of 30 patients and a 2-month follow-up, which, while adequate for detecting primary pain and early recovery differences, cannot assess rare complications or long-term fixation. Nonetheless, the pragmatic formula of SBP + 100 mmHg is universally applicable in operating rooms without requiring specialized Doppler sensor equipment.

Conclusion

This prospective randomized comparative study demonstrates that tailoring pneumatic tourniquet inflation pressure to the patient's baseline systolic blood pressure (SBP + 100 mmHg) during primary total knee arthroplasty significantly reduces acute postoperative pain and accelerates functional rehabilitation (WOMAC and Knee Society Scores) during the first two postoperative weeks, compared to the conventional fixed empirical pressure of 350 mmHg. Furthermore, this individualized regimen maintains excellent surgical visibility, does not increase operative time, and carries a lower incidence of tourniquet-site thigh pain without compromising patient safety. We strongly recommend abandoning empirical high fixed tourniquet pressures in favor of individualized systolic-based pressures in routine total knee arthroplasty practice.

References

1. Leão MGS, Martins Neta GP, Coutinho LI, da Silva TM, Ferreira YMC, Dias WRV. Comparative analysis of pain in patients who underwent total knee replacement regarding the tourniquet pressure. Rev Bras Ortop. 2016;51(6):672-9.
2. Carr AJ, Robertsson O, Graves S, Price AJ, Arden NK, Carr A, et al. Knee replacement. Lancet. 2012;379(9823):1331-40.
3. Pachore JA, Vaidya SV, Thakkar CJ, Bhal DL, Solanki KD. Current state of total knee arthroplasty in India. J Arthroplasty. 2013;28(8):1245-9.
4. Wainwright TW, Gill M, McDonald DA, Middleton RG, Reed M, Sahota O, et al. Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery after Surgery (ERAS®) Society recommendations. Acta Orthop. 2020;91(1):3-19.
5. Kumar N, Yadav C, Singh S, Kumar A, Vaithilingam A, Yadav S. Evaluation of pain in bilateral total knee replacement with and without tourniquet; a prospective randomized control trial. J Clin Orthop Trauma. 2015;6(2):85-8.

6. Sharma JP, Salhotra R. Tourniquets in orthopedic surgery. Indian J Orthop. 2012;46(4):377-83.
7. Zhang W, Li N, Chen S, Tan Y, Al-Aidaros M, Chen L. The effects of tourniquet used in total knee arthroplasty: a meta-analysis. J Orthop Surg Res. 2014;9(1):13.
8. Tejwani NC, Immerman I, Achan P, Egol KA, McLaurin T. Tourniquet cuff pressure: the gulf between science and practice. J Trauma. 2006;61(6):1415-8.
9. Odinsson A, Finsen V. Tourniquet use and its complications in Norway. J Bone Joint Surg Br. 2006;88(8):1090-2.
10. Shaw JA, Murray DG. The relationship between tourniquet pressure and underlying soft-tissue pressure in the thigh. J Bone Joint Surg Am. 1982;64(8):1148-52.
11. Estebe JP, Davies JM, Richebe P. The pneumatic tourniquet: mechanical, ischaemia-reperfusion and systemic effects. Eur J Anaesthesiol. 2011;28(6):404-11.
12. Bruner JM. Time, pressure, and temperature factors in the safe use of surgical tourniquets. Hand. 1970;2(1):39-42.
13. Klenerman L. The tourniquet in surgery. J Bone Joint Surg Br. 1962;44(4):937-43.
14. Shetty T, Nguyen JT, Sasaki M, Wu A, Bogner E, Deland E, et al. Risk factors for acute nerve injury after total knee arthroplasty. Muscle Nerve. 2018;57(6):946-52.
15. Olivecrona C, Ponzer S, Hamberg P, Blomfeldt R. Lower tourniquet cuff pressure reduces postoperative wound complications after total knee arthroplasty: a randomized controlled study of 164 patients. J Bone Joint Surg Am. 2012;94(24):2216-21.
16. Worland RL, Arredondo J, Angles F, Lopez-Jimenez F, Jessup DE. Thigh pain following tourniquet application in simultaneous bilateral total knee replacement arthroplasty. J Arthroplasty. 1997;12(8):848-52.
17. Ishii Y, Noguchi H, Matsuda Y, Takeda M, Higashihara T. A new tourniquet system that determines pressures in synchrony with systolic blood pressure in total knee art hroplasty. J Arthroplasty. 2008;23(7):1050-6.
18. Younger AS, McEwen JA, Inkpen K. Wide contoured thigh cuffs and automated limb occlusion measurement allow lower tourniquet pressures. Clin Orthop Relat Res. 2004;(428):286-93.
19. Abdel-Salam A, Eyres KS. Effects of tourniquet during total knee arthroplasty. A prospective randomised study. J Bone Joint Surg Br. 1995;77(2):250-3.
20. Vandenbussche E, Duranthon LD, Couturier M, Fabre L, Man M, Augereau B. The effect of tourniquet use in total knee arthroplasty. Int Orthop. 2002;26(5):306-9.
21. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol. 1988;15(12):1833-40.
22. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res. 1989;(248):13-4.
23. Iorio R, Healy WL. Tourniquet use during total knee arthroplasty did not reduce total blood loss. J Bone Joint Surg Am. 2001;83(8):1282.
24. Saunders KC, Louis DL, Weingarden SI, Waylonis GW. Effect of tourniquet time on postoperative quadriceps function. Clin Orthop Relat Res. 1979;(143):194-9.
25. Du Z, Liu P, Zhang Y, Li D, Li M. Effect of tourniquet on preoperative blood loss and short-term effectiveness in total knee arthroplasty. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2013;27(11):1318-23.
26. Din R, Geddes T. Skin protection beneath the tourniquet: a prospective randomized trial. ANZ J Surg. 2004;74(9):721-2.
27. Clarke MT, Longstaff L, Edwards D, Rushton N. Tourniquet-induced wound hypoxia after total knee replacement. J Bone Joint Surg Br. 2001;83(1):40-4.
28. 28. Pedowitz RA, Gershuni DH, Botte MJ, Kuiper S, Rydevik BL, Hargens AR. The use of lower tourniquet inflation pressures in extremity surgery facilitated by curved and wide tourniquets and an integrated cuff inflation system. Clin Orthop Relat Res. 1993;(287):237-44.