International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Efficacy and Safety of Intra-Articular Glucocorticoid Injection for Post-Operative Mobility and Pain Control After Knee Arthroscopy

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OPEN ACCESS

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Received: 26-01-2026
Accepted: 18-02-2026
Available online: 26-02-2026

ABSTRACT

Background: Knee arthroscopy is one of the most commonly performed orthopaedic procedures worldwide. Post-operative pain and restricted mobility remain significant challenges that impact patient recovery, rehabilitation, and overall satisfaction. Intra-articular glucocorticoid injection has been proposed as an adjunct analgesic modality to improve early post-operative outcomes.

Objectives: To evaluate the efficacy of intra-articular glucocorticoid injection (methylprednisolone acetate 40 mg) administered at the end of knee arthroscopy in reducing post-operative pain (VAS), improving range of motion, and minimising analgesic consumption, while also assessing the safety profile of this intervention.

Materials & Methods: A prospective, randomised, double-blinded, placebo-controlled study was conducted over 13 months (June 2024 – July 2025) at MGM Medical College & LSK Hospital. Twenty-five patients undergoing elective knee arthroscopy were randomised into Group A (n=13, methylprednisolone acetate 40 mg intra-articular) and Group B (n=12, normal saline placebo). Pain was assessed by Visual Analogue Scale (VAS) at 2, 6, 24, 48 hours, 1 week, and 2 weeks post-operatively. Range of motion (ROM) and analgesic consumption were recorded at defined intervals.

Results: Group A demonstrated significantly lower VAS pain scores at all post-operative time points ($p<0.001$), superior knee ROM recovery at 24 hours (68.3° vs 48.2°; $p<0.001$) through 6 weeks, significantly reduced rescue analgesic requirements, and higher patient satisfaction scores (8.3 vs 5.9; $p<0.001$). No cases of septic arthritis or serious adverse events were recorded. Transient hyperglycaemia occurred in 2 patients (15.4%) in Group A, which was self-limiting.

Conclusion: Intra-articular glucocorticoid injection at the conclusion of knee arthroscopy provides significant early analgesic benefit, accelerates joint mobility recovery, reduces systemic analgesic burden, and is safe in the short term. It represents a valuable, low-cost adjunct in arthroscopic pain management protocols.

Keywords*: Knee arthroscopy, intra-articular injection, glucocorticoid, methylprednisolone, post-operative pain, range of motion, analgesic.*

INTRODUCTION

Knee arthroscopy is among the most frequently performed surgical procedures in orthopaedics, with over 4 million procedures performed annually worldwide [1]. It serves both diagnostic and therapeutic roles in the management of a wide spectrum of intra-articular pathologies including meniscal tears, anterior cruciate ligament (ACL) injuries, chondral defects, plica syndrome, and synovial pathology [2].

Despite its minimally invasive nature, knee arthroscopy is not devoid of post-operative morbidity. Pain, swelling, and restricted mobility in the immediate post-operative period constitute significant barriers to early rehabilitation and can lead to prolonged recovery, patient dissatisfaction, and increased healthcare costs [3]. Adequate post-operative pain

management is therefore a cornerstone of arthroscopic care, influencing not only patient comfort but also the trajectory of functional recovery.

Conventional multimodal analgesia following knee arthroscopy includes systemic non-steroidal anti-inflammatory drugs (NSAIDs), opioids, and local intra-articular local anaesthetic instillation [4]. Intra-articular bupivacaine, for instance, has been widely adopted; however, its analgesic effect is typically short-lived, lasting only 4–6 hours post-operatively [5]. The need for a longer-acting, well-tolerated intra-articular analgesic agent has prompted investigation into the role of glucocorticoids as an adjunct.

Glucocorticoids exert potent anti-inflammatory effects through multiple mechanisms: inhibition of phospholipase A2 and cyclooxygenase pathways, suppression of pro-inflammatory cytokines (IL-1β, IL-6, TNF-α), stabilisation of synovial membranes, and reduction of capillary permeability [6]. When administered intra-articularly, they act locally with minimal systemic absorption, potentially offering sustained anti-inflammatory and analgesic benefit without the systemic side effects of oral or parenteral steroid use [7].

Several studies and meta-analyses have examined the use of intra-articular corticosteroids in the post-arthroscopic setting, yielding largely positive results with acceptable safety profiles [8,9]. However, concerns remain regarding the risk of septic arthritis, transient hyperglycaemia in diabetic patients, chondrotoxicity with repeated injections, and the potential for impaired wound healing [10,11].

Given the limited data from the Indian subcontinent and the lack of institutional protocols at our centre, this study was designed to prospectively evaluate the efficacy and safety of a single dose of intra-articular methylprednisolone acetate 40 mg at the conclusion of knee arthroscopy, compared with a placebo (normal saline) injection, focusing on post-operative pain scores, range of motion recovery, and analgesic consumption during the first 6 weeks post-operatively.

OBJECTIVES

Primary Objectives

1. To compare post-operative pain levels (measured by Visual Analogue Scale – VAS) between the glucocorticoid injection group and the control group at 2, 6, 24, and 48 hours, and at 1 and 2 weeks following knee arthroscopy.
2. To evaluate the effect of intra-articular glucocorticoid injection on post-operative knee range of motion (ROM) recovery at defined intervals up to 6 weeks.

Secondary Objectives

3. To quantify total analgesic consumption (opioid, paracetamol, and NSAID use) and time to first rescue analgesia in each group.
4. To assess patient satisfaction scores in both groups.
5. To evaluate the safety profile of intra-articular glucocorticoid injection, specifically monitoring for septic arthritis, haemathrosis, hyperglycaemia, deep vein thrombosis, and other complications.

MATERIALS AND METHODS

Study Design and Setting

This study was a prospective, randomised, double-blinded, placebo-controlled clinical trial conducted in the Department of Orthopaedics at MGM Medical College & LSK Hospital over a period of 13 months, from June 2024 to July 2025. Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement (IEC Ref: MGM/IEC/2024/043). All patients provided written informed consent prior to enrolment.

Sample Size

A total of 25 patients who underwent elective knee arthroscopy were enrolled and randomised: Group A (Glucocorticoid Group, n=13) and Group B (Control Group, n=12). Sample size was calculated based on a prior pilot study estimating a mean VAS difference of 1.8 (SD 1.3) between groups, with 80% power and a significance level of 0.05.

Inclusion Criteria

(i) Age 18–60 years; (ii) Patients undergoing elective knee arthroscopy for meniscal pathology, ACL tear, or chondral defect; (iii) ASA physical status Grade I or II; (iv) Willingness to participate and provide informed consent; (v) Ability to follow up for 6 weeks post-operatively.

Exclusion Criteria

(i) Known hypersensitivity to glucocorticoids; (ii) Pre-existing infection at or around the knee joint; (iii) Uncontrolled diabetes mellitus (HbA1c >8%); (iv) Chronic systemic steroid therapy; (v) Concurrent intra-articular pathology requiring additional interventions; (vi) Coagulopathy or anticoagulant therapy; (vii) Pregnancy or lactation; (viii) Pre-existing severe knee stiffness or contracture.

Randomisation and Blinding

Randomisation was performed using a computer-generated random number sequence, with sealed opaque envelopes used for allocation concealment. Both the patient and the outcome assessor were blinded to the group allocation. The operating surgeon was not blinded but was not involved in outcome assessment.

Intervention

All patients received standard spinal anaesthesia with 0.5% hyperbaric bupivacaine. Knee arthroscopy was performed using a standard two-portal technique under tourniquet control. At the conclusion of the arthroscopic procedure, before port closure, the study solution was injected intra-articularly through the arthroscopic portal:

Group A: Methylprednisolone acetate 40 mg (1 mL) + 0.5% bupivacaine 9 mL (total 10 mL solution).

Group B: Normal saline 1 mL + 0.5% bupivacaine 9 mL (total 10 mL solution – placebo).

All patients received standard post-operative analgesia protocol including regular paracetamol 1g IV TDS. Rescue analgesia in the form of tramadol 50 mg IV was available on patient demand.

Outcome Measures

Pain was evaluated using a 10-point Visual Analogue Scale (VAS; 0 = no pain, 10 = worst imaginable pain) at 2, 6, 24, 48 hours, 1 week, and 2 weeks post-operatively by a blinded assessor. Active-assisted knee range of motion (ROM) was measured in degrees using a standard goniometer pre-operatively and at 24 hours, 48 hours, 1 week, 2 weeks, and 6 weeks post-operatively. Analgesic consumption, time to first rescue dose, and patient satisfaction (10-point Likert scale) were recorded. Adverse events were documented throughout the study period.

Statistical Analysis

Data were entered and analysed using IBM SPSS Statistics version 26.0 (Armonk, NY). Continuous variables are expressed as Mean ± Standard Deviation (SD). Between-group comparisons were performed using the independent samples t-test for normally distributed data and the Mann-Whitney U test for non-parametric data. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.

RESULTS

Of the 30 patients initially screened, 25 met the inclusion criteria and were randomised into two groups: Group A (Glucocorticoid, n=13) and Group B (Control/Saline, n=12). All 25 patients completed the 6-week follow-up. There were no dropouts or protocol deviations.

Demographic and Baseline Characteristics (Table 1)

Both groups were comparable with respect to age, sex, BMI, ASA status, surgical diagnosis, and operative duration. No statistically significant differences were noted in baseline characteristics ($p>0.05$ for all parameters), confirming successful randomisation.

Table 1: Demographic and Baseline Characteristics of Study Participants

Characteristic	Group A (Glucocorticoid) n=13	Group B (Control/Saline) n=12	p-value
Age (years), Mean ± SD	38.6 ± 9.4	40.1 ± 8.7	0.623
Sex (Male/Female)	9/4	8/4	0.891
BMI (kg/m²), Mean ± SD	24.8 ± 3.2	25.3 ± 3.5	0.681
ASA Grade I/II	10/3	9/3	0.960
Diagnosis (Meniscal/ACL/Chondral)	7/4/2	6/4/2	0.950
Duration of Surgery (min)	47.3 ± 12.1	48.6 ± 11.8	0.758

*Note: *p<0.05 considered statistically significant. SD = Standard Deviation. ASA = American Society of Anesthesiologists Physical Status Classification. No significant baseline differences were observed between the two groups, confirming comparability.*

Post-Operative Pain Scores – VAS (Table 2)

Pre-operative VAS pain scores were comparable between the groups (3.8±1.1 vs 3.9±1.2; p=0.812). Following surgery, Group A exhibited significantly lower VAS scores at every time point from 2 hours through 2 weeks post-operatively. The maximum inter-group difference was observed at the 6-hour and 24-hour post-operative assessments, where Group A scores were nearly half those of Group B. This analgesic advantage was maintained through the 2-week follow-up.

Table 2: Post-Operative Pain Assessment – Visual Analogue Scale (VAS; 0–10)

Time Point	Group A (Glucocorticoid) Mean ± SD	Group B (Control/Saline) Mean ± SD	p-value
Pre-operative	3.8 ± 1.1	3.9 ± 1.2	0.812

At 2 hours post-op	3.2 ± 1.0	5.1 ± 1.3	0.001*
At 6 hours post-op	2.7 ± 0.9	5.4 ± 1.4	<0.001*
At 24 hours post-op	2.1 ± 0.8	4.8 ± 1.2	<0.001*
At 48 hours post-op	1.8 ± 0.7	4.3 ± 1.1	<0.001*
At 1 week	1.4 ± 0.6	3.5 ± 1.0	<0.001*
At 2 weeks	1.1 ± 0.5	2.6 ± 0.8	<0.001*

*Note: *Statistically significant (p<0.05). Both groups had comparable pre-operative VAS scores. Group A demonstrated significantly superior pain control at all post-operative time points. The greatest inter-group differences were observed at 6 and 24 hours post-operatively, consistent with the anti-inflammatory pharmacokinetics of intra-articular methylprednisolone.*

Range of Motion Recovery (Table 3)

Pre-operative ROM was similar in both groups (112.4°±14.6° vs 110.8°±15.2°; p=0.742). By 24 hours post-operatively, Group A achieved a mean ROM of 68.3° compared to 48.2° in Group B (p<0.001), reflecting a clinically significant advantage in early mobilisation. This superior ROM recovery persisted through all subsequent follow-up intervals up to 6 weeks.

Table 3: Knee Range of Motion (ROM) Recovery at Defined Time Points (degrees)

Time Point	Group A (Glucocorticoid) degrees	Group B (Control) degrees	p-value
Pre-operative ROM	112.4 ± 14.6	110.8 ± 15.2	0.742
24 hours post-op	68.3 ± 12.4	48.2 ± 10.6	<0.001*
48 hours post-op	82.7 ± 11.8	58.4 ± 12.1	<0.001*
1 week post-op	98.5 ± 10.2	74.6 ± 11.4	<0.001*
2 weeks post-op	110.2 ± 9.6	88.4 ± 10.8	<0.001*
6 weeks post-op	126.8 ± 7.4	118.2 ± 9.1	0.012*

*Note: *Statistically significant (p<0.05). Pre-operative ROM was equivalent in both groups. Group A showed significantly superior ROM at every post-operative assessment. At 2 weeks, mean ROM in Group A had nearly returned to pre-operative baseline, while Group B lagged by approximately 22°. This advantage persisted but narrowed at 6 weeks (126.8° vs 118.2°; p=0.012).*

Analgesic Consumption and Patient Satisfaction (Table 4)

Intraoperative opioid requirements were equivalent in both groups. However, rescue analgesia in the post-anaesthesia care unit (PACU) was required by 23.1% of Group A patients versus 75% in Group B (p=0.012). Total paracetamol consumption over 48 hours was significantly lower in Group A (1680±420 mg vs 2840±530 mg; p<0.001). NSAID use at 1 week was also markedly lower in Group A. Mean time to first rescue analgesic dose was 6.8 hours in Group A versus 2.4 hours in Group B (p<0.001). Patient satisfaction scores were significantly higher in Group A (8.3 vs 5.9; p<0.001).

Table 4: Analgesic Consumption, Time to First Rescue Dose, and Patient Satisfaction

Parameter	Group A (Glucocorticoid)	Group B (Control)	p-value
Intraoperative opioid (mg morphine eq.)	4.2 ± 1.8	4.5 ± 1.9	0.621
Rescue analgesia at PACU (n, %)	3 (23.1%)	9 (75.0%)	0.012*
Total paracetamol use - 48hrs (mg)	1680 ± 420	2840 ± 530	<0.001*
NSAID use at 1 week (n, %)	4 (30.8%)	10 (83.3%)	0.008*
Time to first rescue analgesia (hrs)	6.8 ± 2.1	2.4 ± 1.1	<0.001*
Patient Satisfaction Score (1-10)	8.3 ± 1.1	5.9 ± 1.4	<0.001*

*Note: *Statistically significant (p<0.05). PACU = Post-Anaesthesia Care Unit. Group A showed substantially reduced rescue analgesic requirements at all levels of assessment, with a delayed time to first rescue dose of nearly 3 times longer than Group B, indicating effective prolonged post-operative analgesia. Patient satisfaction was significantly superior in the glucocorticoid group.*

Safety and Adverse Events (Table 5)

No cases of septic arthritis, deep-space infection, or thromboembolic events were recorded in either group throughout the 6-week study period. Post-operative haemathrosis requiring aspiration occurred in 1 patient (7.7%) in Group A and 2 patients (16.7%) in Group B (p=0.481). Transient hyperglycaemia (random blood glucose >180 mg/dL) was observed in 2 patients (15.4%) in Group A, both of whom were pre-diabetic; this resolved spontaneously within 24–36 hours without pharmacological intervention. One patient in Group B required manipulation under anaesthesia (MUA) for early-onset post-operative stiffness. One patient in Group B required readmission within 30 days for wound-related issues. The overall

adverse event rate was 23.1% in Group A versus 33.3% in Group B (p=0.551), favouring Group A, though not reaching statistical significance.

Table 5: Post-Operative Safety Profile and Adverse Events

Complication / Adverse Event	Group A (Glucocorticoid) n=13	Group B (Control) n=12	p-value
Wound infection / septic arthritis	0 (0%)	0 (0%)	—
Post-operative haemathrosis	1 (7.7%)	2 (16.7%)	0.481
Transient hyperglycaemia (>180 mg/dL)	2 (15.4%)	0 (0%)	0.213
DVT/Thromboembolic event	0 (0%)	0 (0%)	—
Allergic / hypersensitivity reaction	0 (0%)	0 (0%)	—
Stiffness requiring MUA	0 (0%)	1 (8.3%)	0.300
Hospital readmission within 30 days	0 (0%)	1 (8.3%)	0.300
Total adverse events	3 (23.1%)	4 (33.3%)	0.551

Note: MUA = Manipulation Under Anaesthesia. DVT = Deep Vein Thrombosis. No serious adverse events (septic arthritis, DVT, or anaphylaxis) were recorded in either group. Transient hyperglycaemia occurred exclusively in Group A but was mild and self-limiting. The overall complication rate did not differ significantly between groups (p=0.551), supporting the safety of intra-articular glucocorticoid injection in the short to medium term.

DISCUSSION

This prospective randomised controlled trial evaluated the clinical utility of intra-articular methylprednisolone acetate 40 mg administered at the end of knee arthroscopy. Our results demonstrate a statistically significant and clinically meaningful improvement in post-operative pain, early joint mobility recovery, and reduction in analgesic burden in the glucocorticoid group, without a significant increase in adverse outcomes.

Pain Relief

Our findings align closely with those of Rasmussen et al. (2002), who conducted a landmark randomised controlled trial of 40 patients undergoing knee arthroscopy and reported significantly lower VAS pain scores in patients receiving intra-articular bupivacaine and methylprednisolone compared to saline controls at 2, 4, and 8 hours post-operatively [12]. Similarly, Rowe et al. (2004) demonstrated reduced pain scores and opioid consumption in patients receiving intra-articular corticosteroid at arthroscopy completion [13].

A meta-analysis by Kozanoglu et al. (2009) pooling data from 12 randomised trials found that intra-articular corticosteroids reduced early post-operative pain by a mean VAS difference of 2.1 cm (95% CI: 1.4–2.8) compared to control, consistent with the VAS difference of approximately 2.7 cm observed in our study at 24 hours [14]. Hashem et al. (2022) corroborated these findings in a more recent multi-centre study in Egypt, reporting lower VAS scores up to 1 week post-arthroscopy in the steroid group [15].

Range of Motion

The significant improvement in ROM observed in Group A from 24 hours onward is particularly noteworthy. Reduced pain and joint inflammation facilitate early physiotherapy and ambulation, which are critical determinants of functional outcome following knee arthroscopy. Melton et al. (2010) similarly reported that intra-articular corticosteroid injection accelerated ROM recovery in the early post-operative period in a cohort of 50 patients undergoing arthroscopic partial meniscectomy, with the greatest advantage noted in the first 2 weeks [16].

In our study, Group A had returned nearly to pre-operative ROM at 2 weeks (110.2° vs 112.4°), while Group B lagged significantly (88.4°). This parallels the findings of Bellamy et al. in their Cochrane systematic review, which confirmed that intra-articular corticosteroids improve function and mobility in the short term with effects sustained up to 4–8 weeks [17].

Analgesic Consumption

The reduction in rescue analgesic requirements in Group A is clinically significant. Reduced opioid consumption translates to fewer opioid-related side effects such as nausea, vomiting, sedation, and respiratory depression. This is particularly relevant in the context of the global movement toward opioid-sparing analgesia [18]. Alagol et al. (2005) demonstrated that intra-articular methylprednisolone reduced tramadol requirements by approximately 40% in the first 24 hours post-arthroscopy, comparable to our finding of reduced paracetamol use of approximately 41% [19]. The prolonged time to first rescue analgesia in our study (6.8 vs 2.4 hours) further supports a sustained local analgesic effect of the glucocorticoid.

Safety Considerations

The most critical safety concern with intra-articular glucocorticoids is septic arthritis, which has a reported incidence of approximately 1:3,000–1:50,000 intra-articular injections [20]. In our study, no cases of septic arthritis were recorded, consistent with the existing literature on single-dose intra-articular corticosteroid at arthroscopy. Tallia and Cardone (2002)

reviewed the safety of intra-articular injections and concluded that the risk of septic arthritis with appropriate technique and single-use vials is extremely low [21].
The 2 cases of transient hyperglycaemia observed in Group A represent a known, well-documented side effect, particularly in pre-diabetic individuals. Habib et al. (2009) reported a similar hyperglycaemic response after intra-articular triamcinolone, peaking at 12–24 hours and normalising within 48 hours [22]. Clinicians should nonetheless exercise caution and monitor blood glucose levels in at-risk populations for 24–48 hours following intra-articular steroid administration.
Concerns regarding chondrotoxicity with repeated corticosteroid injections exist, particularly from in vitro studies; however, single-dose administration as employed in this study is not associated with clinically significant cartilage damage in the existing human clinical trial literature [23].

Comparison with Other Modalities
Several comparative studies have examined intra-articular corticosteroids against other adjuncts such as bupivacaine alone, morphine, ketorolac, and platelet-rich plasma (PRP). Chirwa et al. (2018) found that the combination of bupivacaine and dexamethasone was superior to bupivacaine alone in terms of pain control at 24 hours [24]. Park et al. (2017) demonstrated that while PRP provided longer-term cartilage protection, corticosteroids were more effective for early pain relief in the first 4 weeks [25]. Our combination of bupivacaine with methylprednisolone may therefore represent an optimal short-to-medium term strategy.

Limitations
This study is limited by its relatively small sample size of 25 patients, which reduces statistical power and may limit the generalisability of findings. The 6-week follow-up, while sufficient to capture early outcomes, does not address potential delayed effects or complications. Long-term follow-up studies with larger sample sizes and multi-centre designs are warranted to confirm these findings. Additionally, outcomes beyond 6 weeks, including functional scores (KOOS, Lysholm), were not assessed in this study.

CONCLUSION
This prospective randomised controlled trial provides evidence that intra-articular methylprednisolone acetate (40 mg) administered at the conclusion of knee arthroscopy is an efficacious and safe adjunct analgesic intervention. Patients in the glucocorticoid group experienced significantly superior pain control across all post-operative time points, faster and more complete restoration of knee range of motion, significantly reduced analgesic consumption and dependency, delayed time to first rescue analgesia, and higher overall patient satisfaction scores.

The safety profile of a single intra-articular corticosteroid dose at arthroscopy is favourable, with no serious adverse events recorded in this study. Transient hyperglycaemia remains a consideration in pre-diabetic and diabetic patients and warrants routine monitoring.

Intra-articular glucocorticoid injection at the end of knee arthroscopy should be considered as a standard component of multimodal post-operative analgesia protocols, particularly in settings where opioid-sparing strategies are desirable. Larger multi-centre randomised controlled trials with extended follow-up and functional outcome measures are recommended to establish definitive guidelines.

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