Keywords
Melatonin, Postoperative pain, Visual Analogue Scale (VAS), Behavioural Pain Assessment Scale (BPAS), Functional activity score (FAS), Patient satisfaction score (PSS)

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Effect of melatonin on postoperative pain in patients undergoing lower limb surgery: Open-label exploratory randomised study

Abstract

Objective: To evaluate the effect of melatonin on postoperative pain, perioperative anxiety, functional recovery, and safety in patients undergoing lower limb orthopaedic surgery using the Visual Analogue Scale (VAS), Visual Analogue Scale Anxiety (VAS-A), Functional Activity Score (FAS), WHO causality assessment scale.

Methods: Patients aged 20–60 years with ASA grade I–II were randomised into two groups (n=40 each). Group A received oral melatonin 6 mg one hour preoperatively and nightly for five postoperative days; Group B served as the control. All participants received intramuscular diclofenac 50 mg twice daily for five days. Anxiety was assessed using VAS-A from baseline to 24 hours postoperatively. Pain was evaluated using VAS and Behavioural Pain Assessment Scale (BPAS), and functional recovery using FAS, from baseline to 120 hours. Patient satisfaction assessed periodically. Data were analysed using repeated-measures ANOVA with Bonferroni post hoc test and unpaired t-test.

Findings: Baseline characteristics were comparable between groups. Melatonin significantly reduced VAS pain scores at rest and during movement from 2 hours postoperatively. Anxiety scores decreased within 1 hour of administration and remained significantly lower at 12 and 24 hours. BPAS scores improved from 12 hours onward, while FAS demonstrated better recovery at 48 hours compared with control. At 120 hours, 80% of patients receiving melatonin reported excellent satisfaction compared with 35% in the control group. Adverse effects were mild, comparable between groups.

Conclusion: Melatonin may be an effective and safe adjuvant to NSAIDs for reducing postoperative pain and anxiety and improving functional recovery following lower limb orthopaedic surgery.

1. Introduction

Postoperative pain is a common concern in the early postoperative period. Adequate pain control plays a vital role in improving patient outcomes and promoting functional recovery, especially in individuals undergoing orthopaedic procedures.[1] Approximately 75 % of patients have inadequate postoperative pain relief, partly because the use of analgesics such as non-steroidal anti-inflammatory drugs (NSAIDs) is limited by their adverse effects.[2] Hence, multimodal analgesia has been tried for complete pain relief, and further studies are necessary in this regard.[3]

The pineal gland secretes a hormone called melatonin. A large number of studies have used a single dose of melatonin as a pre-emptive medication and observed a reduction in post-operative pain.[4-6] It is also effective in treating painful conditions such as migraine, neuropathic pain, traumatic brain injury, endometriosis, temporo-mandibular disorders, burning mouth syndrome and irritable bowel syndrome.[7] It was used for a duration of 10 days to 12 weeks with a varying dose of 3mg per day to 20mg per day orally.[7] The analgesic effect is believed to be mediated through its action on MT1 and MT2 receptors present in the spinal cord, thalamus and spinal trigeminal tract. Due to its anti-inflammatory and antioxidative effects, it reduces inflammation and tissue damage, contributing to peripheral analgesic action.[7]

While many studies have investigated the analgesic effect of melatonin, there are few studies evaluating its role in post-operative pain relief following surgical procedures for lower limb fractures in India.[2-3]

The primary outcome was to assess the effect of melatonin on postoperative pain relief in patients undergoing lower limb orthopaedic surgery using the Visual Analogue Scale (VAS). Secondary outcomes were to assess postoperative pain using the Behavioural Pain Assessment Scale (BPAS) and Functional Activity Score (FAS), to evaluate the effect of melatonin on perioperative anxiety using the Visual Analogue Scale for Anxiety (VAS-A), and to assess the safety profile of melatonin using the WHO causality assessment scale.

2. Materials and Methods

An open-label, parallel-group, exploratory randomised study was conducted by the Departments of Pharmacology and Orthopaedics in patients undergoing lower limb orthopaedic surgery visiting a tertiary care hospital, Tamaka, Kolar, Karnataka, India 563103. This study was carried out from April 2024 to October 2025. The study was approved by the Central Ethics Committee of Sri Devaraj Urs Academy of Higher Education and Research, with approval reference number: (SDUAHER/KLR/R&D/CEC/S/PG/Dissertation/100 /2024-25), and written informed consent was obtained from all the patients willing to participate in the study. Patient information was recorded according to the study protocol.

Clinical Trial Registration number: CTRI/2024/06/068288 dated 04th June 2024.

Patients aged 20–60 years of either gender, scheduled for elective lower limb orthopaedic surgery under spinal anaesthesia, and belonging to American Society of Anaesthesiologists (ASA) grade I or II were included. Patients with associated head injury, bronchial asthma, peripheral neuropathy, haemorrhagic disorders, renal calculi, hepatic or renal impairment were excluded. Those with active substance use disorders (current smoking, alcohol use disorder or other drug dependence), a history of gastrointestinal bleeding or peptic ulcer disease, and pregnant or breastfeeding women were also excluded.[8]

Based on previous literature by Javaherforooshzadeh et al., evaluating postoperative VAS scores following melatonin administration in lumbar spine surgery, the sample size was calculated using the formula [9]

$$n = \frac{2(Z_{\alpha/2} + Z_{\beta})^2 \sigma^2}{d^2}$$

where n= sample size per group, Zα/2= 1.96 at 95% confidence interval, Zβ= 0.84 for 80% power, σ= pooled standard deviation, and d= expected mean difference between the groups.

To detect a mean difference of 0.3 in VAS score at 24 hours postoperatively between standard treatment and standard treatment along with Melatonin, confidence interval of 95 %, power of 80 %, alpha error of 5 %, with a dropout rate at 10 %, the required sample size was calculated to be 40 patients in each group using OpenEpi software. 7,9

Written informed consent was obtained, and patients were allocated to two groups (Group A and Group B) using computer-generated 2×2 block randomisation, with a minimum of 40 participants in each group. At baseline, demographic data, clinical history, and physical examination findings were recorded, and patients were familiarised with the pain scoring scales, anxiety scales and were advised to inform the investigators about any adverse events experienced during hospitalisation. Baseline investigations included complete blood count, routine urine examination, serum creatinine, blood urea, clotting time, bleeding time, serology and fasting blood glucose. Following surgery, both groups received an injection of diclofenac 50mg twice daily (morning and night) by intramuscular route for 5 days.6 Patients in Group A received tablet melatonin 6 mg orally with a sip of water 60 minutes before surgery and subsequently at 9 PM daily from the day of surgery (day 0) until postoperative day 5, and Group B served as control.7 Adherence to melatonin was ensured by directly administering the medication to the patients every night at 9 PM, and compliance was assessed the following morning during postoperative evaluation and pain score assessment. All surgeries were performed under spinal anaesthesia using

0.5 % hyperbaric bupivacaine (15–17 mg; 3 mL) as per institutional protocol.

Pain intensity was assessed using the Visual Analogue Scale (VAS)[10] ranging from 0 to 10 (0 indicating no pain and 10 indicating the worst possible pain) at baseline (prior to administration of study medication) and at 2, 4, 6, 8, 12, 24, 48, 72, 96, and 120 hours. Since VAS score is subjective, evaluation of pain was also done by using objective pain scales like Behavioural Pain Assessment Scale (BPAS)10 scored 0–10 (0 indicating no pain and 10 indicating worst possible pain) at baseline and 12, 24, 48, 72, 96 and 120 hours and Functional Activity Score (FAS)10 at baseline and at 2, 4, 6, 8, 12, 24, 48, 72, 96 and 120 hours. Anxiety score was recorded using the Visual Analogue Scale for Anxiety (VAS-A)[10] at baseline, 60 minutes after administration of melatonin, postoperatively before shifting from the recovery room, at 12 and 24 hours.

Patient's blood pressure, pulse rate and respiratory rate were monitored following recovery from anaesthesia and at 2, 4, 8, 12, 24, 48, 72, 96, and 120 hours postoperatively. Rescue medication with tramadol 100 mg was planned for patients with a VAS score >3 and inadequately controlled or intolerable pain during the postoperative period. Patient satisfaction regarding pain relief was evaluated using a satisfaction scale (1= poor, 2= fair, 3= good, 4= excellent). This assessment was conducted at 24, 72, and 120 hours after surgery. Any adverse effects related to melatonin or diclofenac were monitored and assessed according to the WHO causality assessment scale.[11]

The demographic variables were analysed using descriptive statistics. The VAS, VAS-A, BPAS and FAS scores were analysed using repeated measures ANOVA within each group, followed by a Bonferroni post hoc test, while an unpaired t-test was used to compare differences between the groups at each interval. PSS and Adverse effects were analysed by the chi-square test. A p-value < 0.05 was considered statistically significant. Data was analysed using IBM SPSS Statistics Version 22.

3. Results

The study included 80 patients scheduled for elective lower limb orthopaedic procedures under spinal anaesthesia to assess the role of melatonin in postoperative pain management and recovery. They were randomised into the melatonin group (n = 40) and the control group (n = 40). All participants completed the study, and their allocation and follow-up were represented in the CONSORT flow diagram (Figure 1).

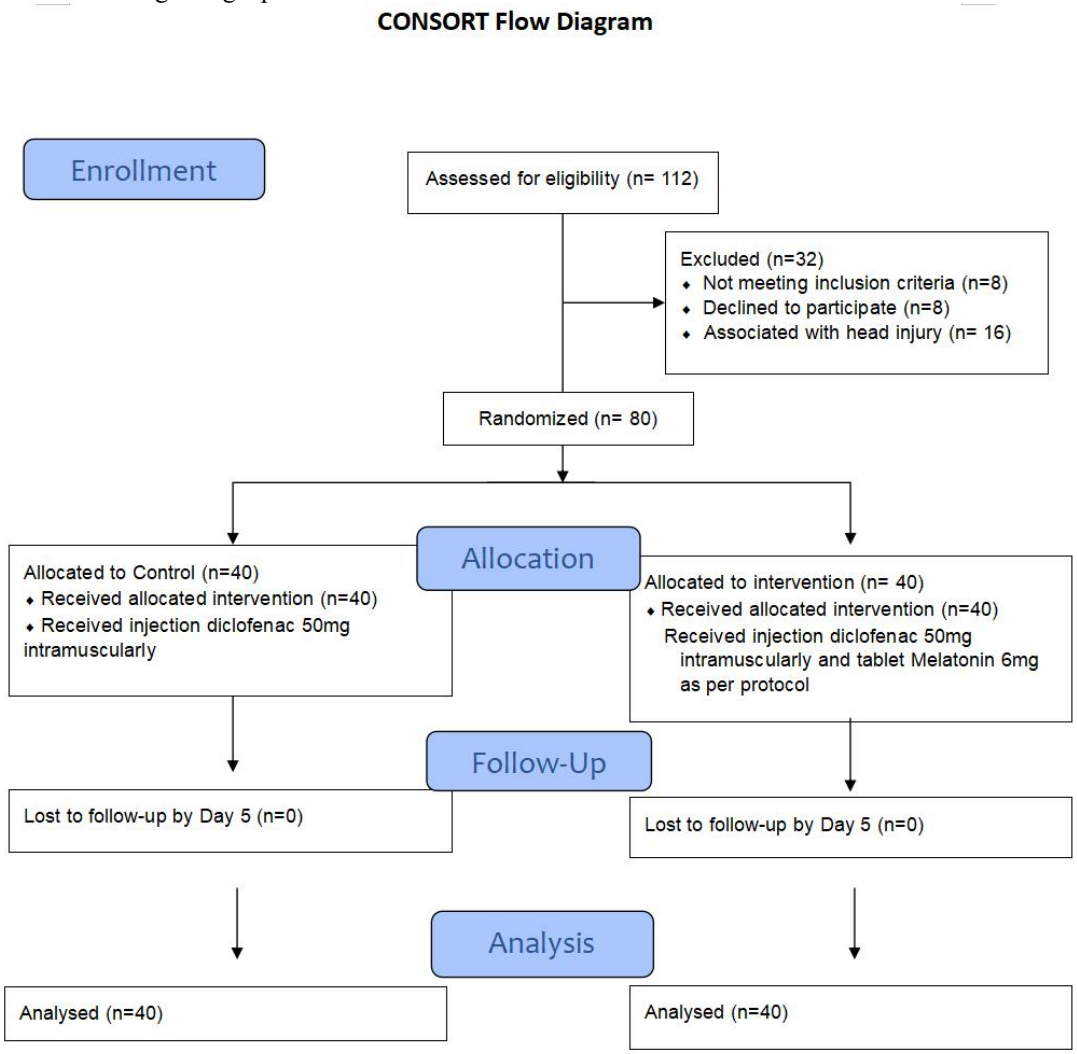


Figure 1. CONSORT flow diagram representing recruitment and follow-up of patients

Table 1. Baseline characteristics of the patients in the groups

Parameters	Control (n=40)	Melatonin (n=40)	*p-value
Age in years (Mean ± SD)	40.5 ± 13.7	40 ± 13.8	0.87
Male/ Female	32/8	29/11	0.6
History of smoking	14 (35 %)	17 (42.5 %)	
Cause of Trauma- Road traffic accident	40	40	
Duration of surgery in minutes (Mean ± SD)	120.8 ± 20.5	124.8 ± 14.4	0.31
Hemoglobin (g/dl) (Mean ± SD)	12.1 ± 2.1	11.5 ± 2.3	0.22
Total WBC count (cells/mm3) (Mean ± SD)	9.4 ± 1.8	9.5 ± 1.7	0.79
Platelet count (cells/microliter) (Mean ± SD)	224250 ± 56406	230725 ± 63399	0.63
Urea (mg/dl) (Mean ± SD)	22.1 ± 6.2	22.4 ± 6.7	0.83
Creatinine (mg/dl) (Mean ± SD)	0.7 ± 0.1	0.7 ± 0.1	1.00
Bleeding time (minutes) (Mean ± SD)	2.7 ± 0.4	2.8 ± 0.4	0.26
Clotting time (minutes) (Mean ± SD)	5.0 ± 0.9	5.0 ± 0.8	1.00
Random blood glucose (mg/dl) (Mean ± SD)	125.2 ± 21.5	118.6 ± 22.2	0.18
Aspartate amino transferase (U/L) (Mean ± SD)	33.7 ± 5.2	31.6 ± 5.1	0.07
Alanine amino transferase (U/L) (Mean ± SD)	32.4 ± 15.3	27.2 ± 13	0.10
Alkaline phosphatase (U/L) (Mean ± SD)	96.2 ± 29.9	87.2 ± 30.4	0.18

*Unpaired t-test, $p<0.05$ indicates statistical significance

The baseline demographic characteristics, such as age, sex distribution and mean surgical duration, were comparable across both groups. Baseline haematological and biochemical parameters in both groups were similar (Table 1).

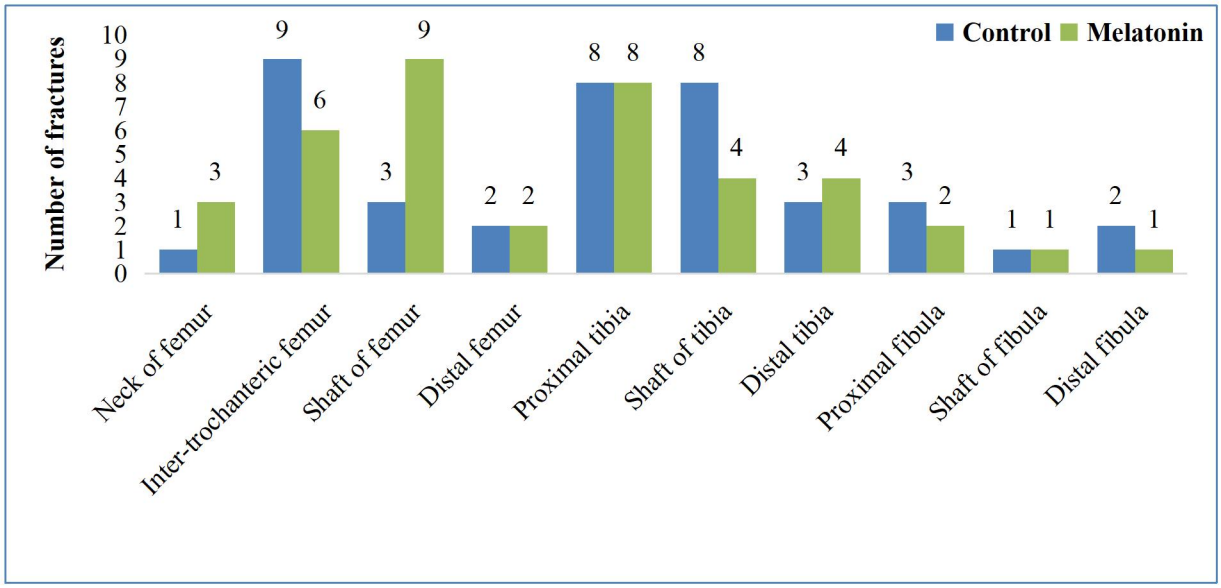


Figure 2. Types of fracture in both groups

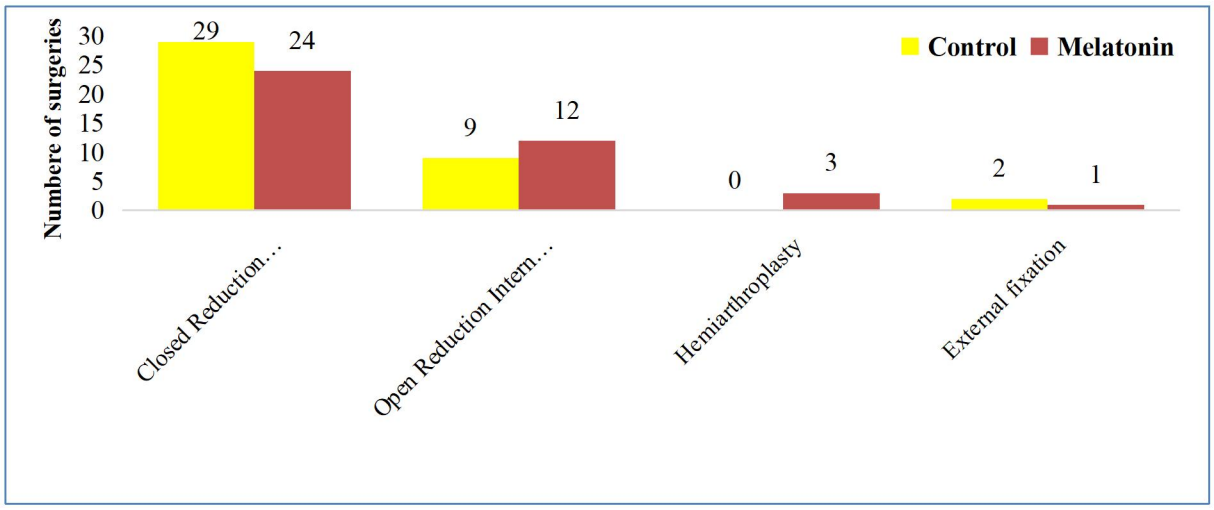


Figure 3. Type of surgeries in both groups

The most common type of fracture was tibia, followed by femur in the control group and vice versa in the melatonin group. Patients in both groups underwent closed reduction and internal fixation, plating, hemiarthroplasty or external fixation (Figures 2 and 3).

Table 2. Pre-operative and post-operative vital parameters

Parameters	Baseline (pre-operative)		*p-value	Day 5 (post-operative)		*p-value
	C	M		C	M	
Heart rate (per minute)	79.5 ± 9.5	76.5 ± 10.4	0.18	82.3 ± 11.7	79.5 ± 11.7	0.28
Systolic BP (mmHg)	115.2 ± 9.7	112.8 ± 10.4	0.28	113.5 ± 11.8	113.5 ± 12.5	1.00
Diastolic BP (mmHg)	73.6 ± 7.3	74.8 ± 9.3	0.52	75.7 ± 9.6	77.5 ± 9.2	0.39
Respiratory rate (per minute)	14.8 ± 1.8	14.4 ± 1.7	0.31	14.5 ± 1.9	14.1 ± 1.8	0.33

Results reported as Mean ± SD. *Unpaired t-test, C- control, M- Melatonin, p<0.05 indicates statistical significance

Pre-operative systolic and diastolic blood pressure, heart rate and respiratory rate were comparable between the two groups. Patients were monitored post-operatively at regular intervals up to 120 hours (postoperative day 5). All parameters remained within normal limits in both groups throughout the postoperative period (Table 2). No significant differences were noted between the melatonin and control groups at any time point.

Table 3. Comparison of Anxiety Scores Using the Visual Analogue Scale for Anxiety

Time (hours)	Control (Mean ± SD) (n=40)	Melatonin (Mean ± SD) (n=40)	*p-value
0	7.9 ± 0.8	7.9 ± 0.8	1.00
1	7.9 ± 0.8	4.1 ± 0.8	0.0001
12	5.1 ± 0.8	4.1 ± 0.8	0.0001
24	4.7 ± 0.4	3.4 ± 0.5	0.0001
# p-value	0.0001	0.0001	

#R-ANOVA and *unpaired t test, p<0.05 indicates statistical significance
A statistically significant reduction in anxiety scores from baseline to 24 hours was observed in both groups. (p=0.0001). The baseline VAS scores for anxiety were comparable in both groups. A marked reduction in anxiety score was observed in the melatonin group 1 hour after administration, but this reduction in the control group was observed after 12 hours. Melatonin group participants had reduced scores at 1, 12 and 24 hours postoperatively compared to the control group, and this difference was statistically significant. (Table 3)

Table 4. Visual Analogue Scale Score for Pain at rest in patients of both groups

Time (hours)	Control (n=40)	Melatonin (n=40)	*p-value
0	5.7 ± 0.7	5.7 ± 0.7	--
2	5.6± 0.6	3.6 ± 0.6	0.0001
4	5.5± 0.6	3.5 ± 0.6	0.0001
6	5.1± 0.5	3.1 ± 0.5	0.0001
8	5.1± 0.5	3.1 ± 0.5	0.0001
12	3.4± 0.5	1.6 ± 0.6	0.0001
24	3.4± 0.5	1.5 ± 0.5	0.0001
48	3.4± 0.5	1.4 ± 0.5	0.0001
72	3.4± 0.5	1.4 ± 0.5	0.0001
96	3.4± 0.5	1.4 ± 0.5	0.0001
120	3.4± 0.5	1.4 ± 0.5	0.0001
# p-value	0.0001	0.0001	

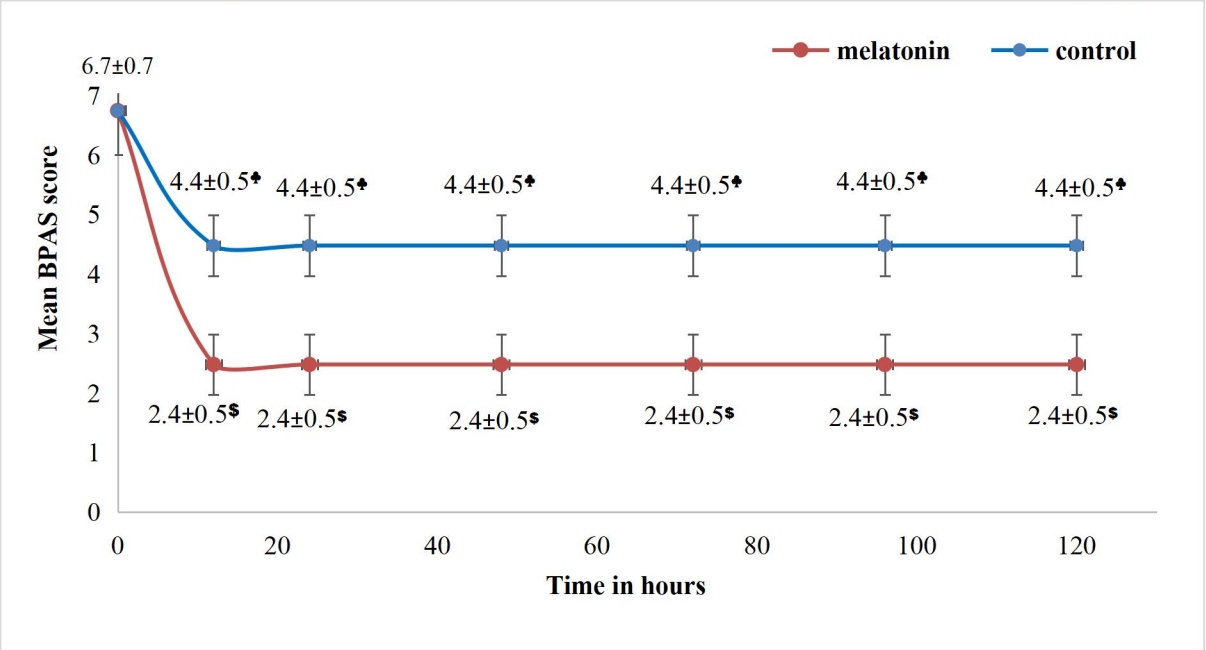
#R-ANOVA within group and *unpaired 't' test between groups.
#p within group, *p between groups, p<0.05 indicates statistical significance

Table 5. Visual Analogue Scale Score for Pain on Movement in patients of both groups

Time (hours)	Control (n=40)	Melatonin (n=40)	*p-value
0	6.7 ± 0.7	6.7 ± 0.7	--
2	6.6 ± 0.6	4.6 ± 0.6	0.0001
4	6.5 ± 0.6	4.5 ± 0.6	0.0001
6	6.1 ± 0.5	4.1 ± 0.5	0.0001
8	6.1 ± 0.5	4.1 ± 0.5	0.0001
12	4.4 ± 0.5	2.5 ± 0.9	0.0001
24	4.4 ± 0.5	2.5 ± 0.5	0.0001
48	4.4 ± 0.5	2.4 ± 0.5	0.0001
72	4.4 ± 0.5	2.4 ± 0.5	0.0001
96	4.4 ± 0.5	2.4 ± 0.5	0.0001
120	4.4 ± 0.5	2.4 ± 0.5	0.0001
# p-value	0.0001	0.0001	

#R-ANOVA within group and *unpaired 't' test between groups.
#p within group, *p between groups, p<0.05 indicates statistical significance
The baseline VAS pain scores at rest were comparable in both groups. A notable reduction in VAS scores was observed from 2 hours onward in both groups, with a consistently greater decline in the patients who received melatonin. This difference was statistically significant at all postoperative time points from 2 to 120 hours ($p < 0.0001$), with patients receiving melatonin reporting lower pain intensity throughout the observation period (Table 4). Post hoc Bonferroni analysis showed that this reduction was statistically significant from 2 hours onwards with melatonin but from 4 hours onward in the control group. A similar observation was made for movement-related pain, where patients receiving

melatonin demonstrated significantly reduced pain scores across all time intervals relative to the control group (Table 5).

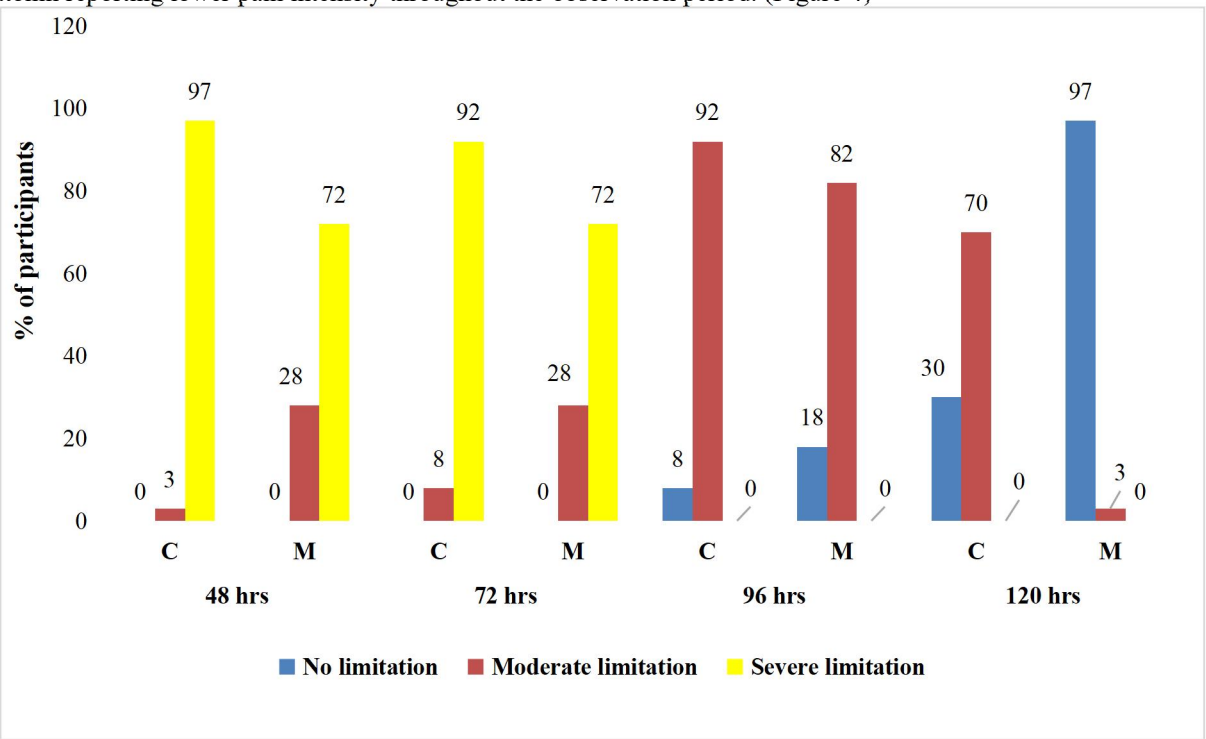


$p= 0.0001 indicates comparison between baseline and melatonin group

♣ p = 0.0001, indicates comparison between baseline and control group, p<0.05 indicates statistical significance

Figure 4. Comparison of Behavioural Pain Assessment Score (BPAS) within and between the groups

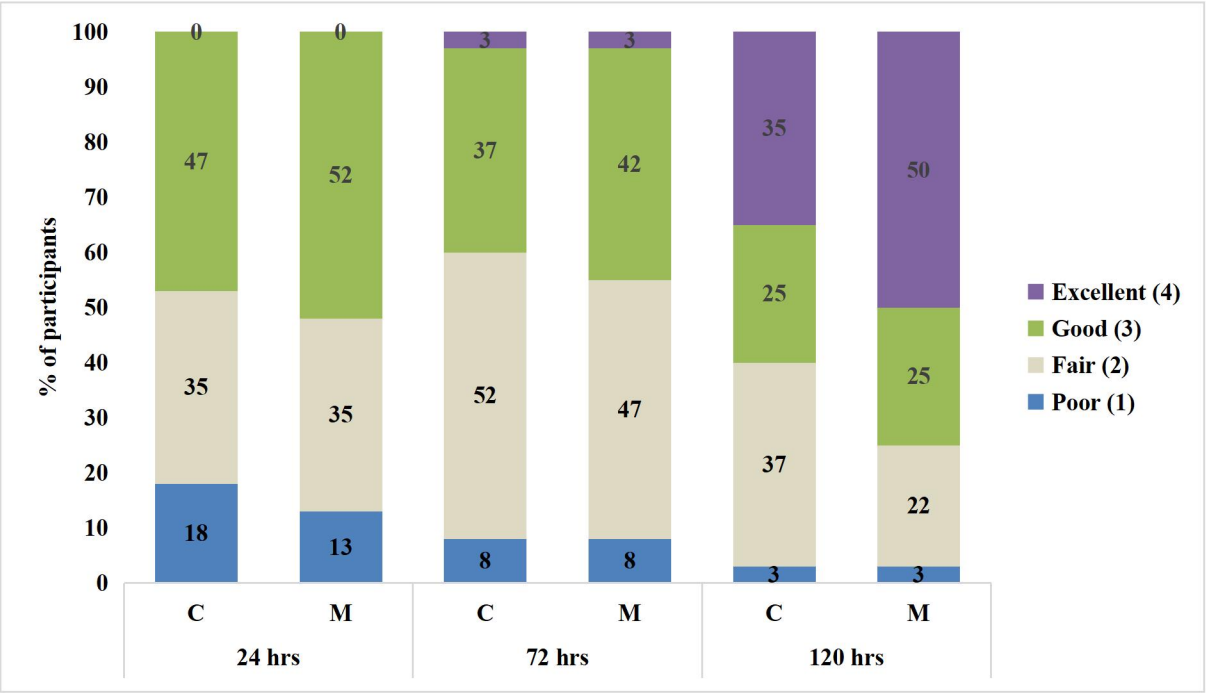
The baseline BPAS scores at rest (0 hours) were comparable between the two groups. However, from 12 hours onward, BPAS scores declined in both groups, with the melatonin group demonstrating a greater reduction. This difference was statistically significant at all postoperative time points from 12 to 120 hours ($p < 0.001$), with patients receiving melatonin reporting lower pain intensity throughout the observation period. (Figure 4)



C-control, M-melatonin

Figure 5. Comparison of the mean functional activity score between the two groups

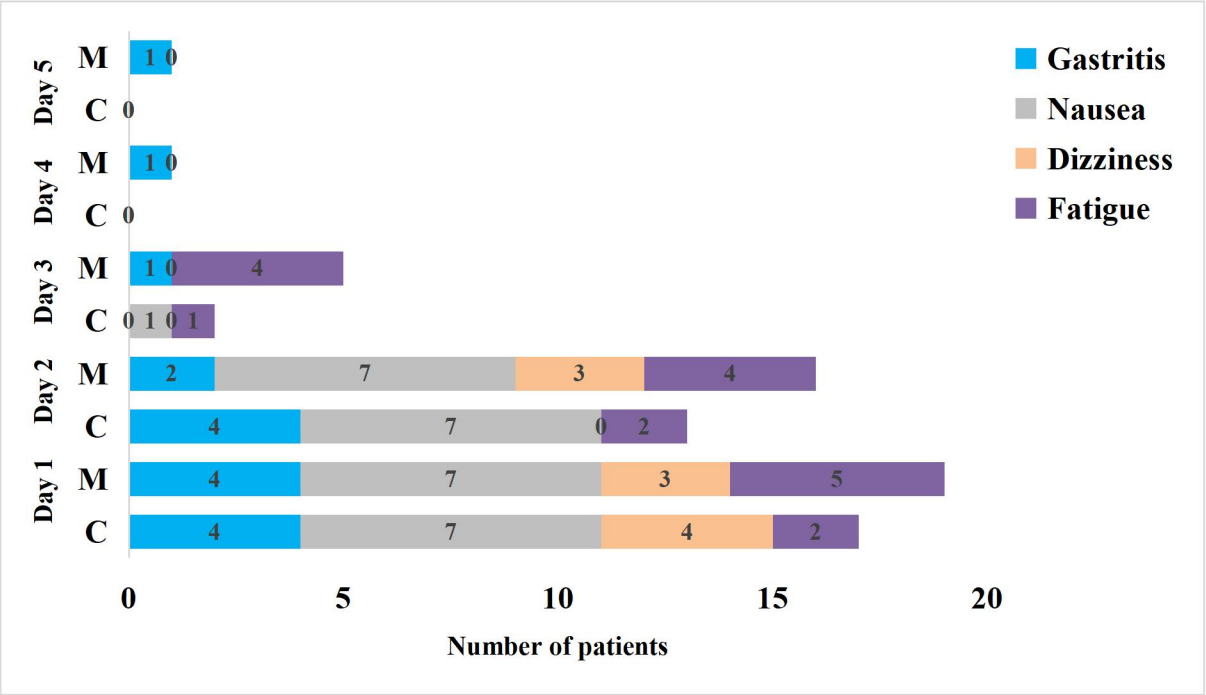
Twenty-eight per cent of patients who received melatonin were able to move their toes or ankle joint with minimal pain within 48 hours, compared to only 3 % in the control group. By the fifth postoperative day, 97 % of patients reported no pain during movement, in contrast to 30 % in the control group. These findings suggest improved functional recovery in patients receiving melatonin. (Figure 5)



C-control, M-melatonin

Figure 6. Patient Satisfaction Score (PSS) in both the groups

Patient satisfaction improved progressively in both groups from 24 hours to 120 hours postoperatively, with a greater proportion of patients in the melatonin group reporting good and excellent satisfaction, particularly at 120 hours (Figure 6)



C-control, M-melatonin

Figure 7. Adverse effects due to Diclofenac

Adverse effects associated with diclofenac were observed in 17 patients in the control group and 19 patients in the melatonin group during the first three postoperative days and declined gradually thereafter. (Figure 7) Adverse effects associated with melatonin were myalgia and headache. Myalgia was present only during the first two days, and headache persisted up to the fifth day. All were categorised as Possible as per the WHO causality assessment. No serious or unexpected adverse reactions were observed.

4. Discussion

Postoperative pain remains a concern, especially in orthopaedic surgeries involving the lower limbs, as they are associated with considerable tissue injury and inflammatory responses. Inadequately managed postoperative pain may delay rehabilitation and may affect functional recovery and patient satisfaction. Although analgesics such as NSAIDs and opioids

form the backbone of pain management, their adverse effects often limit optimal dosing.

Melatonin, an endogenous hormone secreted by the pineal gland, has been studied for its analgesic, anxiolytic, antioxidant, and neuroprotective properties. These effects may be due to modulation of pain pathways, reduction in sympathetic activity and influence on sleep regulation, which makes it a promising adjunct for postoperative pain management. In our study, melatonin was evaluated as an adjuvant to diclofenac for postoperative pain and anxiety in patients undergoing lower limb orthopaedic surgery.

Most patients included in this study were male, a finding similar to that reported in other studies.[1-3] This predominance has been attributed to higher exposure to road travel, increased use of two-wheelers, and greater engagement in risk-taking behaviours. Patients in the melatonin group were aged between 26 and 54 years, which closely aligns with the working-age group (20–49 years) identified as the most vulnerable in previous studies. In both groups, the majority of patients sustained injuries due to road traffic accidents, further supporting the vulnerability of young and middle-aged males to traffic-related trauma. There was no significant difference in the duration of surgery between the two groups, which is consistent with the findings of Jouybar R et al.[2]

To minimise variability in pain perception, the study included patients with fractures involving long bones such as the tibia, femur, and fibula, as these are associated with more intense and deeply perceived pain due to higher structural stress and rich periosteal innervation. In contrast, fractures of the smaller bones of the foot tend to cause more localised or less intense pain. This selection ensured greater uniformity in pain severity and allowed for a more reliable comparison of the analgesic effect of melatonin. Our study predominantly included patients who underwent closed reduction and internal fixation with intramedullary nailing, followed by open reduction and internal fixation using locking compression plates. Procedures associated with relatively lower postoperative pain, such as K-wire fixation, implant removal, and other minor surgical procedures, were excluded to maintain uniformity in postoperative pain intensity, as extensive procedures are known to produce higher pain levels due to muscle dissection and periosteal elevation when compared with smaller bone or minimally invasive surgeries, as noted by Zhang L et al.[12]

Systolic blood pressure is known to increase in response to pain; however, in our study, no significant change was observed in either group. This finding is similar to that reported by Vajdi M et al,[13] who demonstrated that melatonin supplementation does not affect systolic blood pressure.

We observed that anxiety scores had reduced by one hour in the melatonin group, indicating an early onset of anxiolytic effect (Table 3). This aligns with the results reported by Jouybar et al [2], where the melatonin group showed lower postoperative Hospital Anxiety and Depression Scale [HADS] scores compared with patients who received dexmedetomidine and gabapentin at 2 and 6 hours. In contrast, studies comparing melatonin with zolpidem found no major difference in anxiety control.[4] Overall, most studies reporting psychological outcomes support our finding that melatonin can contribute to perioperative anxiolysis.[5]

We observed that melatonin had significantly reduced pain scores both at rest and on movement at regular follow-up time points till 5th postoperative day. Pain relief was evident as early as 2 hours, and the effect persisted up to 120 hours. However, in the control group, a significant decrease in pain score was observed only at 12 hours, which lasted for 120 hours [Table 4,5]. These findings suggest that melatonin may be beneficial for pain control during the initial 12 hours of the postoperative period. A meta-analysis of randomised controlled trials demonstrated that melatonin significantly lowered pain scores in acute and chronic pain conditions. Studies comparing melatonin with placebo in abdominal[3] and orthopaedic procedures[14-15] have also shown reduced pain intensity in the first 24 hours postoperative period. In patients undergoing zygomaticomaxillary fracture repair, melatonin reduced pain from the third postoperative day onward, supporting its analgesic potential.[16] A clinical trial on mandibular third molar surgery reported no difference in pain, discomfort, edema, or trismus after a single 15 mg preoperative dose of melatonin. The lack of effect in that study may relate to the short duration of melatonin exposure and the nature of the procedure. In our study, we used repeated doses over five days, which may have contributed to sustained analgesic action. Differences in surgical trauma, timing of administration, and outcome measures may also explain the variability between studies.

Reduction in Behavioural Pain Assessment Scale scores was observed in both groups at 12 hours and remained the same throughout the study period. Melatonin produced a significant decrease in BPAS scores (2.4±0.5 vs 4.4±0.5) compared to control at all time points, indicating pain control during recovery is better when melatonin is added to diclofenac. None of the patients in both groups received rescue medications. Lower behavioural scores have been reported in studies where melatonin was combined with standard analgesia, often accompanied by reduced need for supplemental pain medication. Trials comparing melatonin with vitamin C and placebo[3] have shown lower morphine or diclofenac requirements in the melatonin group, similar to our study.

In our study, we also observed that functional recovery was faster in patients receiving melatonin, with all participants achieving normal activity levels by 120 hours. In the study by Pavithran et al.,[16] the improvement with melatonin was observed from the second postoperative week onwards, and more pronounced differences were evident by 4 weeks

after surgery compared with the control group.
Rescue medication with tablet tramadol 100 mg was planned for patients with a VAS score >3; but none of the patients in the study expressed that they were unable to tolerate the pain even though the score was more than defined. The mean VAS score in the control group remained >3 throughout the study period, while in the melatonin group it remained >3 only up to 8 hours postoperatively. During assessment at different postoperative time points, VAS scores were in the range of 4-6 during in the first 8 hours after surgery in both groups, during which patients received an injection diclofenac. According to VAS grading, scores of 1–3 indicate mild pain, 4–7 moderate, and 8–10 severe. Patients with moderate VAS scores were counselled, and the pain was tolerated by the patients. Therefore, pain was adequately managed with diclofenac, and the need for additional rescue medication did not arise. Since tramadol is an opioid and can cause vomiting, it was withheld unless the pain was unbearable and in this study none of the patients experienced intolerable pain, so rescue medication tramadol was not administered.
Patients receiving melatonin were satisfied with the medication they received for pain, as observed by a higher satisfaction score in our study. The analgesic and anxiolytic effect of melatonin may have influenced this effect. Similar findings have been noted in studies where improved sleep, reduced pain, or decreased need for analgesics contributed to better subjective recovery, which could have resulted in better patient satisfaction.
Melatonin was tolerated by all patients except a few experiencing mild headache, dizziness, and fatigue, which did not lead to discontinuation of the study medication. Most studies also report a favourable safety profile for melatonin, with no serious adverse effects identified even when used for several days or weeks postoperatively.

5. Limitations

The postoperative follow-up period was five days; therefore, long-term outcomes such as duration of hospital stay and persistent pain could not be assessed. In addition, variations in fracture type and surgical procedures among patients may have influenced postoperative pain perception and recovery. Although spinal anaesthesia was administered according to institutional protocol, minor variations in anaesthetic dosing and adjuvant use could also have affected postoperative pain outcomes.

6. Conclusion

Perioperative melatonin reduced postoperative pain and anxiety, enhanced functional recovery, and improved patient satisfaction earlier with no serious adverse effects. Thus, melatonin can be an effective adjuvant for postoperative pain in lower limb orthopaedic surgery.
CONSORT reporting guidelines were followed for this randomised clinical trial.

Author Contributions

All authors contributed to the conception and design of the study. Mohammed Faisel HA prepared the study protocol, collected the data, performed the analyses and drafted the manuscript. Bhuvana K contributed to the study concept, design, supervised the research, interpreted the findings and critically revised the manuscript. Nagakumar JS facilitated patient recruitment, provided clinical guidance regarding the orthopaedic cases and reviewed the manuscript. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work

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Conflict of interest: None

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