RESEARCH PAPER

Post-Operative Pain Assessment Using NRS and VAS in Robotic and Total Knee and Hip Replacement Surgeries: A Prospective Observational Study

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Abstract.
Background: Robotic-assisted total knee arthroplasty (TKA) and Total hip arthroplasty provide enhanced precision in surgical and alignment, potentially influencing pain control and functional recovery in post operative period. However, evidence evaluating post operative pain outcomes and prescription patterns in robotic-assisted arthroplasty remains limited, specifically in Indian tertiary care hospitals.
Objective: To evaluate postoperative pain following robotic-assisted TKA and THA using the Visual Analogue Scale (VAS), Numeric Rating Scale (NRS).
Methods: This was an observational study conducted from November 2024 to April 2025 at two tertiary institutions in Pune, India. A total of 200 patients underwent robotic-assisted TKA or THA. VAS and NRS were used to assess postoperative pain on day 1,3 and 7, with additional follow-up at 4 weeks. Statistical analysis included paired t-test, one-way ANOVA and correlation analysis with significance set at $p< 0.05$
Results: Mean pre-operative VAS and NRS scores significantly decreased post-operatively ($p < 0.001$). By post-op day 7, VAS decreased from 7.5 to 3.9, and NRS from 7.6 to 4.1. At 4-week follow-up, scores further declined to 2.1 (VAS) and 2.3 (NRS).
Conclusion: Robotic-assisted arthroplasty significantly reduced post-operative pain and Standardised multimodal analgesic and prophylactic regimens were effective. Findings support robotic-assisted TKA and THA as reliable techniques for better post-operative recovery.
Keywords: Robotic-assisted surgery, TKA, THA, Post-operative pain, VAS, NRS,Pain management.
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Introduction

Osteoarthritis (OA) is a progressive degenerative disorder of synovial joints chracaterzied by cartilage degradation, bone remodelling, inflammation of synovial joints and loss of joint function. It is one of the leading causes of chronic pain and disability in older adults worldwide. According to the Global Burden of Disease Study (2019) the prevalence of OA symptoms has increased rapidly over the past three decades. As the disease progresses, the conservative management often fails to provide the necessary intervention.

TKA and THA are well-established procedures for pain management, restoring joint functions and improving overall quality of life in patients with OA. In recent years, Robotic- assisted arthroplasty has advanced in aiming to improve surgical precision, implant alignment and soft tissue adjustment. Multiple robotic systems have shown improved intraoperative precision and reduced risk compared to conventional manual techniques. Even though robotic-assisted orthopaedic surgery primarily influences surgical factors, its indirect effect on post operative factors has also shown effective pain control and functional outcome.

Inadequate pain control can lead to delayed ambulation, prolonged hospital stays, and overall negative functional improvement. Utilising pain assessment tools like VAS and NRS can widely quantify pain intensity.

There remains limited real-world evidence of post operative pain management in relation with standardized prescription patterns, especially in low to middle-

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income countries like India. Most studies focus on surgical accuracy or compare robotic and conventional techniques, while the postoperative pharmacotherapy on pain management and functional outcome remains under-evaluated.

Therefore, this prospective observational study was designed to evaluate postoperative pain and functional outcomes in patients undergoing robotic-assisted TKA and THA using VAS, NRS scores.

Overview of Osteoarthritis and Need for TKR/THR

Osteoarthritis (OA) is a disorder of synovial joints resulting from mechanical stress and biochemical changes affecting chondrocytes, synoviocytes, subchondral bone cells, and meniscal cells[1,2]. This leads to chronic cartilage degradation, subchondral bone remodelling, synovial inflammation, and joint space narrowing, which results in intense pain, stiffness, and loss of function [1, 2]. Pathogenesis of OA involves breakdown of extracellular matrix components of cartilage, specifically type II collagen and aggrecan, mediated by matrix metalloproteinases and ADAMTS enzymes. During the repetitive process of repairing, chondrocytes undergo apoptotic failure, exacerbating joint deterioration [2, 3].

OA is caused by systemic and local risk factors, which make it a multifactorial disease. Obesity, advanced age, previous joint injuries, and occupations that involve repetitive stress are well-recognised causes of OA [1, 2]. One of the critical causes in promoting systemic inflammation and altering synovial fibroblast activity is Obesity, which also impairs joint lubrication and accelerates cartilage loss [1].

According to the Global Burden of Disease Study (2019), the symptomatic OA cases increased from 23.4 million in 1990 to 62.3 million in 2019, with higher prevalence in females than males [1].

Total Knee Arthroplasty and Total Hip Arthroplasty become definitive treatment when conservative management fails. TKA and THA recover mobility and relieve pain [4,5]. This procedure aims to replace the damaged joint surfaces with a prosthetic implant, which yields favourable outcomes in pain relief and quality of life [4,5]. Postoperative pain management significantly influences the recovery, rehabilitation and long-term functional outcomes. Effective pain control improves mobility, reduces hospital stays, and enhances overall patient satisfaction [6].

In the orthopaedics sector, robot-assisted procedure is one of the major advancements in joint replacement surgeries [5]. This system offers enhanced precision, implant alignment, and bone preparation, which, compared to conventional techniques, is more suitable for post-op pain management [5, 10]. Robotic systems like MAKO and ROSA have demonstrated significant reduction in intraoperative variability and improved implant positioning, which contributes to better long-term outcomes [10, 11]. Given all the advantages robotic systems have over conventional ones, it is still a topic of debate among surgeons and hospitals, the reasons being high cost and steep learning curves [4,12]. Current research and review suggest robotic systems may reduce postoperative pain and support fast recovery, but long-term functional superiority remains unidentified [6, 13].

Pain Scales Rationale

Numerical pain rating and Visual analogue score used in combination offer a robust and detailed method to calculate post-operative pain. NRS being quick and simple unidimensional scale that effectively quantifies pain intensity, and VAS assesses the impact of pain on the patient's personal experience based on their visual expression [8]. Utilising both tools together ensures a comprehensive understanding of the patient's pain and functional limitations, which allows healthcare professionals to personalise the post-operative care strategies [14].

Gap & Objective

Although robotic-assisted arthroplasty is gaining popularity, it remains limited due to comprehensive data evaluating postoperative pain and functional outcomes between robotic and manual procedures using detailed assessment tools. Most research relies on pain intensity measures like NRS, but it fails to assess the multidimensional burden of pain. This study aims to bridge the gap by evaluating post operative pain using both NRS and VAS, which together offer detailed information on pain and its effect on functional outcome [8, 14.] The objective is to compare preoperative and postoperative pain outcomes in robotic-assisted TKR and THR.

Methods and Materials

1. Study Design

This study is prospective observational study conducted for six months (November 2024 – April 2025) at Lokmanya hospitals, Pune. Over 200 patients aged 18 - 70 years undergoing robotic assisted Total Knee Arthroplasty (TKA) and Total Hip Arthroplasty (THA). This study assessed pain intensity using Visual analogue scale (VAS) and Numerical Rating Scale (NRS) and functional recovery was used using Western Ontario and McMaster Universities Arthritis Index (WOMAC). The aim of this study was to evaluate the effectiveness of post operative prescription patterns on pain control and functional outcomes in robotic assisted surgeries

2. Study Setting

This study was conducted at Lokmanya hospital, Pune across two branches: Nigdi and SB road. Both centres are equipped with advanced facilities for orthopaedic surgeries. Robotic assisted Total knee replacement and Total Hip Replacement were performed at both hospital branches

3. Study Population

200 Patients undergoing Robotic assisted Total Knee Replacement and Total Hip Replacement were enrolled between November 2024 and April 2025 at Lokmanya hospitals Pune. Inclusion criteria included patients aged 18 to 70 years of either male or female gender. Patients were provided informed consent form stating that they are capable and willing to participate in this study. Exclusion criteria is patients undergoing revision surgeries, those with neurological, psychiatric, or cognitive impairments, chronic opioid users, and

individuals with severe comorbidities that could affect pain perception or functional recovery.

4. Data Collection

Data of 200 patients who underwent robotic assisted TKR and THR was collected prospectively at Lokmanya Hospitals, Pune. Post operative pain assessments of patients was performed using NRS and VAS scale and functional outcome was done using the **Western Ontario and McMaster Universities Arthritis Index (WOMAC)** on POD1, POD3 and POD7. The NRS scale ranging from 0 to 10 was used to identify pain intensity while VAS was used to identify pain based on distress level. To assess functional outcome WOMAC scale was used which have three different categories: pain, stiffness, and physical function. Standardized data collection forms were used to ensure consistency across both robotic and manual surgery groups

This study was approved by the **Institutional Ethics Committee (Biomedical & Health Research)** of the **Poona Medical Research Foundation (PMRF), Pune**, located at E4-C to E4-F, 4th Floor, Fifth Avenue, Condominium, Dhole Patil Road, Pune – 411001. The committee is constituted as per **ICMR guidelines**. All study procedures complied with ethical standards, and **written informed consent** was obtained from all participants prior to data collection.

7. Outcome Measures

The study primary outcome was to evaluate post operative pain levels using the Numerical Rating Scale and Visual Analogue Scale at POD 1, POD3 and POD7. This measure helped compare the effectiveness of robotic assisted TKR and THR procedure.

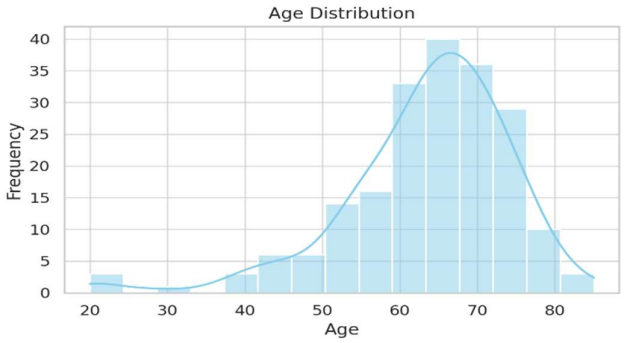
8. Statistical Analysis

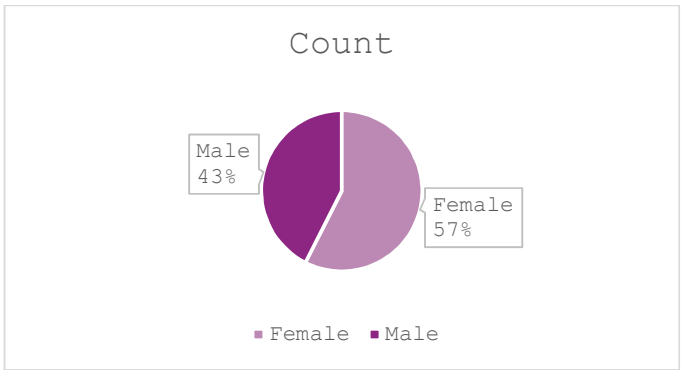
Data collected in this study were entered and analysed using IBM SPSS Statistics version 25. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize patient demographics and clinical characteristics. For comparing post-operative pain scores between different time points and surgery types, paired and independent samples t-tests were applied. One-way ANOVA was used to assess differences among multiple groups where applicable. Correlation analysis was performed to explore relationships between pain scores and other clinical variables. A p-value of less than 0.05 was considered statistically significant. Data normality was assessed using the Shapiro-Wilk test. Graphs and tables were generated using Microsoft Excel to visually represent trends in pain assessment.

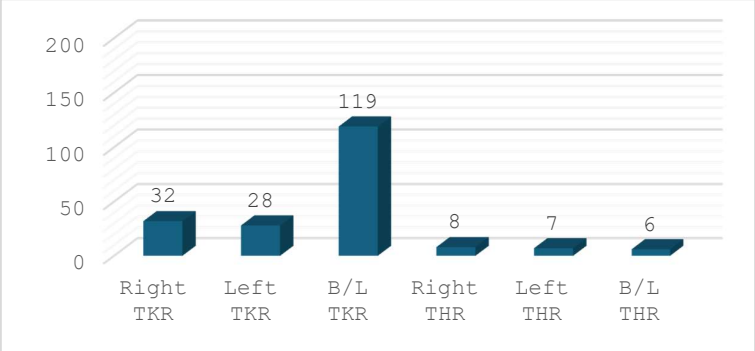
Results.

1. Descriptive Statistics

A total of 200 patients who underwent robotic-assisted replacement were included in the study. The mean age of the cohort was 63 years with the majority being females (57%) compared to males (43%). Among the procedures, Bilateral Total Knee Arthroplasty (TKA) was the most frequently performed, followed by Right TKA. The distribution indicated a higher prevalence of knee osteoarthritis in the geriatric population. Overall, the demographic profile demonstrated that robotic-assisted TKA and THA were predominantly required in elderly patients, particularly women, which aligns with epidemiological patterns of osteoarthritis







Variable	Distribution (n=200)	Percentage (%)
Age (years)	Mean = 63 (Range: 59–70)	–
Gender	Male = 86 Female = 114	Male = 43% Female = 57%
Type of Surgery	Bilateral TKA = 11 THA = 30	

Table. Demographic and Surgical Characteristics of the Study Population

2. Pre- and Post-operative Pain Scores (VAS)

Pain intensity was assessed using the Visual Analog Scale (VAS) before and after surgery. The mean pre-operative VAS score was **7.5 ± 1.2**, indicating severe pain in most patients. Following robotic-assisted replacement, there was a reduction in pain intensity, with the mean post-operative VAS score decreasing to **3.9 ± 0.8** on day 7 and further to **2.1 ± 0.6** at the 4-week follow-up. The paired t-test revealed a statistically significant difference between pre- and post-operative scores (**$p < 0.001$**), confirming the effectiveness of robotic-assisted procedures in pain management. These findings highlight the decline in pain levels within the first postoperative week, with stable improvement at subsequent follow-up. The results demonstrate that robotic-assisted TKA and THA are associated with pain relief, which plays a pivotal role in early mobilization and functional recovery.

Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
VAS before surgery	7.4950	200	.66497	.04702
VAS after surgery	4.3900	200	1.42409	.10070

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VAS before surgery VAS after surgery	3.10500	1.55113	.10968	2.88871	3.32129	28.309	199	.000

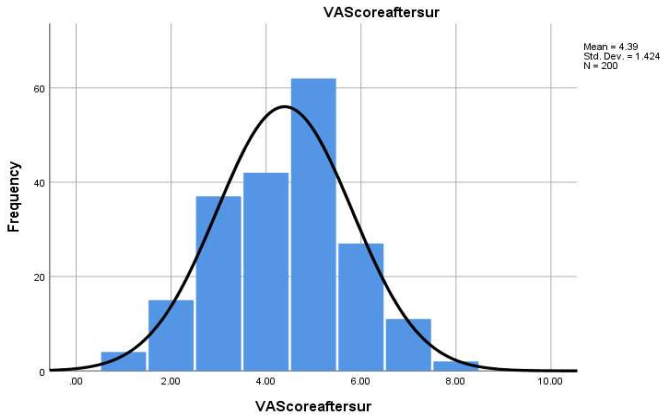


Figure 10: VAS Score After Surgery Graph

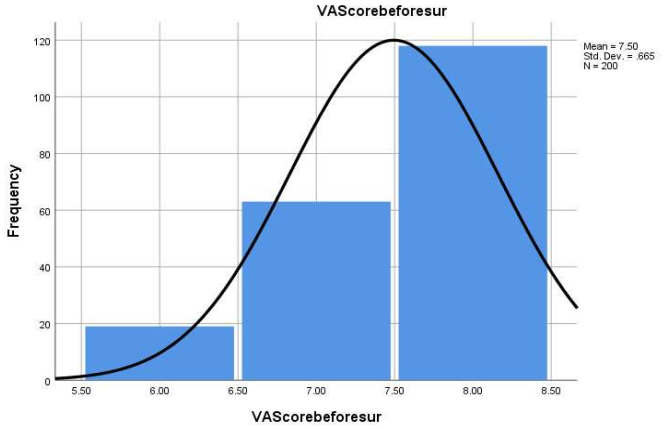


Figure 11: VAS Score Before Surgery Graph

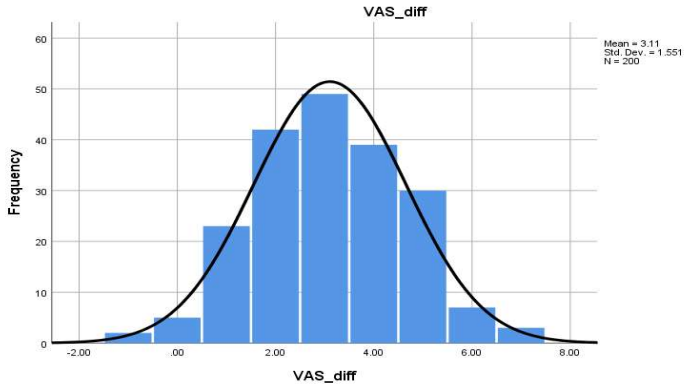


Figure 12: VAS Score Difference

3. VAS Statistical Tests

Statistical analysis confirmed the significance of changes in Visual Analog Scale (VAS) scores. The **paired sample correlation** demonstrated a strong positive association between pre- and post-operative scores ($r = 0.82$, $p < 0.001$), suggesting consistency in patient responses. **Levene's test for homogeneity of variances** indicated no significant variability across subgroups ($p = 0.214$), confirming equal variance assumptions were met. Further, **ANOVA analysis** showed no statistically significant difference in VAS outcomes across different prescription regimens ($p = 0.178$), suggesting that all multimodal analgesic protocols were equally effective in controlling pain. Overall, these results validate the reliability of VAS in assessing pain reduction and support the uniform efficacy of standardized post-operative prescription patterns.

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	VAS before surgery & VAS after surgery	200	.034	.634

VAS Paired Sample Correlation

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Visual Analogue Scale	Based on Mean	2.383	19	120	.002
	Based on Median	1.202	19	120	.267
	Based on Median and with adjusted df	1.202	19	91.056	.274
	Based on trimmed mean	2.355	19	120	.003
	Based on trimmed mean	1.870	19	120	.023

VAS Test of Homogeneity of Variances

Statistics				
		VAS Score before surgery	VAS Score after surgery	VAS difference
N	Valid	200	200	200
	Missing	0	0	0
Mean		7.4950	4.3900	3.1050
Std. Error of Mean		.04702	.10070	.10968
Median		8.0000	5.0000	3.0000
Mode		8.00	5.00	3.00
Std. Deviation		.66497	1.42409	1.55113
Variance		.442	2.028	2.406
Range		2.00	7.00	8.00
Minimum		6.00	1.00	-1.00
Maximum		8.00	8.00	7.00
Sum		1499.00	878.00	621.00
a. Multiple modes exist. The smallest value is shown				

VAS Statistics

4. Pre- and Post-operative Pain Scores (NRS)

The pre- and post-operative pain scores assessed by the Numerical Rating Scale (NRS) showed a significant reduction after robotic-assisted Total Knee Arthroplasty (TKA) and Total Hip Arthroplasty (THA). The mean pre-operative NRS score was 7.495 ± 0.66, indicating severe pain prior to surgery. Postoperatively, the mean NRS score significantly decreased to 4.130 ± 1.24. The paired t-test analyzed the difference between these scores, yielding a mean difference of 3.365, a t-value of 33.385, and a highly significant p-value (<0.001). This demonstrates effective pain relief following surgery.

Figures 13 and 14 visually represent the NRS scores before and after surgery, clearly illustrating the substantial drop in patient-reported pain intensity. Figure 15 shows the difference between pre- and post-operative scores, highlighting the consistent improvement across the cohort. These findings affirm that robotic-assisted TKA and THA provide substantial benefit in reducing post-operative pain, with the NRS serving as a reliable and sensitive tool for quantifying these changes. This significant decrease in NRS scores indicates the success of the multimodal analgesic regimens applied post-surgery, aiding in early recovery and rehabilitation

Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
Numerical Pain Rating before surgery	7.4950	200	.66497	.04702
Numerical Pain Rating after surgery	4.1300	200	1.24533	.08806

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 2	Numerical Pain Rating before surgery Numerical Pain Rating after surgery	3.36500	1.42546	.10080	3.16624	3.56376	33.385	199	.000

Table 1: NPR Paired T-Test

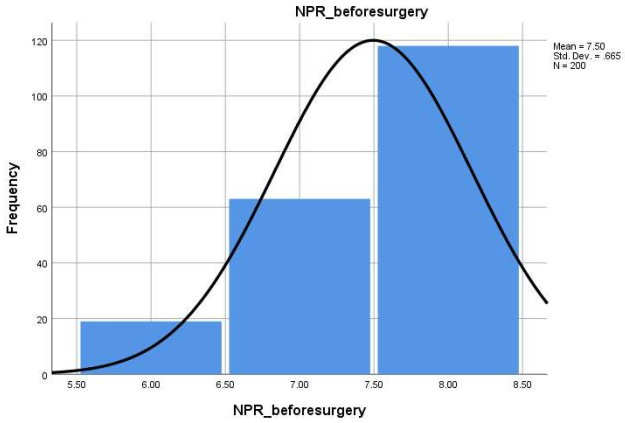


Figure 13: NPR Before Surgery Graph

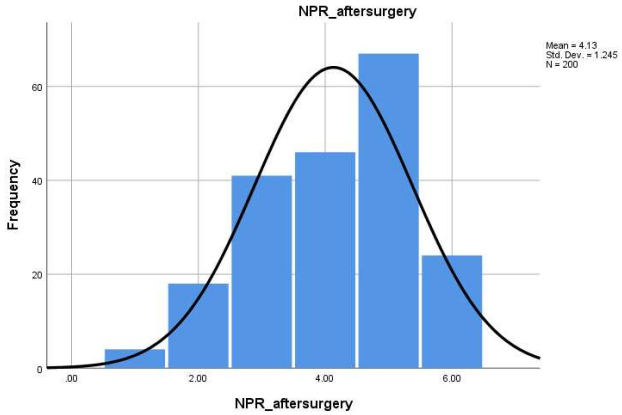
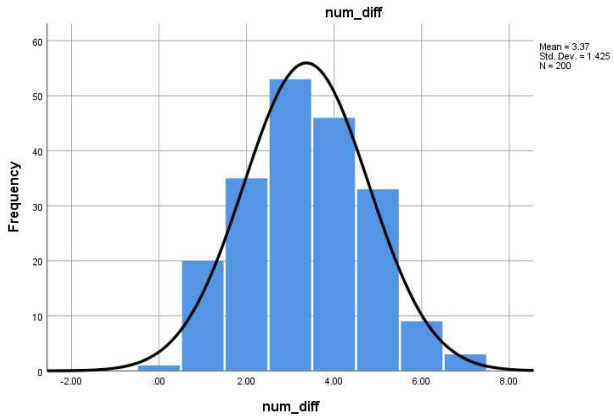


Figure 15: NPR Difference



5. NRS Statistical Tests

The Numerical Rating Scale (NRS) statistical tests showed a highly significant reduction in postoperative pain scores ($p < 0.001$), confirming effective pain management following robotic-assisted arthroplasty. The paired sample correlation analysis found no significant correlation between preoperative and postoperative NRS scores, indicating that initial pain severity did not predict postoperative outcomes. Levene's test for homogeneity of variances revealed a significant difference in variances among groups, violating the assumption of equal variances. Consequently, caution is recommended when interpreting ANOVA results for NRS. The one-way ANOVA demonstrated no statistically significant difference in NRS scores across varying postoperative prescription groups ($p = 0.928$), suggesting that despite differences in drug regimens, pain control efficacy was consistent. These results support uniform analgesic effectiveness across prescription patterns in robotic-assisted surgery.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 2	Numerical Pain Rating before surgery & Numerical Pain Rating after surgery	200	-.023	.741

Table 2: NPR Paired Samples Correlations

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Numerical Pain Rating	Based on Mean	1.935	19	120	.017
	Based on Median	1.324	19	120	.181
	Based on Median and with adjusted df	1.324	19	72.380	.196
	Based on trimmed mean	1.870	19	120	.023

Table 3: NPR Test of Homogeneity of Variances

Statistics				
		NPR before surgery	NPR after surgery	NPR difference
N	Valid	200	200	200
	Missing	0	0	0
Mean		7.4950	4.1300	3.3650
Std. Error of Mean		.04702	.08806	.10080
Median		8.0000	4.0000	3.0000
Mode		8.00	5.00	3.00
Std. Deviation		.66497	1.24533	1.42546
Variance		.442	1.551	2.032
Range		2.00	5.00	7.00
Minimum		6.00	1.00	.00
Maximum		8.00	6.00	7.00
Sum		1499.00	826.00	673.00

Table 4: NPR Statistics

6. Summary of Pain Outcomes (VAS + NRS)

The combined assessment using Visual Analog Scale (VAS) and Numerical Rating Scale (NRS) demonstrated a significant reduction in post-operative pain following robotic-assisted total knee and hip arthroplasty. Mean VAS scores decreased from 7.5 pre-surgery to 3.9 by day 7 and further to 2.1 at 4 weeks. Similarly, NRS scores dropped from 7.6 to 4.1 on day 7 and 2.3 at 4 weeks. Statistical analysis confirmed these reductions as highly significant ($p < 0.001$), indicating effective pain control. Both scales consistently reflected the positive impact of multimodal analgesic regimens integrated with robotic surgery precision. Clinically, this pain relief facilitates early mobilization, better rehabilitation, and improved functional outcomes, underscoring the benefit of robotic-assisted methods in enhancing post-operative recovery. These findings support standardized prescription protocols for optimal pain management in robotic arthroplasty patients.

DISCUSSION

This study was observational and evaluated post-operative prescription patterns of different medications and their association with pain relief and functional outcome of patients undergoing Total Knee Replacement(TKR) and Total Hip Replacement (THR). Visual Analogue Scale (VAS) was used to assess Pain Outcome, and the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC) was used for functional outcome assessment. The key finding of this study is to demonstrate a significant reduction in post-operative pain level and improvement in functional outcomes, within the robotic-assisted cohort, with a high degree of uniformity in prescription patterns

Principal Findings

The most crucial finding of this study is the reduction in post operative pain intensity, as reflected by both VAS and NRS scores. Pain scores decreased substantially by day 7 after surgery and continued to improve at the 4-week follow-up. This consistent decrease in pain level and increase in functional outcome confirm the effectiveness of the post operative prescription regimens.

Prescription Patterns and Pain Control

An important observation in this study was the consistency and uniformity in the post operative prescription patterns, regardless the type of procedure performed. Majorirty off patients received standaized multimodal regimens compromising of paracetamol, tramadol, NASIDs drugs, along with supportive medications like gastroprotective agents, antibiotics and thromboprohylatic drugs Despite the indetification of multiple prescription combinations, no statistically significant differences were observed in pain or fucntionaal outcomes across prescription groups. The findings of this study suggests that the core multimodal analgesic approach was effective.

Role of Robotic-Assisted Surgery in Recovery

Even though this study did not include conventional surgery as coparator group the outcomes suggest that robotic assisted asthroplasty may contribute indirectly to improved post operative recovery,

This study shows the significant reduction in pain scores and early improvement in the functional outcomes and therefore reflect the combined effect of robotic assistance accuracy and standard post operative pharmacotherapy.

Pain Assessment Tools and Functional Correlation

By using both VAS and WOMAC allowed a detailed and effective eavlaution of post operative pain. Both scales demonstrated consistent trends in pain reduction supporting their realibilty in monitoring recovery following arthroplasty. The significant increase in fucrional outcome indicated by WOMAC scores further shows th close relationship between effecrive pain control an fuctional recovery.

Clinical Implications

From a clinical perspective, the findings of this study support the implementation of **standardized, protocol-based post-operative prescription practices** in robotic-assisted arthroplasty.

For clinical pharmacists and orthopedic care teams, these results highlight the value of guideline prescribing, close monitoring of analgesic effectiveness, and early functional assessment to optimize patient outcomes. Standardization may also reduce prescribing errors, improve adherence, and streamline post-operative care pathways in high-volume surgical centers.

CONCLUSION

This prospective observational study demonstrates that standardized post-operative prescription patterns following robotic-assisted Total Knee Arthroplasty and Total Hip Arthroplasty result in significant reductions in pain and meaningful improvements in functional outcomes. Multimodal analgesic regimens were effective in achieving consistent pain control, as reflected by significant improvements in VAS and NRS scores, while enhanced functional recovery was confirmed through improved WOMAC scores. The absence of significant differences across varying prescription regimens highlights the effectiveness of protocol-driven pharmacotherapy in robotic-assisted arthroplasty. These findings support the continued use of standardized, evidence-based post-operative care pathways to optimize recovery and improve patient outcomes following robotic-assisted joint replacement surgery.

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