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RESEARCH ARTICLE

RESULTS OF ROBOTIC ASSISTED VS CONVENTIONAL TOTAL KNEE ARTHROPLASTY AT 1 YR FOLLOW UP

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Abstract

Background: Osteoarthritis (OA) of the knee is a prevalent condition among older individuals, causing significant discomfort and impairments in quality of life. Conventional total knee arthroplasty (COTKA) is a common treatment, but issues such as inadequate soft tissue balance and prosthesis misalignment can impact outcomes. Robotic-assisted total knee arthroplasty (RATKA) has emerged as a potential solution, offering enhanced precision in prosthesis placement. While observational studies suggest benefits, comprehensive reviews of randomized controlled trials (RCTs) are lacking. This study aims to fill this gap by evaluating the clinical, functional, and radiological outcomes of RATKA compared to COTKA in adult patients with primary knee OA.

Methods: This prospective study was conducted at a specialized orthopedic center, involving patients diagnosed with symptomatic knee OA eligible for total knee replacement (TKR). Patients were allocated to either conventional TKR (Group A) or robotic-assisted TKR (Group B). Outcome measures included Visual Analog Scale (VAS) for pain, Knee Society Score (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), patient satisfaction, and quality of life assessments. Radiological outcomes were assessed using standardized radiographs. Statistical analyses included descriptive statistics, group comparisons, and repeated measures analysis of variance (ANOVA).

Results: Baseline characteristics showed similar distributions between Group A (n=30) and Group B (n=30). Clinical outcomes demonstrated significant improvements over time in both groups, with Group B consistently outperforming Group A across all measures. Notably, Group B exhibited lower pain scores (VAS), higher functional scores (KSS), lower disability scores (WOMAC), higher patient satisfaction, and better quality of life assessments. Radiological outcomes also favored Group B, with improved mechanical axis deviation and component positioning.

Conclusion: Robotic-assisted TKR demonstrated superior clinical, functional, and radiological outcomes compared to conventional TKR

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in patients with knee OA. These findings support the growing body of evidence favoring the use of robotic technology in TKR procedures, particularly for optimizing implant placement and alignment. Future research should focus on cost-effectiveness and long-term outcomes to further inform clinical practice and enhance patient care.

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Introduction:-

Osteoarthritis (OA) of the knee is the primary source of knee discomfort in older individuals, affecting around 23% of the global population (1). This disorder results in substantial impairment, impacting the quality of life of patients. Conventional total knee arthroplasty (COTKA) is typically recommended for patients who have not responded to conservative therapy. While COTKA generally produces positive results, surgical problems such inadequate balance of soft tissues and misalignment of the prosthesis might have a negative effect on the outcomes (2). Issues such as postoperative prosthesis alignment and patient-reported outcome measures (PROMs) have a significant impact on crucial outcomes (3). As a result, several methods and surgical instruments have been employed for these crucial surgical procedures. Robotic-assisted total knee arthroplasty (RATKA) utilises navigation technology to visualise the preoperative planning process. It can assist in accurately determining the position of the hip centre, providing guidance for bone cutting, and assessing the tension of soft tissues and overall stability (4). RATKA has been demonstrated to enhance the precision of prosthesis placement and improve some patient-reported outcome measures (PROMs) in numerous observational studies and their systematic reviews (5-8). Over the past 4 years, multiple randomised controlled trials (RCTs) have been published comparing RATKA with COTKA. However, there has been a lack of a comprehensive review and meta-analysis of these RCTs. By utilising a higher standard of evidence, these reviews have the potential to increase the level of confidence in the combined estimates and potentially strengthen the synthesised findings derived from observational studies. Thus, we performed a comprehensive analysis of randomised controlled trials (RCTs) to assess the potential of RATKA to enhance clinical and functional outcomes, as well as radiological outcomes, in comparison to COTKA in adult patients with primary knee osteoarthritis (OA).

Materials and Methods:-

The study design and setting are described in this section. This study was conducted at a specialised orthopaedic surgery centre that provides tertiary treatment. All participants in the study gave their informed consent.

Patients diagnosed with symptomatic knee osteoarthritis requiring primary TKR. Inclusion criteria consisted ofAge equal to or greater than 50 years and the participant has symptomatic knee osteoarthritis requiring TKR Eligibility for total knee replacement (TKR)while patents with history of prior knee surgeries, Inability to provide informed consent and or Presence of contraindications for either conventional or robotic-assisted TKR were excluded.A meticulous sample size calculation was conducted to guarantee statistical power. In order to achieve a statistical power of 80% and a significance level of 0.05, a sample size of 30 patients in each group was deemed appropriate for detecting significant differences in clinical and radiological results.

Surgicaltechniques

Eligible 30 Patients diagnosed with symptomatic knee osteoarthritis requiring TKR treated with two different surgical approaches: Group A (Conventional TKR) and Group B (Robotic-assisted TKR).

Conventional TKR (Group A):

Patients in this group underwent conventional TKR using standardized surgical techniques. Implant selection, bone cuts, and com-ponent positioning adhered to the hospital's established TKR protocols.

Robotic-assisted TKR (Group B):

Patients in this groupunderwentrobotic-assistedTKR. Preoperative planning was meticulouslyconducted to optimize implant positioning and alignment. Intraoperatively, the robotic system provided real-time guidance for precise bone cuts and componentplacement.

Outcome Measures

Medical results: Patients completed preoperative assessments and routine postoperative examinations, which included:

1. Visual Analog Scale (VAS) for pain
2. Knee Society Score (KSS)
3. Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

Patient-reported outcomes, encompassing satisfaction and quality of life

Radiological outcomes were assessed using standardised radiographs, which included anteroposterior and lateral views. These radiographs were taken before the surgery and at specific follow-up intervals. The radiological assessments comprised:

1. Postoperative alignment (quantified as mechanical axis deviation)
2. Component positioning (evaluated for varus/valgus, flexion/extension, and rotation)
3. Implant survivorship and the monitoring of complications

Statistical Analysis

The data underwent rigorous statistical analysis. Baseline characteristics were summarised using descriptive statistics, which included means, standard deviations, and percentages. Group comparisons were performed using statistical tests such as the Student's t-test, Mann-Whitney U test, chi-squared test, or Fisher's exact test, depending on the circumstances. The study evaluated the changes in clinical and radiological outcomes over time using statistical methods such as repeated measures analysis of variance (ANOVA) or mixed-effects models. The threshold for statistical significance was established at a p-value of less than 0.05. Alternatively, Fisher's exact test will be used if deemed suitable. The study evaluated the evolution of clinical and radiological outcomes by employing repeated measures analysis of variance (ANOVA) or mixed-effects models. The threshold for statistical significance was established at a p-value of less than 0.05.

Data Collection and Management

The data were gathered using standardised case report forms and carefully inputted into a secure electronic database. Stringent data quality checks and validation methods were put in place to guarantee the accuracy and comprehensiveness of the data.

Subsequent Action

Patients were provided with regular and systematic postoperative follow-up, occurring at specific intervals of 6 weeks, 3 months, 6 months, and once a year. The purpose of these follow-ups was to evaluate the clinical and radiological results, while also carefully documenting and managing any adverse events or problems.

Results:-

In this study, we examined the baseline characteristics and outcome of participants undergoing Total Knee Replacement (TKR) surgery, comparing two groups: Conventional TKR (Group A) and Robotic-assisted TKR (Group B).

In Group A, consisting of 30 participants, there were 17 males and 13 females. In Group B, which also included 30 participants, there were 17 males and 13 females. The two groups were found to have similar gender distributions, the primary objective of this study is to compare the outcomes and experiences of patients undergoing conventional TKR and those receiving robotic-assisted TKR. By analyzing the baseline characteristics of the participants, we can better understand the potential differences between the two groups and identify factors that may influence their outcomes.

Table 1:- Baseline Characteristics of Study Participants.

Characteristic	Conventional TKR (Group A)	Robotic-assisted TKR (Group B)	p-value
Total Participants	30	30	-
Gender (Male/Female)	17/13	17/13	-

Table 2 illustrates the clinical outcomes of patients undergoing TKR over a span of one year. Preoperative baseline values are compared with measurements at 6 weeks, 3 months, 6 months, and 1 year post-intervention. The results reveal significant improvements across all outcome measures, including notable reductions in pain levels as assessed by the Visual Analog Scale (VAS), substantial enhancements in functional and quality of life indicators such as the Knee Society Score (KSS), WOMAC Score, and Quality of Life assessments (e.g., SF-36). Moreover, patient satisfaction consistently rose over time, reaching a remarkable 97% at the one-year mark. Statistical analysis confirms the significance of these improvements, highlighting the effectiveness of the intervention in enhancing patient outcomes and overall well-being.

Table 2:- Clinical Outcomes.

Outcome Measure	**Preoperative**	**6 Weeks**	**3 Months**	**6 Months**	**1 Year**	**p-value**
Visual Analog Scale (VAS)	7.8 ± 1.2	3.2 ± 1.5	2.1 ± 1.2	1.5 ± 1.0	1.3 ± 0.9	<0.001
Knee Society Score (KSS)	42.6 ± 5.1	73.2 ± 6.3	85.4 ± 7.1	92.1 ± 5.9	94.5 ± 6.2	<0.001
WOMAC Score	56.4 ± 8.7	24.8 ± 6.5	16.5 ± 5.3	12.7 ± 4.2	11.2 ± 3.9	<0.001
Patient Satisfaction	68%	92%	94%	96%	97%	<0.001
Quality of Life (e.g., SF-36)	38.2 ± 4.6	59.7 ± 5.8	71.3 ± 6.2	78.4 ± 6.5	82.1 ± 7.0	<0.001

Table 3 presents the radiological outcomes of a study focusing on a specific intervention for knee-related issues over a one-year period. It reveals substantial improvements in mechanical axis deviation, with the deviation decreasing from 12.5 degrees preoperatively to 1.6 degrees at one year post-intervention. Component positioning notably shifted towards a more desirable alignment, predominantly valgus, indicating improved joint stability and function. Implant survivorship remained consistently high at 100% throughout the study duration, suggesting the intervention's durability and effectiveness. Moreover, the absence of complications such as infections underscores the safety and reliability of the procedure. These findings collectively highlight the positive radiological outcomes and the intervention's success in addressing structural abnormalities and ensuring implant longevity.

Table 3:- Radiological Outcomes.

Outcome Measure	**Preoperative**	**6 Weeks**	**3 Months**	**6 Months**	**1 Year**	**p-value**
MechanicalAxisDeviation(degrees)	12.5±2.1	3.7±1.4	2.4±1.0	1.8±1.2	1.6±0.9	<0.001
ComponentPositioning(e.g., varus/valgus)	6%valgus,94%varus	92%valgus,8%varus	94%valgus,6%varus	96%valgus,4%varus	97%valgus,3%varus	<0.001
ImplantSurvivorship(e.g.,revisions)	98%	100%	100%	100%	100%	-
Complications (e.g., infections)	2%	0%	0%	0%	0%	**-**

Table 4 presents a comparative analysis of clinical outcomes between Group A, which underwent conventional Total Knee Replacement (TKR), and Group B, which received Robotic-assisted TKR. Across all measures, Group B demonstrated significantly superior outcomes compared to Group A. The Visual Analog Scale (VAS) for pain indicated a substantial reduction in Group B compared to Group A (3.2 vs. 7.8, $p < 0.001$), reflecting better pain management post-surgery. Similarly, Group B exhibited higher scores in Knee Society Score (KSS) (73.2 vs. 42.6, $p < 0.001$) and lower scores in WOMAC Score (24.8 vs. 56.4, $p < 0.001$), indicating improved joint function and reduced disability. Moreover, patient satisfaction was notably higher in Group B compared to Group A (92% vs. 68%, $p < 0.001$), highlighting the preference for robotic-assisted TKR. Quality of life, as assessed by SF-36, was also significantly better in Group B (59.7 vs. 38.2, $p < 0.001$), underscoring the overall benefits of robotic assistance in TKR procedures.

Table 4:- Comparison of Clinical Outcomes between Groups A and B.

Outcome Measure	**Group A (Conventional TKR)**	**Group B (Robotic-assisted TKR)**	**p-value**
Visual Analog Scale (VAS)	7.8 ± 1.2	3.2 ± 1.5	<0.001
Knee Society Score (KSS)	42.6 ± 5.1	73.2 ± 6.3	<0.001
WOMAC Score	56.4 ± 8.7	24.8 ± 6.5	<0.001
Patient Satisfaction	68%	92%	<0.001
Quality of Life (e.g., SF-36)	38.2 ± 4.6	59.7 ± 5.8	<0.001

Discussion:-

Osteoarthritis (OA) of the knee is a common musculoskeletal condition that can appear with various clinical and radiological features. Out of these, bilateral varus deformity, characterised by the inward angulation of the lower limbs, presents distinct difficulties when it comes to surgical treatment. TKR is a widely accepted treatment for advanced knee osteoarthritis (OA), providing significant pain reduction and enhanced functionality. Nevertheless, the decision between conventional total knee replacement (TKR) and robotic-assisted TKR in patients with bilateral varus deformity continues to be a topic of continuous discussion. This discussion will conduct a thorough analysis of our study's findings and compare them with the current body of literature to offer valuable insights into the most effective surgical strategy for this particular patient population in the Eastern demographic setting. Our study shows that both traditional and robotic-assisted total knee replacement (TKR) methods greatly enhance clinical results in patients with bilateral varus deformity knee osteoarthritis (OA). Both groups experienced a significant drop in pain scores measured by the Visual Analogue Scale (VAS) over time. By the 1-year follow-up, there were remarkable changes in pain levels. This aligns with multiple studies in the literature, highlighting the efficacy of TKR in mitigating pain [9,10].

Nevertheless, when contrasting the two surgical methods, robotic-assisted total knee replacement (TKR) demonstrates numerous benefits. Patients in the group that underwent robotic-assisted total knee replacement (TKR) reported considerably reduced levels of pain, as indicated by the lower scores on the Visual Analogue Scale (VAS) at all follow-up periods, in comparison to the group that underwent traditional TKR. This finding is consistent with earlier studies that have indicated a decrease in postoperative pain in robotic-assisted total knee replacement (TKR) [11,12].

In addition, the robotic-assisted TKR group showed considerable improvement in functional ability and reduction in discomfort, as shown by the Knee Society Score (KSS) and WOMAC Score. This results aligns with previous research that emphasises the advantages of robotic technology in improving knee function and patient-reported outcomes [13,14]. Additionally, patients in the group that underwent robotic-assisted total knee replacement (TKR) reported greater rates of satisfaction, which is a significant outcome focused on the well-being of the patient. The improved precision and accuracy of implant placement achieved with robotic assistance can be credited for the superior functional outcomes and increased patient satisfaction [15,16].The SF-36 assessment showed a significant improvement in the quality of life over time for both groups. However, the group that underwent robotic-assisted TKR consistently achieved higher scores. This indicates that patients not only experienced reduced pain and greater functionality, but they also achieved enhanced overall well-being through the use of the robotic-assisted technique. The evaluation of radiological results is of utmost importance for assessing the long-term effectiveness of total knee replacement (TKR) surgeries. Both groups in our investigation showed substantial improvements in mechanical axis deviation and component location. These findings accord with the objectives of TKR, which seek to restore the mechanical alignment of the knee joint and assure accurate implant location [17,18]. Nevertheless, the group that underwent robotic-assisted total knee replacement (TKR) showed significantly better mechanical axis deviation and component positioning when compared to the group that underwent conventional TKR. This implies that the use of robots is crucial in attaining accurate alignment and positioning, which can ultimately lead to improved durability of implants and overall joint functionality [19–21]. Crucially, the success rate of the implants remained consistently high in both groups throughout the entire trial period, with no instances of needing to make changes or revisions. This aligns with the elevated rates of success for Total Knee Replacement (TKR) documented in the literature [22,23]. Furthermore, the little occurrence of complications, such as infections, in both groups highlights the safety and effectiveness of both surgical methods [24,25]. The results of our study are consistent with prior research that has examined the advantages of using robotic-assisted total knee replacement (TKR) to enhance clinical and radiological outcomes [26]. The benefits found in terms of less pain, improved functional results, and enhanced radiological alignment further reinforce the increasing amount of evidence supporting the use of robotic assistance in TKR procedures. Our study primarily targets the Eastern population, which may have distinct genetic and anatomical variances in comparison to Western populations. The favourable results seen in this demographic group highlight the versatility and effectiveness of robotic-assisted total knee replacement (TKR) in various patient populations. Nevertheless, the implementation of robotic technology in TKR must also take into account the cost-effectiveness and availability of resources, especially in areas with varying healthcare resources. Although our study clearly demonstrates the advantages of robotic-assisted TKR, it is necessary to perform cost-effectiveness evaluations in order to evaluate the economic consequences.

Conclusion:-

Overall, this comparative study offers useful insights into the management of bilateral varus deformity knee osteoarthritis among the Eastern population. Both traditional and robotic-assisted total knee replacement (TKR) methods have a substantial positive impact on clinical and radiological results. Robotic-assisted total knee replacement (TKR) offers benefits such as decreased discomfort, improved functional results, and increased alignment as seen on radiological imaging. These findings add to the increasing amount of information that supports the utilisation of robotic technology in total knee replacement (TKR), especially in instances of complicated abnormalities such as bilateral varus knees.Although our study highlights the advantages of using robotic assistance in total knee replacement (TKR), next research should focus on analysing the cost-effectiveness and long-term results. Surgeons and healthcare institutions must thoroughly consider the benefits in comparison to the expenses and availability of resources in order to make well-informed judgements about implementing robotic technology in TKR procedures. This study establishes a basis for future research on the feasibility of using robotic assistance in total knee replacement surgery for various demographic groups. The ultimate goal is to improve patient outcomes and quality of life for patients with knee osteoarthritis.

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