



Advances in Joint Replacement Surgery and Their Impact on Healthcare Outcomes, Cost Efficiency, and Functional Recovery in Aging Populations

Article History:

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Received: 18-11-2025

Revised: 06-12-2025

Accepted: 16-01-2026

Published: 10-01-2026

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Abstract: Background: One of the best interventions to use in the treatment of end-stage degenerative joint disease is joint replacement surgery, especially in old age. In the last ten years, the clinical practice has undergone a tremendous change due to improvements in implant materials, surgical procedures, perioperative services and rehabilitation guidelines. Nevertheless, the practical effects of these developments on the health outcomes, cost-effectiveness, and functional recovery of older adults are still reported inconsistently..

Objective / Aim: To determine the effects of joint replacement surgery improvements in clinical outcomes, recovery of functioning, and cost-efficiency in older populations with institutional data, secondary registries evidence, and patient-reported outcome. **Methods:** A cross-sectional observational study was carried out that involved secondary data analysis in terms of published joint replacement registries, retrospective analysis of anonymized local hospital records, and patient-reported outcome survey. The data provided by institutions comprised 98 patients with a primary total hip or total knee arthroplasty that took place between January 2022 and June 2024 and were aged 60 years or more. The descriptive analysis and comparison of clinical outcomes, indicators of healthcare utilization and functional recovery measures were compared with published registry data. **Results:** Mean hospital stay was 4.1 /1.3 days and 73.5% of the patients were discharged to home. There was a complication of 9.2 percent postoperative and the 30-day readmission was 5.1 percent. Patient reported outcomes indicated significant change in pain relief and mobility with 81.0% of the surveyed patients expressing a notable reduction in pain and 69.0% of the respondents gaining independence in day-to-day activities in the third month. The results of the institutions were similar to the trends in national registries. Indirect measures indicated better cost-effectiveness, such as a shorter length of stay and a projected inpatient cost-saving based on better recovery measures.

Conclusion: Increased capabilities in joint replacement surgery are linked to positive clinical outcomes, meaningful recovery in functions, and better cost-effectiveness among the old age populations. The results affirm the further implementation of modern surgical and perioperative techniques in order to address the increasing joint replacement care needs among the elderly population.

Keywords: Joint replacement surgery ,Total hip arthroplasty, Total knee arthroplasty, Aging population, Functional recovery, Healthcare outcomes, Cost-effectiveness, Enhanced recovery after surgery.

INTRODUCTION

Degenerative joint diseases are an increasing global health issue especially among the aging population where arthritis conditions like osteoarthritis have a great influence on the mobility, independence and quality of life. Due to the growing life expectancy

across the globe, the number of disorders that are associated with the joints has been on the increase making the need to have effective surgical intervention to be on the rise. Joint replacement surgery and especially the total hip arthroplasty (THA) and total knee arthroplasty (TKA) are now one of

the most effective and frequently conducted orthopedic surgeries in the management of end-stage joint disease (1). The aim of these interventions is not only to reduce pain but also to rehabilitate the joint functioning, enhance the mobility of the patient, and his well being.

The past 2 decades have been characterized by tremendous advancement of joint replacement surgery owing to the advancement of the implants and the way they are designed, the biomaterials, the way they are operated, the perioperative management process, and the post operative rehabilitation procedures. Modern implants have utilized highly stiff materials such as cross-linked polyethylene, ceramic bearings and improved alloys of metals, both of which have increased the longevity of the implants and reduced the revision rates (2,3). Meanwhile, the enhancement of the surgical techniques, including minimal invasive surgery and the principles of the better alignment, has resulted in better functional outcomes and the reduction of the recovery time. This type of technological and procedural development is particularly relevant among the elderly that are more prone to comorbidity and possess low physiological reserve.

The paradigm shift has also been to value-based healthcare where emphasis is placed more on the cost effectiveness and the patient centered outcomes besides the clinical effectiveness. A high proportion of orthopedic medical expenditure is made up of joint replacement surgeries and as such, financial aspect of joint replacement surgeries is a crucial area of research (4). The length of stay in hospitals, the complications during the perioperative period, readmission, and the necessity of revision surgery are all cost factors. With growing financial pressures on the healthcare system, the impact of modern joint replacement techniques on the cost-efficiency of the care is crucial to the sustainability of the system in terms of care provision, particularly in the publicly-funded systems with high numbers of the aging population.

Functional recovery has become the main outcome measure used in the current joint replacement studies. More effective measures of the patient experience are not conventional measures such as implant survival and radiographic alignment though are also important. The importance of patient-reported outcome measures (PROMs) is on the rise now, including pain relief, physical functioning and ability to perform activities of daily living (5). The functional recovery has a close relationship with independence, fall prevention, and institutionalization in the case of the elderly patient. Thus, functional outcomes should be measured following joint replacement surgery to define the actual success of this intervention.

The remodeling of the perioperative care in joint replacement surgery has remained through improved recovery following surgery (ERAS). These cross-functional pathways embrace evidence based strategies, such as optimized anesthesia, multimodal pain management, early mobilization, and patient education to accelerate recovery as well as reducing complications (6). The reduction of length of stay by use of ERAS protocols without putting the patients at risk has been demonstrated in various literature even in older and more vulnerable groups (7). The joint development of the ERAS principles and the improvement of surgical practices is a positive step towards the optimization of the clinical and economic outcomes of the joint replacement care.

Another notable development that has occurred in the sphere is the use of computer-assisted and robotic-assisted surgical systems. The technologies will optimize the positioning of implants, soft tissue balance, and implant alignment accuracy which are some of the determinants of long term functionality and implant survival (8). Despite certain encouraging reports related to the potential benefits in terms of improved functional outcomes and reduced variations, the cost of such technologies remains a controversial issue. This is particularly where the elderly population is concerned where the risk of investing in technology and the clinical benefit should be measured stringently (9).

Although there is an increasing amount of literature on the joint replacement surgery, inconsistency is still present in the reported outcomes in various healthcare settings and patient groups. Age, sex, burden of comorbidity, socioeconomic status, and access to postoperative rehabilitation are all factors that may affect the trajectories of recovery (10). Elderly people, especially, can have delayed functional recovery or increased rates of complications, and it is important to do age-specific analyses. Moreover, the results of real-world studies tend to vary compared to those of controlled clinical trials, which is why it is essential to consider outcome measures with the inclusion of registry data, institutional data, and observational studies (11).

The cost effectiveness of joint replacement surgery is not only limited to the time spent in the operating room and in hospital. Long-term healthcare spending is also involved in postoperative rehabilitation services, outpatient follow-up, and management of complications. The long-term recovery or functional decline in the aging population may result in the increased use of social and long-term care services, which further increases the economic impact (12). Thus, the outcomes of joint replacements should be thoroughly evaluated based on direct medical costs connected with their participation in society and

further implications.

Based on the above considerations, it can be seen that there is a need to undertake an encompassing assessment of the advances in the area of joint replacement surgery that would both review the healthcare outcomes, cost effectiveness, and functional recovery on the aging populations. Though these aspects have been researched in isolation studies relatively, not many studies have been conducted based on a holistic approach that depicts real clinical practice. The opportunity of contextualizing the existing evidence and identifying those trends applicable in the daily medical care provision can be attained by the use of secondary data in the published literature, national registries and the local hospital records.

Such gap will be addressed in this paper by synthesizing the existing research studies that have been conducted regarding advancements that have been made in the area of joint replacement surgery and their implications on clinical, economic and functional recovery in the elderly adulthood. The purpose of this work is to present an objective and clinically applicable perspective, combining the findings of the current studies and the data on institutions and patient-reported outcomes. It is a kind of approach to enlighten clinicians, policymakers and healthcare administrators as they navigate the issues of delivering high quality and cost-effective joint replacement care to an ageing population.

MATERIALS AND METHODS

Study Design

The observational design used in this paper was a mixed-method design that involved the synthesis of secondary data, retrospective institutional analysis and patient-reported outcome measure. The choice of this method was to provide a detailed evaluation of the joint replacement surgery innovations and their impact on the health care outcome, cost effectiveness and functional recovery of the aging populations in real clinical settings.

The institutional section of the study was done in one tertiary-based hospital providing elective orthopedic surgery. The data were collected in the form of retrospective information on electronic medical records of patients of age 60 years and above who had undergone primary total hip arthroplasty or total knee arthroplasty between January 2022 and June 2024. The environment of the research is reflected in the daily clinical practice including standardized pathways to perioperative care, and postoperative rehabilitation guidelines.

Besides institutional data, secondary outcome data were also obtained through published national joint

replacement registries and large cohort studies to enable us to compare the trends that were observed in a context. A sub-group of the patients was surveyed using a patient-reported outcome survey to determine postoperative functional recovery as viewed by patients. The combined nature of these data sources allowed evaluating clinical, functional, and economic outcomes related to the current joint replacement practices among an aging population.

Population and Sampling Method

The hospital-based component was restricted to patients aged 60 years and above who had primary total hip arthroplasty or total knee arthroplasty in tertiary-care center during January 2022-June 2024. A consecutive sampling technique was also used, meaning that, all eligible patients who came through the study period were incorporated to reduce selection bias. The exclusion criteria included revision surgeries, trauma-based arthroplasties, and missing medical records.

In the institutional dataset, 78 patients were identified to meet the inclusion criteria and were enrolled. In the case of patient-reported outcome survey, a convenience sample of 42 patients with at least six months of postoperative follow-up was chosen due to the availability and consent of the patient.

Data Collection Procedures

Electronic medical records and hospital administrative databases were used to collect data retrospectively. Some of the extracted clinical variables were demographic factors, nature of joint replacement surgery, duration of stay, perioperative complications, destination at discharge, and 30-day readmission. The data on costs were obtained based on aggregated hospital billing records and were presented in terms of the cost of procedural and inpatient care, but not on the specific costs of a patient. Published national joint replacement registries and large cohort studies were accessed to get secondary data that would give institutional outcomes a contextual comparison. Patient-reported outcome survey was conducted during regular follow-ups or through telephone interviews through standardized questionnaires.

Variables and Outcome Measures.

The study variables were classified into demographic, clinical, functional and economic variables which were obtained based on the institutional records, secondary data sources and patient-reported outcomes.

The clinical variables were type of joint replacement surgery (total hip arthroplasty or total knee arthroplasty), length of stay, discharge destination, postoperative complications and 30-day readmission.

These variables were chosen to indicate short-term safety of surgery and healthcare use. Patient-reported outcome measures that were aimed at evaluating functional variables were pain relief, mobility, and the capacity to perform activities of daily living. A subset of the patients who took postoperative follow-up surveys at least six months postoperative was assessed using functional recovery. Economic variables considered were the estimated inpatient care costs and indicators of cost efficiency in an indirect way which can be the length of hospital stay and the discharge pattern. The data on costs was processed at an aggregate level to determine the trends as opposed to the spending on a single patient.

Ethical Considerations

The research was done following the institutional ethical standards and principles of the Declaration of Helsinki. The local institutional review board approved the retrospective data use and the administration of the survey to the patients. Informed consent was received either in writing or verbally by all participants of the survey. The potential harm to the participants was low because the study did not imply direct clinical intervention and used mostly

anonymized secondary data as the research source.

Statistical Analysis

The research was done following the institutional ethical standards and principles of the Declaration of Helsinki. The local institutional review board approved the retrospective data use and the administration of the survey to the patients. Informed consent was received either in writing or verbally by all participants of the survey. The potential harm to the participants was low because the study did not imply direct clinical intervention and used mostly anonymized secondary data as the research source.

Data Reliability and Management.

Data gathered were all anonymized before analysis and stored in institutional systems that were password-protected and could only be accessed by the research team. Two reviewers were used to extract the data in order to minimize transcription errors, and the discrepancies were addressed by consensus. Reliability and comparability of the data were improved by the use of the validated patient-reported outcome tools and the developed sources of registries.

RESULTS

The findings will be in the form of a narrative synthesis of institutional data, secondary registry results, and patient-reported outcomes. Demographic characteristics, clinical outcomes, functional recovery, and cost-related indicators were summarized with the help of descriptive analyses. Table 1 presents the demographic and clinical features of the study population.

Table 1:-Demographic and Clinical Characteristics of the Local Hospital Study Population (n = 98)

Variable	Value
Mean age (years), mean $\pm$ SD	68.4 $\pm$ 6.9
Age group, n (%)	
60–69 years	46 (46.9)
70–79 years	38 (38.8)
≥ 80 years	14 (14.3)
Sex, n (%)	
Male	44 (44.9)
Female	54 (55.1)
Type of procedure, n (%)	
Total hip arthroplasty (THA)	52 (53.1)
Total knee arthroplasty (TKA)	46 (46.9)
Mean length of hospital stay (days), mean $\pm$ SD	4.1 $\pm$ 1.3
Discharge destination, n (%)	
Home	72 (73.5)
Rehabilitation facility	26 (26.5)
Postoperative complications*, n (%)	9 (9.2)
30-day readmission, n (%)	5 (5.1)

Complications included wound-related issues, transient infection, and thromboembolic events.

Study Population Characteristics

The institutional dataset consisted of 98 patients aged 60 and above who have primary joint replacement surgery. Table 1 presents the demographic characteristics of the cohort as 68.4 years old with a standard deviation of 6.9, with almost half of the patients (46.9) aged 60–69 years (Table 1). The patients aged between 70 to 79 years made up 38.8 percent of the cohort and those aged 80 years and above made up 14.3 percent. The study population was a little bit

higher among female patients (55.1%) than among males (44.9%).

In terms of the type of procedure, total hip arthroplasty (THA) was done in 52 patients (53.1%), and total knee arthroplasty (TKA) was done in 46 cases (46.9%). This fairly even distribution enabled descriptive comparisons between the types of procedures, but no formal inferential testing was conducted. The demographic profile is indicative of the average joint replacement populations as determined by national registry data on aging groups.

Clinical Outcomes and Healthcare Utilization

Favorable short term postoperative profiles were also exhibited in the institutional cohort. The average stay was 4.1 days of 1.3 days with most of the patients being discharged in the fifth day of operation. Most of the patients (73.5%), were discharged to their homes, and only 26.5% needed to be transferred to a rehab center where they could get further postoperative services. These discharge trends indicate that there are efficient early mobilization and recovery policies in the institutional level.

In 9.2% of patients, the complications were noted after operation. The complications reported were minor wound related complications, transient infections treated conservatively and few thromboembolic events. Notably, there was no perioperative mortality in the cohort. The 30-day readmission rate was 5.1, and it implied that there was not high short-term morbidity after the operation. The results are summarized in Table 1, and generally agree with large registry-based studies.

Descriptively, patients in THA were more likely to get shorter hospital stays with more direct home discharges than patients in TKA, although these differences were not statistically compared. In general, the institutional clinical results show that joint replacement surgery among older adults has a positive safety profile in the study environment.

Functional Recovery Outcomes

The use of patient-reported outcome measures as the assessment of functional recovery was conducted based on a survey subgroup of 42 patients who had undergone at least six months of postoperative follow-up. Most respondents to the survey indicated that they experienced significant pain relief and pain functional improvements after surgery as illustrated in Table 2.

In particular, 81.0% of the surveyed patients indicated that they felt a significant reduction in pain as opposed to their preoperative condition. Enhancement of mobility was also conspicuous, with 69.0% of the respondents reporting a back to independence in performing daily activities three months after surgery. These results demonstrate the practical value of joint replacement surgery among the elderly, which goes beyond relieving pain to the significant recovery of autonomy.

Standardized patient-reported measures that received functional improvement scores showed an average functional improvement of about 33.7% and this is very similar to functional gains reported in published registry and cohort trials. Although each recovery pattern was different, the general tendency was great functional recovery within the six months of surgery.

Comparison With Secondary Registry Data

Secondary data that was retrieved through published joint replacement registries was used to provide a contextual reference point in interpreting institutional outcomes. Table 2 shows that the mean length of stay as reported by registries was 3.8 -4.5 days, which is very close to the 4.1 days mean length of stay in the institutions. On the same note, reported complication rates in registry data were between 8.5% to 10.3 which is similar to the institutional complication rate of 9.2.

Registry-based increases in functional outcomes were usually between 30 to 35 percent which is similar to the functional improvements that patients in the survey subgroup reported. These parallels indicate that the results of the institutional study are widely reflective of the practice patterns in the real world, and support the extrapolative validity of the presented results.

The registry data on readmission rates (4.862) could also be compared to the institutional rates of 5.1, meaning the similarity of short-term postoperative outcomes in various healthcare environments.

Cost-Related Outcomes and Efficiency Indicators

Analysis of direct costs at the patient level was not conducted, but indirect measures of cost efficiency were measured using length of hospital stay, discharge destination, and estimated trends of inpatient cost. The implementation of improved recovery measures was linked to an estimated 12-15% decrease in the cost of inpatient services at the

institutional level, which was mainly caused by the decreased length of stay and increased rates of direct home discharge as summarized in **Table 2**.

Registry data also showed similar estimates of cost efficiency with inpatient cost savings of 10-18 percent after the implementation of improved recovery pathways. This evidence implies that modern perioperative care policies play a significant role in cost reduction without affecting patient safety and functional outcomes.

Patients directly discharged to home also tended to need fewer post-acute care resources, which also favors the cost-efficiency of lean recovery paths. Although the formal cost-effectiveness modeling was not within the scope of this study, these descriptive findings suggest positive economic trends that surround modern joint replacement practices in aging populations.

Integrated Outcome Assessment

On examination of the results of the conjunction of clinical, functional and cost related outcomes, the findings showed a stable pattern of benefit in terms of the improvement of joint replacement surgery. The surgeons, perioperative, and rehabilitation appeared to have been enhanced, and therefore, it appeared to be transposed into fewer hospitalizations, manageable complication, functional recovery, and improved utilization.

Remarkably, this was the case in an older cohort of patients, which suggests the opportunities and effectiveness of the current joint replacement plans, in patients who are more vulnerable to age. There was a combination of institutional data and secondary registry findings and patient-reported outcomes, which gave a complete picture of actual performance in various outcome domains.

A comparative summary of clinical, functional, and cost-related outcomes across data sources is presented in **Table 2**.

Table 2:-Clinical, Functional, and Cost-Related Outcomes Across Data Sources

Outcome Measure	Local Hospital Data	Published Registry Data	Patient Survey Subgroup (n = 42)
Mean length of hospital stay (days)	4.1	3.8–4.5	—
Postoperative complication rate (%)	9.2	8.5–10.3	—
30-day readmission rate (%)	5.1	4.8–6.2	—
Functional improvement score*, mean (%)	—	30–35	33.7
Patients reporting significant pain relief, n (%)	—	—	34 (81.0)
Return to independent daily activities within 3 months, n (%)	—	—	29 (69.0)
Estimated inpatient cost reduction with ERAS (%)	12–15	10–18	—

Functional improvement based on validated patient-reported outcome measures.

Overall, the results support the conclusion that advances in joint replacement surgery are associated with favorable healthcare outcomes, improved functional recovery, and enhanced cost efficiency in aging populations. These findings provide a strong foundation for further interpretation and contextualization in the Discussion section.

DISCUSSION

The current analysis investigated the effects of the innovation in joint replacement surgery on clinical outcomes and functional recovery as well as cost effectiveness in an aging population based on institutional data with secondary evidence of the registries and patient-reported outcomes. As it has been shown, the current practice of joint replacement is linked to positive short-term safety rates, significant functional change, and the evidence of greater healthcare efficiency, including the older adults.

The low postoperative complication and readmission rates of the institutional cohort are in line with the

trends of large registry-based studies, which have reported the improvement of perioperative safety due to the development of better implant materials, fixation methods, and surgical methods (1,3,14). The latter benefits are especially applicable to the older demographics where comorbidities and low physiological reserve are historically associated with the elevated risk of surgery. The findings of the study contribute to the emerging evidence that the modern joint replacement surgery is safe when it is conducted in elderly patients provided that proper perioperative management strategies are adopted (12).

One of the key results of this research was functional recovery as the focus on patient-centered measures in joint replacement studies continued to grow. Most of the patients surveyed indicated significant pain relief

and enhanced mobility and many of them within three months after the surgery were able to resume their activities of daily living independently. These are also in line with other studies that have shown that there are great improvements in patient-reported outcome measures after total hip and knee arthroplasty even in the older age groups (8,9,19). The rates of functional improvement, which were observed in the current study, were similar to the ones reported in the national registries, which supports the external validity of the institutional findings (16).

The positive outcomes were probably due to enhanced recovery after surgery protocols. The evidence-based practice of multimodal pain management, early mobility, and integrated care during perioperative periods have demonstrated the minimization of the hospital length of stay without raising the complication rates (6,7). Such protocols can be especially helpful in older adults, as they will reduce postoperative deconditioning and help them resume functioning sooner. The large number of patients discharged directly to home in the current study justifies the success of such strategies in supporting functional recovery as well as effective use of healthcare.

Economically, joint replacement surgery is a formidable part of the orthopedic healthcare spending. Even though no formal cost-effectiveness modeling was done in this study, indirect measures like decreased length of stay and higher rates of home discharge indicate enhanced cost efficiency related to the modern care pathways. The same decrease in inpatient expenses with the introduction of enhanced recovery programs has been reported in other economic reviews of arthroplasty care (10,11). With the increasing volumes of procedures due to the aging of the population, these efficiency gains can be of great consequences to the sustainability of healthcare.

The fact that the institutional results are consistent with those presented in the registry data, also enhances the topicality of the results. Registry studies have gained more significance in assessing the actual results and future performance of joint replacement surgeries in a variety of patients (16,17). This correlation in the rate of complications, functional outcome, and readmission rates indicate that the results of this study are reflective of larger clinical practice and not limited to institutional practice.

A number of limitations ought to be recognized. The single-center setting and retrospective design does not allow making causal conclusions and generalizing results to the whole population. The patient-reported outcome survey was also done on a sub-group of patients and this may have created bias in responses. Moreover, there were descriptive and indirect cost-

related analyses. However, institutional data combined with secondary registry evidence and patient-reported outcomes offer a sound and realistic evaluation of the modern outcomes of joint replacement.

Future studies must consider multicenter studies that have longer follow-up times to assess long-term functional outcomes, implant survivorship, and overall cost-effectiveness. With the ongoing technological advances like robotic-assisted surgery and personalized rehabilitation programs, more research is necessary to ascertain their usefulness in enhancing outcomes in particularly the aging populations (4,5).

Comprehensively, the results of the present research would help conclude that the development of joint replacement surgery has led to better clinical outcomes, functional recovery, and cost-effectiveness among older adults. These developments will most likely become more and more significant in addressing the increasing demand of joint replacement surgeries in aging communities.

CONCLUSION

The development of the joint replacement surgery has greatly changed the control of the degenerative joint disease among the aging communities. The results of the current research prove that modern joint replacement practices are related to positive clinical outcomes, significant functional recovery, and signs of better cost efficiency. The high rates of low complications and reduced readmission rates with significant patient-reported pain relief and mobility improvements seem to form the core of effectiveness and safety of contemporary total hip and knee arthroplasty in older patients. The combination of better implant designs, perfection of surgical procedures, and postoperative recovery protocols seems to be the primary factor of maximizing the outcomes. Multidisciplinary perioperative care, early mobilization, and patient centered rehabilitation strategies led to reduced hospitalizations and increased discharge to home, which help in reducing functional independence and effective use of healthcare resources. These benefits are particularly timely in aging populations when the long-term hospitalization and slow recovery can lead to an increase in morbidity and cost of healthcare. Although the research was conducted on both observational and secondary data the fact that the results of institutions and published registries agree makes the results more applicable to the real-life clinical practice. The findings also show that age alone is not an impediment to joint replacement surgery in case the selection of the patient and pre-operative measures are undertaken.

Further Directions. The future should also be characterized by the use of larger multicenter studies that have a longer follow-up in order to further evaluate long-term functional outcomes and cost-effectiveness due to the constant evolution of branched technologies and personalized care pathways. Overall, the existing findings confirm the further adoption and extension of innovative joint replacement strategies to meet the growing needs of aging groups and deliver the high-quality and sustainable healthcare delivery.

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