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RESEARCH

Trends in adoption of robotics in arthroplasty: an analysis of the Indian landscape

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Abstract

Robotic-assisted technology in total joint arthroplasty (TJA) offers improved precision in component placement and alignment, addressing challenges, such as ligament imbalance, malalignment, and patient dissatisfaction. In India, where diverse healthcare settings exist, trends in robotic adoption remain underexplored. This study examines the adoption patterns and geographic distribution of robotic systems for TJA in India, highlighting market dynamics over the past 5 years. A cross-sectional observational study was conducted using data from manufacturers of robotic arthroplasty systems. Annual installations, tier-wise city classifications, and geographic distributions were analyzed. Statistical methods included descriptive analysis for installation trends, time-series visualization for adoption trajectories, and linear regression to forecast 2025 installations. As of September 2024, 290 robotic systems were installed across India. Among these, the CUVIS system (Meril) accounted for 89 installations (30.7%), followed by CORI (Smith and Nephew) with 66 installations (22.8%), and VELYS (DePuy) with 52 installations (17.9%). The MAKO system (Stryker) contributed 38 installations (13.1%), while MISSO (Meril) and ROSA (Zimmer) had 25 (8.6%) and 20 (6.9%) installations, respectively. Tier I hospitals dominated with 50% of installations, while Tier III and IV facilities accounted for only 10%. Linear regression predicts steady growth, with over 80 new robotic installations in 2025. Robotic technology adoption in Indian TJA has surged, with a strong preference for systems offering precision and versatility. However, barriers such as high costs and limited training impede penetration in lower tier facilities. Addressing these challenges could enhance equitable access and support the integration of robotics into diverse healthcare settings.

Keywords Robotic-assisted arthroplasty · Total joint arthroplasty · Technology adoption trends · Indian healthcare market · Healthcare tier classification

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Introduction

Total joint arthroplasty (TJA) is one of the most successful elective procedures in the surgical management of end-stage arthritis of the hip or knee joints [1]. With longer life expectancy and growing active young to middle-aged population, surgeons face an increased burden of primary hip and knee osteoarthritis across the world [1, 2]. However, surgeons are still faced with the challenges of dissatisfaction and revision after the index procedure. Dissatisfaction after TJA may be multifactorial, with commonly cited factors including ligament imbalance or instability, persistent pain, malalignment, dislocation risk with THA, and psychosocial factors to name a few [3, 4].

In the pursuit of patient satisfaction and to reduce complication or revision rates, there have been advances in

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prosthetic design, multimodal analgesia, rapid-recovery protocols, and psychosocial counseling to deal with the impact of unmet expectations and depression/anxiety disorders [5–7]. There have been several technological advancements in the execution of TKA/THA, notably patient-specific instrumentation (PSI), computer-assisted navigation (CAS), and robotic-assisted arthroplasty [8–11]. The goal of these technology aids was to reduce outliers in component positioning and limb alignment, to restore "native" knee phenotypes and kinematics in the hope that this would improve clinical outcomes and reduce revision rates [12].

Evidence has established the clear superiority of robotics in improving accuracy of component positioning and reducing outliers of planned alignment [13, 14]. There is emerging evidence about the clinical benefits of robotics in terms of reduced blood loss, reduced length of stay, reduced soft-tissue damage, improved patient satisfaction, and patient-reported outcomes [15, 16]. With increased interest in implementing alternate or personalized alignment strategies in TKA, robotic technology is the tool of choice to execute any alignment strategy of choice with the added benefit of objective ligament balancing [17].

A recent survey-based paper targeting Indian Arthroplasty surgeons reported surgeon perceptions on the adoption of robotics, focusing on challenges faced by surgeons, current practice, and to understand perspectives on robotics training programs [18].

The aim of this paper is to study the market for robotic technology for arthroplasty available in India and to report trends in adoption of the technology over the past 5 years. Secondary objectives include reporting the patterns of technology adoption, based on Indian geography and Tier city classification.

Methods

This was a cross-sectional observational study of several manufacturers of arthroplasty robotic systems available in India. This study was performed at a single high-volume arthroplasty institute and was approved for a waiver from the Institutional Ethics Committee. There are no patient data or case volume numbers reported in this study. Data pertaining to the annual number of installations were obtained from each manufacturer, with additional data on year of installation and the city in which the robotic system was installed. The identity of institutes which acquired the robotic systems was removed from the collated data prior to screening by the primary author. All manufacturers provided data in the form of Microsoft Excel Data sheets, which were collated and analyzed in aggregate.

The following robotic systems are available in the Indian arthroplasty market as of 2024:

1. **Mako**- CT Image-based Semi-autonomous robotic-arm-assisted system (Stryker, Kalamazoo, MI, USA). This robot can be used for total knee, partial knee, and total hip arthroplasty. Implant used is the Triathlon cemented TKA prosthesis. THA is performed with the Accolade II stem, Trident acetabular shell (uncemented) or Exeter (cemented).
2. **Cori**- (previously Navio), Image-Free, Semi-autonomous burr-based system (Smith and Nephew). Workflows enable total and partial knee arthroplasty surgeries.
3. **Rosa-** Image-less or plain radiograph-based Semi-active system with intra-operative mapping (Zimmer, USA). Implant used is the Zimmer Persona TKA solution.
4. **Cuvis-** CT Image-based Fully autonomous Active robotic system with Burr-only workflow for TKA (Meril-Curexo).
5. **Velys-** Image-less Semi-autonomous robotic-arm-assisted system (Johnson and Johnson, DePuy). The implant used is the DePuy Attune cemented TKA prosthesis.
6. **Misso-** CT Image-based Fully-autonomous Active robotic system with Burr-only workflow for TKA (Meril, Vapi, India). The implant used is the Maxx Freedom and Destiknee TKA prostheses.

Statistical analysis

The statistical analysis was conducted using Python (version 3.11.3) and involved several methods to assess the trends and project future adoption of robotic systems. Descriptive statistics were used to summarize the total number of robotic system installations across various hospital tiers, with data presented as counts and percentages to describe the market share and distribution of each system using Microsoft Excel. The tier-wise distribution of installations was analyzed using counts to illustrate the adoption patterns among Tier I, II, III, and IV healthcare facilities.

Time-series analysis was performed to visualize the annual installation trends of each robotic system from 2016 to 2024. This was done using line graphs, which allowed for the identification of growth trajectories and periods of rapid adoption or market saturation for each system.

Linear regression was applied to forecast the number of installations in 2025. The model's adequacy was evaluated through residual analysis to ensure that the linearity assumption was met, confirming that the linear model captured the trend in the data. This model allowed for projections by extrapolating the trend to predict the installations for 2025.

Results

Overview of robotic system adoption

As of September 2024, a total of 290 robotic systems have been installed across various hospital tiers in India, reflecting a substantial increase in the adoption of robotic technologies for total joint arthroplasty. Among these, the CUVIS (Meril) system leads with 89 installations (30.7%), followed by CORI/NAVIO (Smith and Nephew) with 66 installations (22.8%), VELYS (DePuy) with 52 installations (17.9%), MAKO (Stryker) with 38 installations (13.1%), MISSO (Meril) with 25 installations (8.6%), and ROSA (Zimmer) with 20 installations (6.9%). (Table 1) The annual growth patterns of different robotic systems is summarized and represented in Fig. 1.

Table 1 Summary of robotic systems along with market share percentage

Robotic system	Total installations	Market share (%)
CUVIS (Meril)	89	30.7
CORI/NAVIO (Smith and Nephew)	66	22.8
VELYS (DePuy, Johnson and Johnson)	52	17.9
MAKO (Stryker)	38	13.1
MISSO (Meril)	25	8.6
ROSA (Zimmer)	20	6.9

Tier-wise city distribution of robotic systems (Fig. 2)

Analysis of the distribution of installations across hospital tiers revealed distinct patterns:

- **CUVIS** is predominantly installed in Tier I hospitals (48 installations). Its presence in lower tier hospitals is more limited, with 15 installations in Tier II, 10 in Tier III, and only 1 in Tier IV.
- **VELYS (DePuy)** shows a balanced distribution with installations in Tier I (24), Tier II (17), and Tier III (10) hospitals, suggesting that it is well suited for a range of healthcare providers.
- **CORI/NAVIO (Smith and Nephew)** has a significant presence in Tier II hospitals (44 installations. Additionally, it has 17 installations in Tier I hospitals and 5 in Tier III facilities.
- **ROSA (Zimmer)** exhibits equal distribution between Tier I and Tier II hospitals (10 each), with no installations in Tier III or IV facilities.
- **MISSO** installations are concentrated in Tier I (11) and Tier II (14) hospitals. Given its recent entry, further evaluation is needed to assess its market expansion.

Forecasted trends for 2025 (Fig. 3)

Linear regression analysis was used to forecast the expected installations of robotic systems for 2025:

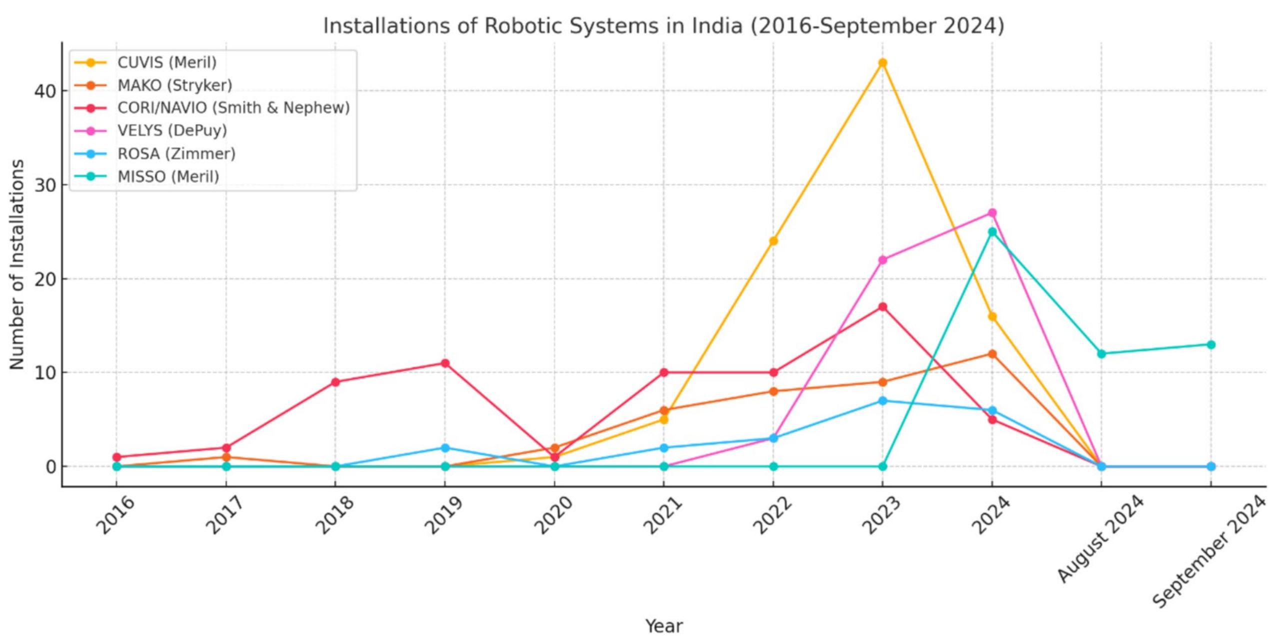

Fig. 1 Line graph showing the installation trend of robotic systems in India

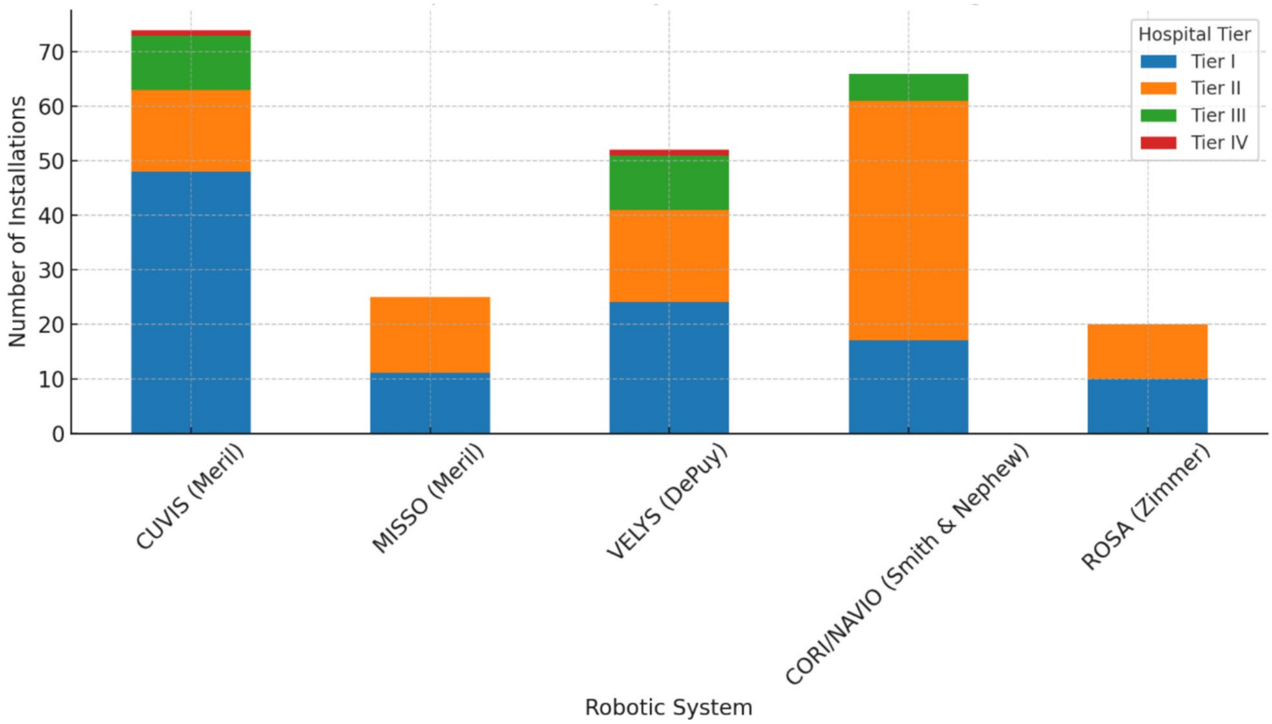

Fig. 2 Tier-wise distribution of robotic systems in India

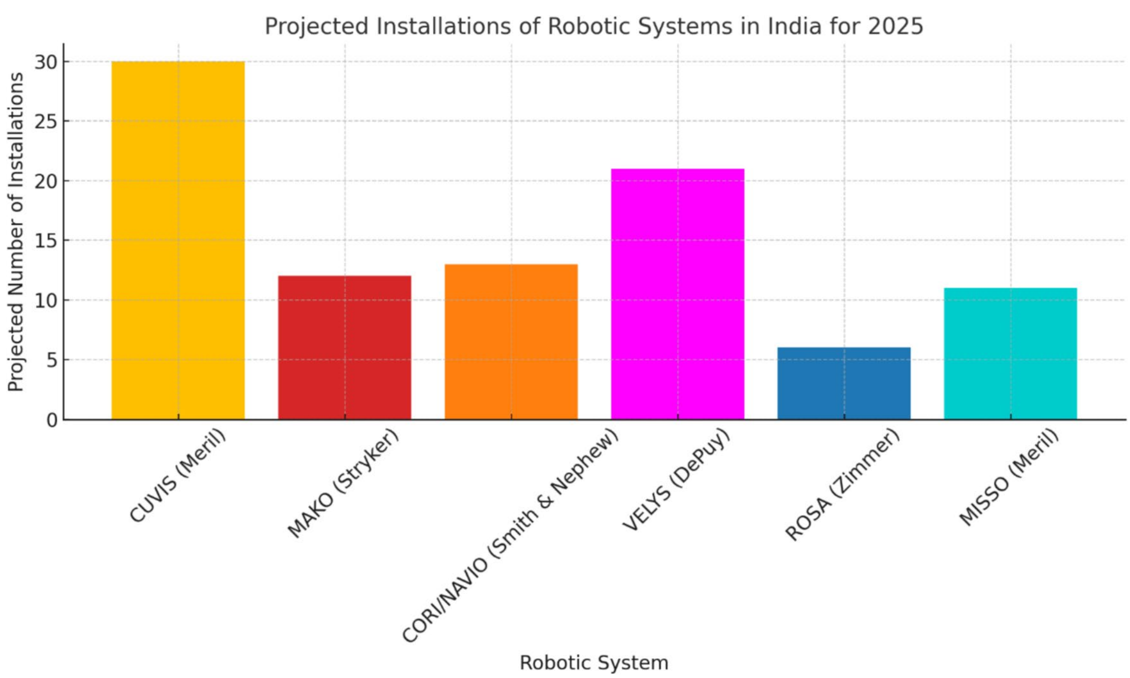

Fig. 3 Projected installations for 2025

- **CUVIS (Meril)** is expected to maintain its market leadership with approximately 30 installations.
- **MAKO (Stryker)** is projected to remain stable, with around 12 installations.
- **CORI/NAVIO (Smith and Nephew)** may experience modest growth, with approximately 13 installations anticipated.
- **VELYS (DePuy)** is forecasted to have around 21 installations, suggesting continued interest among providers.
- **ROSA (Zimmer)** is expected to maintain a stable presence with 6 installations.
- **MISSO (Meril)**, given its recent entry and rapid adoption, could potentially exceed initial estimates; however, more data are required for precise forecasting.

These projections indicate a continued expansion of robotic systems in the Indian market.

Discussion

Our study provides an in-depth analysis of the adoption trends of robotic systems for arthroplasty in India over the past 5 years. With 290 installations recorded across different hospital tiers as of September 2024, the data highlight a clear upward trajectory in robotic arthroplasty adoption. The findings show that in terms of installation numbers, CUVIS (Meril) leads the market with 30.7% of the total installations, followed by CORI/NAVIO (Smith and Nephew) at 22.8%, and VELYS (DePuy) at 17.9%. Interestingly, newer systems like MISSO (Meril) have quickly entered the competitive landscape, gaining significant traction since their launch.

Our data also shows that with increased adoption of robotics in different practice types (private and institutional), there are robotic systems now installed in all tiers of Indian cities. With increasing practice in the non-metro cities and with an increased number of surgeons able to cater to the rising requirement for primary TKA and THA, there is an increased demand for technology; however, case volume and cost may be the main limiting factors [19].

Comparison to global trends

These findings are in line with global adoption patterns, where the introduction of robotic systems has seen progressive growth, initially in high-volume centers before expanding into smaller hospitals [16, 20–22]. However, compared to Western markets, the Indian healthcare landscape presents unique challenges, including affordability, infrastructure requirements, and patient expectations. Robotic systems such as CUVIS and MISSO, both of which have autonomous features, seem to cater well to the demand for precision while reducing dependence on surgeon skill variability.

Benefits and challenges of robotic adoption

Evidence supports the use of robotics in enhancing surgical precision, reducing alignment outliers, and improving patient-reported outcomes [12, 23–25]. Recent studies have also shown that robotic-arm-assisted THA systems are more cost-effective than manual THA [26, 27]. Our data echo this growing preference for robotic systems, possibly driven by the desire to improve patient satisfaction, reduce revision rates, and adopt personalized alignment strategies.

However, the study also identifies challenges associated with robotic adoption. Cost remains a significant barrier, limiting wider adoption, particularly in Tier III and IV hospitals [28]. Robotic surgery, including computer navigation, is associated with increased hospital charges for the procedure, as shown in several studies [21]. However, other studies indicate a decrease in facility and index costs, which is a subject of debate [29, 30]. Second, the need for specialized training programs for surgeons and staff contributes to the slower penetration of advanced systems. Third, the extended operative times and the learning curve related to robotic technology often cause surgeons to hesitate in adopting it [31]. Finally, lack of concrete evidence from meta-analyses shows no difference between conventional and robotic total knee arthroplasty (TKA), which is another reason why most surgeons are slow to implement technology [32].

Forecast for future growth

Based on our projections, the adoption of robotic systems will continue to grow in 2025. With increasing number of systems in the market, eventually there will be a price reduction and disruption, leading to increased adoption of robotics [33]. With more literature emerging in favor of improved clinical outcomes with robotics or alignment philosophies that need robotic-aid, peer-pressure, there will be a rapid increase in adoption of robotics [34]. These trends suggest a maturing market where hospitals increasingly seek robotic systems that balance precision, affordability, and versatility.

A USA-based market survey in 2022 reported that of 112,161 TKA procedures, 7.2% were technology-assisted. The proportion of technology-assisted TKA is expected to reach 50% by 2032, based on regression forecasts done in this study [20].

A study of Indian arthroplasty surgeons reveals key challenges in adopting robotic technology. The main barrier is the high installation cost of robotic systems, noted by 93.5% of respondents, which limits access mainly to well-funded institutions. Additionally, insufficient insurance coverage for robotic-assisted procedures adds financial pressure on hospitals and patients. The lack of formal training programs also affects surgeon confidence and proficiency in using robotics. Despite these challenges, 78.1% of surgeons are willing to adopt the technology if costs decrease. The primary hurdles to adoption are high installation costs (93.5%) and incomplete insurance coverage (82.7%), followed by insufficient training opportunities (73.3%), corporate resistance (69.1%), and patient acceptance issues (68.1%) [18].

In a recently published survey of surgeon-members of the American association of hip and knee surgeons (AAHKS), 246 (33.8%) of 727 respondents use robotics in arthroplasty. Even of the 234 robotic users, cost (23.9%) and lack of data (28.6%) were concerns for adoption in daily practice. Cost was the primary obstacle to the routine use of robot arm assistance for 22.9% of current non-users of robotics and 23.9% of users [35].

This study has some limitations and is limited by its focus on aggregate data from manufacturers, which may not fully capture the clinical outcomes associated with these robotic systems. Additionally, as the study focuses on installation trends without correlating usage rates or clinical success of individual systems, further research will be necessary to understand the full impact of robotics on patient outcomes and cost-efficiency.

Conclusion

The findings from this study underscore the expanding role of robotics in total joint arthroplasty across India. While Tier I hospitals currently lead adoption, newer systems are enabling penetration into mid- and lower-tier city facilities. With continuous advances in technology, increasing awareness, and growing surgeon expertise, the market for robotic arthroplasty in India is poised for sustained growth. Future research should focus on clinical outcome comparisons, cost–benefit analyses, and strategies to overcome the barriers to adoption in lower-tier cities.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no conflict of interest.

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