

Indigenous Innovation in Orthopedic Robotics: Making Joint Replacement Affordable in India

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Learning Point of the Article:

Indigenous innovation in orthopedic robotics offers India a practical pathway to combine technological advancement with improved healthcare accessibility. Locally developed systems demonstrate that high surgical precision can be achieved at significantly lower costs, enabling wider adoption beyond major urban centers. The editorial highlights ongoing challenges, including financial constraints, limited insurance coverage, and the need for structured training. It also emphasizes that collaborative efforts between clinicians, industry, and policymakers are essential to integrate safe, affordable, and effective robotic platforms into routine orthopedic practice.

Abstract

Robotic-assisted joint replacement has transformed contemporary arthroplasty by improving surgical precision, implant positioning, and soft-tissue balancing, with emerging evidence suggesting benefits in early functional recovery and alignment accuracy. Despite these advantages, the widespread adoption of orthopaedic robotics in India remains constrained by high capital investment, recurring maintenance costs, limited insurance reimbursement, and restricted access to structured training. Consequently, robotic arthroplasty continues to be concentrated within high-resource urban institutions, limiting its population-level impact.

The evolution of indigenous robotic platforms represents a pivotal shift in addressing these barriers. Locally engineered systems offer the potential to reduce acquisition and procedural costs while maintaining procedural accuracy and workflow efficiency. Such innovations align with national initiatives promoting self-reliance in medical technology and allow contextual adaptation to Indian anatomical variations, healthcare economics, and surgical volumes.

This editorial examines the current landscape of orthopaedic robotics in India, highlighting technological advances, economic constraints, policy dynamics, and the growing role of indigenous innovation. It underscores that achieving equitable access will require synergistic collaboration among clinicians, industry stakeholders, insurers, and policymakers. Ultimately, the integration of cost-effective robotic solutions may redefine joint replacement from a premium offering to a scalable standard of care across diverse healthcare settings.

Keywords: Orthopaedic robotics; Robotic-assisted arthroplasty; Indigenous innovation; Joint replacement; Healthcare affordability; India; Surgical technology.

Introduction

Robotic-assisted joint replacement elevates surgical accuracy by enabling exceptionally precise implant positioning and refined ligament balancing, thereby lowering post-operative complications and improving clinical and functional outcomes

and patient satisfaction [1]. Likewise, hospitals may achieve long-term cost efficiencies by decreasing complication rates and lowering the incidence of revision surgeries, as emphasized in recent healthcare system analyses. However, these advantages come at a steep price. Most commercial systems cost on the order

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of \$0.6–1.0 million (plus ~10% annual maintenance), restricting their use to well-funded centers [2]. Survey responses from Indian orthopedic surgeons suggest a clear trend: most surgeons – 93.5% – feel that the high installation cost is the main hurdle to bringing robotic systems into their practice. At the same time, 78.1% shared that they would be open to using technology if the overall costs were more manageable [2]. In essence, the primary barrier to broader adoption is not the capability of robotic systems but their cost. This editorial emphasizes developing indigenous (“Atmanirbhar”) robotic platforms, which are essential for making advanced surgical technology both affordable and accessible across the Indian healthcare system.

Advances in Orthopedic Robotics: Transforming Surgical Precision and Patient Outcomes

Robotic systems have evolved from first-generation platforms (e.g., ROBODOC and ACROBOT) to modern semi-active and fully autonomous devices. Today’s robots (such as MAKO and OMNIBotics) use high-definition 3D imaging and haptic or navigation feedback to guide bone preparation precisely [3]. The CUVIS-joint system (CUREXO, South Korea) employs pre-operative computed tomography (CT)-based planning and advanced tracking to achieve submillimeter cutting accuracy [4, 5]. Similarly, the new MISSO joint robotic system (Meril Healthcare Pvt. Ltd., Vapi, India) combines real-time intraoperative feedback with submillimeter precision and individualized pre-operative CT-based planning, enabling more accurate implant alignment and overall surgical optimization [6]. Robotic-assisted total knee arthroplasty (RATKA) has been associated with less early post-operative pain and faster return of mobility compared with conventional techniques [7]. Although long-term advantages are still being studied, hospitals are seeing practical benefits today. More accurate implant placement means fewer alignment-related revisions and lower overall complication-related costs [6, 8]. A single-center randomized controlled trial of 100 patients with bilateral knee osteoarthritis showed that RATKA achieved greater alignment accuracy (82% within $\pm 3^\circ$) than conventional total knee arthroplasty (TKA) (64%), despite similar 6-month functional outcomes, suggesting that the key benefit of robotics lies in improved precision with potential long-term implications [9].

The Economics of Access: Why Robotics Remains Out of Reach

The cost structure of robotic arthroplasty presents considerable challenges to widespread adoption. A recent market analysis

found that a typical orthopedic robotic system costs \$554,000–\$1,000,000 (with annual service fees $\approx 10\%$ of that) [10]. In addition, the overall cost is further elevated by the need for pre-operative imaging, typically a CT scan, along with single-use robotic instruments (such as cutting guides, burrs, arrays, and drapes that cannot be sterilized and reused) and periodic software upgrades [11]. Consequently, only large private hospitals or tertiary government institutions can realistically absorb these recurring expenses, leaving smaller or rural centers unable to adopt robotic systems [3]. Even where robotics is available, patients may still face significant out-of-pocket payments if insurance plans do not cover the added cost of these premium technologies. Indeed, ClearState Consulting notes that throughout Asia, insurance coverage for robot-assisted joint surgery is still very limited, deterring many hospitals from investing [12]. In India’s 2025 survey, 82.7% of surgeons cited incomplete insurance coverage as a barrier, and 73.3% pointed to a lack of training [13]. In practice, these economic factors create a vicious cycle: low volumes and missing subsidies keep per-case costs high, which, in turn, limits adoption.

Emerging evidence indicates that reimbursement frameworks across Asia are evolving, gradually improving the feasibility of robotic arthroplasty. Reports from China indicate that select metropolitan regions, including Beijing, now provide full insurance coverage for specific robotic joint procedures [12]. These policy shifts have markedly expanded access by reducing direct patient expenditure. In India, similar transitions are anticipated. Market analysts project that RATKA could experience annual growth exceeding 30% over the next decade, driven by falling technology costs, indigenous manufacturing, and more supportive reimbursement mechanisms as they develop [12].

Ultimately, the aim is to shift robotic assistance from a premium, optional technology to a standard component of joint replacement – achieving cost parity with conventional instrumentation through greater scale, innovation, and automation.

Indigenous Innovation

India’s growing burden of joint disease, combined with limited healthcare resources, makes the development of domestically engineered robotic solutions not only relevant but also essential. National initiatives such as “Make in India” and “Atmanirbhar Bharat” explicitly encourage high-tech, homegrown medical devices [14]. Locally designed robots avoid import duties and foreign licensing fees and can be built with affordable indigenous components. They also let engineers optimize the system for Indian conditions, for



example, Indian patients often have different bone shapes and densities, or present at younger ages with advanced deformities, compared to Western cohorts [15]. A robot tuned for these realities (and for common implant sizes in India) can improve outcomes while lowering operating complexity [6]. Home-based service networks can handle maintenance and software support at far lower cost than foreign vendors [16, 17].

Within the current landscape of orthopedic robotics in India, MISSO (launched in 2024), remains the only domestically engineered platform with published evidence (although limited) of clinical use in knee arthroplasty and a defined pathway toward broader joint-replacement applications [6]. It is the world's first platform to provide both automated burr and precision surgical saw-based cutting tools to execute bony cuts, providing greater versatility and options to the treating surgeon. [6]. It is intended to reduce the cost of RATKA relative to imported systems by making such technology more affordable for Indian hospitals, without compromising accuracy or precision [18]. As noted by the marketing head of the organization, the system is priced at approximately 2 crore (≈USD \$240,000), compared with nearly \$1 million for most imported robotic platforms [18].

In addition to these indigenous innovations, several globally established robotic systems are currently deployed in India and contribute to the overall landscape of robotic knee and hip arthroplasty.

CUVIS Joint (Curexo, S. Korea)

CUVIS uses patient-specific 3D CT-based planning and optical tracking to execute accurate bone resections during TKA [19]. In a prospective cohort of 360 patients, CUVIS demonstrated marked improvement in Oxford Knee Scores without any early revisions [20]. According to market research, CUVIS has achieved 89 installations, representing 30.7% of robotic systems in India [13].

MAKO (Stryker, USA)

MAKO is a CT-based, semi-active robotic arm system for knee and hip arthroplasty, reported as the most widely used system globally [21]. It creates a patient-specific 3D plan from pre-operative scans and guides bone cuts, improving accuracy and consistency. Recent meta-analyses suggest MAKO-assisted TKA can yield better functional outcomes than manual TKA [21].

CORI (Smith and Nephew, USA)

CORI, a portable, imageless handheld robotic system, was introduced in the US in 2020 and has since expanded globally

[10]. It uses real-time camera tracking and a burr-based cutting tool, letting the surgeon execute planned bone resections and alignment without pre-operative CT. An Indian series of 500 CORI TKAs found a short learning curve (~6 cases) and only minor issues (no infections or revisions) [22].

VELYS (DePuy/Johnson and Johnson)

VELYS is a table-mounted, imageless robotic platform designed to integrate with the ATTUNE knee system. Early clinical studies report shorter operative times and faster recovery compared with conventional TKA, and the system now represents a significant portion of India's robotic installations [23].

India now hosts a mix of indigenous and international robotic TKA systems, each showing promise in real-world use. As of 2024, roughly 290 robotic units were installed nationwide (CUVIS ~30.7%, CORI ~22.8%, VELYS ~17.9%, MAKO ~13.1%, and MISSO ~8.6%) [13] (Table 1).

International and Alternative Models

The Indian strategy reflects global trends. Worldwide, companies are launching lower-cost robots and pricing schemes. Mini robots for single-joint applications are emerging in Europe and North America, with evidence of growing interest in specialized robotic platforms for surgical and rehabilitation contexts [10]. The evidence suggests a trend toward more compact, targeted robotic systems. For instance, analysts predict these will force legacy device prices down by 20–30% over a few years [10]. In parallel, providers are experimenting with usage-based pricing or leasing to soften the financial impact of adoption [10]. Such innovations aim to eventually bring the per-case cost of robotics closer to conventional tools.

International experience illustrates how expanded insurance coverage can accelerate the adoption of robotic orthopedics in India. In Beijing, Class A medical insurance covers TiRobot (TINAVI Medical Technologies Co., Ltd., Beijing, China) procedures at 100%, and orthopedic surgeries using Tinavi's robots are explicitly included in local reimbursement schemes [12]. With these policies in place, Chinese hospitals rapidly adopted robotic systems.

India has begun policy reforms to catch up with these trends. In 2019, the IRDAI mandated that insurers cover a list of modern treatments (including robotic surgery), and by 2024, it explicitly required all health plans to include robotic-assisted procedures. However, in practice, many policies still impose sub-limits or deny claims for robotics [24,25]. Surgical societies and patient groups point out that these insurance gaps, not the

Table 1: Comparative overview of major robotic platforms utilized in orthopedic knee and hip arthroplasty

Robotic system	Manufacturer/Developer	Application (knee/hip)	Region of use	Year (first commercial use)	Notes
CASPAR	OrthoMaquet	TKA, THA	Global	1990	Active robot (discontinued due to complications.)
ROBODOC	Curexo Technology Corporation/Think Surgical	THA, TKA	Global	1992	First robotic system in orthopedics to assist with precise bone preparation in THA
PiGalileo	PLUS Orthopedics	TKA	Global	1999	Assists with computer-assisted orthopedic surgery for enhanced precision.
ACROBOT	Acrobot Company Ltd.	Unicompartmental knee arthroplasty	Global	2003	Semi-autonomous robot-assisted system.
Mako Smart Robotics	Stryker	Partial knee replacement, THA, TKA	Global	2006	Uses CT-based 3D models and haptic feedback; the most widely used THA robot globally.
OMNIBotics	OMNIlife Science, Inc.	TKA	Global	2010	Offers advanced planning software for ligament balancing and implant positioning.
TiRobot (TiRobot™/Orthbot)	Tinavi Medical Technologies Co., Ltd.	Spine, trauma, TKA	China, Asia	2016	Added to Beijing public insurance; works with standard implants.
TSolution One	Think Surgical	TKA, THA	Global	2019	Open-platform robotics, compatible with multiple implant systems.
ROSA Robotics	Zimmer Biomet	TKA, THA	Global	2019	Adapted from neurological surgeries for total knee and hip replacements.
Navio/CORI Surgical System	Smith and Nephew	Partial knee replacement, TKA, THA	Global	2020	Navio provides tactile guidance without pre-operative imaging. CORI is semi-active.
CUVIS Joint	Curexo	TKA	Global	2020	Fully automatic robotic TKA system; USFDA approved, European CE mark.
VELYS Robotic-Assisted Solution	DePuy Synthes	TKA	Global	2021	Offers real-time adaptive planning for personalized procedures.
SkyWalker Orthopedic Surgical Robot	MicroPort	TKA	Global	2022	Semi-active system.
RobPath Total Hip Application	Hangzhou Lancet Robotics	THA	Global	2023	Semi-active system.
MISSO Joint Robotic System	Meril Healthcare Pvt. Ltd.	TKA and partial knee arthroplasty	India	2024	Fully autonomous, designed for submillimeter accuracy in bone resection, and AI-driven adaptability.

THA: Total hip arthroplasty, TKA: Total knee arthroplasty, AI: Artificial intelligence, FDA: Food and Drug Administration, CT: Computed tomography

technology itself, remain the chief barrier. For example, a panel of Indian orthopedic experts noted that India's ~60 million arthritis patients get robotic joint replacement only very rarely, largely because insurers do not pay beyond conventional surgery limits [24,25]. The panel emphasized that patients should not be forced to choose between better care and insurance support.

In summary, Indian experts conclude that only by expanding equitable insurance coverage and continuing indigenous

innovation can robotic orthopedics take off. Policymakers are urged to enforce consistent reimbursement (building on the IRDAI's steps), so patients are not penalized for choosing robotics.

Challenges and the Road Ahead

A key challenge in India is education; there are currently few formal training programs for robotic arthroplasty, and no

standardized curriculum [2]. Each new robot requires surgeons and operating room teams to learn new workflows. Similarly, regulatory and ethical issues must be addressed, for example, ensuring proper patient consent, data privacy, and equitable access in a tech-driven surgical environment. These challenges are increasingly manageable, as national training programs and professional bodies supported by the government and dedicated simulation centers continue to expand surgeon education in robotics [10].

Crucially, indigenization must not compromise safety or efficacy. Early evidence is promising, with independent evaluations indicating that MISSO consistently provides high surgical precision and reliability, supporting their potential to enhance accuracy and outcomes in joint replacement procedures [3]. As the adoption of Indian-designed robotic platforms expands across hospitals, the accumulating multicenter clinical data will play a critical role in confirming their accuracy, safety, and functional outcomes [13]. By 2030, it is conceivable that robotic assistance could become routine in many Indian joint arthroplasty centers, just as it is in the USA and European hospitals [2].

Conclusion

Robotic-assisted orthopedic surgeries promise better patient

care, but only if technology becomes affordable. The evidence is clear: cost is the main barrier to adoption. Indigenous innovation offers a compelling solution by harnessing local engineering talent and market forces to slash prices. India is already taking decisive steps toward developing indigenous, innovative robotic solutions such as MISSO. With policy support (Make in India, insurance reforms) and a growing ecosystem of startups and academia, India can meet its large orthopedic needs at much lower cost. In short, by combining its surgical expertise with visionary engineering, India can make robotic precision a standard of care, no longer a luxury but an everyday reality for patients everywhere.

Clinical Message

Indigenous robotic systems such as MISSO show that India can combine surgical precision with true cost-effectiveness, making advanced joint replacement feasible beyond large metropolitan hospitals. By reducing capital and per-case expenses while maintaining high accuracy, these platforms open the door for wider access to safe, high-quality arthroplasty. With continued training, supportive policies, and robust clinical validation, India is well-positioned to lead the world in affordable robotic orthopedic care.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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