Editorial
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Rise of Revision Arthroplasties in Indian Subcontinent: An Inadvertent Future

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Learning Point of the Article:

The increase in revision arthroplasties in India is associated with factors such as an ageing population, prevalent lifestyle diseases, and limited implant durability. Contributing factors include elevated infection rates, wear, instability, and malalignment, particularly among younger, more active individuals. Technological innovations, including robotic-assisted surgery and improved implant designs, aid in reducing revision rates. Effective prevention requires the integration of advanced techniques, specialized surgeon training, and patient education. Nonetheless, cost remains a significant barrier, necessitating public-private partnerships to improve access, minimize complications, and optimize patient outcomes

Introduction

In the past two decades, developing countries like India have experienced a surge in joint replacement surgeries, driven by an aging population, rising lifestyle diseases, and increased awareness of arthroplasty's benefits. However, this growth has led to a rise in revision arthroplasties due to complications such as implant failure, infection, and malalignment, placing a strain on both patients and healthcare systems [1]. A better understanding of causes, preventive strategies, and advancements in implant technology and surgical techniques is crucial to address this issue.

Understanding the Rise of Revision Arthroplasties

Suboptimal implant survivorship

The increasing incidence of revision arthroplasties is largely attributed to the limited longevity of implants. Contributing factors include the use of potentially less durable implants, a younger, more active patient demographic, and a high prevalence of osteoarthritis and avascular necrosis. Globally, implant survivorship typically exceeds 15–20 years, but in India, revisions are often needed within a decade due to wear, aseptic loosening, or mechanical failures [2].

Periprosthetic joint infection (PJI)

PJI is among the most challenging and common complications following lower-extremity joint arthroplasty and are a leading cause of revision surgeries [1]. Reported infection rates after primary total knee arthroplasty (TKA) range from 0.51% to 1.55% [3], while for total hip arthroplasty (THA), the incidence is estimated at 0.5–0.7% within the 1st-year post-surgery. Late-onset infections present a cumulative incidence of 0.04–0.06% per prosthesis-year [4]. Alarmingly, studies from India indicate infection rates as high as 87% [1].

Aseptic loosening and wear

Aseptic loosening is the leading cause of implant failure,

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accounting for approximately 55% of hip revisions and 31% of knee revisions [2]. Aseptic loosening is often linked to polyethylene wear, where particulate debris triggers osteoclast-mediated bone resorption, leading to periprosthetic osteolysis and eventual loosening. This issue is particularly pronounced in younger, more active patients, suggesting a rising prevalence in this population [5].

Instability and malalignment

Joint instability, resulting from factors such as ligament imbalance, improper component alignment, and surgical errors, is another significant cause of revision surgeries [1]. Malalignment, particularly of the femoral component, has been strongly linked to increased revision rates [6]. Poor positioning can accelerate wear, diminish functionality, and compromise the overall outcome of the procedure. Furthermore, mechanical malalignment that fails to replicate natural joint movement can lead to long-term complications [6].

Patient-related factors

The growing trend of joint replacements in younger, more active patients has been associated with increased revision rates. Elevated activity levels in this demographic often result in accelerated wear and degradation of prosthetic components [1]. Whereas, in older adults, increasing comorbidities and associated ailments are the major cause of implant failure or decreased satisfaction rate.

Prevention: The Key to Curbing Revision Burden

Advanced technologies

Recent advancements in surgical technologies aim to improve precision and accuracy in orthopedic procedures. Innovations like patient-specific instrumentation, navigation systems, smart tools, and computer or robotic-assisted surgery enable tailored interventions based on individual anatomy and ligament characteristics. These technologies enhance 3D surgical planning, optimize implant positioning, and improve alignment precision, leading to superior outcomes [7].

Modular operating theaters (Ots)

Modular OTs equipped with advanced infection control technologies significantly reduce PJI and post-operative complications. Featuring HEPA filters, laminar airflow systems, and efficient sterilization, these OTs ensure a sterile environment, enhance workflow adaptability, and contribute to better surgical outcomes [8].

Robotic-assisted arthroplasty

Robotic systems have revolutionized orthopedic surgeries, by providing unmatched precision and consistency. The introduction of ROBODOC in 1992 marked a pivotal moment in robotic-assisted joint surgeries, improving bone resection accuracy and component alignment while reducing reliance on conventional cutting guides and manual positioning. Since then, robotic-assisted technologies have continuously evolved, with a primary focus on minimizing human error during surgery.

Conventional robotic-assisted TKA platforms typically rely on haptic feedback and oscillating saws controlled by surgeons for bone preparation. In contrast, the novel MISSO active robotic system (Meril Healthcare Pvt. Ltd., Vapi, India) represents a significant leap forward with its fully automated approach. This cutting-edge system integrates artificial intelligence and machine learning to enhance both pre-operative planning and intraoperative execution. By utilizing patient-specific computed tomography data, MISSO generates precise 3D bone models and personalized surgical plans tailored to individual anatomical variations [9]. The system's real-time guidance ensures optimal prosthetic alignment and precise bone cuts, improving surgical accuracy, preserving soft tissues, and reducing the risk of complications. In addition, MISSO's virtual simulation capability allows surgeons to rehearse procedures on 3D bone models, ensuring sub-millimetric precision during surgery. By automating complex tasks, the system enhances soft tissue management, minimizes collateral damage, and accelerates recovery, contributing to improved long-term patient outcomes.

Surgeon training and mentorship

Specialized training programs are crucial for equipping surgeons with the skills needed to adopt advanced technologies in orthopedic care. Organizations like Meril Life Sciences and Johnson and Johnson provide comprehensive educational frameworks that include live surgeries, hands-on workshops, cadaveric labs, and virtual reality (VR) simulations [10]. These programs emphasize key aspects such as patient selection, robotic system utilization, and complication management, enhancing surgical precision and decision-making. Mentorship is a cornerstone of these initiatives, with expert surgeons leading case discussions and offering real-time feedback. Virtual mentorship and remote collaborations further enhance accessibility, fostering peer connections and promoting global knowledge-sharing. VR simulations and cadaveric training allow surgeons to practice complex procedures, accelerating their learning curve and building confidence in robotic-assisted surgeries. By combining hands-on training with mentorship and cutting-edge simulations, these programs ensure that surgeons remain proficient, improving surgical outcomes and optimizing the use of innovative technologies.

Patient education and engagement

Patients may be hesitant to embrace robotic total joint arthroplasty (rTJA), often due to misperceptions about the technology. Common concerns include potential robotic malfunctions causing harm, incorrect procedures, inadequate surgeon training, high costs, and prolonged surgical times. Only half of surveyed patients fully understood the robot's role in rTJA [11]. Tailored pre-operative counseling can address individual concerns, improve shared decision-making, and identify patients most likely to benefit from rTJA. In addition, factors such as education, income, and age may influence patient understanding and acceptance of such innovations, with marketing campaigns potentially increasing interest and preference for rTJA.

Implant innovations: The game changers

In revision THA, tapered fluted titanium stems, both Modular and Monoblock, are essential for managing bone loss and restoring hip function. The Wagner Cone Prosthesis (Zimmer Biomet), introduced in the 1980s, was a pivotal innovation but faced limitations like subsidence and dislocation [12]. Modern modular systems, such as the S-ROM Modular Hip System (DePuy Synthes Johnson and Johnson, Warsaw, IN, USA), offer proximal fixation with a porous-coated sleeve and intraoperative adjustability to correct femoral anteversion and leg length discrepancies [13]. The RECLAIM™ (DePuy Synthes Johnson and Johnson, Warsaw, IN, USA) [14] and Restoration® Modular Systems (Stryker, Kalamazoo, MI USA) [15] provide distal fixation and modular reconstruction for significant femoral bone loss, while the Exeter® V40 Cemented Stem (Stryker, Kalamazoo, MI, USA) [16] ensures long-term durability with its double-tapered design. Innovations like the Latitud MonoMod Stem (Meril Healthcare Pvt. Ltd, India) merge modular flexibility with Monoblock durability to optimize joint stability in complex cases [17].

In revision TKA, modern rotating hinge knee systems, such as the NexGen LCCK (Zimmer Biomet), provide rotational flexibility and joint stabilization in severe ligamentous instability [18, 19]. The TC3® System (DePuy Synthes Johnson and Johnson, Warsaw, IN, USA) [20] and Freedom PCK® System (Meril Healthcare Pvt. Ltd, India) [21] use modular augments and condylar blocks for severe bone loss while balancing flexion laxity and extension stability. The DESTIKNEE® (Meril Healthcare Pvt. Ltd, India) supports high-flexion motion with minimal bone resection, and the Opulent™ Total Knee System (Meril Healthcare Pvt. Ltd, India) features TiNbN-coated components to reduce metal ion release and infection risks [22, 23]. DePuy Synthes' Attune® Revision Knee System employs an S-curve cam to optimize femoral rollback and patellofemoral tracking [24], while Zimmer Biomet's LPS-Flex Mobile Bearing Knee accommodates deep flexion (up to 155°) supported by an enhanced cam/spine mechanism, catering to patients with specific physical or cultural needs [25]. Bone deficiency solutions, such as Trabecular Metal Cones (Zimmer Biomet) and Restoration Tritanium Cones (Stryker Kalamazoo, MI, USA), promote osseointegration and address metaphyseal defects [26, 27]. In addition, systems like G7® Acetabular System (Zimmer Biomet) and dual-mobility acetabular cups (Zimmer Biomet, DePuy Synthes) offer enhanced stability and lower dislocation risk in hip revisions, particularly for patients with prior trauma or neuromuscular disorders [28, 29]. These innovations collectively increase implant longevity and address complex revision scenarios in both THA and TKA.

The road ahead: Balancing cost and accessibility

The integration of advanced implants and robotic-assisted technologies is crucial for improving arthroplasty outcomes, yet economic constraints often limit their widespread adoption. To combat this, collaboration among healthcare providers, policymakers, and manufacturers is essential to develop cost-effective solutions. Initiatives such as public-private partnership, subsidies, and targeted investments in training and research can bridge the gap between innovation and affordability. The development of modular implants and accessible robotic platforms, along with streamlined training programs, can further enhance the global reach of advanced arthroplasty care.

Conclusion

The increasing prevalence of revision surgeries in orthopedics underscores the importance of a comprehensive strategy to optimize primary procedures and minimize failures. Addressing key factors such as component malalignment, bone loss, infection, and implant wear involves adopting a multipronged approach that integrates advanced implant designs, robotic-assisted surgery, and improved perioperative protocols. Standardizing pre-operative planning, improving surgical precision, and fostering research on long-term implant performance are pivotal in achieving durable outcomes. In addition, continuous investment in surgeon education and the development of modular operating systems can further reduce revision rates. By prioritizing innovations, collaboration, and data-driven improvements, the orthopedic community can significantly reduce the burden of revision arthroplasties and improve long-term patient outcome globally.

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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