



India first tele-robotic hernia repairs using the SSI mantra system: a feasibility study

Mahak Bhandari¹ · Mohit Bhandari² · Susmit Kosta¹ · Winnie Mathur¹ · Manoj Reddy¹ · Mrigendra Singh¹ · Vinod Bhandari¹

Received: 14 August 2025 / Accepted: 8 February 2026

© The Author(s), under exclusive licence to Springer-Verlag France SAS, part of Springer Nature 2026

Abstract

Background Tele-robotic surgery represents an evolving model for delivering advanced surgical care using robotic platforms operated from a physically separate console within a connected institutional network.

Aim To evaluate the feasibility, safety, and short-term outcomes of robotic tele-robotic inguinal hernia repair using the SSI Mantra system in a simulated tele-robotic surgery model.

Methods This prospective case series involved ten adult patients with primary inguinal hernias including six indirect and four direct operated in July 2025. All surgeries were performed using the SSI Mantra robotic platform, with the surgeon operating remotely from a console within the same institutional network in different locations. Operative and postoperative data were collected and analyzed descriptively.

Results All ten procedures were completed successfully without conversion or device malfunction. The mean docking time was 7 min, console time 36.8 ± 4.5 min, and total operative time 42.6 ± 5.3 min. Intraoperative blood loss was < 20 ml in all cases. No intraoperative complications occurred. Patients were ambulated the same day and resumed oral intake within 24 h. The average hospital stay was 1.6 ± 0.4 days, and pain was well-managed with a mean VAS score of 2.1 on postoperative day one. No readmissions or early wound complications were noted.

Conclusion This case series marks a in documenting India's first clinical experience with robotic tele-robotic inguinal hernia repair using the SSI Mantra system. We emphasize that the outcomes reported are restricted to short-term feasibility and early postoperative safety, not long-term efficacy or recurrence outcomes.

Keywords Tele-Robotic · Inguinal hernia · SSI mantra · India · Minimally invasive surgery

Introduction

Robotic-assisted surgery has redefined the landscape of modern surgical practice by offering enhanced precision, improved dexterity, and superior visualization compared to conventional laparoscopic methods. These advantages have translated into tangible clinical benefits across multiple specialties, including reduced operative trauma, quicker recovery, shorter hospital stays, and improved surgical outcomes

[1, 2]. As robotic platforms continue to evolve, their integration into routine surgical workflows has become increasingly common in high-income healthcare settings.

One of the most promising frontiers in robotic surgery is tele-robotic surgery the ability to perform surgical procedures remotely by leveraging robotic systems connected through high-speed communication network. This concept enables a skilled surgeon to operate on a patient located at a different physical site, potentially even hundreds or thousands of kilometres away. Tele-robotic surgery offers the potential to transcend geographic limitations and extend expert surgical care to regions lacking specialist services, making it especially relevant in countries with uneven access to healthcare infrastructure [3, 4].

The feasibility of tele-robotic surgery has been demonstrated in several landmark international cases, including the well-known “Lindbergh Operation” in 2001, where

✉ Mahak Bhandari
susmitkosta@gmail.com

¹ Sri Aurobindo Medical College and PG Institute, Sri Aurobindo University, Indore, India

² MOHAK Hi Tech speciality hospital, Sri Aurobindo University, Indore, India

a surgeon in New York performed a cholecystectomy on a patient in Strasbourg, France, using a robotic platform [5]. Since then, various robotic systems have been tested for remote operations, and improvements in latency, video resolution, and instrument responsiveness have further increased its practical applicability [6]. However, the widespread implementation of tele-robotic surgery remains limited, largely due to the high cost and technological demands of globally available robotic platforms, such as the da-Vinci Surgical System. These systems are not only expensive to acquire and maintain, but also require proprietary equipment, licensed software, and dedicated infrastructure, restricting their use to well-funded tertiary centers in urban regions [7].

In India, access to advanced surgical care remains uneven, with much of the rural and semi-urban population lacking specialist services. Tele-robotic surgery holds potential application by enabling expert surgeons in urban centers to operate on patients in remote areas. However, its adoption has been limited by infrastructure challenges and cost constraints. To address this gap, Indian engineers and surgeons developed the SSI Mantra the nation's first domestically manufactured robotic system offering high-quality features like wristed instruments and 3D visualization at a significantly lower cost [8]. Designed for compatibility with standard operating rooms, the SSI Mantra system makes robotic surgery more accessible across diverse healthcare settings.

This study was designed as a pilot initiative to assess the SSI Mantra system's feasibility in a tele-robotic surgery model, where operates from a remote console within the

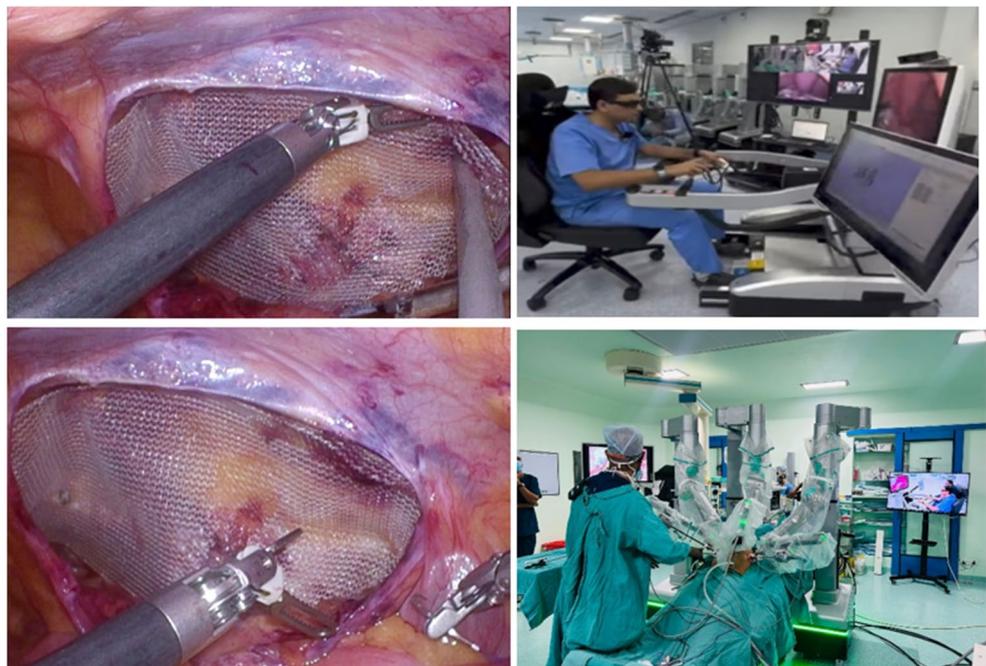
same facility. The procedure was inguinal hernia repair, a standardized and commonly performed surgery that is well-suited to robotic techniques due to its reproducible anatomy and technical requirements. We report India's first clinical case series of robotic tele-robotic inguinal hernia repairs using the SSI Mantra system. By evaluating operative metrics, technical feasibility, safety, and short-term outcomes, this study provides early insights into the platform's capabilities. More broadly, it contributes to the growing body of evidence supporting indigenous innovations in healthcare delivery and the expanding role of tele-robotic surgery in addressing surgical access gaps across India.

Methodology

Study design and setting

This prospective, observational case series was conducted in July 2025 at XYZ a high-volume tertiary care surgical center. The study aimed to evaluate the feasibility, technical safety, and short-term outcomes of robotic tele-robotic inguinal hernia repair using the SSI Mantra robotic system. All ten procedures were performed using a simulated tele-robotic surgery model in which the operating surgeon was physically separated from the patient. It was operated from a dedicated robotic console located at AA, within the same institutional network, while the patient and robotic cart were in the operating surgeon theatre of XYZ (Fig. 1). This arrangement enabled a real-time robotic tele-robotic setup using intra-institutional network connectivity. Written

Fig. 1 Intraoperative view and tele-robotic setup during robotic inguinal hernia repair using the SSI Mantra system. (Left) Mesh placement in the preperitoneal space during r-TAPP repair. (Right) Tele-surgical setup showing remote operation from the console and robotic docking at the patient's side



informed consent was obtained from all patients prior to enrollment.

Patient selection

Ten consecutive adult patients with primary inguinal hernias were selected for the study. Inclusion criteria were age between 18 and 70 years, ASA physical status I or II, and a clinically and ultrasonographically confirmed diagnosis of reducible inguinal hernia (direct or indirect). Patients were excluded if they had recurrent or strangulated hernias, irreducible hernias, prior abdominal or pelvic surgeries, body mass index (BMI) > 35 kg/m², or significant cardiopulmonary comorbidities.

Tele-surgical setup

The SSI Mantra robotic surgical system, developed in India, was used for all procedures. The robotic patient cart was stationed in the operating surgeon room at XYZ, while the controlled the system from the remote surgical console located at AA, physically separated within the same hospital complex. A high-speed fiber-optic local area network (LAN) ensured stable and latency-free communication between the console and patient cart. A trained bedside surgical assistant and robotic team remained in the operating surgeon room throughout each procedure to assist with trocar placement, instrument exchange, suction, and patient support.

Surgical Procedure

All patients underwent robotic transabdominal preperitoneal (r-TAPP) inguinal hernia repair using a standardized approach. Under general anaesthesia, patients were positioned supine with a mild Trendelenburg tilt. A 10-mm camera port was inserted infraumbilically, and two 8-mm robotic working ports were placed under direct vision in the lower quadrants. After achieving pneumoperitoneum, the robotic arms were docked, and the surgeon commenced the procedure from the AA console.

The peritoneum was incised, and the hernia sac was carefully dissected and reduced. A polypropylene mesh was introduced and placed in the preperitoneal space without fixation. The peritoneal flap was then closed using barbed sutures. After undocking the robotic system, all port sites were closed in layers. The procedures were carried out

without conversion to open or conventional laparoscopic surgery.

Data collection

All operative and postoperative data were systematically recorded for each patient. Parameters collected included demographic details (age, sex, and body mass index), hernia type (direct or indirect), docking time, console time, total operative time, and estimated intraoperative blood loss. Postoperative recovery was assessed using standardized metrics: time to ambulation, time to initiation of oral intake, pain intensity on the first postoperative day (measured using the Visual Analog Scale (VAS)), length of hospital stay, and the presence of any wound-related complications. All patients were followed for up to 10 days postoperatively to evaluate early clinical outcomes, limited to early postoperative adverse events only.

Data analysis

Collected data were analyzed descriptively. Continuous variables such as operative times and pain scores were reported as means with standard deviations, while categorical variables like hernia type and complication rates were expressed as absolute numbers and percentages. Given the small sample size and the exploratory nature of the study, no inferential statistical testing was performed.

Results

Patient demographics

A total of ten patients underwent robotic tele-robotic inguinal hernia repair using the SSI Mantra robotic surgical system. All procedures were performed at XYZ, with operations conducted remotely from AA, within the same institutional network in different location. The mean age of patients was 50.0±8.6 years. The average BMI was 26.7±2.5 kg/m². Among the hernia types, six cases were indirect inguinal hernias and four were direct. Details are provided in Table 1.

Operative metrics

All surgeries were successfully completed using the robotic tele-robotic surgery model with no need for conversion to open or conventional laparoscopic surgery. The mean docking time was 7.0±1.1 min, while the console time was 36.8±4.5 min. The total operative time ranged from 30 to 50 min, with a mean of 42.6±5.3 min. Intraoperative blood

Table 1 Patient demographics

| Parameter | Value |
|-------------------------------|----------------------|
| Number of patients | 10 |
| Mean age (years) | 50.0±8.6 |
| Mean BMI (kg/m ²) | 26.7±2.5 |
| Hernia Type | 6 Indirect, 4 Direct |

Table 2 Operative metrics

| Parameter | Value |
|--------------------------------|------------------------|
| Docking time (minutes) | 7.0±1.1 |
| Console time (minutes) | 36.8±4.5 |
| Total operative time (minutes) | 42.6±5.3 (Range 30–50) |
| Estimated blood loss | <20 ml in all cases |
| Conversion rate | 0% |
| Intraoperative complications | None |

Table 3 Postoperative outcomes

| Outcome | Observation |
|---------------------------|---------------------|
| Time to ambulation | Same day |
| Time to oral intake | Postoperative Day 1 |
| Mean hospital stay (days) | 1.6±0.4 |
| Pain score (VAS) Day 1 | 2.1±0.5 |
| Wound complications | None |
| Readmissions | None |

loss was minimal (<20 ml) in all cases, and no intraoperative complications or device-related errors were encountered. These operative performance metrics are presented in Table 2.

Postoperative recovery and outcomes

Postoperative recovery was uniformly smooth across all patients. Ambulation was initiated on the same day of surgery, and oral intake resumed on the first postoperative day. The mean hospital stay was 1.6±0.4 days. Pain control was effective, with a mean VAS score of 2.1±0.5 on postoperative day one. There were no wound complications or readmissions during the short-term postoperative period. These findings are summarized in Table 3.

Discussion

This case series represents the first clinical experience in India with robotic tele-robotic inguinal hernia repair using the SSI Mantra robotic system. The findings from these ten cases demonstrate that tele-robotic hernia repair is not only technically feasible but also safe, with excellent short-term outcomes and no conversions, complications, or readmissions. The ability to successfully perform these procedures with the surgeon physically separated from the patient while still within the hospital premises validates the operational integrity of this indigenous robotic system in a tele-robotic surgery model.

The mean operative time of 42.6 min and console time of 36.8 min are comparable to early robotic experiences reported in the literature for in-person r-TAPP hernia repair [9, 10]. The low estimated blood loss and absence of intraoperative complications further highlight the stability and

precision of robotic instrumentation. The absence of conversions, infections, or early recurrences supports the clinical safety of tele-robotic workflows when conducted under controlled conditions and by experienced teams.

Tele-robotic surgery, while conceptually well-established, remains underutilized globally primarily due to the prohibitive cost and proprietary nature of most commercially available robotic platforms. In India, where healthcare resources and surgical expertise are unevenly distributed, tele-robotic surgery offers potential application in bridging the rural–urban surgical access divide. However, until recently, the high cost of imported robotic systems has prevented any practical implementation of such models at scale.

The development and deployment of the SSI Mantra system, an Indian-designed and manufactured robotic platform, addresses these challenges. It offers essential robotic capabilities such as 3D high-definition vision, wristed instrument articulation, and ergonomic console controls at a substantially reduced cost [5, 7, 8]. Importantly, the platform has been engineered for compatibility with existing operating rooms and infrastructure, allowing seamless adoption in public and private hospitals across India. By demonstrating successful tele-robotic functionality in this case series, the SSI Mantra system proves its viability not only as a tool for robotic surgery but as a vehicle for expanding tele-robotic access in the Indian healthcare ecosystem.

Inguinal hernia repair, being a standardized and frequently performed general surgical procedure, was an appropriate choice for this initial pilot. Prior studies have shown that robotic inguinal hernia repair provides superior ergonomics, more precise dissection, and better visualization of the inguinal anatomy compared to conventional laparoscopy, although with increased operative time and cost in some settings. In our series, the short operative time, minimal blood loss, and efficient closure using barbed sutures reflect both the learning curve benefits and the suitability of the SSI Mantra system for such procedures.

The successful use of a tele-robotic surgery model with the operating from AA while the patient was in the adjacent operating suite at XYZ serves as a proof-of-concept. It demonstrates the absence of latency, smooth control transfer, and uninterrupted procedural flow, even in tele-robotic mode. This lays the groundwork for future long-distance tele-robotic surgery, which could allow expert surgeons in urban hubs to extend their services to district hospitals and rural centers without physical relocation. With improvements in digital connectivity (e.g., 5G, fiber-optic backbones) and regulatory frameworks for tele-robotic practice, such models could redefine surgical outreach in India.

This study has several strengths. It is the first of its kind in India, using an indigenous robotic system for tele-robotic surgery. The data were prospectively collected

and digitally tracked through a standardized clinical tool (Hernia Tracker), ensuring real-time documentation and outcome monitoring. All cases were completed without technical issues, supporting the system's reliability. However, the study is not without limitations. The sample size is small and restricted to a single center and procedure type. The follow-up duration was limited 10 days, which may not capture late complications or hernia recurrences. Additionally, the tele-robotic surgery model, while informative, does not fully replicate the technical challenges of remote long-distance tele-robotic surgery involving wider geographical separation. Future studies should focus on expanding sample size, including multiple centers, diversifying surgical procedures, and testing connectivity across cities or states.

Conclusion

This case series marks a in documenting India's first clinical experience with robotic tele-robotic inguinal hernia repair using the SSI Mantra system. We emphasize that the outcomes reported are restricted to short-term feasibility and early postoperative safety, not long-term efficacy or recurrence outcomes.

This case series marks a in the advancement of robotic surgery in India by documenting the country's first clinical experience with robotic tele-robotic inguinal hernia repair using the SSI Mantra system. All procedures were performed successfully with no intraoperative complications, conversions, or postoperative adverse events. Operative efficiency, rapid patient recovery, and the absence of technical difficulties demonstrate that tele-robotic surgery using an indigenous robotic platform is both feasible and safe.

The successful implementation of a tele-robotic model where the operating surgeon was physically remote from the patient but within the same institutional network provides a proof-of-concept for broader tele-robotic deployment. As India continues to expand its digital infrastructure, the integration of tele-robotic surgery into routine surgical care holds potential application, particularly in rural and underserved regions where access to specialist care remains limited. The SSI Mantra system has proven itself to be a reliable, cost-effective, and clinically viable solution for robotic surgery in India. This study sets the foundation for larger, multicentric trials and long-distance tele-robotic applications that. In summary, robotic tele-robotic surgery using an indigenous platform is not just a technological advancement it is a step forward toward.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10029-026-03629-3>.

Acknowledgements We thank our team members and sincerely acknowledge the patients for their trust and participation.

Declarations

Conflicts of interest The authors declare no conflicts of interest and no external funding for this study.

References

- Herron DM, Marohn M (2008) A consensus document on robotic surgery. *Surg Endosc* 22:313–325. <https://doi.org/10.1007/s00464-007-9727-5>
- Lanfranco AR, Castellanos AE, Desai JP, Meyers WC (2004) Robotic surgery: A current perspective. *Ann Surg* 239:14–21. <https://doi.org/10.1097/01.sla.0000103020.19595.7d>
- Anvari M (2007) Remote telepresence surgery: the Canadian experience. *Surg Endosc* 21:537–541. <https://doi.org/10.1007/s00464-006-9073-9>
- Hashizume M, Tsugawa K (2004) Robotic surgery and cancer: the present state, problems and future vision. *Jpn J Clin Oncol* 34:227–237. <https://doi.org/10.1093/jjco/hyh043>
- Marescaux J, Leroy J, Gagner M, Rubino F, Mutter D, Vix M, Butner SE, Smith MK (2001) Transatlantic robot-assisted tele-robotic surgery. *Nature* 413:379–380. <https://doi.org/10.1038/35096636>
- Sterbis JR, Hanly EJ, Herman BC, Talamini MA, Horgan S, Ferreres A, Moser F, Curet M, Choti M, Marohn M, Fowler DL (2008) Transcontinental telesurgical nephrectomy using the Da Vinci robot in a Porcine model. *Urology* 71:971–973. <https://doi.org/10.1016/j.urology.2007.11.128>
- Barbash GI, Glied SA (2010) New technology and health care costs—the case of robot-assisted surgery. *N Engl J Med* 363:701–704. <https://doi.org/10.1056/NEJMp1006602>
- SS Innovations International Inc (2025) SSi Mantra – SS Innovations International Inc. [Internet]. SS Innovations International Inc., Gurgaon, India. Available from: <https://ssinnovations.com/si-mantra/> [Accessed 16 Jul 2025]
- Kudsi OY, McCarty JC, Paluvoi N, Mabardy AS (2017) Transitioning from laparoscopic to robotic transabdominal preperitoneal (TAPP) inguinal hernia repair: outcomes from 100 consecutive robotic TAPP inguinal hernia repairs. *Surg Endosc* 31:4187–4192. <https://doi.org/10.1007/s00464-017-5475-3>
- Zhang Y, Zhang R, Li J et al (2021) Robotic versus laparoscopic inguinal hernia repair: A meta-analysis. *Surg Endosc* 35:2082–2091. <https://doi.org/10.1007/s00464-020-05189-4>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.