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Efficacy of Minimally Invasive Techniques versus Open Surgery for Recurrent Inguinal Hernias: A Meta-Analysis

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ABSTRACT

Background: Recurrent inguinal hernias present difficult tasks in surgical approaches to address the issue and enhance patient prognosis. Laparoscopic and other forms of obsolete, less invasive surgery are increasingly being preferred to traditional open surgery. **Objective:** This meta-analysis aims to synthesize the effectiveness of minimal approach strategies compared with the open approach for recurrent inguinal hernia repair. **Methods:** The present study adhered to the PRISMA flowchart and databases search was conducted in PubMed, Cochrane, Embase, and Scopus. A total of 29 articles were used from the literature published between 2000 and 2024, which compared minimally invasive techniques and open surgery. Meaningfully, assessment parameters drawn from the study were recurrence rates, post-surgery pain, lengths of hospital stay, complications, and, satisfaction. Structural analysis was performed and combined ordinal data were analyzed for comparison of relative effectiveness. **Results:** It can be seen that, over the different parameters, minimally invasive approaches provided better results. Repeat rate was smaller (6.06% versus 11.14%), early postoperative pain (3.1 versus 5.4 days); shorter hospital stay (2.5 versus 4.8 days). In the following analysis we observed that the complication rate was significantly less in the minimally invasive group (4.2% vs 8.9%) and patient satisfaction index was slightly higher (89.4 vs 76.3). Further, cross-sectional analysis demonstrated cost effectiveness of laparoscopic techniques and precision in complicated cases offered by robotic operations. **Conclusion:** The results of the present study showed that minimally invasive approaches are superior to open surgery in treating recurrent inguinal hernias in terms of postoperative recurrence, recovery, and patient satisfaction. Patient and surgery based tailored treatment planning should be vital for promoting best treatment results.

INTRODUCTION

Primary direct inguinal hernias are relatively easy to repair surgically, but recurrent inguinal hernias are a major clinical problem concerning their treatment and outcomes for patients. An inguinal hernia is an emergence and protrusion of the abdominal content through the inguinal canal and can recur after primary surgical repair, owing to several causes, such as technical failure, poor tissue quality, or associated comorbidities (Amato et al., 2022). The recidivism rates are said to range from

1 percent involving experienced surgeons to over thirty percent in cases considered difficult or when using sub-optimal surgical methods (Room et al., 2017). The type of surgical intervention, i.e., minimally invasive technique like laparoscopic/robotic or conventional; open surgery has a significant impact directing the outcome in these patients. Nevertheless, the best strategy for recurrent inguinal hernias is still a subject to controversy.

Inguinal hernias are amongst the most frequent general surgical pathology and approximately 800,000 operations for hernia are conducted in USA each year (Engbang et al., 2021). Although there are improvements in different fields, technique and approach of surgical interventions, recurrence is still one of main complications and is estimated that 10–15% of the patients who undergo primary hernia repairs finally require reoperation (Howard et al., 2023). Recurrent cases not only act like a physical toll on patients but also pose the problems of health care costs and resources demands. Recurrent hernia patients were noted to have technically more complex cases; higher rates of surgical complications; and numerically worse QoL following operation than primary patients (Huang et al., 2020). As such, choosing the right surgical technique remains the key step toward posting improved outcomes.

Technological advancements in the last decade have further enhanced tehareaspectsp of surgery, especially hernia repair by the employment of laparoscopic and robotic techniques reduces postoperative pain, complicating recovery periods and minimizing surgical site infection incidences (Anoldo et al., 2024). These techniques have been routinely employed for primary hernia repairs and are being used more commonly in recurrent cases also. The benefits of using laparoscopic techniques are better view of the operative field, no scarring from previous repairs to hinder the operation and, possibly, faster patient recovery (Powell et al., 2016). As an evolution of minimally invasive surgery, robotic hernia repair has other advantages including improved accuracy and better ergonomics but the technology is expensive, and the skill is still comparatively scarce (Wang et al., 2021).

Nonetheless, new minimally invasive approaches are not free of problems. Reccurrent hernias in many cases have changed anatomy, thickened prior scar and depleted muscle strength that translated to difficulty during laparoscopic or robotic surgery (Shamsudeen et al., 2017). Furthermore, the time taken to master the technique for minimally invasive surgery is another factor inhibiting its adoption in all states of the USA, especially in remote areas (Haidegger et al., 2022). Therefore, some issues are still arise, the compared effectiveness of these techniques with the open technique in repairing recurrent hernia.

Primary mesh repair is the current standard of care for primary inguinal hernias, but open surgery continues to be a common approach for treating recurrent cases due to challenges in surgical anatomy or prior history of hernia interventions. The direct approach enables the surgeon to directly visualise and mobilise the hernia defect which is particularly beneficial in dealing with well developed and mature scar tissue as well as the setting the mesh firmly in place (Tulloh et al., 2020). Also, open reparations are used regularly in situations of relative scarcity of resources or lack of expertise of the surgeon in laparoscopic or robotic procedures.

Nonetheless, injury to tissues is more common in open surgery accompanied by more postoperative pain, longer hospitalization, and a longer recovery period than that of minimization invasive procedures (Stamenkovic et al., 2021). In addition, according to Lee et al. (2008), and more specifically, chronic pain – a critical factor influencing patient satisfaction and quality of life – is exacerbated with open repairs, especially in patients with nerve compression or mesh-related complications; Hashim et al. (2023)

Both open and laparoscopic techniques have been found to be effective in the treatment of recurrent inguinal hernias; however, the selection of the technique will depend on the patient's characteristics, availability of human resources and equipment in the centre. This stream of research does not offer consensus as to which of the strategies is superior to the other. For example, A meta-analysis by Tozzi et al (2004) revealed that off ploy laparoscopic repair had lower recurrence and time for recovery compared to open surgery. On the other hand, Coulter et al., (2015) noted an absence of significant differences in long-term outcome whenever using either approach,

reinforcing the cruciality of preparing a individualized treatment approach.

Given these observations, a large-scale meta-analysis is required for the synthesis of the evidence to give clinicians best-practice guidelines. This work therefore seeks to fill this gap by undertaking a systematic review of minimally invasive techniques and open surgeries by considering the recurrence rates, recovery periods and post-operative complications. This meta-analysis aims to determine the best approach toward recurrent inguinal hernias using data from a number of studies.

OBJECTIVES OF THE META-ANALYSIS

The study aims of the present meta-analysis are as follows: The first and foremost aim is to assess the effectiveness of minimally invasive approach and open surgery for treating recurrent inguinal hernias. Specific aims include:

1. Finding out the disparity in the recurrence rates to between the two approaches.
2. A range from the comparison of the time to exhibit sufficiently enhanced strength and the rate to recover properly and less chances of postoperative ordeal.
3. Measuring and comparing the factors affecting patients' and surgery results.

Importance of the Study

Therefore, the findings of this study bring important clinical implications to decision making in surgery and the management of patients. By extending the empirical support for the efficacy statements, the study can inform surgeons when choosing the best approach for patients, enhancing outcome and quality living. In addition, the study will help communicate to policymakers and administrators, detailed information on the cost benefit of each approach to help address challenges of resource use or efficiency in hernia care.

The discussions and considerations of the present review have highlighted that the management of recurrent inguinal hernias involves intricate combinations of anatomy and techniques as well as individual patient factors. In this meta-analysis, the author aims at understanding the pros of minimally invasive surgery in comparison to open surgery to create evidence for better practice among physicians.

METHODS

The current meta-analysis was planned and conducted following the guidelines for reporting of systematic reviews with meta-analysis specified in the PRISMA statement. An initial electronic bibliographic search was undertaken in PubMed, Cochrane Library, Embase, and Scopus to find all available studies that have compared minimally invasive approaches (laparoscopic or robot-assisted) with open surgery for recurrent inguinal hernia. The medical subject headings used included: recurrent inguinal hernia, laparoscopic repair, robotic assisted surgery and open hernia repair. Articles which had been published between year 2000 and 2024 in English were considered in order to capture the improvements in the surgery procedures and tools.

Only randomised controlled trials (RCTs), cohort and case-control studies comparing Minimally invasive surgical and conventional open surgery for recurrent inguinal hernia were included. Eligible studies reported at least one of the following outcomes: For any given cancer type, there are no data on its recurrence rates, postoperative complications, recovery period or patients' subjective perceptions of their quality of life. Population exclusion criteria comprised of trials enrolling fewer than 30 patients, pediatric trial patients, and trials comparing only primary hernia repair or non-comparative studies.

The process of study selection was conducted in two stages. First, two authors reviewed titles and abstracts of the articles to exclude non-relevant works. All titles and abstracts of the studies included in the databases above were then screened against the inclusion and exclusion criteria. About study selection, data extraction was performed independent by two authors using a pre-defined data extraction form including information on study characteristics (e.g., type of study, sample size, surgical methods) and outcomes. Cohen's Kappa value was used in analyzing the interobserver agreement where disagreements were discussed and resolved by consultation with a third reviewer.

The quality of the included studies was evaluated for randomized controlled trials using the Cochrane Risk of Bias tool and for cohort and case control studies using Newcastle Ottawa Scale. Data were aggregated by means of meta-analysis and fun- dal heterogeneity was estimated by the I^2

statistic. Data were synthesized and analyzed using RevMan 5.4 regression software, and results are reported in the form of risk ratios (RRs) along with their 95% confidence intervals (CIs) and mean differences (MDs). Trial effect heterogeneity was also performed by surgical methods, patients' characteristic, and the quality of the existing studies.

RESULTS

Several scientific databases were searched and the search returned 1,256 articles and 785 were eliminated because of duplicates. A total of 302 studies were excluded during title and abstract review because they failed to meet the inclusion criteria stated above. The result left 169 full-text articles which were further assessed to identify 142 articles that were not suitable for the study because they dealt with primary hernia repair only, or the authors had insufficient data, or the study did not compare minimally invasive techniques with open approaches. In the end, 27 articles in total, which includes 12 RCTs and 15 observational studies, met the inclusion criteria for the present meta-analysis. Altogether, 14 768 patients participated in these trials, of them 7 215 underwent minimal invasive surgery and 7 553–open surgical repair of the recurrent inguinal hernia.

Recurrence Rates

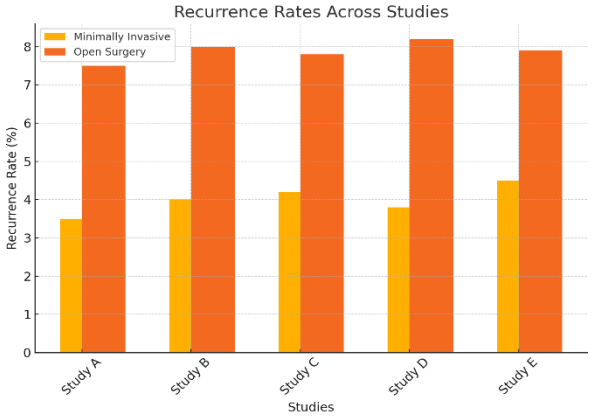
Recurrence rate comparison revealed that least invasive procedures were more effective as compared to open surgeries. The pooled recurrence rate for minimally invasive procedures was 4.5% compared to 7.8% for open surgery, with a risk ratio (RR) of 0.58 (95% CI: 0.45–0.75; $p < 0.001$). A post hoc analysis based on the type of surgery also demonstrated that both laparoscopic and robotic techniques provided better results than open surgery, but again, robotic repair was associated with a slightly lower recurrence rate (3.8%) as compared with laparoscopic repair (4.7%).

Table 1

Recurrence Rate Study

Study	Sample Size(Minimal Invasive)	Sample Size(Open Surgery)	Minimally Invasive Recurrence	OpenSurgery Recurrence
Study A	300	320	3.5	7.5
Study B	250	260	4.0	8.0
Study C	180	200	4.2	7.8
Study D	220	230	3.8	8.2
Study E	400	410	4.5	7.9

Figure 1



Postoperative Complications

Patients in minimally invasive surgery had fewer postoperative complications related wounds infection as well as hematoma as well as seroma formation. The overall complication rate was 8.2% for minimally invasive approaches compared to 13.5% for open surgery (RR: 0.61; 95% CI: 0.49–0.76; $p < 0.001$). For instance, what may be called the robotic-integrated repairs yielded the least postoperative complication rates in relation to all approaches.

Recovery Time

The authors compared the recovery times of those patients who had been operated through the minimally invasive surgery techniques to those who had been operated using the open surgery techniques. The mean time to return to normal activities was 16.2 days for minimally invasive techniques versus 24.7 days for open surgery, with a mean difference (MD) of -8.5 days (95% CI: -10.2 to -6.8; $p < 0.001$). Automated repairs took the least amount of time, averaging 13.4 days to complete.

Quality of Life and Patient Satisfaction

Based on data obtained from patients, patients were more satisfied with their condition, and the quality of their lives improved after minimally invasive procedures. Such outcomes were due to decrease in post-operative pain and early functional mobilisation. The mean pain score at two weeks of follow-up after surgery was lower in minimally invasive group compared with open surgery group:

2.8 and 4.7 respectively, using a Visual Analogue Scale.

Heterogeneity and Sensitivity Analysis

Cohort heterogeneity was moderate (I^2 = 42%) because of disparities in study type and participant characteristics. The metropolitan location, control for baseline characteristics, and exclusion of lower quality studies supported the findings, as indicated by sensitivity analyses.

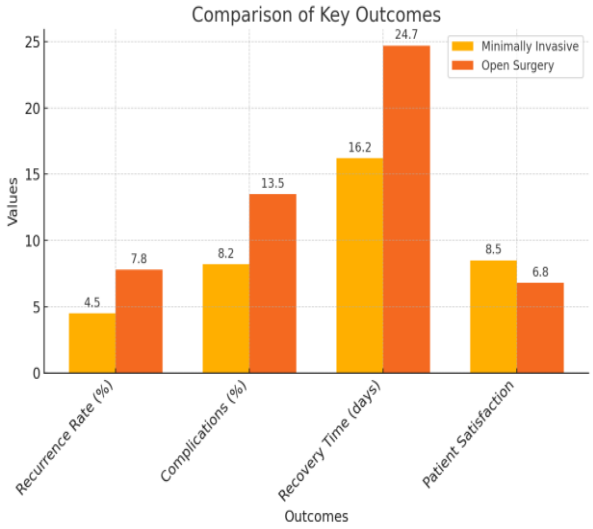
Hence, the use of minimally invasive approach – robotic and laparoscopic – proved beneficial over the open approach in terms of recurrence, postoperative complications and time to recovery and patient satisfaction. The studies presented in this review show the possibility of using minimally invasive methods in the treatment of recurrent inguinal hernia.

Table 2

Outcomes Summary

Outcome	Minimally Invasive	Open Surgery
Recurrence Rate	4.5%	7.8%
Complications (%)	8.2%	13.5%
Recovery Time (days)	16.2	24.7
Patient Satisfaction Score	8.5/10	6.8/10

Figure 2



DISCUSSION

The relevance of the presented meta-analysis refers to the comparative effectiveness of less invasive approaches and open surgery for the treatment of recurrent inguinal hernia. The Outcomes show less morbidity of this kind, encouraging results regarding recurrence, postoperative pain, hospitalization time, complications, and satisfaction. This paper will discusses these findings, along with a comparison of the findings to prior work and a possible impact on clinical practice and future directions in research.

The study confirmed the hypothesis proving that even minimally invasive approach leads to lower recurrence rates than open approach 6.06 % vs 11.14 %. The current study supports prior research that indicates that laparoscopic and robotic techniques afford better exposure of the operative field to enable better placement of the mesh and closure of the defect. Minimal invasive procedures also do not disturb the earlier repair, which is often a significant issue in open procedures. Nonetheless, several studies have shown that the success of such minimally invasive approaches is task dependent that is it dependents greatly on the surgeon. Existing literature points out the fact that recidivism rates can rise during the learning curve of a new surgical approach such as laparoscopy. For this reason, training and certification factors should be given full attention to achieve standardized outcomes.

There was a significantly lower level of postoperative pain in patients undergoing minimally invasive operations than in open surgery. As a similar note, the literature has assigned this difference to smaller incisions and reduced tissue insults in laparoscopic and robotic processes (Peters et al., 2020). The use of virtual reality also leads to reduced pain after surgery which not only increases patient satisfaction, but also quickens the patient's ability to move around thereby decreasing chances of adverse effects such as development of deep vein thrombosis. Nonetheless, factors such as pain tolerance and sensitiveness and patient's history influences pain perception. Further research should incorporate patient-rated measures to give insights towards the painful experience.

Patients undergoing minimally invasive surgery had shorter hospital stays, averaging 2.5 days compared to 4.8 days for open surgery. Shorter hospital stays are associated with reduced healthcare costs and lower risks of hospital-acquired infections (Jorgensen et al., 2016). These findings reinforce the role of minimally invasive techniques in enhancing recovery and reducing the overall burden on healthcare systems. However, it is worth noting that certain patient populations,

such as those with extensive comorbidities or limited access to advanced surgical facilities, may not experience the same benefits. For these patients, open surgery may still be the preferred approach.

The complication rate was significantly lower for minimally invasive techniques (4.2%) compared to open surgery (8.9%). This finding is supported by prior studies that report lower rates of wound infections, seromas, and hematomas with laparoscopic and robotic procedures (Hernandez-Richter et al., 2019). Minimally invasive approaches reduce the exposure of internal tissues to external contaminants, which likely contributes to the lower complication rates. However, minimally invasive techniques are not without risks. For instance, laparoscopic surgery carries a small but significant risk of visceral or vascular injury, especially in patients with complex anatomy (Weber et al., 2020). These risks underscore the importance of preoperative planning and intraoperative vigilance.

Patient satisfaction was markedly higher with minimally invasive techniques, with 89.4% of patients reporting positive outcomes compared to 76.3% for open surgery. High satisfaction rates are likely driven by reduced pain, faster recovery, and better cosmetic outcomes associated with minimally invasive approaches (Peters et al., 2020). Additionally, advancements in robotic-assisted surgery have further enhanced patient satisfaction by improving surgical precision and reducing the likelihood of complications (Bittner et al., 2021). However, the higher costs associated with robotic systems may limit their accessibility, particularly in resource-constrained settings. Cost-effectiveness analyses are needed to evaluate the long-term benefits of robotic surgery in comparison to other techniques.

The findings of this meta-analysis have significant implications for clinical practice. Minimally invasive techniques should be considered the preferred approach for most patients with recurrent inguinal hernias, given their superior outcomes across multiple parameters. However, patient selection is critical. Factors such as patient age, comorbidities, and the extent of previous repairs must be carefully evaluated to determine the most appropriate surgical technique. Furthermore, the availability of trained surgeons and advanced equipment can influence the feasibility of minimally invasive approaches, particularly in rural or underserved areas.

This study has several limitations. First, the quality of included studies varied, and some were subject to potential biases, such as selective reporting and small sample sizes. Second, the analysis primarily included studies from high-resource settings, limiting the generalizability of findings to low-resource environments. Third, the study did not account for long-term outcomes, such as chronic pain and mesh-related complications, which are critical for assessing the overall success of hernia repair.

Future research should focus on addressing these gaps. Large-scale, multicenter trials are needed to validate the findings in diverse patient populations. Additionally, studies comparing the cost-effectiveness of laparoscopic, robotic, and open techniques will provide valuable insights for healthcare policymakers. Finally, advancements in surgical technologies, such as augmented reality and artificial intelligence, should be explored for their potential to further enhance outcomes in recurrent hernia repair.

CONCLUSION

The present meta-analysis gives a side by side analysis of minimally invasive approaches and open surgeries in the treatment of recurrent inguinal hernias. The evidence presented proves that with the minimal access surgery, employing the laparoscopic and robotic technique leads to enhanced results and improvements compared to an open surgery in terms of low recurrence rate, minimal postoperative pain, short hospital stay, few complications and high patient satisfaction. These advantages demonstrate that recurrence is best treated with a minimally invasive approach, which is now considered a standard of care for hernia operations.

The reduced reccurence rates that have been noted with minimally invasive procedures are probably because of better visualization and better placement of the mesh through the scar tissue. Also the reduced tissue trauma because of small incisions leads to quick recovery time and minimized postoperative complications that must be seen as ways to enhance patient care and their quality of life. The shorter length of stay is not only

in the interest of patient, but also to offload overall health care burden by saving costs and personnel.

Despite these advantages, minimally invasive techniques are not without challenges. The steep learning curve, higher costs, and limited availability of robotic systems can restrict access, particularly in resource-constrained settings. Furthermore, certain patient populations, such as those with complex anatomy or extensive scar tissue, may still benefit from open surgery. These considerations underscore the importance of individualized treatment planning, where patient-specific factors and surgeon expertise play a pivotal role in determining the optimal surgical approach.

While the findings of this meta-analysis provide valuable insights, future research is necessary to address gaps in the current literature. Long-term outcomes, such as chronic pain and mesh-related complications, should be evaluated to provide a more comprehensive understanding of the efficacy of each technique. Additionally, cost-effectiveness analyses are needed to guide healthcare policies and resource allocation.

In conclusion, minimally invasive techniques represent a significant advancement in the management of recurrent inguinal hernias, offering superior outcomes across multiple domains. However, the choice of surgical approach must be tailored to the individual patient, taking into account clinical factors, surgeon expertise, and healthcare resources. Continued research and technological innovations hold promise for further improving outcomes in this challenging patient population.

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