

Original Research Article

Received : 18/05/2026
Received in revised form : 09/06/2026
Accepted : 25/07/2026

Keywords:

Inguinal hernia; Lichtenstein repair; Laparoscopic hernia repair; TAPP; TEP; Mesh repair; Postoperative complications; Chronic groin pain.

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DOI: 10.47009/jamp.2026.8.4.94

Source of Support: Nil,

Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (4); 541-547



INNOVATIONS IN INGUINAL HERNIA REPAIR: CURRENT CONCEPTS AND FUTURE DIRECTIONS

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ABSTRACT

Background: There is no general surgical procedure more widely done around the world than inguinal hernia repair. While the open Lichtenstein mesh technique is still the norm at a good number of centers, laparoscopic methods such as transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) are being embraced with greater frequency on account of what they can offer in terms of postoperative recovery. The present study was undertaken to put the clinical results of an open repair up against those of the laparoscopic approach. **Materials and Methods:** We carried out a prospective observational study across multiple centres over the course of a year, from July 2025 through June 2026. The cohort consisted of 475 adults scheduled for an elective inguinal hernia repair. Depending on institutional practice, the surgeon's expertise and the make up of the patient, they were assigned to have either an open Lichtenstein mesh procedure (312 in number) or a laparoscopic approach such as TAPP/TEP (163). The study looked at a range of outcomes including how long the operation took, any complications after surgery, length of hospitalisation, time to resume normal activities and whether there was recurrence or chronic groin pain at the three month mark. **Result:** Males made up the bulk of the patient population at 95.4%, and the 41 to 50 year bracket saw the most cases (26.3%). Inguinal hernias were predominantly indirect (63.4%) and on the right side (62.7%). While a laparoscopic approach took more time in the operating room than an open one (71.5 ± 13.6 as against 56.8 ± 11.7 minutes; $p < 0.001$), it had distinct advantages in the postoperative period. Patients undergoing the laparoscopic procedure had fewer early complications ($p = 0.016$) and were discharged sooner, with hospital stays averaging 1.65 ± 0.74 days compared to 2.84 ± 0.91 for open repair ($p < 0.001$). They also got back to their regular routines in less time (10.2 ± 2.7 versus 17.5 ± 4.1 days; $p < 0.001$) and reported less chronic groin pain after three months (1.2% vs. 4.5%; $p = 0.040$). As for recurrence, the rates were low and on par for both groups (0.6% vs. 1.3%; $p = 0.471$). **Conclusion:** In terms of safety and efficacy, there is little to choose between an open Lichtenstein and a laparoscopic inguinal hernia repair; short-term recurrence figures are on a par for both. The laparoscopic method does demand more time in the operating room, but it more than makes up for it with a better postoperative course. Patients see fewer complications and less chronic groin pain, they spend less time in the hospital and are back to their usual routines sooner. For that reason, when the necessary expertise and resources are at hand, the laparoscopic option is often the one of choice for an elective procedure.

INTRODUCTION

General surgery would be hard to practice without encountering inguinal hernia; it is among the most

common conditions and a significant source of healthcare expenditure around the world. With an ageing and growing population, especially in the male demographic, the numbers of groin hernias are

on the rise.^[1] While the repair of an inguinal hernia is for the most part a safe and effective undertaking, the sheer volume of operations ensures that even infrequent complications have a wide reach. Adverse events like infection, recurrence, a diminished quality of life or chronic postoperative pain will impact many patients globally.^[1,2] For this reason, modern hernia surgery has come to demand more than just closing the defect: it must also offer durable reinforcement, spare abdominal-wall function and preclude chronic pain while allowing for a swift recovery.

Techniques have evolved over time from the tissue-based methods of old to tension-free mesh and then to posterior approaches that are minimally invasive. The open Lichtenstein is still a go-to for its reliability and accessibility in places where laparoscopic know-how or equipment is not on hand. Yet laparo-endoscopic options such as totally extraperitoneal or transabdominal preperitoneal repair are now well established. In the hands of a seasoned surgeon they can mean fewer wound issues, less chance of long-term groin pain and a quicker convalescence for the patient, all with recurrence rates in line with open mesh work.^[2,3] International guidelines reflect this, advising that the choice of procedure be dictated by the hernia itself, the patient and what resources the institution has to offer, rather than a one-size-fits-all approach.^[3]

Clinical practice has been reshaped by advances in prosthetics and how they are fixed. Today's meshes come in different weights, compositions and pore sizes to foster better tissue integration and minimise the feeling of a foreign body or fibrosis. One finds lightweight synthetic meshes being used more often in the right candidates, though no product is universally superior in every case.^[3] To mitigate nerve damage and the pain that can come with fixation, there is a move towards less traumatic methods, be it self-gripping mesh, tissue adhesives or foregoing fixation altogether. Some systematic reviews point to glue fixation in a laparoscopic setting as a way to curtail early haematoma and pain vis-à-vis tacks, without raising the risk of recurrence, but the evidence is not always of a consistent calibre.^[4,5]

There is a push towards data-driven, personalised care. Pathways are being adjusted to include enhanced-recovery and multimodal analgesia protocols. Even artificial intelligence is under scrutiny for its potential to identify operative phases, flag complications or discern inguinal anatomy.^[6-9] Promising as the initial results are, these tools are largely in development and need to be put to the test with robust datasets before they see everyday use, not to mention the ethical questions of bias and privacy that have to be settled.^[8,9]

Ultimately, the way forward for inguinal hernia repair is not simply about new gadgets or materials. It requires a synthesis of refined minimally invasive skills, better biomaterials and decisions based on precision and objective measures of competence. Only through good comparative trials and registries

can we tell if the latest technology is truly adding value in terms of cost, pain and quality of life. This review looks at what is being done in open and laparoscopic c inguinal hernia repair today and considers the innovations that may lead to safer, more individualized surgical care.

MATERIALS AND METHODS

Carried out at the Department of General Surgery in two Uttar Pradesh institutions, namely Rama Medical College Hospital & Research Centre in Hapur and the Sardar Patel Institute of Medical Sciences and Research Centre in Lucknow, this is a prospective observational study with a multicentre design. Over the course of a year, between July 2025 and June 2026, we enrolled 475 patients in consecutive order once written informed consent was secured. All had been diagnosed with an inguinal hernia and were set for elective surgical repair.

The criteria for inclusion were adult patients, 18 or older, with a primary unilateral or bilateral inguinal hernia. We made no exceptions for those with complicated cases such as obstructed, strangulated or gangrenous hernias that would necessitate emergency surgery, nor for recurrent hernias demanding urgent intervention. Patients deemed medically unfit or not wishing to take part in the study were also left out.

As for the operative approach, whether it be an open Lichtenstein mesh repair, laparoscopic TAPP or TEP, the decision rested on institutional practice, the surgeon's expertise and the individual patient's profile. A standard proforma was used to put on record intraoperative data like the type of hernia, how long the operation took, the mesh and fixation used, and any complications that arose.

In the postoperative phase we looked at pain levels, early morbidity and wound issues including seroma, hematoma or surgical site infection, as well as urinary retention and length of hospitalisation. We also noted how quickly a patient was able to resume normal daily life. Follow up was conducted at one week, one month and three months.

RESULTS

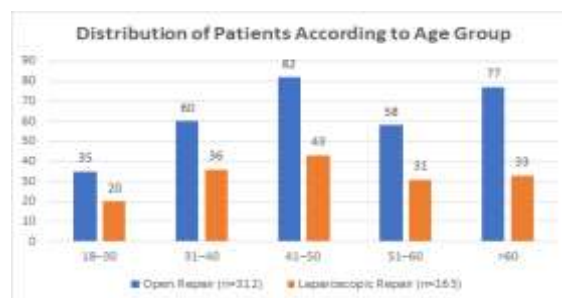


Figure 1: showing Distribution of Patients According to Age Group

Among the 475 patients included in the study, the highest proportion (26.3%) belonged to the 41–50-

year age group, followed by patients aged more than 60 years (23.2%). The least represented group was 18–30 years (11.6%). These findings indicate that

inguinal hernia was more commonly observed in middle-aged and elderly individuals.

Table 1: Distribution of Patients According to Age Group (n = 475)

Age Group (Years)	Open Repair (n=312)	Laparoscopic Repair (n=163)	Total (n=475)	Percentage (%)
18–30	35	20	55	11.6
31–40	60	36	96	20.2
41–50	82	43	125	26.3
51–60	58	31	89	18.7
>60	77	33	110	23.2
Total	312	163	475	100

Table 2: Gender Distribution

Gender	Open Repair	Laparoscopic Repair	Total	Percentage (%)
Male	298	155	453	95.4
Female	14	8	22	4.6
Total	312	163	475	100



Figure 2: showing Gender Distribution

The majority of study participants were males (95.4%), whereas females accounted for only 4.6% of the total study population. This demonstrates the marked male predominance of inguinal hernia, which is consistent with its known epidemiological distribution.

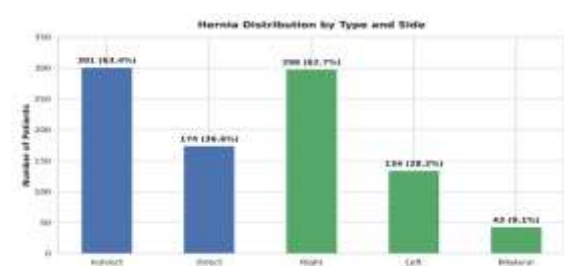


Figure 3: showing Distribution According to Hernia Characteristics

Indirect inguinal hernia was the most common type, accounting for 63.4% of all cases, while direct inguinal hernia constituted 36.6%. With regard to the side of involvement, right-sided hernias were the most frequent (62.7%), followed by left-sided hernias (28.2%), whereas bilateral hernias were observed in only 9.1% of patients.

Table 3: Distribution According to Hernia Characteristics

Variable	Number	Percentage (%)
Type of Hernia		
Indirect	301	63.4
Direct	174	36.6
Side of Hernia		
Right	298	62.7
Left	134	28.2
Bilateral	43	9.1

Table 4: Distribution According to Surgical Technique

Surgical Technique	Number	Percentage (%)
Open Lichtenstein Repair	312	65.7
Laparoscopic Repair (TAPP + TEP)	163	34.3
Total	475	100

Table 5: Comparison of Operative Duration

Operative Duration (minutes)	Open Repair (Mean ± SD)	Laparoscopic Repair (Mean ± SD)	t value	p value
Duration	56.8 ± 11.7	71.5 ± 13.6	-11.62	<0.001

Table 6: Comparison of Early Postoperative Complications

Complication	Open Repair n (%)	Laparoscopic Repair n (%)	Chi-square	p value
Seroma	13 (4.2)	3 (1.8)	5.84	0.016
Surgical Site Infection	9 (2.9)	1 (0.6)		
Hematoma	5 (1.6)	2 (1.2)		
Urinary Retention	5 (1.6)	1 (0.6)		
No Complication	280 (89.7)	156 (95.7)		

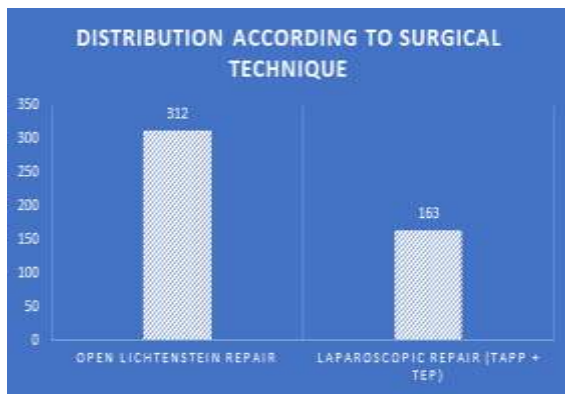


Figure 4: showing Distribution According to Surgical Technique

Open Lichtenstein mesh repair was performed in 65.7% of patients, whereas laparoscopic repair (TAPP and TEP combined) was performed in 34.3% of patients. This indicates that open repair remained the preferred surgical approach during the study period, although laparoscopic techniques were increasingly adopted.

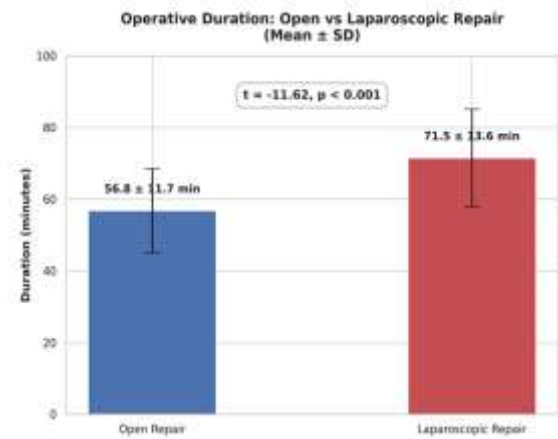


Figure 5: showing Comparison of Operative Duration

The mean operative duration was significantly higher in the laparoscopic repair group (71.5 ± 13.6 minutes) compared with the open repair group (56.8 ± 11.7 minutes). The difference was statistically highly significant ($p < 0.001$), suggesting that laparoscopic repair required more operative time than open repair.

Table 7: Comparison of Hospital Stay and Return to Normal Activities

Variable	Open Repair (Mean ± SD)	Laparoscopic Repair (Mean ± SD)	t value	p value
Hospital Stay (days)	2.84 ± 0.91	1.65 ± 0.74	13.45	<0.001
Return to Normal Activities (days)	17.5 ± 4.1	10.2 ± 2.7	21.84	<0.001

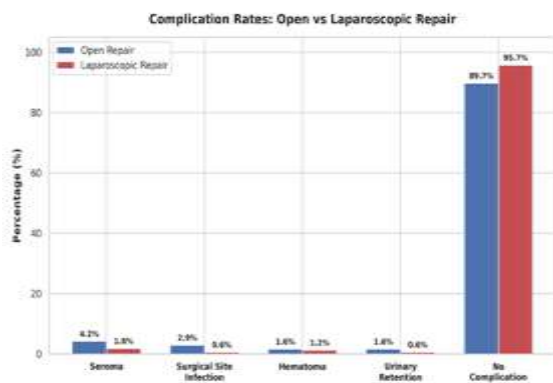


Figure 6: showing the Comparison of Early Postoperative Complications

Early postoperative complications were observed less frequently in the laparoscopic group than in the open repair group. Seroma was the most common postoperative complication in both groups, followed by surgical site infection, hematoma, and urinary retention. Overall complication rates differed significantly between the two groups ($p = 0.016$), indicating a lower incidence of postoperative morbidity following laparoscopic repair.

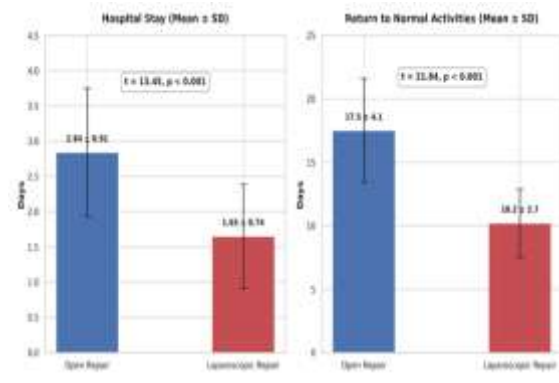


Figure 7: showing Comparison of Hospital Stay and Return to Normal Activities

Patients undergoing laparoscopic repair had a significantly shorter duration of hospital stay (1.65 ± 0.74 days) compared with those undergoing open repair (2.84 ± 0.91 days). Similarly, the mean time required to return to normal daily activities was significantly lower in the laparoscopic group (10.2 ± 2.7 days) than in the open repair group (17.5 ± 4.1 days). Both differences were statistically highly significant ($p < 0.001$), indicating that laparoscopic repair facilitated faster postoperative recovery.

Table 8: Follow-up Outcomes at 3 Months

Outcome	Open Repair n (%)	Laparoscopic Repair n (%)	Chi-square	p value
Chronic Groin Pain	14 (4.5)	2 (1.2)	4.23	0.040
Recurrence	4 (1.3)	1 (0.6)	0.52	0.471

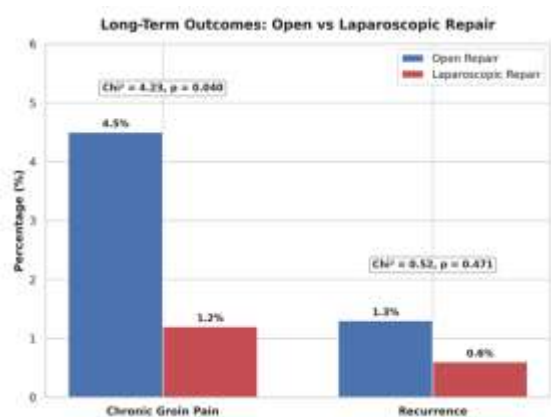


Figure 8: showing Follow-up Outcomes at 3 Months

At the three-month follow-up, chronic postoperative groin pain was significantly less common in patients who underwent laparoscopic repair (1.2%) compared with those who underwent open repair (4.5%) ($p = 0.040$). Although hernia recurrence was numerically lower in the laparoscopic group (0.6%) than in the open repair group (1.3%), the difference was not statistically significant ($p = 0.471$). These findings suggest that laparoscopic repair offers better postoperative comfort while maintaining recurrence rates comparable to open repair.

DISCUSSION

The present study evaluated 475 patients undergoing inguinal hernia repair, of whom 312 (65.7%) underwent open Lichtenstein mesh repair and 163 (34.3%) underwent laparoscopic repair (TAPP/TEP). The study compared demographic characteristics, operative outcomes, postoperative complications, recovery, and short-term follow-up outcomes between the two techniques.

Age Distribution: In the current study, the 41–50 year bracket was the most common age group for patients at 26.3 per cent, with those over 60 coming in a close second (23.2%). By contrast, just 11.6% of the cohort were between 18 and 30 years old. Such data would suggest that inguinal hernia is an ailment of the middle-aged and elderly for the most part.

This is in line with what Burcharth et al. have put forward; they found the incidence to be at its peak from 40 to 60, rising in older populations as abdominal muscle and connective tissue give way.^[1] One can draw similar comparisons with the work of Primates and Goldacre, who noted that some 70% of admissions for inguinal hernia were in patients past the age of 40.^[2] The EHS guidelines are also consistent with this pattern, pointing to a steady climb in direct inguinal hernia cases with age as the transversalis fascia weakens.^[3]

We see a like scenario in the results of Kingsnorth and LeBlanc, whose subjects for hernia repair had a mean age in the region of 50.^[4] That we should see so many middle-aged patients here is perhaps not surprising given the toll of occupational demands,

chronic cough or constipation, smoking and the intra-abdominal pressure that comes with them, all of which contribute to the degeneration of tissue over time.

Gender Distribution: In the present study, males constituted 95.4% (453/475) of the study population, whereas females represented only 4.6% (22/475), giving a male-to-female ratio of approximately 20.6:1.

These findings are consistent with the epidemiological literature. Jenkins and O'Dwyer reported that approximately 90–95% of inguinal hernia patients are males owing to anatomical differences and persistence of the processus vaginalis. Likewise, Burcharth et al. found that men have nearly a 27% lifetime risk of developing inguinal hernia compared with only 3% in women.^[1] Similar male predominance (92–97%) has been reported in studies by Neumayer et al. (95%) and Grant (94%).^[6,7]

The present findings therefore support the well-established observation that inguinal hernia remains predominantly a disease of males.

Hernia Characteristics: The present study demonstrated that indirect inguinal hernia accounted for 63.4% (301 patients), whereas direct hernia represented 36.6% (174 patients). Right-sided hernias were observed in 62.7%, left-sided in 28.2%, and bilateral hernias in 9.1%.

These findings agree with Skandalakis et al., who reported indirect hernias in approximately 60–70% of adult patients and direct hernias in 30–40%.^[8] Similarly, Rutkow observed indirect hernias in nearly 65% of surgically treated cases.^[9]

The predominance of right-sided hernias observed in the present study is also consistent with previous reports. Kingsnorth and LeBlanc reported right-sided involvement in approximately 55–60%, left-sided in 25–30%, and bilateral hernias in 10–15% of patients. Delayed descent of the right testis and later closure of the processus vaginalis have been proposed as explanations for the higher incidence of right-sided hernias.^[10]

Surgical Technique: Open Lichtenstein mesh repair was performed in 65.7% of patients, whereas laparoscopic repair accounted for 34.3%.

Comparable findings have been reported from several developing countries where open mesh repair continues to be the preferred technique because of lower costs, easier availability, and surgeon familiarity.^[11] In contrast, large Western registries report progressively increasing adoption of laparoscopic repair, particularly for bilateral and recurrent hernias.^[12]

The relatively higher proportion of open repair in the present study probably reflects institutional surgical practices and resource availability.

Operative Duration: The mean operative duration was significantly longer in the laparoscopic group (71.5 ± 13.6 minutes) than in the open repair group (56.8 ± 11.7 minutes) ($p < 0.001$).

These findings are highly consistent with the randomized trial by Neumayer et al., who reported operative times of 65 minutes for laparoscopic repair compared with 54 minutes for open Lichtenstein repair.⁶ Similarly, the Cochrane Review by McCormack et al. demonstrated that laparoscopic repair generally requires 10–20 minutes longer operative time than open mesh repair because of trocar placement, creation of the preperitoneal space, and mesh fixation.^[13]

Eklund et al. also reported mean operative durations of 70 minutes for laparoscopic TEP compared with 56 minutes for open repair,^[14] closely matching the present findings.

The longer operative time in laparoscopic surgery is likely related to greater technical complexity and the associated learning curve.

Early Postoperative Complications: Overall postoperative complications were significantly lower following laparoscopic repair ($p = 0.016$). Seroma occurred in 4.2% of open repairs compared with 1.8% of laparoscopic repairs. Surgical site infection occurred in 2.9% versus 0.6%, hematoma in 1.6% versus 1.2%, and urinary retention in 1.6% versus 0.6%, respectively.

These findings correspond well with the meta-analysis by McCormack et al., which demonstrated significantly fewer wound infections after laparoscopic repair while maintaining similar rates of hematoma and seroma.^[13] Likewise, EU Hernia Trialists Collaboration reported wound infection rates of approximately 3–4% following open repair compared with less than 1% after laparoscopic surgery.^[15]

The lower incidence of wound complications after laparoscopic repair may be attributed to smaller incisions, minimal tissue handling, and reduced exposure of prosthetic mesh to the external environment.

Hospital Stay: The mean hospital stay was significantly shorter following laparoscopic repair (1.65 ± 0.74 days) compared with open repair (2.84 ± 0.91 days) ($p < 0.001$).

These findings are consistent with Neumayer et al., who observed average hospital stays of approximately 1.5 days after laparoscopic repair and 2.6 days after open repair.⁶ Similarly, Eklund et al. reported hospital stays of 1.2 days following laparoscopic repair compared with 2.4 days after open surgery.^[14]

The reduced hospital stay following laparoscopic repair likely reflects reduced postoperative pain, earlier mobilization, and faster recovery.

Return to Normal Activities: Patients undergoing laparoscopic repair resumed normal activities significantly earlier (10.2 ± 2.7 days) than those undergoing open repair (17.5 ± 4.1 days) ($p < 0.001$). These findings closely resemble those reported by Grant, who found return to work after 10–14 days following laparoscopic repair compared with 18–21 days after open repair.^[7] Similarly, the Cochrane Review reported that laparoscopic repair enables

patients to resume normal activities approximately 7 days earlier than open mesh repair.^[13]

The earlier recovery observed in the present study is probably related to reduced postoperative pain, minimal soft tissue trauma, and faster restoration of physical function.

Chronic Groin Pain: At three months, chronic groin pain occurred in 4.5% of patients undergoing open repair compared with 1.2% after laparoscopic repair ($p = 0.040$).

These findings are consistent with the study by Eklund et al., which demonstrated chronic pain rates of 5–6% after open repair versus 1–2% after laparoscopic repair.^[14] Similarly, Neumayer et al. observed significantly lower chronic postoperative pain after laparoscopic repair during long-term follow-up.^[6]

The lower incidence of chronic pain following laparoscopic repair is likely due to reduced manipulation of the inguinal nerves and less tissue dissection.

Hernia Recurrence: Recurrence was observed in 1.3% of patients undergoing open repair and 0.6% following laparoscopic repair. Although recurrence was numerically lower in the laparoscopic group, the difference was not statistically significant ($p = 0.471$).

These findings agree with the HerniaSurge International Guidelines, which conclude that recurrence rates following laparoscopic and open mesh repair are generally comparable when procedures are performed by experienced surgeons.¹⁶ Similarly, Neumayer et al. and McCormack et al. reported recurrence rates between 1% and 3% for both techniques without statistically significant differences during short-term follow-up.^[6,13]

The low recurrence rates observed in the present study suggest that both surgical techniques provide durable repair when mesh reinforcement is appropriately performed.

Overall Interpretation: The findings of the present study demonstrate that although laparoscopic inguinal hernia repair required a significantly longer operative duration (71.5 vs 56.8 minutes; $p < 0.001$), it was associated with superior postoperative outcomes, including significantly lower complication rates (95.7% vs 89.7% without complications; $p = 0.016$), shorter hospital stay (1.65 vs 2.84 days; $p < 0.001$), earlier return to normal activities (10.2 vs 17.5 days; $p < 0.001$), and lower chronic groin pain (1.2% vs 4.5%; $p = 0.040$), while maintaining recurrence rates comparable to open Lichtenstein repair (0.6% vs 1.3%; $p = 0.471$). These findings are consistent with contemporary randomized controlled trials, systematic reviews, and international guidelines supporting laparoscopic repair as an effective minimally invasive alternative that offers faster postoperative recovery without compromising surgical success.

CONCLUSION

This prospective study compared the outcomes of open Lichtenstein repair and laparoscopic (TAPP/TEP) repair in 475 patients with inguinal hernia. Inguinal hernia was most commonly observed in middle-aged males, with indirect (63.4%) and right-sided hernias (62.7%) being the predominant presentations. Open repair remained the more commonly performed procedure (65.7%).

Although laparoscopic repair required a significantly longer operative time (71.5 ± 13.6 vs. 56.8 ± 11.7 minutes; $p < 0.001$), it resulted in fewer postoperative complications, shorter hospital stay, earlier return to normal activities, and lower incidence of chronic groin pain compared with open repair. Hernia recurrence rates were low and comparable between both techniques.

Overall, both techniques are safe and effective for inguinal hernia repair. However, laparoscopic repair offers superior postoperative recovery and patient comfort while maintaining comparable recurrence rates, making it the preferred option where adequate surgical expertise and facilities are available.

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