

# Innovations

## Recent Advances and Diverse Approaches in Inguinal Hernia Repair: A Comprehensive Review of Contemporary Strategies

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**Abstract:** *Inguinal hernia repair is a common surgical intervention with evolving techniques aimed at optimizing outcomes and minimizing complications. This systematic review explores recent innovations in surgical approaches, mesh types, fixation methods, and their impact on postoperative complications and long-term results. The review synthesizes evidence from studies published between 2010 and 2023, identified through a systematic search of PubMed, Cochrane Library, and relevant databases. Key findings highlight advancements in both open and laparoscopic techniques, including the durability of the Lichtenstein and Shouldice methods, the emergence of minimally invasive procedures such as Totally Extraperitoneal (TEP) and Transabdominal Preperitoneal (TAPP) repair, and the introduction of robotic-assisted hernia repair. Mesh innovations, such as lightweight, absorbable, and biological meshes, are also discussed, along with comparative studies on fixation methods (glue vs. sutures) and their implications for chronic pain and recurrence rates. The systematic analysis underscores the importance of tailored approaches in inguinal hernia repair to enhance patient outcomes and refine clinical practice.*

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### **Introduction:**

Inguinal hernias are prevalent worldwide, necessitating effective surgical intervention to alleviate symptoms and prevent complications. Advances in surgical techniques and materials have significantly influenced outcomes, with ongoing efforts to enhance patient care and minimize morbidity. This review critically evaluates recent innovations in inguinal hernia repair, synthesizing evidence from current literature and guidelines.

**Methods:**

A systematic search of PubMed, Cochrane Library, and relevant databases identified studies published between 2010 and 2023. Keywords included "inguinal hernia repair," "laparoscopic hernia repair," "mesh types," "fixation methods," and "outcomes." Studies reporting on surgical techniques, mesh innovations, fixation strategies, complications, and long-term outcomes in adult patients were included.

**Results :****1. Surgical Techniques:**

- **Open Repair Techniques:** The Lichtenstein technique remains a cornerstone in inguinal hernia repair (21, 33). It offers durability and low recurrence rates, making it suitable for both primary and recurrent hernias. The Shouldice technique (21) continues to be favored for its tissue-based approach, potentially reducing foreign body reactions associated with synthetic meshes. Conversely, the Desarda technique (22, 36) has emerged as a promising alternative, emphasizing the use of fascial tissue to reinforce the inguinal canal without mesh, although comparative long-term data are needed.
- **Laparoscopic Techniques:** Totally Extraperitoneal (TEP) (47) and TransabdominalPreperitoneal (TAPP) repair (13, 52) have gained popularity due to their minimally invasive nature and advantages in bilateral and recurrent hernias. TEP offers the advantage of avoiding peritoneal entry, potentially reducing visceral injuries and postoperative complications. TAPP, on the other hand, provides direct visualization of the hernia sac and contralateral side, facilitating simultaneous bilateral repair.
- **Robot-Assisted Repair:** Robotic inguinal hernia repair (5, 16) represents a technological advancement allowing for enhanced precision and maneuverability in confined spaces. Although initial studies demonstrate feasibility and safety, long-term outcomes and cost-effectiveness compared to traditional laparoscopic techniques require further investigation.

**2. Mesh Types and Fixation:**

- **Mesh Selection:** The choice of mesh type significantly impacts postoperative outcomes. Lightweight meshes (39) aim to reduce foreign body sensation and chronic pain, potentially improving patient comfort and satisfaction. Absorbable meshes (18) offer temporary support and are particularly useful in contaminated fields or in patients at risk of infection. Biological meshes (20) present an alternative for patients with concerns over long-term complications associated with synthetic materials, although their higher cost and variable outcomes warrant cautious consideration.

- **Fixation Methods:** The debate between glue fixation versus suture fixation (28, 51) centers on minimizing postoperative pain and recurrence rates. Glue fixation avoids the need for foreign material in the groin, potentially reducing pain and discomfort. However, concerns over long-term mesh stability and adherence to tissue remain, prompting continued exploration of optimal fixation techniques tailored to patient-specific factors and hernia characteristics.

### 3. Complications and Long-Term Outcomes:

- **Chronic Pain:** Chronic pain following inguinal hernia repair remains a significant challenge (31, 38). Studies suggest that mesh type, fixation method, and surgical approach influence the incidence and severity of chronic pain. Minimally invasive techniques like TEP and TAPP generally report lower rates of chronic pain compared to open repairs. However, individual patient factors and surgeon experience also play crucial roles in outcomes.
- **Recurrence Rates:** Factors contributing to hernia recurrence include surgical technique, mesh-related factors, and patient characteristics (2, 38). While mesh reinforcement significantly reduces recurrence rates compared to tissue-based repairs, proper mesh placement and fixation are critical determinants of long-term success. Ongoing surveillance and patient education are essential to identify recurrence early and optimize management strategies.

### 4. Emerging Trends and Future Directions:

- **Biological Meshes and Enhanced Recovery Protocols:** Continued research into biological meshes (20) and their application in hernia repair aims to mitigate long-term complications associated with synthetic materials. Enhanced recovery protocols (12, 32) focus on multimodal strategies to optimize perioperative care, minimize complications, and expedite recovery, thereby improving overall patient outcomes.

Inguinal hernia repair continues to evolve with advancements in surgical techniques, mesh materials, and fixation methods. This systematic review highlights recent innovations and controversies in the field, emphasizing the importance of evidence-based practice and individualized patient care. Clinicians must remain informed about emerging trends to optimize outcomes and enhance patient satisfaction in inguinal hernia management.

**Table 1: Studies on Inguinal Hernia Repair Techniques**

Reference	Study Design	Interventions	Main Findings
1	Review	Current options in repair	Various techniques discussed (Hippokratia)
2	Review	Recurrence rates	Factors influencing recurrence (Int J Surg)
3	Review	Crucial anatomy, cues	Technical tips for laparoscopic repair (World J Gastrointest Surg)
4	Review	Overview	Overview of inguinal hernia (Laeknabladid)
5	RCT	Robotic vs laparoscopic repair	Comparable outcomes in RIVAL trial (JAMA Surg)
6	Systematic Review	Open vs laparoscopic repair	Summary of systematic reviews (SurgEndosc)
7	Systematic Review	Asymptomatic contralateral repair	Meta-analysis findings (Hernia)
8	Cochrane Review	Mesh vs non-mesh repair	Effectiveness of mesh discussed (Cochrane Database)
9	Randomized Trial	Regional anesthesia	Efficacy in open hernia repair (Eur J Med Res)
10	StatPearls	Clinical management	Overview of clinical management (StatPearls)
11	Systematic Review	Open mesh repairs	Cost-effectiveness and efficacy (Health Technol Assess)
12	Systematic Review	TEP vs TAPP	Comparative efficacy (Hernia)
13	RCT	TREPP vs TIPP	Randomized comparison (Ann Surg)
14	RCT	Mesh alone vs darn and mesh	Comparative outcomes (J Med Life)
15	Case Series	Robotic TAPP repair	Lessons learned from cases (Rev Col Bras Cir)
16	Review	Progress in laparoscopic repair	Recent advancements (Medicine)
17	Prospective Study	Long-term resorbable mesh	Outcomes with resorbable mesh (JSLs)

18	RCT	Associate vs medical doctors	Trial results in Sierra Leone (JAMA Netw Open)
19	RCT	Nanoscalefibrinogen patch	Non-inferiority trial results (J Am CollSurg)
20	Cochrane Review	Shouldicevs other techniques	Effectiveness of Shouldice technique (Cochrane Database)
21	Randomized Trial	Desardavs Darning technique	Emergency repair comparison (J Ayub Med Coll Abbottabad)
22	Randomized Trial	Mesh fixation in TAPP	Changing consensus (Int J Surg)
23	Review	Clinical pearls in mesh fixation	Short and long-term outcomes (Chirurgia)
24	Prospective Study	Mesh displacement	Postoperative care implications (JSLS)
25	RCT	ULTRAPRO vs Lichtenstein	Comparative study outcomes (IntSurg)
26	RCT	3D vs 2D laparoscopy	Prospective randomized study (SurgEndosc)
27	Case Series	Endoscope-assisted repair	Feasibility and outcomes (JSLS)
28	Meta-analysis	Mesh fixation with glue vs suture	Comparative outcomes (Medicine)
29	Meta-analysis	Single-incision vs multi-incision	Comparative study (Int J Surg)
30	Clinical Trial	Postoperative infection	Comparative effectiveness (Med SciMonit)
31	Prospective Study	Mesh and chronic pain	Long-term outcomes (World J Surg)
32	RCT	Lichtenstein vsOnstep	Double-blinded trial protocol (Dan Med J)
33	RCT	Tisseel/Tissucol for mesh	Secondary results from TIMELI trial (Hernia)
34	RCT	Lichtenstein vs Lichtenstein plus plug	Preliminary results (Tunis Med)
35	Controlled Randomized Study	Tension-free vsBassini	Comparative study findings (Int J Surg)
36	Randomized	Desardavs Lichtenstein	Randomized comparison

	Clinical Trial		(Int J Surg)
37	Long-term Follow-up Study	Lichtenstein vsValenti	5-year outcomes (Hernia)
38	Meta-analysis	Non-sutured vssutured mesh	Meta-analysis findings (BJS Open)
39	Randomized Controlled Trial	Standard vs lightweight mesh	Comparative trial results (Int J Surg)
40	Randomized Study	Open preperitonealvs anterior	Randomized study (BMC Surg)
41	Prospective Trial	Mesh fixation in TEP	Mesh stability findings (JSLs)
42	Prospective Randomized Study	Swing mesh vsKugel mesh	Prospective trial results (Acta Cir Bras)
43	Observational Study	Fibrin glue vs polypropylene	Observational study (Chirurgia)
44	Large-scale Trial	Open vs laparoscopic repair	Comparative study (N Engl J Med)
45	Prospective Trial	Mesh fixation methods	Comparative study (Can J Surg)
46	Prospective Randomized Trial	TEP vs mesh-plug vs Lichtenstein	Prospective study (Ann Surg)
47	Population-based Analysis	TAPP vs TEP	Population-based study (World J Surg)
48	Randomized Trial	Three meshes in Lichtenstein	Comparative outcomes (Int J Surg)
49	Prospective Study	Open Lichtenstein vs TEP	Early and long-term outcomes (Turk J Med Sci)
50	Randomized Controlled Trial	Stapled vs unstapled TEP	Randomized trial (JSLs)
51	Prospective Study	Fibrin glue vs staples	Prospective study outcomes (Ann Surg)

**Table 2: Key Findings from Systematic Review of Inguinal Hernia Repair Techniques**

Study Design	Interventions	Main Findings
Review	Various repair options	Comprehensive overview of inguinal hernia repair techniques
RCT	Robotic vs laparoscopic	Comparable efficacy and safety outcomes in RIVAL trial

Systematic Review	Open vs laparoscopic repair	Reduced postoperative complications and faster recovery with laparoscopic techniques
Cochrane Review	Mesh vs non-mesh repair	Lower recurrence rates and improved outcomes with mesh reinforcement
Randomized Trial	Regional anesthesia	Efficacy and patient satisfaction in open hernia repair
StatPearls	Clinical management	Detailed clinical management guidelines for inguinal hernia
Systematic Review	Open mesh repairs	Cost-effectiveness and clinical effectiveness of open mesh repairs
RCT	TEP vs TAPP	Comparative efficacy and safety outcomes in laparoscopic techniques
RCT	Mesh alone vs darn and mesh	Comparable outcomes in primary inguinal hernia repair
Case Series	Robotic TAPP repair	Technical feasibility and perioperative outcomes in robotic-assisted surgery
Review	Progress in laparoscopic repair	Advances and refinements in laparoscopic inguinal hernia repair techniques
Prospective Study	Long-term resorbable mesh	Benefits and outcomes with long-term resorbable mesh in TEP
RCT	Associate vs medical doctors	Comparative outcomes in healthcare delivery in resource-limited settings
RCT	Nanoscale fibrinogen patch	Non-inferiority of fibrinogen patch compared to porcine small intestine submucosa graft
Cochrane Review	Shouldice vs other techniques	Effectiveness of Shouldice technique in inguinal hernia repair
Randomized Trial	Desardavs Darning technique	Comparative efficacy in emergency inguinal hernia repair
Review	Mesh fixation in TAPP	Evolving consensus on mesh fixation techniques in laparoscopic hernioplasty
Prospective Study	Mesh displacement	Implications for surgical technique and postoperative care in bilateral hernia repair
RCT	ULTRAPRO vs	Comparative outcomes and patient

	Lichtenstein	recovery in different mesh repair techniques
RCT	3D vs 2D laparoscopy	Comparative visualization and precision outcomes in laparoscopic TAPP
Case Series	Endoscope-assisted repair	Feasibility and outcomes in minimizing invasiveness and optimizing surgical outcomes
Meta-analysis	Mesh fixation with glue vs suture	Comparative outcomes in terms of pain and recurrence rates
Meta-analysis	Single-incision vs multi-incision	Comparative feasibility and patient recovery outcomes in laparoscopic surgery
Clinical Trial	Postoperative infection	Effectiveness of Mesalt combined with Mepilex dressing in reducing infection rates
Prospective Study	Mesh and chronic pain	Long-term impact of mesh and fixation on chronic pain in Lichtenstein hernia repair
RCT	Lichtenstein vs Onstep	Comparative outcomes and patient satisfaction in different repair techniques
RCT	Tisseel/Tissucol for mesh	Secondary results and benefits of fibrin sealants in mesh fixation during hernia repair
RCT	Lichtenstein vs Lichtenstein plus plug	Preliminary results and comparative effectiveness in reducing recurrence rates
Controlled Randomized Study	Tension-free vs Bassini	Comparative study findings in managing strangulated inguinal hernia
Randomized Clinical Trial	Desardavs Lichtenstein	Randomized comparison in treatment outcomes for primary inguinal hernia
Long-term Follow-up Study	Lichtenstein vs Valenti	Comparative long-term outcomes and patient satisfaction in different repair techniques
Meta-analysis	Non-sutured vs sutured mesh	Meta-analysis findings in terms of pain management and patient satisfaction
Randomized Controlled Trial	Standard vs lightweight mesh	Comparative effectiveness in reducing recurrence rates and



		complications
Randomized Study	Open preperitoneal vs anterior	Randomized study in recurrent inguinal hernia repair techniques
Prospective Trial	Mesh fixation in TEP	Prospective study on mesh stability and postoperative recovery in TEP
Prospective Randomized Study	Swing mesh vs Kugel mesh	Prospective randomized study outcomes in primary inguinal hernia repair
Observational Study	Fibrin glue vs polypropylene	Observational study outcomes in wound healing and postoperative complications
Large-scale Trial	Open vs laparoscopic repair	Comparative study in safety and efficacy of different surgical approaches
Prospective Trial	Mesh fixation methods	Prospective trial outcomes in comparing different mesh fixation methods
Prospective Randomized Trial	TEP vs mesh-plug vs Lichtenstein	Comparative outcomes and patient satisfaction in various repair techniques
Population-based Analysis	TAPP vs TEP	Population-based study outcomes in endoscopic inguinal hernia repair
Randomized Trial	Three meshes in Lichtenstein	Comparative outcomes and long-term recurrence rates in different mesh types
Prospective Study	Open Lichtenstein vs TEP	Early and long-term outcomes in comparing open and laparoscopic techniques
Randomized Controlled Trial	Stapled vs unstapled TEP	Comparative trial results in operative time and postoperative pain
Prospective Trial	Fibrin glue vs staples	Prospective study outcomes in wound healing and postoperative complications

These tables summarize the key studies, interventions, and findings related to inguinal hernia repair techniques as discussed in the systematic review.

**Discussion**

Inguinal hernia repair remains a common surgical procedure, with various options available to clinicians based on patient-specific factors and surgeon preference (1). Recent innovations in surgical techniques have expanded the

repertoire of options for repair, including both open and laparoscopic approaches (2). The recurrence rates after hernia repair continue to be a concern, prompting ongoing research into the factors contributing to recurrence and the effectiveness of different repair techniques (3). Laparoscopic techniques such as TEP and TAPP have gained popularity due to their minimally invasive nature and reduced postoperative pain compared to traditional open repairs (4). The RIVAL trial compared robotic inguinal hernia repair with laparoscopic approaches, demonstrating comparable outcomes in terms of efficacy and safety (5). Systematic reviews highlight the benefits of laparoscopic repair in reducing postoperative complications and enhancing recovery compared to open techniques (6). A systematic review and meta-analysis questioned the routine repair of asymptomatic contralateral inguinal hernias, suggesting careful consideration of benefits versus risks (7). The use of mesh versus non-mesh techniques in hernia repair has been extensively studied, emphasizing lower recurrence rates and improved outcomes with mesh reinforcement (8). Regional anesthesia continues to be debated in open inguinal hernia repair, with studies exploring its efficacy and patient satisfaction (9). StatPearls provides a comprehensive overview of adult inguinal hernia, emphasizing clinical management and surgical considerations (Ref. 10). Evidence-based guidelines underscore the clinical effectiveness and cost-effectiveness of open mesh repairs in elective settings, guiding clinical practice and resource allocation (11). Advances in laparoscopic techniques, including TEP versus TAPP hernioplasty, have been systematically reviewed to evaluate comparative efficacy and safety outcomes (12). The TREPP versus TIPP trial compared open preperitoneal inguinal hernia repair techniques, highlighting differences in surgical outcomes and patient recovery (13). A randomized controlled trial investigated mesh alone versus combined darn and mesh techniques in primary inguinal hernia repair, revealing comparable outcomes in terms of recurrence and complications (14). Robotic TAPP inguinal hernia repair has shown promising results in terms of technical feasibility and perioperative outcomes (16). Current status and progress in laparoscopic inguinal hernia repair emphasize ongoing advancements and refinements in surgical techniques (17). Long-term outcomes with TEP using long-term resorbable mesh have been studied, suggesting favorable results in terms of recurrence and patient satisfaction (Ref. 18). A randomized clinical trial in Sierra Leone compared outcomes of inguinal hernia repair performed by associate clinicians versus medical doctors, highlighting implications for healthcare delivery in resource-limited settings (19). Comparative studies have evaluated electrospun nanoscale fibrinogen patches versus porcine small intestine submucosa grafts in inguinal hernia repair, revealing non-inferiority of the fibrinogen patch in terms of efficacy and safety (20). Cochrane reviews have compared the Shouldice technique with other open techniques for inguinal hernia repair, informing clinical decision-making and surgical practice (21). A study comparing Desarda's versus Darning

technique in emergency inguinal hernia repair demonstrated comparable outcomes in terms of surgical efficacy and patient recovery (22).

Changing consensus on mesh fixation in laparoscopic inguinal hernioplasty has prompted research into short- and long-term outcomes associated with different fixation methods (23). Mesh displacement after bilateral inguinal hernia repair with no fixation has been studied, highlighting implications for surgical technique and postoperative care (24). Comparative studies have evaluated ULTRAPRO Hernia System versus Lichtenstein repair, revealing differences in surgical outcomes and patient recovery (25). Three-dimensional versus two-dimensional laparoscopy in TAPP repair has been investigated, suggesting potential advantages in surgical visualization and precision (26). Endoscope-assisted inguinal hernia repair has been studied for its feasibility and outcomes in minimizing invasiveness and optimizing surgical outcomes (27).

A meta-analysis compared mesh fixation with glue versus suture in Lichtenstein inguinal hernia repair, highlighting differences in postoperative pain and recurrence rates (Ref. 28). Systematic reviews have evaluated single-incision versus multi-incision laparoscopic surgery for inguinal hernia repair, revealing comparable outcomes in terms of surgical feasibility and patient recovery (29). Clinical effectiveness of Mesalt combined with Mepilex dressing in postoperative infection of inguinal hernia has been studied, emphasizing strategies to minimize infectious complications and optimize wound healing (30). Long-term outcomes from the Finn Mesh Study have evaluated the impact of mesh and fixation on chronic inguinal pain in Lichtenstein hernia repair, providing insights into factors influencing postoperative pain management (31).

A randomized trial comparing Lichtenstein versus Onstep techniques for inguinal hernia repair has investigated differences in surgical outcomes and patient satisfaction, informing surgical practice and technique selection (32). The TIMELI trial investigated post-operative benefits of Tisseel/Tissucol for mesh fixation in Lichtenstein inguinal hernia repair, highlighting implications for surgical technique and postoperative care (33). Preliminary results from randomized controlled trials have compared Lichtenstein versus Lichtenstein plus plug techniques in prosthetic inguinal hernia repair, suggesting potential advantages in reducing recurrence rates (34). Comparative studies have evaluated tension-free repair versus Bassini technique for strangulated inguinal hernia, emphasizing differences in surgical outcomes and complications (35).

Randomized clinical trials comparing Desarda versus Lichtenstein repair for treatment of primary inguinal hernia have investigated differences in recurrence rates and patient recovery, informing technique selection in clinical practice (36). Long-term follow-up studies have evaluated Lichtenstein repair versus the Valenti technique, revealing differences in recurrence rates and patient satisfaction over extended follow-up periods (37). Meta-analysis of postoperative pain using non-sutured or sutured single-layer open mesh repair has compared outcomes in terms of pain management and patient satisfaction (38). Randomized controlled

trials have compared standard polypropylene mesh versus lightweight mesh for Lichtenstein repair of primary inguinal hernia, investigating differences in recurrence rates and complications (39).

Comparative studies have evaluated open preperitoneal versus anterior approach for recurrent inguinal hernia repair, highlighting differences in surgical outcomes and complication rates (40). Prospective studies have investigated fixation versus no fixation of mesh in totally extraperitoneal inguinal hernia repair, revealing implications for mesh stability and postoperative recovery (41). Comparative trials have evaluated swing mesh versus Modified Kugel mesh for primary inguinal hernia repair, providing insights into differences in surgical technique and patient outcomes (42). Observational studies have compared human fibrin glue sealing versus suture polypropylene fixation in Lichtenstein inguinal herniorrhaphy, highlighting differences in wound healing and postoperative complications (43).

Large-scale trials such as the Veterans Affairs Cooperative Studies Program 456 Investigators have compared open mesh versus laparoscopic mesh repair of inguinal hernia, providing evidence for the safety and efficacy of both approaches (44). Randomized trials have compared sutures, N-butyl-2-cyanoacrylate, and human fibrin glue for mesh fixation during primary inguinal hernia repair, revealing differences in wound healing and postoperative recovery (Ref. 45). Prospective trials have investigated tension-free inguinal hernia repair techniques including TEP, mesh-plug, and Lichtenstein, highlighting differences in recurrence rates and patient satisfaction (46). Population-based analyses have compared TAPP versus TEP for endoscopic inguinal hernia repair, revealing differences in surgical outcomes and recovery rates (47).

A single-surgeon randomized trial compared three meshes in Lichtenstein hernia repair, investigating differences in long-term recurrence rates and patient satisfaction (48). Comparative studies have evaluated early and long-term outcomes of open Lichtenstein repair versus totally extraperitoneal herniorrhaphy for primary inguinal hernias, highlighting differences in postoperative complications and recovery (49). Randomized trials have compared stapled versus unstapled techniques of laparoscopic total extraperitoneal inguinal hernia repair, revealing differences in operative time and postoperative pain (50). Prospective studies have investigated human fibrin glue versus staples for mesh fixation in laparoscopic transabdominal preperitoneal hernioplasty, revealing differences in wound healing and postoperative complications (51).

**Table 3: Incidence on Inguinal Hernia Repair Techniques**

Reference	Study Design	Interventions	Incidence
1	Review	Current options in repair	Varied by technique. Comparative overview (Hippokratia)
2	Review	Recurrence rates	Recurrence rates reported. : Factors influencing recurrence (Int J Surg)
3	Review	Crucial anatomy, cues	N/A. Technical tips for laparoscopic repair (World J GastrointestSurg)
4	Review	Overview	N/A. Overview of inguinal hernia (Laeknabladid)
5	RCT	Robotic vs laparoscopic repair	Comparable in trial cohorts. Comparable outcomes in RIVAL trial (JAMA Surg)
6	Systematic Review	Open vs laparoscopic repair	Reduced complications with laparoscopic. Summary of reviews (SurgEndosc)
7	Systematic Review	Asymptomatic contralateral repair	Varied in meta-analysis. Meta-analysis findings (Hernia)
8	Cochrane Review	Mesh vs non-mesh repair	Lower recurrence with mesh. Effectiveness of mesh (Cochrane Database)
9	Randomized Trial	Regional anesthesia	Effective in pain management. Efficacy in open repair (Eur J Med Res)
10	StatPearls	Clinical management	N/A. Results: Overview of clinical management (StatPearls)
11	Systematic Review	Open mesh repairs	Cost-effective option. Cost-effectiveness and efficacy (Health Technol Assess)
12	Systematic Review	TEP vs TAPP	Varied by technique. Comparative efficacy (Hernia)
13	RCT	TREPP vs TIPP	Outcomes in trial cohorts. Randomized comparison

			(Ann Surg)
14	RCT	Mesh alone vs darn and mesh	Comparative outcomes. Comparative outcomes (J Med Life)
15	Case Series	Robotic TAPP repair	Technical feasibility. Lessons learned (Rev Col Bras Cir)
16	Review	Progress in laparoscopic repair	Advancements in techniques. Recent advancements (Medicine)
17	Prospective Study	Long-term resorbable mesh	Benefits of long-term use. Outcomes with resorbable mesh (JSLS)
18	RCT	Associate vs medical doctors	Healthcare delivery outcomes. Trial results (JAMA Netw Open)
19	RCT	Nanoscale fibrinogen patch	Non-inferiority demonstrated. Trial results (J Am CollSurg)
20	Cochrane Review	Shouldicevs other techniques	Effectiveness in repairs. Effectiveness of Shouldice (Cochrane Database)
21	Randomized Trial	Desardavs Darning technique	Comparative efficacy. Comparison (J Ayub Med Coll Abbottabad)
22	Randomized Trial	Mesh fixation in TAPP	Changing consensus. Changing consensus (Int J Surg)
23	Review	Clinical pearls in mesh fixation	Short and long-term outcomes. Short and long-term outcomes (Chirurgia)
24	Prospective Study	Mesh displacement	Postoperative care. Postoperative care implications (JSLS)
25	RCT	ULTRAPRO vs Lichtenstein	Comparative study outcomes. Comparative outcomes (IntSurg)
26	RCT	3D vs 2D laparoscopy	Prospective study. Prospective randomized study (SurgEndosc)
27	Case Series	Endoscope-assisted repair	Feasibility outcomes. Feasibility and outcomes

			(JSLS)
28	Meta-analysis	Mesh fixation with glue vs suture	Comparative outcomes. Comparative outcomes (Medicine)
29	Meta-analysis	Single-incision vs multi-incision	Comparative study. Comparative study (Int J Surg)
30	Clinical Trial	Postoperative infection	Comparative effectiveness. Comparative effectiveness (Med SciMonit)
31	Prospective Study	Mesh and chronic pain	Long-term outcomes. Long-term outcomes (World J Surg)
32	RCT	Lichtenstein vs Onstep	Double-blinded trial. Double-blinded trial protocol (Dan Med J)
33	RCT	Tisseel/Tissucol for mesh	Secondary results. Secondary results from TIMELI trial (Hernia)
34	RCT	Lichtenstein vs Lichtenstein plus plug	Preliminary results. Preliminary results (Tunis Med)
35	Controlled Randomized Study	Tension-free vs Bassini	Comparative study findings. Comparative study findings (Int J Surg)
36	Randomized Clinical Trial	Desardavs Lichtenstein	Randomized comparison. Randomized comparison (Int J Surg)
37	Long-term Follow-up Study	Lichtenstein vs Valenti	5-year outcomes. 5-year outcomes (Hernia)
38	Meta-analysis	Non-sutured vs sutured mesh	Meta-analysis findings. Meta-analysis findings (BJS Open)
39	Randomized Controlled Trial	Standard vs lightweight mesh	Comparative trial results. Comparative trial results (Int J Surg)
40	Randomized Study	Open preperitoneal vs anterior	Randomized study. Randomized study (BMC Surg)
41	Prospective Trial	Mesh fixation in TEP	Prospective study. Prospective study (World J Surg)

42	Prospective Randomized Study	Swing mesh vs Kugel mesh	Prospective randomized study. Prospective randomized study (Hernia)
43	Observational Study	Fibrin glue vs polypropylene	Observational study outcomes. Observational study outcomes (J Clin Diagn Res)
44	Large-scale Trial	Open vs laparoscopic repair	Safety and efficacy study. Safety and efficacy study (Lancet)
45	Prospective Trial	Mesh fixation methods	Comparative outcomes. Comparative outcomes (J Surg Res)
46	Prospective Randomized Trial	TEP vs mesh-plug vs Lichtenstein	Comparative outcomes. Comparative outcomes (Int J Surg)
47	Population-based Analysis	TAPP vs TEP	Population-based study outcomes. Population-based study outcomes (Hernia)
48	Randomized Trial	Three meshes in Lichtenstein	Comparative outcomes. Comparative outcomes (World J Surg)
49	Prospective Study	Open Lichtenstein vs TEP	Early and long-term outcomes. Early and long-term outcomes (Hernia)
50	Randomized Controlled Trial	Stapled vs unstapled TEP	Comparative trial results. Comparative trial results (Int J Surg)
51	Prospective Trial	Fibrin glue vs staples	Prospective study outcomes. Prospective study outcomes (Hernia)

**Comparison of Effectiveness of Inguinal Hernia Repair Procedures**

**1. Open Mesh Repair (Lichtenstein Technique):**

- **Effectiveness:** Widely accepted as a standard technique due to low recurrence rates (5-10%) and relatively straightforward implementation (Reference 8).
- **Advantages:** Lower recurrence rates compared to non-mesh techniques, effective for both primary and recurrent hernias (8, 20).
- **Disadvantages:** Potential for chronic pain, longer recovery time compared to laparoscopic techniques (6).



**2. Laparoscopic Techniques (TAPP and TEP):**

- **Effectiveness:** Comparable or lower recurrence rates (10-20%) with reduced postoperative pain and quicker recovery times compared to open repair (6, 12).
- **Advantages:** Minimally invasive, suitable for bilateral hernias, lower risk of wound infections, faster return to normal activities (6, 12).
- **Disadvantages:** Technical expertise required, higher cost, risk of intraoperative complications such as injury to major vessels or organs (6, 12).

**3. Robotic Assisted Repair:**

- **Effectiveness:** Comparable outcomes to laparoscopic repair with potential advantages in precision and dexterity (15).
- **Advantages:** Enhanced visualization, improved ergonomics for surgeons, potentially reduced conversion rates to open surgery (15).
- **Disadvantages:** High initial setup costs, longer operating times compared to standard laparoscopic techniques (15).

**4. Tissue-Based Repairs (Desarda Technique):**

- **Effectiveness:** Promising results in selected patients, particularly in young and active individuals, with low recurrence rates reported (Reference 21).
- **Advantages:** Utilization of native tissues, potentially lower risk of chronic pain compared to mesh repairs (21).
- **Disadvantages:** Limited long-term data compared to mesh repairs, technique operator-dependent (21).

**5. Biological and Resorbable Meshes:**

- **Effectiveness:** Varying outcomes reported, with some studies suggesting comparable effectiveness to synthetic meshes (17, 19).
- **Advantages:** Reduced risk of long-term complications associated with permanent meshes, potential for better tissue integration (17, 19).
- **Disadvantages:** Higher cost, variability in resorption rates, and potential for hernia recurrence (17, 19).

**6. Hybrid Techniques (e.g., Onstep Procedure):**

- **Effectiveness:** Preliminary studies indicate promising outcomes with potentially reduced postoperative pain and shorter recovery times (32).
- **Advantages:** Combines principles of open and minimally invasive techniques, potentially reducing complications associated with each approach (32).
- **Disadvantages:** Limited long-term data, specific training required for implementation (32).

#### 7. Innovative Approaches (e.g., Nanotechnology, Endoscopic Assistance):

- **Effectiveness:** Emerging data suggests feasibility and potential advantages in specific patient populations, but long-term outcomes need further evaluation (19, 27).
- **Advantages:** Precision, reduced tissue trauma, and potentially faster recovery (References 19, 27).
- **Disadvantages:** Limited comparative data, higher procedural costs initially, and specific technical expertise required (References 19, 27).

### Conclusion

The choice of inguinal hernia repair technique should be tailored to the patient's individual characteristics, hernia type, and surgeon's expertise. While laparoscopic techniques offer advantages in terms of quicker recovery and reduced postoperative pain, open mesh repairs like the Lichtenstein technique remain a reliable option with established long-term outcomes. Emerging technologies such as robotics and biodegradable meshes show promise but require further long-term studies to validate their efficacy and cost-effectiveness compared to traditional methods.

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