

Comparative Study between Outcome of Laparoscopic Inguinal Hernia Repair (TAPP) versus Novel Open 3 Cones Mesh Plug Hernioplasty (Saleh Technique)

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Abstract

Background: Inguinal hernia repair is one of the most common surgical procedures worldwide. While the Lichtenstein tension-free repair remains the gold standard for open repair, laparoscopic transabdominal preperitoneal (TAPP) repair has gained popularity due to its reduced postoperative pain and faster recovery. This study aims to compare the novel 3-Cones Mesh Hernioplasty (Saleh technique) with TAPP repair in terms of operative time, intraoperative complications, postoperative recovery, and recurrence rates.

Methods: This prospective study included 40 male patients with primary inguinal hernia, randomized into two groups: Group A (3-Cones Mesh Hernioplasty) and Group B (TAPP repair). Operative time, blood loss, and complications were recorded intraoperatively. Postoperative outcomes such as pain scores (VAS), recovery time, and recurrence rates were evaluated after 6 months.

Results: Saleh technique had a shorter operative time (82 ± 14 min vs. 133 ± 31 min, $p < 0.001$) but resulted in higher blood loss (70 mL vs. 30 mL, $p < 0.001$). Intraoperative and postoperative complications showed no significant differences ($p > 0.05$). The TAPP group had lower pain scores (median 3 vs. 4, $p = 0.003$) and faster recovery (4 vs. 8 days, $p < 0.001$). Recurrence rates were comparable ($p = 0.661$).

Conclusions: Saleh technique provides a time-efficient alternative to TAPP repair, demonstrating comparable safety and recurrence rates. While TAPP repair offers superior postoperative recovery, the Saleh technique remains a viable and practical option, particularly in resource-limited settings.

Keywords: Inguinal Hernia, TAPP Repair, 3-Cones Mesh Hernioplasty.

Introduction

Primary inguinal hernia is a prevalent surgical condition resulting from a defect in the abdominal wall of the inguinal region, necessitating surgical intervention in approximately 20 million patients worldwide annually ^[1]. The burden of inguinal hernias has been particularly high in India, China, and Brazil, collectively accounting for nearly 39% of global incident cases between 1990 and 2019, with a continuing rise in China ^[2].

Surgical repair remains the most effective treatment option, with Lichtenstein's tension-free repair (LTFR) historically being the most commonly performed open technique. However, the advent of minimally invasive procedures has revolutionized hernia repair, offering patients a range of surgical options, including transabdominal preperitoneal (TAPP) repair, totally extraperitoneal (TEP) repair, and robotic-assisted TAPP (rTAPP) ^[3, 4]

The choice between open and laparoscopic inguinal hernia repair is influenced by multiple factors, including patient-specific anatomical considerations, comorbidities, surgeon expertise, and hospital resources ^[1]. Open repairs, particularly the Lichtenstein technique, have long been the preferred approach due to their simplicity, reproducibility, and low recurrence rates. However, concerns regarding chronic groin pain have led to increased interest in laparoscopic alternatives ^[5]. In contrast, TAPP and TEP techniques have demonstrated advantages in terms of reduced postoperative pain and faster recovery, though TEP has been associated with a slightly higher recurrence risk, particularly in primary unilateral cases ^[6].

Despite the increasing adoption of laparoscopic techniques, debate persists regarding their overall superiority compared to open repair. While systematic reviews and meta-analyses have attempted to clarify the comparative benefits and risks of each technique, no definitive consensus has been reached ^[7, 8]. TAPP repair remains a widely utilized laparoscopic technique, but further research is needed to evaluate its long-term outcomes compared to emerging open mesh-based approaches.

This study aims to compare the open 3-cones mesh plug hernioplasty (Saleh technique) and TAPP repair regarding preoperative, intraoperative (operative time, learning curve), and postoperative outcomes (hematoma, infection, recurrence).

Patients and methods

Design and population:

This prospective study included 40 patients with a history of inguinal hernia, who were recruited from the General Surgery Department at Benha University Hospital. The study was conducted after obtaining approval from the Research Ethics Committee at Benha Faculty of Medicine, and written informed consent was obtained from all participants.

Eligibility criteria

All male patients with a history of primary inguinal hernia, aged 18 to 50 years, with non-complicated inguinal hernias were included. Patients were excluded if they had recurrent hernias or presented with complicated inguinal hernias, including irreducible, obstructed, inflamed, or strangulated cases.

Patients randomized into two equal groups:

Group A (3-Cones Mesh Hernioplasty): patients underwent open inguinal hernioplasty using the Saleh technique. Group B (TAPP Repair): patients underwent TAPP inguinal hernia repair.

All eligible patients underwent a comprehensive assessment, including:

1. General Characteristics Assessment

Baseline evaluations included age, BMI, smoking status, comorbidities, occupation, and symptom duration. Smoking status was determined through self-reported history, while diabetes mellitus and hypertension were confirmed via medical records and clinical evaluations. Occupation was classified as light or heavy labor based on physical demands, and symptom duration was recorded from patient history.

2. Surgical Procedure

The open inguinal hernia repair can be performed using prosthetic or non-prosthetic techniques. Traditional methods include Bassini and Shouldice repairs, while the Lichtenstein repair has undergone modifications to reduce recurrence and complications. In our approach, the **3-cone repair (Saleh technique)**, we modified the Lichtenstein repair to further minimize recurrence. This involves placing three cones at key hernia orifices: the internal ring for indirect hernia, Hesselbach's triangle for direct hernia, and the femoral ring to prevent femoral hernia. These cones are sutured together and covered with an onlay mesh for reinforcement. **Figure 1**

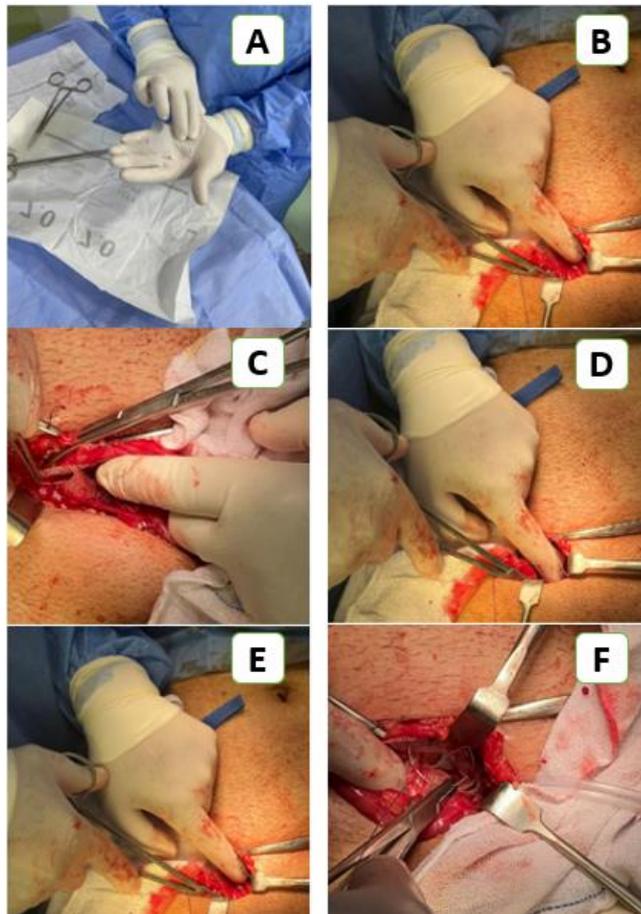


Figure 1: A: Making of the cones, B: Cone in Hasselbach triangle, C: Cone in internal ring, D: Cone in femoral triangle, E: On lay mesh, and F: Connecting cones together.

3. Intraoperative Assessment

Key intraoperative parameters included operative time, blood loss, and complications. Operative time was recorded in minutes from the first incision to skin closure. Blood loss was

estimated by measuring the volume collected in suction devices and soaked gauze pads. Any intraoperative complications, such as vessel or nerve injury, allergic reactions, or excessive bleeding, were documented based on surgical observations and reports.

4. Postoperative Assessment

Postoperative evaluation focused on complications and outcomes. Complications, including wound infection, urinary retention, seroma, and scrotal edema, were assessed clinically, with wound cultures or ultrasound performed as needed. Outcomes were measured using the Visual Analog Scale (VAS) ^[9] for pain at 24, 48, and 72 hours postoperatively. Additionally, time to return to daily activities was recorded based on patient-reported functional recovery, while recurrence rates were determined after 6 months through clinical examination and imaging in follow-up visits.

Statistical methods

Data management and statistical analysis were done using SPSS version 27 (IBM, Armonk, New York, United States). Quantitative data were assessed for normality using the Shapiro-Wilk test and direct data visualization methods. According to normality, quantitative data were summarized as means and standard deviations or medians and ranges. Categorical data were summarized as numbers and percentages. Quantitative data were compared according to intervention type received using Independent T Test and Mann–Whitney U Test for parametric and non-parametric variables, respectively. Categorical data were compared using the Chi-square or Fisher’s exact test. All statistical tests were two-sided. P values less than 0.05 were considered significant.

Results

Regarding general characteristics, our study found no significant differences between both groups in terms of age ($P = 0.235$), BMI ($P = 0.489$), smoking status ($P = 0.507$), diabetes

mellitus (P = 0.451), hypertension (P = 0.661), occupation (P = 0.342), or duration of symptoms (P = 0.807). All participants in both groups were male. **Table 1**

Table 1: General characteristics of the studied participants.

		Group A (n=20)	Group B (n=20)	P-value
Age (years)	Mean \pm SD	36 \pm 10	32 \pm 8	0.235
Sex				
Males	n (%)	20 (100)	20 (100)	-
BMI	Median (range)	26 (18 - 56)	26 (18 - 47)	0.489
Smoking	n (%)	8 (40)	6 (30)	0.507
DM	n (%)	3 (15)	6 (30)	0.451
HTN	n (%)	2 (10)	4 (20)	0.661
Occupation				
Light	n (%)	11 (55)	8 (40)	0.342
Heavy	n (%)	9 (45)	12 (60)	
Duration of symptoms (months)	Median (range)	7 (2 - 36)	8 (1 - 48)	0.807

BMI: Body Mass Index; DM: Diabetes Mellitus; HTN: Hypertension, n: Number.

There were significant differences between Saleh and Laparoscopic groups in operative time and blood loss. The mean operative time was significantly shorter in the Saleh group compared to the Laparoscopic group (82 \pm 14 min vs. 133 \pm 31 min, P < 0.001). Additionally, the Saleh group had significantly higher blood loss, with a median of 70 ml (range 45-95) compared to 30 ml (range 15-90) in the Laparoscopic group (P < 0.001). Intraoperative complications were not significantly different between the groups (P = 1). Specific types of intraoperative complications included allergy to antibiotics and vessel injury (Laparoscopic group only), nerve injury (Saleh group only), and oozing (both groups). **Table 2 and Figure 2**

Table 2: Intra Operative characteristics of the studied participants.

		Group A (n=20)	Group B (n=20)	P-value
Operative time (min)	Mean \pm SD	82 \pm 14	133 \pm 31	<0.001*
Blood loss (ml)	Median (range)	70 (45 - 95)	30 (15 - 90)	<0.001*
Intra-Op complications	n (%)	2 (10)	3 (15)	1
Type of Intra-Op Complication				
Allergy to Antibiotic	n (%)	0 (0)	1 (33.3)	
Nerve Injury	n (%)	1 (50)	0 (0)	-
Oozing	n (%)	1 (50)	1 (33.3)	

Vessel Injury	n (%)	0 (0)	1 (33.3)
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* Statistically significant P-value, n: Number.

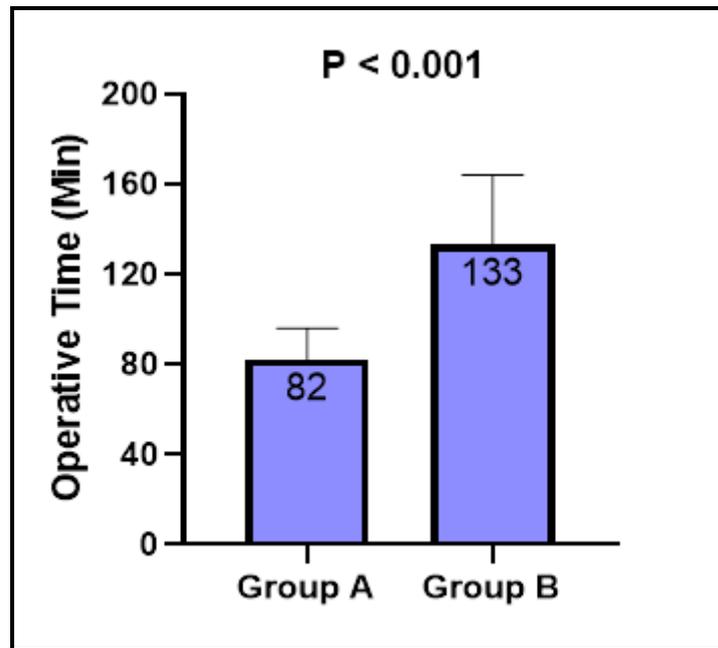


Figure 2: Operative time between the studied groups.

Postoperative complications, including wound infection ($P = 0.695$), urinary retention ($P = 1$), seroma ($P = 0.605$), and scrotal edema ($P = 0.487$) showed no significant differences between the groups. **Table 3**

Table 3: Post Operative complications of the studied participants.

		Group A (n=20)	Group B (n=20)	P-value
Wound infection	n (%)	3 (15)	5 (25)	0.695
Urinary retention	n (%)	4 (20)	3 (15)	1
Seroma	n (%)	3 (15)	1 (5)	0.605
Scrotal edema	n (%)	2 (10)	0 (0)	0.487

* Statistically significant P-value, n: Number.

The study found significant differences in pain scores 24 hours postoperatively and the time to return to daily activities between the Saleh and Laparoscopic groups. The Laparoscopic group reported significantly lower pain scores (median 3, range 1–5) compared to the Saleh group (median 4, range 2–8, $P = 0.003$). Additionally, the Laparoscopic group had a significantly shorter time to return to daily activities (median 4 days, range 2–15) compared to

the Saleh group (median 8 days, range 6–15, $P < 0.001$). No significant difference was found regarding recurrence ($P = 0.661$). **Table 4**

Table 4: Post Operative outcomes of the studied participants.

		Group A (n=20)	Group B (n=20)	P-value
Pain score (24H post-op)	Median (range)	4 (2 - 8)	3 (1 - 5)	0.003*
Time to return to daily activity (days)	Median (range)	8 (6 - 15)	4 (2 - 15)	<0.001*
Recurrence	n (%)	2 (10)	4 (20)	0.661

* Statistically significant P-value, n: Number.

Discussion

In our study, intraoperatively, the Saleh group demonstrated a significantly shorter operative time but experienced higher blood loss compared to the Laparoscopic group. No significant differences in intraoperative complications were observed between the groups, though specific complications varied, with nerve injury reported only in the Saleh group and vessel injury in the Laparoscopic group.

Several studies have consistently shown that TAPP repair requires a longer operative time compared to open mesh repair. Salama and Mostafa^[10] compared 92 inguinal hernia cases and found that operative time was significantly shorter in the open repair group (59.48 ± 40.48 minutes) than in the TAPP group (99 ± 38 minutes). Similarly, Pulikkal Reghunandan et al.^[11] reported a highly significant increase in operative time in the laparoscopic group ($p < 0.0001$) among 84 patients undergoing either open or laparoscopic hernia repair.

These findings indicate that open surgery, including the novel 3 Cones Mesh Hernioplasty (Saleh technique), is superior in terms of operative time while maintaining favorable outcomes compared to laparoscopic repair.

Also concerning postoperative complications, Mohammed et al.^[12] aimed to equate laparoscopic hernioplasty findings with TAPP vs TEP as techniques for inguinal hernia repair involving 50 patients split into two categories, 25 for each. Group A; underwent a TAPP mesh

repair, group B; underwent a total mesh repair using TEP, finding no significant differences regarding total number of intraoperative complications [4 (16%) vs 8 (32%)] for group A and B respectively with a p value of 0.361 (Mohammed et al., 2021). Furthermore, Takayama et al. revealed that no intraoperative complications were observed in either group ^[13]. This indicates no superiority of TAPP over other techniques and also do our results for Saleh technique compared to TAPP. Thus, the 2 techniques are comparable.

The Saleh technique offers distinct advantages over laparoscopic TAPP repair, primarily in terms of procedural simplicity and efficiency. With a significantly shorter operative time, it allows for quicker completion of surgery, reducing overall time in the operating room and minimizing anesthesia exposure. Unlike laparoscopy, which requires specialized equipment and advanced surgical expertise, the Saleh technique is straightforward and can be performed with standard surgical instruments, making it more accessible in resource-limited settings.

Our study found that postoperative complications, including wound infection, urinary retention, seroma, and scrotal edema, were not significantly different between the groups.

Neumayer et al. ^[14] analyzed recurrence rates and complications in 1983 patients undergoing open or laparoscopic tension-free herniorrhaphy, reporting a higher complication rate in the laparoscopic group (39.0%) compared to the open group (33.4%). Similarly, Vidović et al. ^[15] studied 345 patients undergoing inguinal hernia repair, finding no significant difference in postoperative complications between open and TEP repairs, except for higher urinary retention in the TEP group.

Saleh technique and laparoscopic TAPP repair demonstrated comparable safety profiles, with no significant differences in postoperative complications such as wound infection, urinary retention, seroma, or scrotal edema. The comparable postoperative outcomes

further support the effectiveness of the Saleh technique, reinforcing its potential as a reliable alternative to laparoscopic repair.

In this study, the laparoscopic group had significantly lower pain scores at 24 hours and a shorter recovery time compared to the Saleh group, while recurrence rates were similar. Neumayer et al. ^[14] reported less postoperative pain in the laparoscopic group, with a mean difference of 10.2 mm on the day of surgery and 6.1 mm at two weeks. Patients also resumed normal activities one day earlier (HR: 1.2, 95% CI: 1.1–1.3). Similarly, Salama and Mostafa ^[10] found that pain scores were consistently lower in the TAPP group, with scores decreasing more rapidly by the third postoperative day. These findings reinforce that laparoscopic TAPP repair offers faster pain relief and quicker recovery compared to open repair.

In addition, Elmessiry and Gebaly ^[16] compared the results and complications between open tension-free mesh (Lichtenstein) repair and TEP repair. The study cohort was comprised of 345 consecutive patients who underwent an inguinal herniorrhaphy procedure. An open hernia repair was performed on one group of patients (n = 233), whereas TEP repair was performed on the other (n = 112). They found that the mean pain score by the visual analogue scale after the 1st 24 h was significantly less after Lap TAPP compared to open PP repair and Bilateral Lichtenstein repair (3.37 ± 0.71 compared to 4.81 ± 0.74 and 5.12 ± 1.69 respectively, $P < 0.001$). The same pattern was recorded after 7 days, the mean pain score was 1.81 ± 1.21 in Lap TAPP group, compared to 4.13 ± 0.88 and 3.18 ± 0.71 in open PP and Bilateral Lichtenstein groups respectively, $P < 0.001$. This indicating that TAPP showed higher values according pain score.

In accordance, Pulikkal Reghunandan et al. ^[11] concluded that returning to normal activities was significantly different for laparoscopic patients relative to the open group (p-value<0.001). With a high level of significance of $p < 0.001$, laparoscopic hernia repair required less time to recover before returning to normal activities than open hernia repair ($p < 0.005$).

Also, Salama and Mostafa ^[10] found that return to normal daily activity was 21 days after open technique compared to 13 days in TAPP which is better. Furthermore, Elmessiry and Gebaly ^[16] revealed that Lap TAPP group had a significantly faster Return to daily activity compared to open PP group and Bilateral Lichtenstein; (5.87 ± 0.97 compared to 10.64 ± 0.96 and 12.10 ± 1.02 days respectively, $P < 0.001$). Moreover, Lap TAPP group had a significantly shorter time for Return to work compared to open PP group and Bilateral Lichtenstein (12.30 ± 1.47 vs. 19.85 ± 1.06 and 20.20 ± 1.79 days respectively, $p 0.001$). Also, the study by Takayama et al. ^[13] found that the median number of days required to return to normal activity was shorter in TAPP but not significantly different: 15 days (range, 1-365) after TAPP and 20 days (range, 1-180) after MP ($P = .24$).

Concerning to recurrence, Neumayer et al. ^[14] revealed that recurrence was significantly more common after laparoscopic repair than after open repair of primary hernias (10.1 percent vs. 4.0 percent), but rates of recurrence after repair of recurrent hernias were similar in the two groups (10.0 percent and 14.1 percent, respectively). The rates of recurrence after repair of a recurrent hernia did not differ significantly between the groups. The high rate of recurrences after the repair of recurrent hernias by the open technique may be due to the presence of scarring, making further surgery difficult. The overall increased rate of recurrence after laparoscopic repair in this study could be due to several factors. The high rate of retention in the study allowed to assess recurrences thoroughly during the two-year follow-up period. In addition, objective assessment of recurrence was performed by an independent surgeon.

Also, a meta-analysis by McCormack et al. ^[17] identified forty-one eligible trials of laparoscopic versus open groin hernia repair involving 7161 participants to compare minimal access laparoscopic mesh techniques with open techniques and revealed that totals of 86 recurrences were reported amongst 3138 allocated laparoscopic repair and 109 amongst 3504

allocated to open repair with no significant differences (Comparison 01.15: Peto OR 0.81, 95% CI 0.61 to 1.08; $p = 0.16$).

In addition, Takayama et al. ^[13] found that one patient (1.0%) in the TAPP group and five patients (4.3%) in the MP group suffered recurrence ($P=0.30$). Also, Saini et al. ^[18] compared the perioperative complications among 144 patients, of whom 71 underwent TAPP repair and 73 underwent TEP repair and found that neither group experienced a recurrence during the 6-month follow-up. These rates were comparable between the different techniques as well as our technique revealing the effectiveness of our technique decreasing recurrence similar to laparoscopy.

Laparoscopic TAPP repair demonstrated superior postoperative recovery, with lower pain scores in the first 24 hours and a significantly faster return to daily activities compared to the Saleh technique. However, recurrence rates are comparable between both techniques, supporting the effectiveness of the Saleh technique in preventing hernia recurrence. While TAPP offers better early postoperative comfort, the Saleh technique remains a reliable alternative with similar long-term efficacy.

Our study's limitations include the small sample size of 40 participants, which may restrict the generalizability of the findings to a broader population. Additionally, the study was conducted at a single institution, limiting the ability to account for variations in surgical expertise, resource availability, and patient demographics across different centers. Furthermore, the study primarily focused on short-term outcomes, without evaluating long-term recurrence rates, chronic pain, or other potential complications that may develop over time.

Conclusions

Both techniques show comparative outcomes as Saleh technique demonstrated shorter operative time, but is associated with higher intraoperative blood loss compared to TAPP.

Postoperatively, TAPP repair shows lower pain scores and quicker return to daily activities, making it a favorable option for faster recovery. Both techniques show comparable rates of complications and recurrence suggesting that Saleh technique provides a time-efficient alternative.

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