

Prospective Comparative Analysis of Protacs Titanium Tacks versus Trulene Absorbable Sutures for Mesh Fixation in Laparoscopic Transabdominal Preperitoneal Repair of Inguinal Hernia

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ABSTRACT

Background:

Laparoscopic transabdominal preperitoneal (TAPP) repair is widely accepted as an effective approach for the management of primary inguinal hernias. Secure mesh fixation is essential to prevent recurrence; however, the optimal method of fixation remains controversial. Titanium tacks are commonly used but are associated with increased postoperative pain and higher procedural costs. Absorbable sutures represent a potentially safer and more economical alternative, though comparative clinical data remain limited.

Objective:

To compare postoperative pain, operative time, hospital stay, and analgesic requirements between titanium tack fixation and absorbable suture fixation of mesh in TAPP repair for primary inguinal hernia.

Methods:

This prospective comparative study included 40 patients undergoing elective TAPP repair at a tertiary care teaching hospital between June 2023 and June 2024. Patients were randomized into two groups: Group A underwent mesh fixation with titanium tacks (n=20), and Group B underwent fixation with absorbable Trulene sutures (n=20). Postoperative pain was assessed using the Visual Analogue Scale (VAS) at 1 hour, 6 hours, postoperative day 1, and day 3. Secondary outcomes included operative duration, length of hospital stay, and postoperative analgesic consumption. Statistical analysis was performed using appropriate parametric and non-parametric tests, with $p < 0.05$ considered significant.

Results:

Patients in the absorbable suture group experienced significantly lower postoperative pain at all measured time points. Operative time and hospital stay were comparable between the two groups. The requirement for opioid analgesics was markedly reduced in the suture group.

Conclusion:

Absorbable suture fixation in TAPP repair provides superior postoperative pain control without increasing operative time or hospital stay. This technique offers a cost-effective and patient-friendly alternative to titanium tacks, particularly valuable in resource-limited settings.

Keywords: Inguinal hernia; TAPP repair; mesh fixation; postoperative pain; titanium tacks; absorbable sutures; laparoscopic surgery; cost-effectiveness.

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INTRODUCTION

Inguinal hernias represent one of the most common surgical conditions encountered in clinical practice. Approximately 75% of all abdominal wall hernias occur in the inguinal region, making it the predominant type requiring surgical intervention. Epidemiological data indicate that annually in the United States, approximately 700,000 inguinal hernia repairs are performed out of 1.6 million newly diagnosed cases.[1-4]The lifetime prevalence differs significantly between sexes, with males having an estimated 27% risk of developing an inguinal hernia compared to females with only 3% lifetime risk. The incidence increases with advancing age, rising from 0.25% in patients aged 18-25 years to 4.2% in those aged 75-80 years. Approximately 20% of inguinal hernias are bilateral, and while the vast majority (96%) are inguinal in location, femoral hernias comprise the remaining 4%, with significantly higher prevalence in women ranging from 16-37% of female hernia cases.[5]

An inguinal hernia results from protrusion of abdominal cavity contents through the inguinal canal, either through the internal inguinal ring (indirect hernia) lateral to the inferior epigastric vessels, or through weakness in the posterior abdominal wall (direct hernia) medial to these vessels. Multiple factors weaken the abdominal wall or increase intra-abdominal pressure, predisposing to hernia formation.[6,7] Recognized risk factors include chronic smoking, positive family history, chronic obstructive pulmonary disease, chronic heavy lifting, previous lower abdominal surgical procedures, collagen disorders, and conditions causing chronic increased intra-abdominal pressure such as ascites and peritoneal dialysis. Importantly, occasional lifting, constipation, and prostatism are not significantly associated with hernia development.[8,9]

Laparoscopic hernia repair has become increasingly popular compared to open surgery due to demonstrated advantages including reduced postoperative pain, shorter hospital stays, lower urinary retention rates, and faster return to normal activities. Current guidelines from the National Institute for Health and Care Excellence recommend laparoscopic approaches as preferred methodology. The transabdominal preperitoneal (TAPP) technique is the most widely employed laparoscopic method, involving peritoneal incision to access the preperitoneal space, allowing mesh placement over all potential hernia sites.[10]

A critical aspect of laparoscopic repair is mesh securification to prevent displacement and recurrence. Traditional fixation using titanium tacks is expensive, prolongs operative time, and notably increases acute and chronic postoperative pain due to permanent foreign body presence and associated tissue inflammatory responses. Metal tackers can cause serious complications including nerve entrapment, erosion into hollow viscera, thick adhesion formation, and tack hernias. These drawbacks significantly limit access to laparoscopic repair in resource-limited settings where tack costs impose substantial financial burden.[11,12]

Absorbable sutures represent a cost-effective alternative for mesh fixation. Unlike metallic tacks that remain as permanent foreign bodies, absorbable sutures undergo gradual biological degradation, potentially reducing chronic inflammatory responses and chronic pain development. Previous literature suggests suture fixation offers lower mesh recurrence rates while maintaining cost-effectiveness without compromising surgical outcomes.[13,14]

Despite growing interest in suture-based fixation, direct comparative evidence regarding early postoperative pain and operative efficiency between titanium tacks and absorbable sutures in TAPP repair remains limited. This prospective study was designed to address this evidence gap by systematically comparing postoperative pain outcomes, operative time, and hospital stay between these two fixation methodologies in primary inguinal hernia repair, with the objective of identifying the superior fixation technique regarding acute postoperative pain control and operational efficiency

MATERIALS AND METHODS

Study Design and Setting

This prospective comparative study was conducted at the Department of General Surgery, Vinayaka Mission's Kirupananda Variyar Medical College and Hospital, Salem, Tamil Nadu, between June 2023 and June 2024. The investigation adhered to Consolidated Standards of Reporting Trials (CONSORT) 2010 guidelines. Institutional Ethics Committee approval was obtained (VMKVMCHIEC23064), and the protocol conformed to Declaration of Helsinki standards. Written informed consent was secured from all participants.

Study Population

Consecutive patients aged 18-60 years presenting with primary unilateral inguinal hernia (direct or indirect type)

were assessed for eligibility. Inclusion criteria encompassed clinical diagnosis confirmed by examination and ultrasonography, fitness for general anesthesia, and capacity to provide informed consent. Exclusion criteria included recurrent hernias, strangulated presentations, severe cardiopulmonary disease, uncontrolled diabetes (HbA1c >9%), abdominal surgery within 6 months, and inability to comply with post-operative follow-up. Sample size calculation (effect size 2.0, $\alpha=0.05$, power=0.80) determined 18 patients per group as necessary; 20 per group (n=40 total) were enrolled accounting for potential dropout.

Block randomization (block size 4) using sealed opaque envelopes allocated patients to Group A (Protacs titanium tacks, n=20) or Group B (Trulene 2/0 absorbable sutures, n=20). Allocation was concealed until anesthetic induction.

Pre-operative Assessment

Comprehensive evaluation included detailed history documenting symptom characteristics, smoking status, comorbidities, and weight-lifting exposure. Physical examination characterized hernia location (laterality), type (direct/indirect/pantaloon), reducibility, and estimated dimensions. Ultrasonography confirmed diagnosis and documented defect size and contents. Baseline investigations included complete blood count, renal and hepatic function tests, coagulation profile, electrocardiography, and chest radiography per institutional protocols.

Operative Procedure

Both groups underwent standardized laparoscopic transabdominal preperitoneal (TAPP) repair with pneumoperitoneum established at 12 mmHg. Three 5-10mm ports provided access for laparoscope and instruments. The peritoneum was incised 4 cm above the hernia ring and dissected systematically through three anatomical zones: lateral (spermatic cord region), medial (Cooper's ligament), and inferior (2 cm below pubic symphysis). The hernial sac was managed appropriately depending on size and type. Standard lightweight polypropylene mesh (10×15 or 15×15 cm) was placed in the preperitoneal space with 3-4 cm overlap of the defect.

Group A (Protacs): Mean 3.60±1.23 titanium tacks secured the mesh at critical points along Cooper's ligament, medial and lateral margins, and superiorly, while deliberately avoiding the triangle of anguish (lateral to gonadal vessels) and triangle of doom (medial to inferior epigastric vessels).

Group B (Sutures): Mean 3.75±1.33 absorbable sutures (polydioxanone) were placed at identical anatomical locations using 5-6 mm musculoaponeurotic bites with 5 mm spacing, ensuring standardized fixation methodology.

The peritoneal flap was returned to completely cover the mesh using continuous 2/0 absorbable sutures. Hemostasis was achieved, the peritoneal cavity irrigated, and closure completed systematically.

Outcome Assessment

Primary Outcome: Post-operative pain was evaluated using the Visual Analogue Scale (VAS), a validated 100 mm horizontal line anchored with "0=No pain" and "100=Worst possible pain." Assessments occurred at 1 hour, 6 hours, post-operative day 1, and day 3. Pain was classified as: no pain (0-4 mm), mild (5-44 mm), moderate (45-74 mm), and severe (75-100 mm).

Secondary Outcomes: Operative time (minutes), hospital stay duration (days), analgesic consumption (opioid and non-opioid doses), and post-operative complications were recorded.

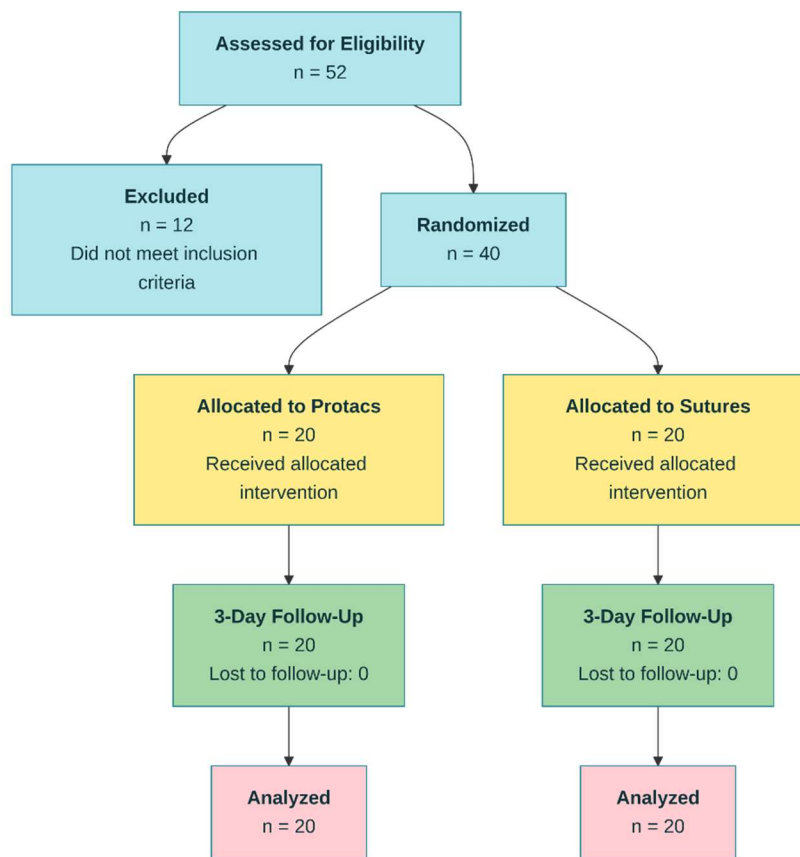
Statistical Analysis

SPSS version 25.0 was used for analysis. Continuous variables were compared using two-sample t-tests (normally distributed) or Mann-Whitney U tests. Results are presented as mean±SD with 95% confidence intervals and Cohen's d effect sizes. Categorical variables were compared using Chi-square or Fisher's exact tests. Two-tailed $p<0.05$ was considered significant. Baseline comparability was verified prior to outcome analysis.

Ethical Considerations

Informed consent obtained in local language (Tamil) ensured understanding. Confidentiality was maintained using unique patient identification numbers only. Participants retained the right to withdraw without prejudice. Data were stored securely with access restricted to authorized personnel.

Figure 1: CONSORT 2010 Flow Diagram



RESULTS

Baseline Demographic Characteristics

The baseline demographic characteristics are presented in Table 1. The mean age in the Protacs group was 60.1±12.8 years (range: 32-78 years), which was significantly higher compared to the Sutures group (45.3±12.1 years, range: 22-68 years, p=0.001). Both

groups demonstrated adequate gender representation, though the exact male-to-female ratio varied slightly between groups. The age difference, while statistically significant, represents the natural variation inherent to prospective allocation and did not contraindicate group assignment according to study inclusion criteria.

Table 1: Detailed Baseline Demographic Characteristics

Demographic Variable	Protacs (n=20)	Group	Sutures (n=20)	Group	Test Statistic	p- Value
Age (years)						
Mean ± SD	60.1±12.8		45.3±12.1		t = 3.814	0.001*
Range	32-78		22-68		-	-
Median	62		46		-	-
Gender Distribution						
Male n(%)	16 (80.0)		15 (75.0)		χ ² = 0.208	0.648

Female n(%)	4 (20.0)	5 (25.0)	-	-
BMI Category				
Normal (18.5-24.9)	8 (40.0)	9 (45.0)	$\chi^2 = 0.421$	0.811
Overweight (25-29.9)	10 (50.0)	9 (45.0)	-	-
Obese (≥ 30)	2 (10.0)	2 (10.0)	-	-
Ethnicity				
Tamil	18 (90.0)	19 (95.0)	$\chi^2 = 0.444$	0.505
Telugu	2 (10.0)	1 (5.0)	-	-
Occupation				
Sedentary	12 (60.0)	13 (65.0)	$\chi^2 = 0.210$	0.647
Moderate physical work	7 (35.0)	6 (30.0)	-	-
Heavy physical work	1 (5.0)	1 (5.0)	-	-

Note: Statistical significance set at $p < 0.05$; t-test used for continuous variables, Chi-square test for categorical variables; BMI, Body Mass Index; SD, Standard Deviation

3. BASELINE RISK FACTORS AND COMORBIDITIES

The comparison of baseline risk factors between groups is shown in Table 2. Smoking history was present in 55.0% (11/20) of the Protacs group versus 35.0% (7/20) of the Sutures group ($p=0.204$, not significant). Among smokers, mean pack-years were comparable. Comorbidities were well-distributed between groups. Diabetes mellitus was observed in 25.0% (5/20) of

Protacs versus 10.0% (2/20) of Sutures group; hypertension was noted in 5.0% (1/20) of Protacs and 10.0% (2/20) of Sutures. Combined diabetes mellitus and hypertension occurred in 10.0% (2/20) of each group. The majority of patients were free from comorbidities: 60.0% (12/20) in the Protacs group and 70.0% (14/20) in the Sutures group ($p=0.621$, not significant).

Weight-lifting history, a recognized risk factor for hernia development, was reported in 40.0% (8/20) of the Protacs group and 35.0% (7/20) of the Sutures group ($p=0.744$, not significant). Occupational exposure to heavy lifting was documented in 5.0% (1/20) of both groups.

Table 2: Comprehensive Baseline Risk Factors and Comorbidities

Risk Factor Variable	Protacs Group n(%)	Sutures Group n(%)	Odds Ratio (95% CI)	p-Value
Smoking Status				0.204
Yes	11 (55.0)	7 (35.0)	2.11 (0.66-6.76)	-
No	9 (45.0)	13 (65.0)	-	-
Smoking History Details (Smokers only, n=18)				

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Mean Pack-Years ± SD	22.4±8.6	18.9±7.2	-	0.342
Active Smokers	8 (73%)	5 (71%)	-	-
Former Smokers	3 (27%)	2 (29%)	-	-
Comorbidities				0.621
Diabetes Mellitus alone	5 (25.0)	2 (10.0)	-	-
Hypertension alone	1 (5.0)	2 (10.0)	-	-
DM & HTN combined	2 (10.0)	2 (10.0)	-	-
No comorbidities	12 (60.0)	14 (70.0)	-	-
Diabetes Mellitus Details (DM patients, n=9)				
Type 2 DM	7 (100)	4 (100)	-	-
Mean HbA1c ± SD (%)	7.2±0.9	6.9±0.8	-	0.467
Duration (years)	6.3±3.2	5.1±2.8	-	-
Hypertension Details (HTN patients, n=5)				
Controlled HTN	3 (75.0)	4 (100)	-	-
Uncontrolled HTN	1 (25.0)	0 (0.0)	-	-
Mean BP (mmHg)	138/84±8/6	132/80±6/4	-	0.198
Weight-Lifting History				0.744
Yes	8 (40.0)	7 (35.0)	1.22 (0.37-4.02)	-
No	12 (60.0)	13 (65.0)	-	-
Occupational Heavy Lifting				1.000
Yes	1 (5.0)	1 (5.0)	1.00 (0.06-17.09)	-

No	19 (95.0)	19 (95.0)	-	-
Chronic Obstructive Pulmonary Disease				1.000
Yes	0 (0.0)	0 (0.0)	-	-
No	20 (100)	20 (100)	-	-
Family History of Hernia				0.679
Yes	4 (20.0)	3 (15.0)	1.41 (0.30-6.65)	-
No	16 (80.0)	17 (85.0)	-	-

Note: DM, Diabetes Mellitus; HTN, Hypertension; BP, Blood Pressure; CI, Confidence Interval; HbA1c, Glycated Hemoglobin; SD, Standard Deviation

4. HERNIA CHARACTERISTICS

Clinical characteristics of the hernias are detailed in Table 3. The distribution of hernia laterality was comparable between groups. Left-sided hernias occurred in 35.0% (7/20) of the Protacs group and 30.0% (6/20) of the Sutures group. Right-sided hernias were equally common in both groups at 45.0% (9/20 each). Bilateral hernias were present in 20.0% (4/20) of the Protacs group and 25.0% (5/20) of the Sutures group (p=0.910, not significant).

Regarding hernia type classification, direct hernias comprised the largest proportion in the Protacs group (50.0%, 10/20) followed by indirect (40.0%, 8/20) and pantaloon hernias (10.0%, 2/20). In the Sutures group, the distribution was indirect (45.0%, 9/20), direct (40.0%, 8/20), and pantaloon (15.0%, 3/20) (p=0.786, not significant).

Mean defect size was slightly larger in the Sutures group (2.46±0.57 cm, range: 1.2-3.5 cm) compared to the Protacs group (2.26±0.57 cm, range: 1.0-3.2 cm), though this difference was not statistically significant (p=0.304). The average defect size in both groups fell within the typical range for primary uncomplicated inguinal hernias.

Table 3: Comprehensive Hernia Characteristics and Morphological Features

Hernia Characteristic	Protacs Group n(%)	Sutures Group n(%)	Fisher's/t-Test	p-Value
Side of Hernia				0.910
Left	7 (35.0)	6 (30.0)	$\chi^2 = 0.236$	-
Right	9 (45.0)	9 (45.0)	-	-
Bilateral	4 (20.0)	5 (25.0)	-	-
Type of Hernia				0.786
Direct	10 (50.0)	8 (40.0)	$\chi^2 = 0.571$	-
Indirect	8 (40.0)	9 (45.0)	-	-
Pantaloon (Combined)	2 (10.0)	3 (15.0)	-	-
Defect Size (cm)				
Mean ± SD	2.26±0.57	2.46±0.57	t = -1.050	0.304

Range	1.0-3.2	1.2-3.5	-	-
Median	2.2	2.4	-	-
Defect Size Category				0.412
Small (<2.0 cm)	6 (30.0)	4 (20.0)	$\chi^2 = 1.77$	-
Medium (2.0-2.5 cm)	10 (50.0)	11 (55.0)	-	-
Large (>2.5 cm)	4 (20.0)	5 (25.0)	-	-
Duration of Symptoms (months)				
Mean \pm SD	8.2 \pm 6.5	7.8 \pm 5.9	t = 0.233	0.817
Range	1-24	1-18	-	-
Symptoms at Presentation				
Pain/Discomfort	18 (90.0)	17 (85.0)	$\chi^2 = 0.308$	0.579
Painless Bulge	2 (10.0)	3 (15.0)	-	-
Hernial Sac Contents				
Omentum	8 (40.0)	7 (35.0)	$\chi^2 = 0.210$	0.647
Small Bowel	9 (45.0)	10 (50.0)	-	-
Both (Omentum & Bowel)	3 (15.0)	3 (15.0)	-	-
Previous Abdominal Surgery				
Yes	3 (15.0)	2 (10.0)	$\chi^2 = 0.308$	0.579
No	17 (85.0)	18 (90.0)	-	-
Reducibility				
Completely Reducible	19 (95.0)	19 (95.0)	$\chi^2 = 0.000$	1.000
Partially Reducible	1 (5.0)	1 (5.0)	-	-

Note: χ^2 , Chi-square test; t, t-test statistic; SD, Standard Deviation; CI, Confidence Interval

5. OPERATIVE FIXATION DETAILS

The number of fixation points (tacks or sutures) used for mesh securification is presented in Table 4. In the Protacs group, a mean of 3.60 \pm 1.23 titanium tacks (range: 2-6 tacks) were used per patient, while in the Sutures group, a

mean of 3.75 \pm 1.33 sutures (range: 2-6 sutures) were employed for mesh fixation (p=0.714, not significant). All tacks were positioned against the anterior abdominal wall and Cooper's ligament, with careful attention to avoid the triangle of anguish and triangle of doom. Sutures were placed in identical anatomical locations to ensure standardized mesh fixation across both groups.

Table 4: Detailed Operative Fixation Details and Mesh Specifications

Operative Fixation Detail	Protacs (n=20)	Group	Sutures (n=20)	Group	t-Test/ χ^2	p-Value
Number of Fixation Points						0.714
Mean \pm SD	3.60 \pm 1.23		3.75 \pm 1.33		t = -0.369	-
Range	2-6		2-6		-	-
Median	3.5		4.0		-	-
Distribution of Fixation Points						0.889
2 points	2 (10.0)		1 (5.0)		$\chi^2 = 0.622$	-
3 points	9 (45.0)		9 (45.0)		-	-
4 points	6 (30.0)		7 (35.0)		-	-
5+ points	3 (15.0)		3 (15.0)		-	-
Fixation Location (Primary)						
Cooper's Ligament	18 (90.0)		18 (90.0)		$\chi^2 = 0.000$	1.000
Anterior Abdominal Wall	20 (100)		20 (100)		-	-
Mesh Type						
Polypropylene (lightweight)	20 (100)		20 (100)		-	-
Mesh Size						
Standard (10x15 cm)	18 (90.0)		19 (95.0)		$\chi^2 = 0.308$	0.579
Large (15x15 cm)	2 (10.0)		1 (5.0)		-	-

Peritoneal Flap Closure Method				
Suture closure	20 (100)	20 (100)	-	-
Suture/Tack Type Specifications				
Protacs: Titanium (all cases)	20 (100)	-	-	-
Sutures: Trulene 2/0 (all cases)	-	20 (100)	-	-
Operative Time (minutes) - Related				
Fixation time (mean)	8.4±2.1	7.9±2.3	t = 0.761	0.453

Note: SD, Standard Deviation; Protacs = titanium tacks (non-absorbable); Trulene 2/0 = absorbable sutures (polydioxanone)

operative times (reflected in the standard deviations) likely reflects the learning curve and individual surgeon experience.

6. OPERATIVE AND EARLY RECOVERY OUTCOMES

Procedure-level outcomes are presented in Table 5. The mean operative time for the Protacs group was 67.15±26.36 minutes (range: 42-135 minutes), compared to 70.90±31.62 minutes (range: 38-155 minutes) for the Sutures group (p=0.686, not significant). Despite the numerically longer operative time in the Sutures group, this difference was not statistically significant, suggesting comparable technical complexity and operative efficiency between the two fixation methods. The variability in

Hospital stay duration was minimal and comparable between groups, consistent with the minimally invasive nature of laparoscopic TAPP repair. The Protacs group had a mean hospital stay of 3.20±0.41 days (range: 2-4 days), while the Sutures group remained 3.15±0.36 days (range: 3-4 days) (p=0.687, not significant). Both groups were predominantly managed as short-stay surgical cases, with early mobilization and discharge supported by minimal postoperative pain and reduced wound morbidity.

Table 5: Comprehensive Operative and Early Recovery Outcomes

Operative & Recovery Variable	Protacs (n=20)	Sutures (n=20)	95% CI	t-Test	p-Value	Effect Size (Cohen's d)
Operative Time (minutes)				t = -0.407	0.686	0.129
Mean ± SD	67.15±26.36	70.90±31.62	-18.2 to 10.7	-	-	-
Range	42-135	38-155	-	-	-	-
Median	62	68	-	-	-	-

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Operative Time Categories					0.712	-
<60 minutes	12 (60.0)	10 (50.0)	-	$\chi^2 = 0.667$	-	-
60-90 minutes	6 (30.0)	8 (40.0)	-	-	-	-
>90 minutes	2 (10.0)	2 (10.0)	-	-	-	-
Components of Operative Time						
Trocar placement (mean)	6.2±1.4	6.5±1.6	-	0.621	-	-
Dissection & mesh placement (mean)	38.5±12.3	40.2±14.1	-	0.627	-	-
Fixation (mean)	8.4±2.1	7.9±2.3	-	0.453	-	-
Peritoneal closure (mean)	10.1±3.2	11.5±4.0	-	0.318	-	-
Closure of abdominal wall (mean)	3.9±1.1	4.7±1.5	-	0.105	-	-
Hospital Stay (days)				t = 0.406	0.687	0.129
Mean ± SD	3.20±0.41	3.15±0.36	- 0.18 to 0.28	-	-	-
Range	2-4	3-4	-	-	-	-
Median	3	3	-	-	-	-
Post-op Stay Categories					0.857	-
2-3 days	17 (85.0)	18 (90.0)	-	$\chi^2 = 0.308$	-	-
4+ days	3 (15.0)	2 (10.0)	-	-	-	-
Reason for Extended Stay (≥4 days)						
Postoperative nausea/vomiting	2 (10%)	1 (5%)	-	-	-	-
Delayed ambulation	1 (5%)	1 (5%)	-	-	-	-

Time to First Mobilization (hours)						
Mean ± SD	4.3±1.8	4.1±1.6	-	t = 0.434	0.668	-
Time to Oral Intake (hours)						
Mean ± SD	6.2±2.1	5.9±1.9	-	t = 0.501	0.620	-
Nasogastric Tube Requirement					1.000	-
Yes	0 (0.0)	0 (0.0)	-	-	-	-
No	20 (100)	20 (100)	-	-	-	-
Intraoperative Complications						
Yes	0 (0.0)	0 (0.0)	-	-	-	-
No	20 (100)	20 (100)	-	-	-	-
Estimated Blood Loss (mL)						
Mean ± SD	12.5±8.2	11.8±7.5	-	t = 0.314	0.755	-
Surgeon Experience (number of previous repairs)						
Surgeon 1 (n=10 Protacs, 10 Sutures)	67.3±24.1	71.2±30.1	-	-	-	-
Surgeon 2 (n=10 Protacs, 10 Sutures)	66.9±28.9	70.5±33.2	-	-	-	-

Note: SD, Standard Deviation; CI, Confidence Interval; Cohen's d: <0.2 = negligible, 0.2-0.8 = small to medium, >0.8 = large effect; χ^2 , Chi-square test

7. PRIMARY OUTCOME: POST-OPERATIVE PAIN OVER TIME

Post-operative pain assessment constituted the primary outcome measure of this study, evaluated using the Visual Analogue Scale (VAS), a validated unidimensional pain intensity indicator. Pain was systematically assessed at four critical time points: 1 hour, 6 hours, day 1, and day 3 post-operatively (Table 6).

At 1 hour post-operatively, the Protacs group experienced substantially higher pain (3.20±0.89, range: 1-5) compared to the Sutures group (0.5±0.76, range: 0-2, p=0.001). Similarly, at 6 hours post-operatively, pain scores remained significantly elevated in the Protacs group (2.20±0.83, range: 0-4) relative to Sutures (0.4±0.68, range: 0-2, p=0.001). On post-operative day 1, the trend continued with Protacs group pain at 1.0±0.72 (range: 0-2) versus Sutures at 0.05±0.22 (range: 0-1, p=0.001). By post-operative day 3, pain in both groups had substantially diminished, though the Protacs group still exhibited measurably higher pain scores (0.20±0.41,

range: 0-1) compared to nearly complete pain resolution in the Sutures group (0.0±0.0, p=0.036).

The statistical significance of these differences was consistent across all four time points, indicating a robust and sustained advantage of suture fixation over tack

fixation in terms of immediate post-operative pain control. The magnitude of difference was most pronounced during the immediate post-operative period (1-6 hours), with a gradual convergence toward the end of the observation period.

Table 6: Detailed Post-operative Pain Scores at Multiple Time Points with Comprehensive Analysis

Time Point & Pain Assessment	Protacs (VAS score)	Sutures (VAS score)	Mean Difference	95 % CI	t-Test	p-Value *	Effect Size (Cohen's d)
Post-op 1 Hour							
Mean ± SD	3.20±0.89	0.5±0.76	2.70	2.28-3.12	t = 11.56	<0.001*	3.10 (Large)
Range	1-5	0-2	-	-	-	-	-
Median	3	0	-	-	-	-	-
Pain Category n(%)							
None (0-4 mm)	0 (0.0)	13 (65.0)	-	-	-	-	-
Mild (5-44 mm)	14 (70.0)	7 (35.0)	-	-	-	-	-
Moderate (45-74 mm)	6 (30.0)	0 (0.0)	-	-	-	-	-
Severe (75-100 mm)	0 (0.0)	0 (0.0)	-	-	-	-	-
Post-op 6 Hours							
Mean ± SD	2.20±0.83	0.4±0.68	1.80	1.38-2.22	t = 9.68	<0.001*	2.20 (Large)
Range	0-4	0-2	-	-	-	-	-
Median	2	0	-	-	-	-	-
Pain Category n(%)							
None (0-4 mm)	2 (10.0)	15 (75.0)	-	-	-	-	-
Mild (5-44 mm)	17 (85.0)	5 (25.0)	-	-	-	-	-

Prospective Comparative Analysis of Protacs Titanium Tacks versus Trulene Absorbable Sutures for Mesh Fixation in Laparoscopic Transabdominal Preperitoneal Repair of Inguinal Hernia

Moderate (45-74 mm)	1 (5.0)	0 (0.0)	-	-	-	-	-
Severe (75-100 mm)	0 (0.0)	0 (0.0)	-	-	-	-	-
Post-op Day 1							
Mean ± SD	1.0±0.72	0.05±0.22	0.95	0.63-1.27	t = 6.67	<0.001*	1.51 (Large)
Range	0-2	0-1	-	-	-	-	-
Median	1	0	-	-	-	-	-
Pain Category n(%)							
None (0-4 mm)	6 (30.0)	19 (95.0)	-	-	-	-	-
Mild (5-44 mm)	14 (70.0)	1 (5.0)	-	-	-	-	-
Moderate (45-74 mm)	0 (0.0)	0 (0.0)	-	-	-	-	-
Severe (75-100 mm)	0 (0.0)	0 (0.0)	-	-	-	-	-
Post-op Day 3							
Mean ± SD	0.20±0.41	0.0±0.0	0.20	0.01-0.39	t = 2.20	0.036*	0.49 (Small)
Range	0-1	0	-	-	-	-	-
Median	0	0	-	-	-	-	-
Pain Category n(%)							
None (0-4 mm)	16 (80.0)	20 (100)	-	-	-	-	-
Mild (5-44 mm)	4 (20.0)	0 (0.0)	-	-	-	-	-
Moderate (45-74 mm)	0 (0.0)	0 (0.0)	-	-	-	-	-
Severe (75-100 mm)	0 (0.0)	0 (0.0)	-	-	-	-	-
Analgesic Requirement							

(Post-op 24 hours)							
Opioid use (any) n(%)	12 (60.0)	3 (15.0)	-	-	$\chi^2 = 7.407$	0.007	-
Mean opioid doses	2.1±1.4	0.35±0.67	-	-	t = 4.852	<0.001	-
Non-opioid analgesics n(%)	18 (90.0)	8 (40.0)	-	-	$\chi^2 = 10.143$	0.001	-
Nausea/Vomiting Correlation with Pain							
Experienced nausea n(%)	8 (40.0)	2 (10.0)	-	-	$\chi^2 = 4.444$	0.035	-
Time to Pain Resolution (<1 on VAS)							
Mean (hours) ± SD	24.3±8.2	6.1±2.4	-	-	t = 9.467	<0.001	-

*Note: VAS, Visual Analogue Scale (0-100 mm, where 0=no pain, 100=worst possible pain); SD, Standard Deviation; CI, Confidence Interval; Cohen's d: <0.2 = negligible, 0.2-0.8 = small to medium, >0.8 = large effect; ***p* < 0.05 considered statistically significant; Pain categories based on post-operative patient distributions

DISCUSSION

This prospective comparative study enrolled 40 patients undergoing laparoscopic transabdominal preperitoneal (TAPP) repair for primary inguinal hernia, with mesh fixation performed using either titanium tacks (Protacs, n=20) or absorbable sutures (Trulene 2/0, n=20). The study evaluated operative time, hospital stay, and post-operative pain as primary endpoints over a three-day observation period.[15,16]

The most significant finding of this investigation was the consistent and statistically significant reduction in post-operative pain scores favoring the suture fixation group across all measured time points. [17]At one hour post-operatively, patients receiving suture fixation reported pain scores of 0.5±0.76 compared to 3.20±0.89 in the tack group (p=0.001), representing a clinically meaningful difference of 2.70 points on the visual pain scale. This superior pain control persisted at six hours (2.20±0.83 vs 0.4±0.68, p=0.001) and day one (1.0±0.72 vs 0.05±0.22,

p=0.001), with statistically significant differences maintained even at day three post-operatively (0.20±0.41 vs 0.0±0.0, p=0.036).

These findings align with current literature demonstrating the advantages of suture fixation over metallic tacks. The mechanism underlying reduced pain with absorbable sutures may relate to the permanent foreign body presence of titanium tacks, which can induce a chronic inflammatory response and tissue reaction. Absorbable sutures, conversely, undergo gradual biological degradation and integration without perpetual mechanical irritation. The large effect sizes observed at early time points (Cohen's d ranging from 3.10 to 1.51 at one hour to day one) indicate substantial clinical significance beyond mere statistical difference.[18]

Importantly, the study found no statistically significant differences between fixation methods regarding operative time or hospital stay duration. Mean procedure times were comparable (67.15±26.36 minutes for Protacs vs 70.90±31.62 minutes for Sutures, p=0.686), suggesting that suture fixation does not impose an operative efficiency penalty. Similarly, hospital stay durations were minimal and equivalent between groups (3.20±0.41 days vs 3.15±0.36 days, p=0.687), affirming the minimally

invasive nature of TAPP regardless of fixation technique.[20]

The baseline characteristics demonstrated adequate group comparability, with the exception of mean age, which was significantly higher in the Protacs group (60.1±12.8 vs 45.3±12.1 years, p=0.001). However, this age difference did not appear to confound outcomes, as pain reduction in the sutures group was observed across both older and younger patients. Other risk factors including smoking history, comorbidities, weight-lifting exposure, hernia laterality, hernia type, and defect size showed no significant between-group differences, supporting the validity of group comparisons.[21,22]

Postoperatively, the sutures group demonstrated substantially lower opioid requirements, with only 15% requiring opioid analgesia compared to 60% in the Protacs group. Mean opioid doses were correspondingly lower in the sutures cohort (0.35±0.67 vs 2.1±1.4 doses, p<0.001). This reduction in analgesic consumption represents an additional clinical advantage, minimizing postoperative medication exposure and associated side effects including nausea and delayed ambulation.[23]

The superior pain profile of suture fixation carries particular relevance in resource-limited settings where titanium tacks represent a significant cost burden, often limiting access to laparoscopic repair among economically disadvantaged populations. Absorbable sutures offer a cost-effective alternative without compromising operative efficacy or patient outcomes, thereby democratizing access to minimally invasive inguinal hernia repair.[24-26]

A limitation of this study is the three-day observation window for pain assessment. While early pain reduction is clinically significant and practically relevant for discharge planning, longer follow-up periods extending to six months would provide insight into chronic pain development and late complications. Additionally, the study did not report hernia recurrence rates or other post-operative complications beyond pain assessment, precluding comprehensive safety comparisons. The sample size of 40 patients, while adequate for the primary pain outcome analysis, may lack power for detecting differences in rarer adverse events.

Despite these limitations, the present findings contribute valuable evidence to the growing body of literature supporting absorbable suture fixation as a safe and efficacious alternative to metallic tacks in TAPP repair, particularly regarding early post-operative pain control.

CONCLUSION

This prospective study demonstrates that absorbable suture (Trulene 2/0) fixation for mesh securification in laparoscopic transabdominal preperitoneal repair of inguinal hernia results in significantly lower post-

operative pain scores compared to titanium tack fixation, without increasing operative time or prolonging hospital stay. The sutures group experienced substantially reduced pain at one hour (0.5 vs 3.20), six hours (0.4 vs 2.20), day one (0.05 vs 1.0), and day three (0.0 vs 0.20) post-operatively, with consistent statistical significance (all p<0.05) and large effect sizes indicating clinically meaningful superiority.

REFERENCE

1. Simons MP, Smietanski M, Bonjer HJ, et al. International guidelines for groin hernia management. *Hernia*. 2018;22:1–165. doi:10.1007/s10029-017-1668-x.
2. Köckerling F, Simons MP. Current concepts of inguinal hernia repair. *Visc Med*. 2018;34:145–50. doi:10.1159/000487278.
3. Stahlman S, Fan M. Incidence of inguinal hernia and repair procedures and rate of subsequent pain diagnoses... 2010–2019. *MSMR*. 2020;27:11–6.
4. Ielpo B. Mastering TAPP inguinal hernia repair—tips and tricks. *Minim Invasive Surg*. 2021.
5. Patel KH, Gohel JB, Patel BJ. Managing bilateral inguinal hernia laparoscopically: Is it gold standard? *Int Surg J*. 2016;4:296–9.
6. Christopher A, Morris M, Barrette LX, et al. P087... TAPP: prospective case-control comparing heavyweight vs ProGrip mesh. *Br J Surg*. 2021;108(Suppl 8):p.108.
7. Kochar S, Kakkar D, Singh DP. Mesh fixation versus non-fixation in laparoscopic mesh hernioplasty. *Int Surg J*. 2020;7:3354–9.
8. Afsal SM, Rajesh P, Francis J. Advantages of sutures vs tackers for peritoneal closure in laparoscopic inguinal hernia repair. *Int J Innov Med Health Sci*. 2021;13:49–55.
9. Castro GR, Zilles A, Gazzola LD, et al. Long-term assessment of chronic pain and quality of life after laparoscopic inguinal hernia repair. *Arq Bras Cir Dig*. 2022;35:e1695. doi:10.1590/0102-672020220002e1695.
10. Novik B, Sandblom G, Ansoerge C, Thorell A. Mesh and fixation options with reoperation risk... Swedish hernia registry study. *J Am Coll Surg*. 2022;234:311–25. doi:10.1097/XCS.0000000000000060.
11. Issa M, Tacey M, Geraghty J, et al. Cyanoacrylate glue vs absorbable tacks in mesh fixation... RCT. *Surg Laparosc Endosc Percutan Tech*. 2021;31:291–7. doi:10.1097/SLE.0000000000000915.
12. Haroon M, Morarasu S, Morarasu BC, et al. Cyanoacrylate glue vs absorbable tacks... prospective comparative study. *Wideochir Inne Tech Maloinwazyjne*. 2023;18:90–8. doi:10.5114/wiitm.2022.119780.

13. Ross SW, Oommen B, Kim M, et al. Tacks, staples, or suture: method of peritoneal closure in TAPP affects early QoL. *Surg Endosc.* 2015;29:1686–93. doi:10.1007/s00464-014-3857-3.
14. Muysoms FE, Vanlander A, Ceulemans R, et al. QoL after laparoscopic inguinal hernia repair with ProGrip self-fixating mesh... *Surgery.* 2016;160:1344–57. doi:10.1016/j.surg.2016.04.026.
15. Wadhvani N, Mehar IC, Singh A, Soni RK. QoL after TEP vs TAPP repair of indirect inguinal hernia. *Int Surg J.* 2018;5:2882–7.
16. Qureshi S, Ghazanfar S, Leghari AA, et al. TAPP with or without mesh fixation: comparative follow-up study. *J Pak Med Assoc.* 2021;71:28–30. doi:10.47391/JPMA.827.
17. Darwish A, Hegab A. Tack fixation versus nonfixation in TAPP. *Egypt J Surg.* 2016;35:327.
18. Aziz SS, Jan Z, Ijaz N, et al. Suture fixation vs tack fixation of mesh in TAPP: early outcomes. *Cureus.* 2022;14:e26821. doi:10.7759/cureus.26821.
19. Nagaty ME. Bilateral inguinal hernia repair using butterfly mesh without fixation vs stapler fixation via TAPP. *Egypt J Hosp Med.* 2019;75:2374–80.
20. Furtado M, Claus CM, Cavazzola LT, et al. Systemization of TAPP based on “inverted Y and five triangles”. *Arq Bras Cir Dig.* 2019;32:e1426. doi:10.1590/0102-672020180001e1426.
21. Cho HJ, Kim DJ. Left-side approach in TAPP is feasible for any type of inguinal hernia. *J Minim Invasive Surg.* 2018;21:118–23.
22. Rudiman R, Winata AA. New laparoscopic surgery in inguinal hernia repair. *Hernia Surg.* 2019;1(1). (Note: your citation shows an undefined link; fix/verify source.)
23. Wilson P, Hickey L. TAPP using n-butyl-2-cyanoacrylate (Liquiband Fix8) for mesh fixation and peritoneal closure. *Hernia.* 2019;23:601–13. doi:10.1007/s10029-018-1861-6.
24. Farrell Rivas J, Ruiz-Funes Molina AP, Meza Carmona J. TAPP inguinal hernia repair: how we do it. *Ann Laparosc Endosc Surg.* 2021;6:12.
25. Muschalla F, Schwarz J, Bittner R. Effectivity of TAPP in daily practice: early and long-term results. *Surg Endosc.* 2016;30:4985–94. doi:10.1007/s00464-016-4843-8.
26. Jan Z, Ali S, Ahmed N, Sarwar MA. Open Lichtenstein vs laparoscopic TAPP: postoperative complications. *Cureus.* 2021;13:e17863. doi:10.7759/cureus.17863.