Original Article

Outcomes of Onlay versus Sublay Mesh Hernioplasty in Primary Ventral Wall Hernia Repair: A Prospective Randomized Comparison

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ABSTRACT

Background: Mesh repair is standard for ventral hernias over 2 cm, but the optimal mesh plane remains debated, and evidence from low-resource regions is scarce. This study compared onlay and sublay mesh hernioplasty for primary ventral wall hernia.

Methodology: This single-center, open-label randomized controlled trial (ClinicalTrials.gov registration No. NCT07896278) was conducted at PHQ Teaching Hospital, Gilgit (November 2024 to April 2026). After written informed consent, 76 consecutively sampled adults aged 20–70 years with a primary ventral hernia (defect 3–10 cm) were randomized to onlay or sublay repair (38 each) and followed for six months. The primary outcome was any wound complication; secondary outcomes were operative duration, pain (visual analogue scale [VAS]), return to normal activity, and recurrence, recorded on a structured proforma. SPSS 26.0 was used for Mann–Whitney U and Fisher's exact tests with 95% confidence intervals (CI); $p < 0.05$ was significant.

Results: Mean age was 38.2 ± 8.1 years; 72.4% were women; onlay patients were older (median 40 vs. 33.5 years; $p = 0.021$); groups were otherwise comparable. Wound complications occurred in 18.4% (onlay) vs. 2.6% (sublay) of patients (odds ratio 8.35, 95% CI 0.97–71.6; $p = 0.056$). Sublay repair took longer (mean difference 8.4 minutes, 95% CI 6.1–10.7) but had lower median VAS scores at 12 hours (5 vs. 6), discharge (2 vs. 4) and two weeks (1 vs. 2), and earlier return to normal activity (median 12.5 vs. 14 days) (all $p \leq 0.001$). All three recurrences followed onlay repair ($p = 0.24$). Adjustment for age and body mass index did not alter estimates.

Conclusion: Sublay hernioplasty prolonged operative duration by a mean of 8.4 minutes but was associated with less postoperative pain and earlier return to normal activity. Its lower wound complication and recurrence rates were not significant; larger multicenter trials are required.

Keywords: Hernia; Ventral; Herniorrhaphy; Surgical mesh; Seroma; Pain; Postoperative

INTRODUCTION

Ventral wall hernias are among the most common conditions seen in general surgical practice.[1] They are classified as primary hernias, which arise spontaneously at sites of natural weakness such as the umbilicus or linea alba, and incisional hernias, which develop in a previous surgical scar.[2] Unrepaired ventral hernias carry a risk of incarceration, strangulation, and bowel obstruction.[1]

Prosthetic mesh has transformed the management of these hernias. For defects larger than 2 cm, mesh repair has lower recurrence than suture repair and has become the standard of care.[1] The remaining question is not whether to use mesh, but where to place it. In the onlay (pre-muscular) technique, the mesh is placed over the anterior rectus sheath after tension-free fascial closure; it is technically simple, quick and does not need retrorectus dissection.[3] In the sublay (retromuscular) technique, the mesh lies between the rectus muscle and the posterior rectus sheath, where it is supported by the abdominal wall muscles and covered by well-vascularized tissue.[4,5] The cost of this advantage is a more extensive dissection and a longer operation.[6,7]

Published studies have not reached a uniform conclusion, and many have combined primary and incisional hernias. A randomized trial of para-umbilical (primary) hernia repair reported higher rates of seroma (10% vs. 3.3%), wound infection (15% vs. 3.3%) and postoperative pain (18.3% vs. 6.7%) after onlay repair, with treatment effectiveness of 80% versus 93.3% in favor of sublay.[8] In an earlier randomized trial of primary para-umbilical hernias with defects of 3–8 cm, recurrence occurred in 6% after onlay and in none after sublay repair over a mean follow-up of 15 months, although the

ARTICLE INFO

Article History:
Received 15.05.2026 | Revised 03.06.2026 | Accepted 28.08.2026
Conflict of Interest: The authors declared no conflict of interest exists.
Funding: None
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Citation: Zahra SS, Changazi SH, Sulaiman H, Hussain I, Shah AH, Khan MA. Outcomes of onlay versus sublay mesh hernioplasty in primary ventral wall hernia repair: A prospective randomized comparison. J Fatima Jinnah Med Univ. 2026;20(3):170-176.
DOI: https://doi.org/10.37018/GSQB5079

difference was not significant.[9] A meta-analysis of ten randomized trials found a pooled relative risk of seroma of 2.61 (95% CI 1.86–3.66) with onlay compared with sublay placement.[10] Evidence on recurrence is less consistent. One study of several types of ventral hernia reported more recurrences after sublay repair at two months,[6] whereas a randomized trial of incisional hernias reported fewer recurrences after sublay repair at one year.[11] A systematic review of incisional hernias found no significant difference in recurrence but less seroma after sublay repair.[12] Current guidelines recommend retromuscular mesh placement for midline incisional hernias,[13] whereas for umbilical and epigastric hernias they favor an open preperitoneal flat mesh, based largely on low-quality evidence.[1]

However, published evidence directly comparing onlay and sublay mesh hernioplasty from Gilgit-Baltistan remains limited. Ventral hernia is common in Gilgit-Baltistan, resources are limited, and postgraduate surgical training started here only a few years ago. Outcomes reported by larger centers elsewhere may not be directly generalizable to patients in Gilgit-Baltistan. The objective of this study was to compare onlay and sublay mesh hernioplasty for primary ventral wall hernia in terms of wound complications, operative duration, postoperative pain, time to return to normal activity, and recurrence.

METHODOLOGY

This was a single-center, parallel-group, open-label randomized controlled trial carried out in the Department of General Surgery, Provincial Headquarters (PHQ) Teaching Hospital, Gilgit, Pakistan. The study ran from November 2024 to April 2026. The patients were recruited until 10th April 2026, and the last six-month follow-up visit took place in October 2026. The Institutional Review Board of PHQ Teaching Hospital, Gilgit approved the protocol (Ref. No. IRB/05/2024/PHQG, dated 19 October 2024), and the trial was registered at ClinicalTrials.gov (NCT07896278). Before enrollment, the nature of the study, the two procedures, their possible complications and the follow-up schedule were explained to each patient, who was told that participation was voluntary and could be withdrawn at any time without affecting treatment. Written informed consent was then obtained from every patient.

Patients were enrolled by non-probability consecutive sampling. Adults of either sex aged 20 to 70 years with a primary ventral wall hernia and a defect diameter of 3 to 10 cm on ultrasound were eligible. A primary ventral hernia was defined as a spontaneous defect in the anterior abdominal wall with no previous surgical incision at that site, in accordance with the European Hernia Society classification.[2] Patients with previous abdominal surgery, obstructed or incarcerated hernia, uncontrolled diabetes mellitus, long-term corticosteroid use, anemia (hemoglobin < 100 g/L), malnutrition (serum albumin < 30 g/L), grand multiparity (more than three previous pregnancies) or who refused consent were excluded. No intraoperative complication such as bowel injury occurred; no randomized patient was withdrawn or excluded after randomization, and all 76 patients were analyzed in the groups to which they had been allocated.

Sample size was calculated with the World Health Organization sample size calculator for comparison of two independent proportions.[14] The calculation used a two-sided significance level of 5% (95% confidence level), a power of 80%, a 1:1 allocation ratio and expected wound complication rates of 13% after onlay and 3% after sublay repair at six months. These expected rates lie within the range of individual wound complication rates reported in previous Pakistani studies of para-umbilical hernia repair (9.6–16.9% after onlay and 2.4–4.8% after sublay repair).[8,15] This gave 38 patients in each group (76 in total).

Patients were allocated 1:1 to onlay (Group A) or sublay mesh hernioplasty (Group B) by blocked randomization using a computer-generated sequence prepared by a person not involved in recruitment. Allocation was concealed in sequentially numbered, sealed opaque envelopes, which were opened in the operating room after induction of anesthesia. Because the two operations use visibly different planes, the surgeons could not be blinded, and patients were not blinded. Outcomes were recorded by the principal investigator, who was aware of the allocation, using predefined criteria; pain scores were reported by the patients. The data analyst was blinded to group allocation.

All operations were performed under general anesthesia by consultant surgeons. In Group A (onlay), the hernial sac was dissected and its contents reduced, the fascial defect was closed without tension, and a polypropylene mesh was placed over the anterior rectus sheath beneath the subcutaneous tissue, overlapping the defect margins by at least 3–5 cm, with a suction drain in the subcutaneous plane above the mesh.[3] In Group B (sublay), the retrorectus space was developed on both sides after reduction of the sac contents, and the mesh was placed between the rectus muscle and the posterior rectus sheath, overlapping the defect margins by at least 5 cm, with the drain in the retrorectus plane, as in the Rives–Stoppa technique.[4,5] All patients received intravenous ceftriaxone 1 g before surgery; after surgery, ceftriaxone 1 g IV 12-hourly was continued for 24–48 hours, followed by oral co-amoxiclav for five days. Postoperative analgesia consisted of intravenous ketorolac 90 mg/day and intravenous paracetamol 3 g/day for 24–48 hours, followed by oral diclofenac 75 mg 12-hourly as required.

The primary outcome was any postoperative wound complication (seroma, hematoma or wound infection) during the six-month follow-up. Secondary outcomes were operative duration in minutes (skin incision to skin closure); pain on a 0–10 visual analogue scale (VAS; 0 = no pain, 10 = worst imaginable pain) at 12 hours, at discharge and at two weeks; time to return to normal activity, defined as the number of days until the patient resumed usual daily or occupational activity without pain or wound problems; and recurrence at six months. Seroma was defined as an anechoic or hypoechoic fluid collection under the wound on ultrasound, or serous fluid on aspiration.[16] Hematoma was defined as a collection of mixed echogenicity on ultrasound, whether or not it needed evacuation. Wound infection was defined according to the Centers for Disease Control and Prevention National Healthcare Safety Network criteria for superficial and deep incisional surgical site infection, that is, purulent discharge from the wound with local signs of inflammation, with or without fever or leukocytosis.[17] Recurrence was defined as a hernia at the operated site within six months, confirmed on clinical examination and ultrasound.[16]

Drains were removed when the output was less than 30 mL in 24 hours, and patients were discharged once drains had been removed and they were fit to go home. They were reviewed between postoperative days 7 and 14 to check wound healing and remove stitches, then every two weeks for two months and monthly for the next four months, giving six months of follow-up for each patient. All data were recorded by the principal investigator on a structured proforma developed by the investigators for this study from its objectives and operational definitions. The proforma had four sections: baseline data (age, sex, body mass index, occupation, comorbidities and hernia type); operative data (procedure and operative duration); early postoperative data (VAS pain scores at 12 hours, at discharge and at two weeks, and wound complications); and follow-up data (time to return to normal activity and findings at each visit, including recurrence). The proforma was a data-recording form based on standard definitions rather than a measurement scale, so it was not subjected to separate psychometric validation; consistency was maintained by having a single investigator complete every form using the predefined definitions.

Data was entered and analyzed in IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Normality of continuous variables was checked with the Shapiro–Wilk test. Because most continuous variables were not normally distributed, they are presented as median (interquartile range) together with mean ± standard deviation, and the two groups were compared with the Mann–Whitney U test. As a measure of effect size, the mean difference between groups (sublay minus onlay) and its 95% confidence interval (CI) were estimated by linear regression with treatment group as the independent variable, using heteroscedasticity-consistent (HC3) robust standard errors because the data were skewed and variances differed between groups. Categorical variables are presented as numbers and percentages and were compared with Fisher's exact test, because at least one expected cell count was below five for the main outcomes; the odds ratio (OR) for the primary outcome is given with its 95% CI (Woolf method). To address the baseline imbalance in age and the borderline difference in body mass index, the analyses were repeated with adjustment: continuous outcomes by linear regression including treatment group, age and body mass index (HC3 robust standard errors), and the primary outcome by the Mantel–Haenszel method stratified by age (< 40 and ≥ 40 years), with the Cochran–Mantel–Haenszel test (continuity-corrected) and the Breslow–Day test for homogeneity, because the small number of events did not allow multivariable logistic regression. All patients were analyzed in the group to which they were randomized (intention to treat). As an exploratory analysis, effect modification by age (< 40 and ≥ 40 years), sex and body mass index (< 30 and ≥ 30 kg/m²) was examined by stratification and by adding a treatment-by-stratum interaction term to the regression model. A two-sided p-value < 0.05 was considered statistically significant.

RESULTS

All 76 randomized patients (38 in each group) completed six months of follow-up. The mean age of the whole sample was 38.2 ± 8.1 years (range 26–60), 55 patients (72.4%) were women, 42 (55.3%) were housewives, 66 (86.8%) had a para-umbilical hernia, and the median body mass index was 31 (28–41) kg/m². Patients in the onlay group were older than those in the sublay group (median 40 vs. 33.5 years; p = 0.021), while body mass index did not differ significantly (median 30 vs. 34 kg/m²; p = 0.072). Sex distribution (68.4% vs. 76.3% women), occupation, hernia type and comorbidities were similar in the two groups. Comorbidities were present in 8 onlay and 7 sublay patients; no patient had more than one comorbidity (Table 1).

Operative duration was longer with sublay than with onlay repair (median 44 vs. 36 minutes; mean difference 8.4 minutes, 95% CI 6.1 to 10.7; p < 0.001) (Table 2). Pain was lower after sublay repair at 12 hours (median VAS 5 vs. 6; mean difference −1.0, 95% CI −1.5 to −0.4; p = 0.001), at discharge (2 vs. 4; −1.9, 95% CI −2.6 to −1.2; p < 0.001) and at two weeks (1 vs. 2; −0.9, 95% CI −1.6 to −0.1; p < 0.001). Median time to return to normal activity was 12.5days after sublay and 14 days after onlay repair (p < 0.001).

Table 1: Baseline characteristics of patients in the two groups

Variable	Onlay (n = 38)	Sublay (n = 38)	p-value*
Age, years, mean ± SD	39.8 ± 6.9	36.6 ± 9.0	
Age, years, median (IQR)	40.0 (34.5–45.0)	33.5 (30.8–40.5)	0.021
Body mass index, kg/m², mean ± SD	31.9 ± 6.8	34.9 ± 7.5	
Body mass index, kg/m², median (IQR)	30.0 (27.0–35.5)	34.0 (29.0–42.3)	0.072
Female sex, n (%)	26 (68.4)	29 (76.3)	0.609
Housewife, n (%)	20 (52.6)	22 (57.9)	0.818
Hernia type, n (%)			0.736
Para-umbilical	34 (89.5)	32 (84.2)	
Epigastric	4 (10.5)	6 (15.8)	
Any comorbidity, n (%)†	8 (21.1)	7 (18.4)	1.000
Diabetes mellitus	3 (7.9)	2 (5.3)	
Hypertension	2 (5.3)	3 (7.9)	
Ischemic heart disease	2 (5.3)	1 (2.6)	
Asthma	1 (2.6)	0 (0)	
Rheumatoid arthritis	0 (0)	1 (2.6)	

*Mann–Whitney U test for continuous variables; Fisher's exact test for categorical variables. †No patient had more than one comorbidity. IQR, interquartile range; SD, standard deviation.

The mean difference was larger (−3.2 days, 95% CI −5.4 to −1.0) because the seven onlay patients with a wound complication had a prolonged recovery (mean 28.0 days, compared with 13.7 days in onlay patients without a complication). After adjustment for age and body mass index, the estimates were almost unchanged (Table 2), and age itself was not significantly associated with any of these outcomes except for a small association with pain at two weeks.

Eight of the 76 patients (10.5%) had a wound complication: seven in the onlay group (18.4%) and one in the sublay group (2.6%) (odds ratio 8.35, 95% CI 0.97 to 71.6; Fisher's exact p = 0.056). After stratification by age, the Mantel–Haenszel odds ratio was 10.9 (95% CI 1.1 to 107.4; Cochran–Mantel–Haenszel p = 0.051), with no heterogeneity between age strata (Breslow–Day p = 0.59). Seroma occurred in three onlay patients (7.9%) and no sublay patient (p = 0.24), wound infection in two onlay patients (5.3%) and no sublay patient (p = 0.49), and hematoma in two onlay patients (5.3%) and one sublay patient (2.6%) (p = 1.00). All three recurrences at six months were in the onlay group (7.9% vs. 0%; p = 0.24); one of these three patients had had an early wound complication (hematoma) (Table 3).

In the exploratory stratified analysis, the differences in operative duration and pain were in the same direction in every age, sex and body mass index stratum, and there was no evidence of effect modification by age or body mass index (all interaction p > 0.05). Effect modification by sex was found for operative duration (mean difference 5.6 minutes in women vs. 16.6 minutes in men; interaction p < 0.001) and for return to normal activity (−4.7 days in women vs. +0.4 days in men; interaction p = 0.012). All seven wound complications in the onlay group occurred in women. Because only 21 men were included, these subgroup findings should be interpreted with caution.

DISCUSSION

In this trial, sublay repair prolonged operative duration by a mean of 8.4 minutes, but patients had lower pain scores at every assessment and returned to normal activity sooner. Wound complications and recurrences were also less frequent after sublay repair, although neither difference reached statistical significance, and the wide confidence interval for the primary outcome means that the size of any effect remains uncertain.

Longer operative duration with sublay repair is expected. Developing the retrorectus plane is a careful, layered dissection, whereas onlay placement after fascial closure is quick. Saleem and coresearchers and a recent randomized trial of ventral hernias also found that sublay procedures took significantly longer.[6,7] In this study, sublay repair was associated with lower pain: median pain was one point lower at 12 hours, two points lower at discharge and one point lower at two weeks. This agrees with the randomized trial of para-umbilical hernias by Babar and coworkers, in which postoperative pain was reported in 18.3% of onlay and 6.7% of sublay patients.[8] One possible explanation is that onlay repair needs wider subcutaneous undermining to expose the anterior rectus sheath, leaving a larger raw area beneath the skin flap, whereas the sublay mesh lies behind the rectus muscle and needs much less flap elevation. This mechanism was not examined in our study and should be regarded as a hypothesis.

The primary outcome needs careful interpretation. Wound complications occurred in 18.4% of onlay and 2.6% of sublay patients, an odds ratio of 8.35, but the p-value was 0.056 and the confidence interval was very wide (0.97 to 71.6). These data are compatible with anything from no

Table 2: Operative duration, pain scores and return to normal activity

Outcome	Onlay (n = 38) median (IQR); mean ± SD	Sublay (n = 38) median (IQR); mean ± SD	Mean difference (95% CI)†	Adjusted mean difference (95% CI)‡	p value*
Duration of surgery, min	36.0 (33.8–40.0); 36.2 ± 3.8	44.0 (40.0–46.5); 44.6 ± 5.9	8.4 (6.1 to 10.7)	8.3 (6.1 to 10.6)	< 0.001
Pain at 12 hours (VAS)	6.0 (5.0–7.0); 6.0 ± 1.3	5.0 (4.0–6.0); 5.0 ± 1.1	−1.0 (−1.5 to −0.4)	−1.0 (−1.6 to −0.5)	0.001
Pain at discharge (VAS)	4.0 (3.0–5.0); 4.4 ± 1.6	2.0 (1.8–3.0); 2.6 ± 1.3	−1.9 (−2.6 to −1.2)	−2.0 (−2.8 to −1.2)	< 0.001
Pain at 2 weeks (VAS)	2.0 (1.0–2.0); 2.4 ± 1.9	1.0 (1.0–1.3); 1.5 ± 1.4	−0.9 (−1.6 to −0.1)	−1.0 (−1.8 to −0.2)	< 0.001
Return to normal activity, days	14.0 (13.0–15.8); 16.3 ± 6.3	12.5 (12.0–14.0); 13.1 ± 2.3	−3.2 (−5.4 to −1.0)	−3.8 (−6.2 to −1.3)	< 0.001

*Mann–Whitney U test (all variables non-normally distributed on the Shapiro–Wilk test). †Sublay minus onlay, from linear regression with treatment group as the only independent variable and HC3 robust standard errors. ‡Sublay minus onlay, adjusted for age and body mass index (linear regression, HC3 robust standard errors). VAS, visual analogue scale (0–10); IQR, interquartile range; SD, standard deviation; CI, confidence interval.

Table 3: Postoperative complications and recurrence

Complication	Onlay (n = 38)	Sublay (n = 38)	p value (Fisher)
Any wound complication, n (%)*	7 (18.4)	1 (2.6)	0.056
Seroma, n (%)	3 (7.9)	0 (0)	0.24
Wound infection, n (%)	2 (5.3)	0 (0)	0.49
Hematoma, n (%)	2 (5.3)	1 (2.6)	1.00
Recurrence at 6 months, n (%)	3 (7.9)	0 (0)	0.24

*Primary outcome: odds ratio 8.35 (95% CI 0.97 to 71.6); age-stratified Mantel–Haenszel odds ratio 10.9 (95% CI 1.1 to 107.4). p values by Fisher's exact test.

difference to a large reduction in wound complications with sublay repair, so this trial cannot establish the size of the effect. The direction of our finding is consistent with previous evidence on seroma. The meta-analysis by Beckers and colleagues, which pooled ten randomized trials, found a relative risk of seroma of 2.61 (95% CI 1.86–3.66) with onlay compared with sublay placement,[10] and a systematic review restricted to incisional hernias also found more seroma after onlay repair.[12] In primary (para-umbilical) hernias, Babar and coworkers reported seroma in 10% of onlay and 3.3% of sublay patients.[8] For wound infection, a Pakistani randomized trial of ventral hernias found significantly fewer infections after sublay repair (8.3% vs. 22.9%), although its difference in seroma was not significant,[18] and a recent Pakistani study of incisional hernias reported lower rates of both seroma and wound infection after sublay repair.[19] Most of these studies included incisional hernias or mixed hernia types, so their results cannot be applied directly to primary ventral hernias. Less dead space and better fluid absorption in the vascularized retromuscular plane may explain the lower seroma rate after sublay repair, but this hypothesis was not examined in our study.

Recurrence occurred in three patients, all in the onlay group (7.9% vs. 0%), but the difference was not significant (p = 0.24), and three events cannot support a firm conclusion. Published results on recurrence are inconsistent. Saleem and coresearchers reported more recurrences after sublay repair in a study that included several types of ventral hernia and had a follow-up of two months,[6] whereas Venclauskas and colleagues reported recurrence in 10.5% of onlay and 2% of sublay patients one year after incisional hernia repair.[11] In primary para-umbilical hernias, the only comparable randomized evidence we found reported a non-significant difference in the same direction as ours (6% vs. 0%) at a mean follow-up of 15 months.[9] A systematic review of incisional hernias found no significant difference,[12] while the European Hernia Society guideline for midline incisional hernia, based on four randomized trials, reported recurrence in 7.2% after onlay and 2.1% after retrorectus repair.[13] Differences in hernia type, defect size, mesh overlap, fixation and length of follow-up may explain these discrepancies, but this is a hypothesis that the cited studies do not test directly. It has also been proposed that intra-abdominal pressure holds a retromuscular mesh against the posterior rectus sheath, whereas an onlay mesh depends on fixation to the anterior sheath;[5] our study was not designed to test this mechanism. Only one of our three patients with recurrence had an early wound complication, so our data do not show a link between wound complications and recurrence.

Median time to return to normal activity was 1.5 days shorter after sublay repair (12.5 vs. 14 days). The mean difference was larger (3.2 days) because the seven onlay patients who developed a wound complication had a prolonged recovery; among patients without a wound complication, the mean difference was 0.8 days. The faster recovery after sublay repair may therefore be related largely to its lower rate of wound complications, although this study was not powered to confirm this.

Despite some limitations, the results are relevant to surgeons working in remote settings with limited resources. Where the retrorectus plane can be opened safely, sublay repair was associated with less pain in the first two weeks and a shorter recovery, at the cost of a mean of 8.4 additional minutes of operative time. Dressing visits, travel burden and costs were not measured in this trial, so any advantage in these respects remains to be shown. Where no surgeon on the team is experienced in the sublay technique, onlay repair remains a reasonable choice.

Further work should follow patients for at least two years to capture late recurrence and should include patient-reported outcomes and costs, which matter particularly in low- and middle-income countries. It would also be worth knowing whether the benefits of sublay repair hold when supervised trainees perform the operation, as they increasingly do in the regional training programs of northern Pakistan.

This study has several limitations. It was carried out in a single center, and all operations were performed by consultant surgeons, so results may differ in units with less experience of retromuscular dissection. The principal investigator who recorded outcomes was not blinded, and pain was self-reported by patients who knew their allocation, which may have introduced bias. Onlay patients were older (median 40 vs. 33.5 years); adjustment for age did not change the results, but residual confounding cannot be excluded. The trial was too small to show a significant difference in wound complications or recurrence, and the stratified analysis was exploratory, with few men in each group. Finally, follow-up was limited to six months. Registry data on incisional hernia show that most recurrences appear within ten years of repair,[20] so six months captures only early recurrences; comparable long-term data for primary ventral hernias repaired with these techniques are lacking.

CONCLUSION

Sublay mesh hernioplasty was associated with less postoperative pain and earlier return to normal activity than onlay repair, although it prolonged operative duration by a mean of 8.4 minutes. Wound complications and recurrence were less frequent with sublay repair, but a definitive advantage could not be established. Larger multicenter randomized trials with longer follow-up are needed to clarify the comparative outcomes of these two techniques for primary ventral wall hernia repair.

Author Contributions

SSZ: Conceptualization, Methodology, Data Curation, Formal Analysis, Writing – Original Draft, Writing – Review & Editing, and Supervision. SHC: Conceptualization, Methodology, Formal Analysis, Writing – Review & Editing, and Validation. HS: Data Curation, Formal Analysis, and Writing – Original Draft. IH: Formal Analysis and Data Curation. AHS: Formal Analysis and Data Curation. MAK: Formal Analysis and Data Curation. All authors reviewed and approved the final manuscript.

AI Disclosure

ChatGPT (OpenAI) was used solely to assist in drafting the covering letter for manuscript submission. AI tools were not used to generate or manipulate research data, perform statistical analyses independently, or develop scientific conclusions or interpretations. All scientific content and AI-generated suggestions, where applicable, were reviewed and verified by the authors, who take full responsibility for the accuracy, originality, and integrity of the manuscript.

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