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Effect of Defect Closure (IPOM-Plus) versus PeTEP on Functional Outcomes

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ABSTRACT

Background

Primary ventral hernias, especially umbilical and paraumbilical hernias, are frequently encountered surgical problems that cause pain, poor quality of life and impaired functionality. Current hernia repair not only seeks to avoid recurrence but also to restore abdominal wall function and patient quality of life. Both Intraperitoneal Onlay Mesh with defect closure (IPOM-Plus) and Preperitoneal Enhanced-view Totally Extraperitoneal Repair (PeTEP) are key minimally invasive repair techniques. The aim of this study was to compare the functional results of IPOM-Plus and PeTEP in the repair of primary ventral hernias.

Materials and Methods

We undertook a comparative observational study of 40 adult patients with primary umbilical and paraumbilical hernias, 20 patients were repaired using IPOM-Plus and 20 using PeTEP. There were no significant differences in demographics and clinical features. Primary outcomes were pain (Visual Analogue Scale [VAS]), time to normal activity, length of hospital stay and functional recovery of the abdominal wall. Secondary outcomes were operative time, seroma, hematoma, ileus, mesh-related complications and recurrence. Data were analysed using SPSS V26.0 with a significance level of $p < 0.05$.

Results

PeTEP was superior to IPOM-Plus in terms of function. At 24 hours postoperatively, VAS pain scores were significantly lower in the PeTEP group (1.86 ± 0.51 vs 2.41 ± 0.66; $p = 0.006$). Hospital stay was shorter (1.50 ± 0.51 vs 2.25 ± 0.44 days; $p < 0.001$), and return to normal activity was significantly earlier (10.30 ± 2.34 vs 14.05 ± 3.22 days; $p < 0.001$). While PeTEP surgery had a longer operative time (157.95 ± 15.58 vs 90.05 ± 15.42 minutes; $p < 0.001$), there was no difference in complications and early recurrence.

Conclusion

PeTEP results in better short-term abdominal wall function than IPOM-Plus in primary ventral hernia repair. Despite a longer operative time, the anatomical retromuscular reconstruction provided by PeTEP is associated with decreased pain, better rehabilitation, shorter hospital stay and superior abdominal wall function. PeTEP may be the ideal minimally invasive technique when postoperative function and quality of life are surgical objectives.

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Keywords: Primary ventral hernia; Umbilical hernia; Paraumbilical hernia; IPOM-Plus; PeTEP; Retromuscular mesh repair; Laparoscopic hernia repair; Abdominal wall reconstruction

INTRODUCTION

Primary ventral hernias (umbilical and paraumbilical hernias) are one of the most frequently encountered problems in general surgery and have been estimated to occur in up to 10-20% of the adult population [1]. Primary ventral hernias are caused by congenital or acquired weakness of the linea alba, the aponeurotic structure that runs between the paired rectus abdominis muscles. The aetiology of these hernias is complex with obesity, old age, chronic cough, constipation, smoking, diabetes mellitus and other factors associated with raised intra-abdominal pressure or disturbances in collagen metabolism known as significant risk factors [1,2]. While often first perceived as a cosmetic issue, primary ventral hernias often cause considerable morbidity in the form of pain, discomfort in performing everyday activities, compromise of core muscle function, and considerable deleterious effect on health-related quality of life (QoL) [2,3]. Historically, surgical treatment has evolved from primary repair (with recurrence rates of up to 20-30%), to the use of prosthetic mesh, which markedly enhanced the recurrence-free survival. This marked the beginning of the tension-free repair concept in abdominal wall surgery [4]. More recently, minimally invasive laparoscopic surgery has further revolutionized ventral hernia repair, with improved wound complications, pain and reduced length of stay, facilitating early recovery compared with open repair [5]. Hence, the current goal of abdominal wall repair is not just the prevention of anatomical recurrence, but also the restoration of abdominal wall function, maintenance of trunk stability and enhancement of patient-reported outcomes [3].

Of minimally invasive techniques, the Intraperitoneal Onlay Mesh Plus (IPOM-Plus) and enhanced-view Totally Extraperitoneal repair (TeTPEP) with its preperitoneal modification (PeTEP) are two significant approaches in the primary management of ventral hernias. IPOM-Plus is a combined laparoscopic approach that consists of primary fascial closure with additional reinforcement of an intraperitoneally deployed composite mesh [6]. It stems from bridged IPOM repair, where the mesh merely bridges the hernia defect. Closing the defect in IPOM-Plus is intended to restore the anatomical continuity of the linea alba and improve the cosmetic appearance of the abdomen by avoiding the dead space in the linea alba, reducing seroma formation and preventing bulging of the mesh, which is often accompanied by discomfort and cosmetic dissatisfaction [7]. By contrast, the PeTEP technique is a different philosophy that focuses on anatomical reconstruction and physiological restoration rather than reinforcement [8]. This approach is entirely extraperitoneal, with a large uncoated mesh being placed in the retromuscular or sublay position, behind the rectus muscles and in front of the posterior rectus sheath and peritoneum [9]. PeTEP avoids placement of mesh within the peritoneal cavity, thereby preventing the potential for bowel adhesion and the need for costly anti-adhesive composite meshes. Crucially, it reestablishes the natural abdominal wall layers and allows mesh incorporation into the musculoaponeurotic structure, thus better mimicking its biomechanics [10]. Therefore, while the

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IPOM-Plus technique primarily facilitates defect closure followed by reinforcement, PeTEP seeks to truly restore anatomical and functional integrity of the abdominal wall.

The definition of success in ventral hernia repair has evolved from the traditional surgical outcomes (i.e. recurrence and complications) to the assessment of functional outcomes, which are now known to be the key factors in long-term patient satisfaction. Functional outcomes include the restoration of abdominal wall function, preservation of core stability, reduction in pain with activities or exertion, absence of bulging or recurrence, a low degree of foreign body sensation and lastly, patient satisfaction with abdominal wall function during everyday activities [4]. A technically successful repair without recurrence may not be satisfactory for the patient if ongoing pain, bulging or continuous awareness of the mesh impairs physical function and QoL. As such, the outcomes of ventral hernia repair need to be evaluated not only anatomically, but also with validated patient-reported outcome (PROM) measures and disease-specific quality of life (QoL) tools [2,3]. These measures offer valuable information on symptom resolution, return to function and overall satisfaction, and often represent the ultimate measure of surgical success for the patient. There is growing recognition that the return of normal abdominal wall function may be more beneficial than recurrence-free survival, especially in young or active patients [4].

This approach supports the distinction between mechanical and physiological repair. IPOM-Plus provides a significant improvement on traditional bridged IPOM by closing the fascial defect, preventing seroma, bulging and mesh eventration [6]. But despite these benefits, the mesh still remains in the peritoneal cavity, and may still induce chronic foreign body response, adhesions, visceral irritation, and chronic pain [4,11]. Despite the introduction of modern barrier-coated composite meshes, there are still concerns about the long-term effects of leaving the mesh within the peritoneal cavity, particularly with respect to chronic pain and mesh sensation. But PeTEP creates a repair in the retromuscular plane, which is believed to be the optimal biomechanical location for abdominal wall repair [12]. Here, the mesh is anchored in well-vascularised tissue and works together with the surrounding musculofascial layers of the abdominal wall to allow more natural transfer of the abdominal wall forces during locomotion, coughing and heavy lifting [10]. Moreover, the mesh is not in contact with the visceral organs, so lightweight, large pore polypropylene mesh can be used, facilitating tissue ingrowth, increasing flexibility, decreasing foreign body sensation and reducing the risk of chronic pain [4]. These anatomical and biomechanical benefits indicate that PeTEP may offer better functional outcomes compared with IPOM-Plus by restoring abdominal wall structure and function.

While IPOM-Plus and PeTEP have been increasingly used, there remains a significant gap in comparing the two. The majority of published literature and meta-analyses have focused on recurrence rates, operation times, duration of hospital stays, and early postoperative complications [12–14]. While these factors are critical in assessing the safety and technical aspects of the procedure, they provide limited information on long-term patient recovery. There is a lack of comparative evidence directly related to pain on activity, abdominal wall strength, bulging after surgery, discomfort on straining, and patient-reported physical recovery. In addition, many existing

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studies have used a mixture of primary ventral hernias and incisional hernias in their populations, which is known to have different pathologies, tissue quality, anatomy of the defect, and technical challenges [15,16].

This variability hampers the translation of these results to patients with primary umbilical and paraumbilical hernias. This means there is a lack of high-quality evidence on which technique, IPOM-Plus or PeTEP, better restores abdominal wall function and leads to a greater quality of life in this population. As such, the main objective of the current study is to assess the functional restoration following repair of primary ventral (umbilical) hernias using IPOM-Plus and PeTEP. In particular, the aim of this study is to compare the intensity of postoperative pain at rest and with a standardized physical load, the abdominal wall function in terms of postoperative bulging and discomfort during everyday activities, and the subjective improvement in symptoms and satisfaction with abdominal wall function using validated quality-of-life questionnaires. The current study aims to help address this clinically important gap in knowledge and provide a broader understanding of the impact of surgical technique on not only recurrence rates but also the physiology of the abdominal wall and patient-centered outcomes.

2. MATERIALS AND METHODS

2.1 Study Design

This prospective comparative observational study was conducted to evaluate and compare the clinical and functional outcomes of laparoscopic Preperitoneal Totally Extraperitoneal (PeTEP) meshplasty and Intraperitoneal Onlay Meshplasty-Plus (IPOM-Plus) in the management of primary umbilical and paraumbilical hernias. The study was carried out in the Department of Minimal Access Surgery at World Laparoscopy Hospital, Gurugram, Haryana, India, over a total duration of 18 months, followed by a 6-month period of analysis and postoperative outcome evaluation

2.2 Study Population

Adult patients with primary ventral hernia (umbilical and paraumbilical) were recruited. Patients who were scheduled for elective minimally invasive repair (IPOM-Plus and PeTEP) were included. Only patients above 18 years of age, with a clinical and radiological diagnosis of reducible primary ventral hernias were analyzed.

Patients with recurrent ventral hernias, incisional hernias, multiple abdominal wall defects, and complicated hernias such as strangulated, incarcerated, or obstructed hernias requiring emergency intervention were excluded. Patients with previous mesh repair, severe systemic illness precluding laparoscopic surgery, or incomplete postoperative follow-up data were also excluded to maintain homogeneity of the study population.

2.3 Group Allocation

Patients were divided into two groups based on the surgical technique performed.

Group A consisted of patients who underwent IPOM-Plus repair, which involved laparoscopic defect closure followed by intraperitoneal mesh placement.

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Group B consisted of patients who underwent PeTEP repair, in which retro muscular mesh placement was performed in the preperitoneal or extraperitoneal plane without intraperitoneal mesh contact.

Group assignment was determined by preoperative planning, surgeon preference, and anatomy and clinical factors of the patient. Randomization was not conducted as this was an observational study.

2.4 Surgical Technique Description

For patients in the IPOM-Plus group, an initial pneumoperitoneum was created via the laparoscopic route and adhesiolysis was done if present. The contents of the hernia were reduced and the fascial defect located. The defect was closed primarily to restore the linea alba and remove dead space using intracorporeal or trans fascial non-absorbable sutures. After defect closure, the intraperitoneal placement of a composite anti-adhesive mesh of adequate overlap and the fixation using tackers with or without transfascial sutures was performed.

In the PeTEP group, the retro rectus or preperitoneal space was entered without entering the peritoneal cavity. The retro muscular spaces were dissected bilaterally with improved laparoscopic view. The hernia sac was tackled and the posterior layer was left whenever possible. The defect was closed when necessary and a large piece of polypropylene mesh was placed in the retro muscular sublay position with sufficient overlap. No protective coating was needed on the mesh as it was not placed inside the peritoneal cavity. The goal of this technique was to preserve normal abdominal wall anatomy and function.

2.5 Outcome Measures

The primary endpoints of the study were related to postoperative function. Pain was measured via the Visual Analogue Scale (VAS) at 6 hours, 1 day and 2 days after surgery. The recovery of abdominal wall function was assessed according to the patient's report of feeling weak in the abdominal wall, bulging, and pain during normal physical activities. Return to normal activity was assessed in days and was an important measure of function. Particularly, we focused on functional recovery of the abdominal wall rather than just recurrence prevention because these outcomes, including pain-free mobility, absence of bulging, and return to normal physical activity are now considered as important factors of patient satisfaction.

Secondary variables included operating time, length of hospital stay, seroma formation, surgical site infection (SSI), hematoma formation, ileus, complications related to the mesh, and short-term recurrence on follow-up. These were taken to evaluate procedures' safety and recovery.

2.6 Data Collection

Data were obtained from the institutional master Excel spreadsheet of prospectively collected perioperative and follow-up data of all patients. Demographic data included age, gender, BMI, and comorbidities, as well as hernia type, size, and location. Surgical variables included type of procedure, duration of surgery and size of defect intra-operatively. Postoperative variables included VAS pain scores at specified time points (6, 24, and 48 hours), seroma formation, SSI, hematoma, ileus, mesh complications, length of stay, time to return to normal activities, and recurrence rate. Postoperative follow-up of all patients was as per institutional protocol with

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scheduled outpatient visits, and variables relating to functional recovery were recorded. All data were checked for integrity prior to analysis.

2.7 Statistical Analysis

The statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 26.0. (IBM Corp., Armonk, NY, USA) or any other validated statistical software. Continuous variables including age, BMI, defect size, operative time, VAS scores, hospital stay and return to activity were reported as mean ± standard deviation or median (interquartile range) as appropriate. Categorical variables including sex, comorbidities, seroma, SSI, hematoma, ileus, mesh complications and recurrence were expressed in frequencies and percentages. Independent sample t-test and Mann-Whitney U test was used to compare continuous variables between the two groups for normally and non-normally distributed variables respectively. Chi-square or Fisher's exact test was used to compare categorical variables. Comparisons were considered significant when the p-value was less than 0.05. The study was carried out to compare the functional results of primary ventral hernias repaired by PeTEP versus IPOM-Plus.

3. RESULTS

3.1 Baseline Characteristics

The study population included 40 patients with primary ventral hernias, with 20 patients treated with IPOM-Plus and 20 treated with PeTEP. There was no significant difference in baseline demographics and clinical factors in the two groups, suggesting the groups were reasonably homogenous for comparison.

The mean age of the IPOM-Plus group was 47.6 ± 11.86 years and 42.2 ± 10.41 years in the PeTEP group ($p = 0.134$). Similarly, the mean body mass index (BMI) was 27.19 ± 3.62 kg/m² in the IPOM-Plus group and 28.88 ± 3.15 kg/m² in the PeTEP group ($p = 0.122$).

The mean preoperative defect size was 3.30 ± 0.70 cm in the IPOM-Plus group and 3.69 ± 0.73 cm in the PeTEP group ($p = 0.094$), while the mean intraoperative defect size was 3.36 ± 0.82 cm and 3.68 ± 0.78 cm, respectively ($p = 0.223$). These differences were not statistically significant.

Both groups had paraumbilical hernias as the most common type of hernia (60% in the IPOM-Plus group and 75% in the PeTEP group), with the remainder being umbilical hernias ($p = 0.501$). There was no significant difference in sex distribution ($p = 0.523$). This indicated that the groups were comparable in the preoperative period.

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Table 1. Baseline Demographic and Clinical Characteristics

Variable	IPOM-Plus (n=20)	PeTEP (n=20)	p-value
Age (years)	47.6 ± 11.86	42.2 ± 10.41	0.134
BMI (kg/m²)	27.19 ± 3.62	28.88 ± 3.15	0.122
Defect size (cm)	3.30 ± 0.70	3.69 ± 0.73	0.094
Intraoperative defect size (cm)	3.36 ± 0.82	3.68 ± 0.78	0.223

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Paraumbilical hernia	12 (60%)	15 (75%)	0.501
Umbilical hernia	8 (40%)	5 (25%)	—

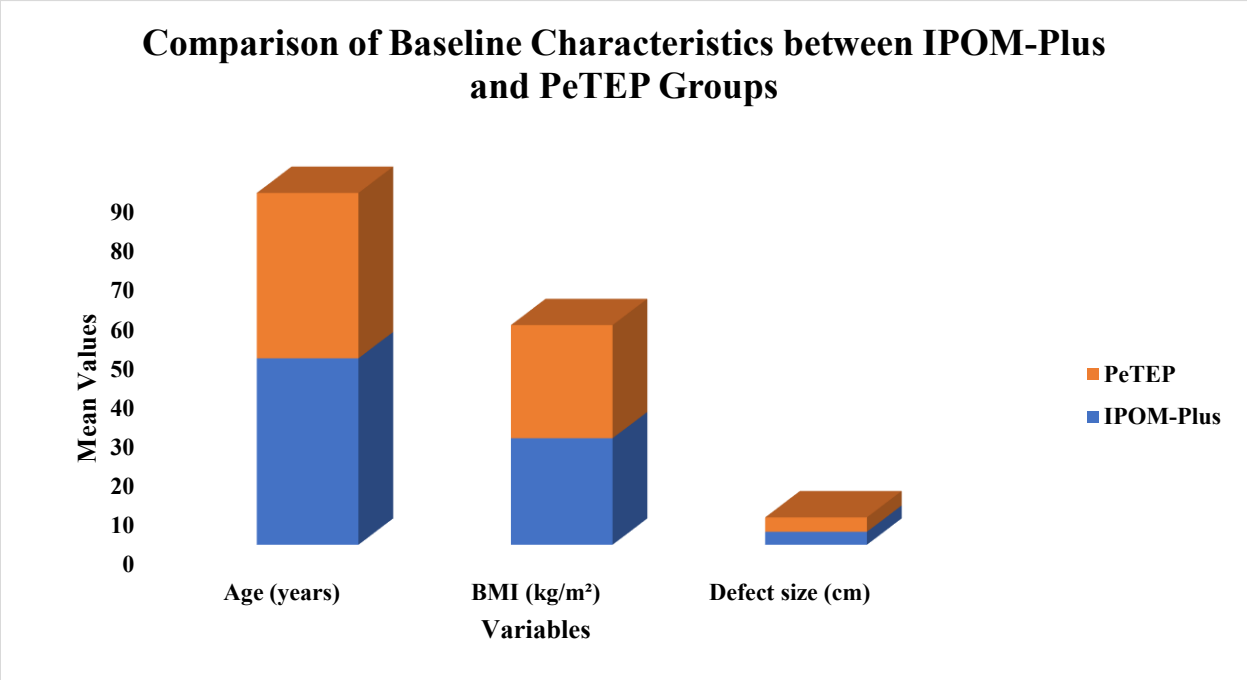


Figure 1. Comparative bar graph showing age, BMI, and defect size between IPOM-Plus and PeTEP groups

3.2 Functional Outcome Comparison

The PeTEP group showed improved postoperative function compared with the IPOM-Plus group. Evaluation of pain using the Visual Analogue Scale (VAS) showed that the PeTEP group had lower pain scores at all recovery intervals. At 6 hours after the surgery, the mean VAS score was 4.16 ± 1.18 in the IPOM-Plus group and 3.55 ± 0.73 in the PeTEP group ($p = 0.057$), which was close to statistical significance. At 24 hours, the PeTEP group showed significantly lower pain scores (1.86 ± 0.51) compared to the IPOM-Plus group (2.41 ± 0.66) ($p = 0.006$).

By 48 hours, the pain score appeared to be lower in the PeTEP group (1.13 ± 0.39 vs 1.45 ± 0.69), but was not significantly different ($p = 0.076$). The PeTEP group had a significantly shorter hospital stay (1.50 ± 0.51 days) than the IPOM-Plus group (2.25 ± 0.44 days) ($p < 0.001$).

There was also a significantly shorter time to return to normal activity after PeTEP repair. The time to return to a normal daily routine was 10.30 ± 2.34 days in the PeTEP group compared to 14.05 ± 3.22 days in the IPOM-Plus group ($p < 0.001$). These results suggest better functional

Table 2. Functional Outcome Comparison

Variable	IPOM-Plus (n=20)	PeTEP (n=20)	p-value
VAS 6 hours	4.16 ± 1.18	3.55 ± 0.73	0.057

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VAS 24 hours	2.41 ± 0.66	1.86 ± 0.51	0.006
VAS 48 hours	1.45 ± 0.69	1.13 ± 0.39	0.076
Hospital stay (days)	2.25 ± 0.44	1.50 ± 0.51	<0.001
Return to activity (days)	14.05 ± 3.22	10.30 ± 2.34	<0.001

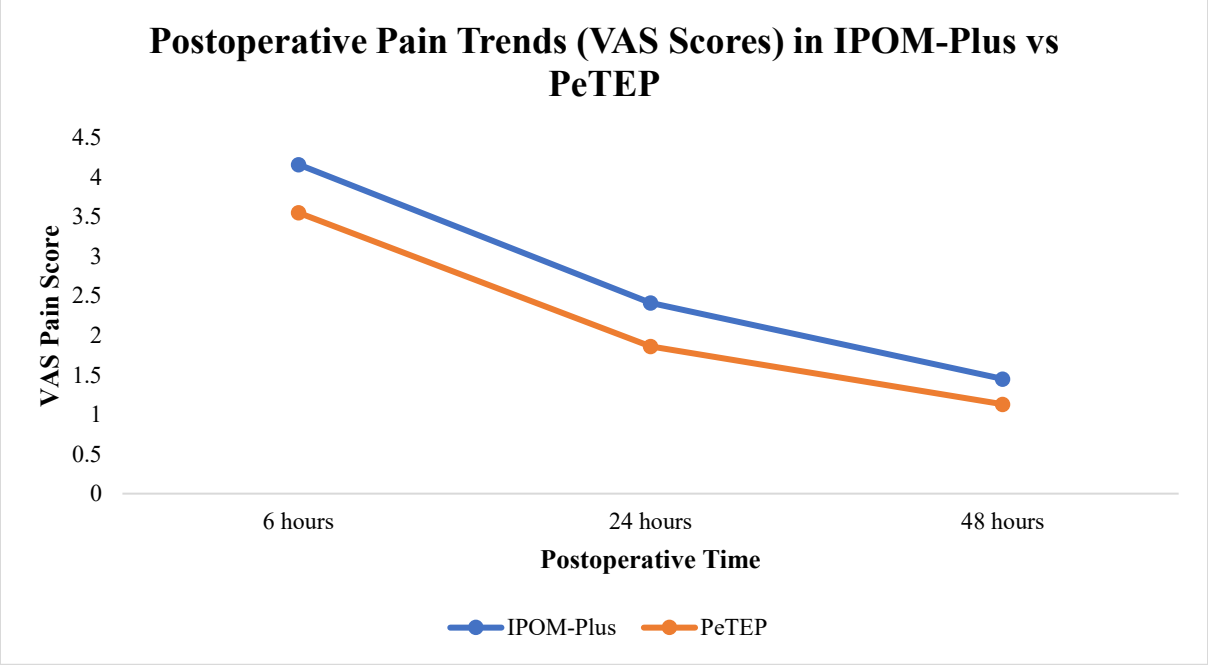


Figure 2. Line graph showing postoperative VAS score trends (6h, 24h, and 48h)

Figure 3. Bar graph comparing return to normal activity between groups

3.3 Operative Characteristics and Symptom Relief

The PeTEP group had a longer operative time due to the complexity of the procedure and the creation of a large retromuscular space for extraperitoneal mesh placement. The mean operative time for IPOM-Plus was 90.05 ± 15.42 minutes, whereas PeTEP required 157.95 ± 15.58 minutes ($p < 0.001$). Despite longer surgery time, PeTEP resulted in better postoperative recovery and faster return to normal physical activity.

Both procedures significantly improved the patient's symptoms after surgery, with pain relief, improved abdominal wall comfort and return to normal daily physical function. But patients in the PeTEP group had improved physical comfort, less pain with physical activities and better abdominal wall function, which translated into quicker return to ambulation and shorter length of hospital stay.

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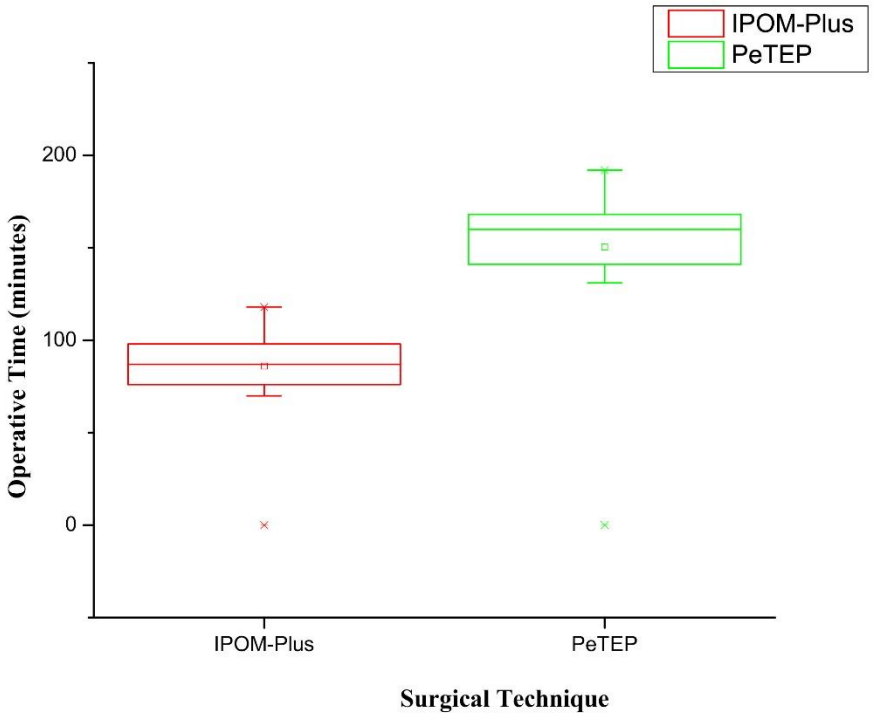


Figure 4. Box plot comparing operative time between IPOM-Plus and PeTEP groups. The PeTEP group demonstrated significantly longer operative duration, with a higher median and wider distribution compared to IPOM-Plus. The boxes represent the interquartile range (IQR), the central line indicates the median, and whiskers denote the range, with outliers shown individually.

3.4 Secondary Findings

Complications that affect function were rare and there were no significant differences in most of the secondary outcomes. Seroma was observed in 1 (5%) patient in the IPOM-Plus group and 2 patients (10%) in the PeTEP group (p = 1.000). Hematoma occurred in 1 patient (5%) in the IPOM-Plus group and 2 patients (10%) in the PeTEP group (p = 1.000).

There was no case of wound infection. Ileus occurred in 4 patients (20%) after IPOM-Plus repair but none in the PeTEP group (p = 0.106). Mesh complications were also more frequent in the IPOM-Plus group, with 2 patients (10%) affected, compared to no complications in the PeTEP group (p = 0.487).

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There was no major recurrence reported in the follow-up period. These results indicate that while the overall complication rate was similar, PeTEP showed a trend towards fewer functional complications.

Table 3. Secondary Outcomes and Early Postoperative Complications

Variable	IPOM-Plus (n=20)	PeTEP (n=20)	p-value
Seroma	1 (5%)	2 (10%)	1.000
Hematoma	1 (5%)	2 (10%)	1.000
Surgical site infection	0	0	—
Ileus	4 (20%)	0	0.106
Mesh complications	2 (10%)	0	0.487

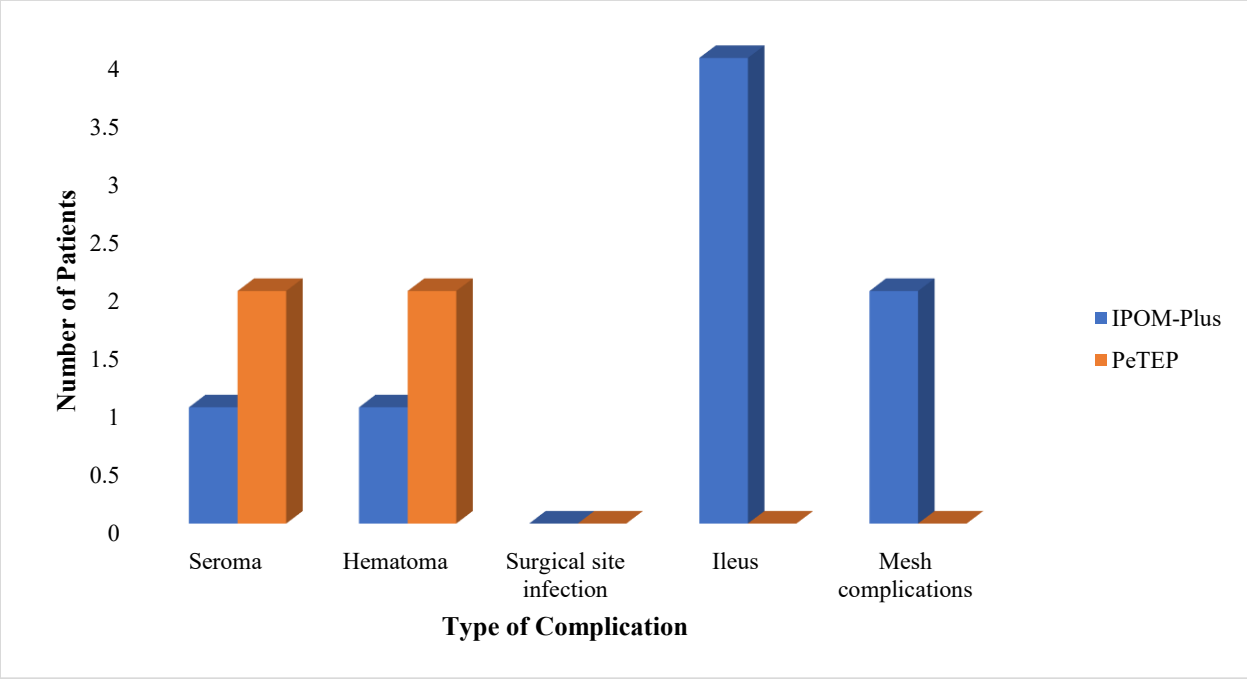


Figure 5. Clustered bar chart showing postoperative complications in both groups

3.5 Key Statistical Findings

The most significant differences between the two groups were operative time, pain at 24 hours, hospital stay and return to normal activity.

VAS pain scores at 24 hours ($p = 0.006$), hospital stay ($p < 0.001$) and return to normal activity ($p < 0.001$) were significantly shorter in the PeTEP repair group compared to IPOM-Plus. This provides strong evidence of improved functional outcome with PeTEP.

While the PeTEP group had longer operative time ($p < 0.001$), this was compensated for by better postoperative recovery and less pain. There were no significant differences in baseline characteristics, seroma, hematoma, or recurrence, suggesting that better functional recovery was

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probably due to better functional restoration of the abdominal wall, rather than differences in baseline characteristics.

Overall, the results suggest that while IPOM-Plus provides effective defect closure and reinforcement, PeTEP offers superior postoperative functional recovery through more anatomical and physiological abdominal wall reconstruction.

4. DISCUSSION

Our study shows that robotic preperitoneal extended totally extraperitoneal (PeTEP) repair of primary ventral hernia has superior functional recovery outcomes to laparoscopic intraperitoneal onlay mesh repair with defect closure (IPOM-Plus), even though the PeTEP repair is associated with a longer operative time. The PeTEP group had significantly reduced postoperative pain scores, quicker return to daily activities, shorter hospital length of stay and superior short-term functional outcomes. While the mean operative time was significantly longer in the PeTEP group, the overall rates of postoperative complications, such as seroma formation, surgical site complications and early recurrence were similar in the two groups. These results indicate that the increased technical difficulty and longer operative times required for retromuscular repair are outweighed by the benefits of improved patient-centered quality of life and enhanced recovery after surgery.

Our results complement the growing evidence of physiological advantages of retromuscular mesh repair over intraperitoneal repair. Our finding of lower postoperative pain and improved return to function in the PeTEP group is consistent with the initial description of the enhanced-view totally extraperitoneal approach (eTEP) [17], which observed very good early results and low rates of chronic pain . Likewise, studies have found that eTEP repair led to reduced postoperative pain and quicker return to work compared with traditional laparoscopic IPOM repair, highlighting the functional benefits of retromuscular repair [18]. Our results further build on this by showing that even relative to IPOM-Plus, which includes closure of the fascial defect and offers improved outcomes compared with bridged IPOM, PeTEP offers better functional outcomes. Similarly, Singh et al. (2025) found that eTEP resulted in less postoperative pain, shorter hospital stay and quicker return to normal activities than IPOM+, consistent with our findings [14]. On the other hand, reports by Pizza et al. (2023) and Kumar et al. (2023), which focused on recurrence and safety of IPOM-Plus, emphasised the success of defect closure, but did not sufficiently address patient-centered outcomes, where we have demonstrated superior outcomes with PeTEP [3,19].

The improved quality of life in the PeTEP group can be attributed to basic biomechanical and anatomical considerations in abdominal wall repair. In contrast to IPOM-Plus, which positions the mesh intraperitoneally in contact with the peritoneum and visceral organs, PeTEP involves placement of the mesh in the retromuscular plane, considered the optimal position for abdominal wall reinforcement. Here, intra-abdominal pressure serves as a natural retention force, resulting in the mesh being compressed on the posterior rectus sheath, allowing diffuse force transmission and mininal tension on fixation sites. Thus, the linea alba is restored and natural abdominal wall

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mechanics are re-established, leading to improved transfer of muscular forces during coughing, bending, lifting and other activities of daily living. In addition, the retromuscular placement of mesh prevents foreign body contact with the intraperitoneal cavity, preventing visceral adhesions and greatly diminishing chronic mesh awareness and foreign body sensation, which can contribute to chronic pain following IPOM repair. The highly vascularised retrorectus plane also facilitates improved mesh integration, ingrowth and long-term stability, along with decreased inflammation and chronic pain. This anatomical advantage may account for the superior functional results seen with PeTEP.

The longer operating time for PeTEP repair is a natural result of the more complex procedure. Creating the retrorectus plane involves careful dissection and preservation of the tissue planes, as well as significant mobilization of the posterior rectus sheath. For larger defects, posterior component separation or transversus abdominis release may be required, which prolongs the time required. On the other hand, IPOM-Plus procedure is technically less challenging and quicker to complete with relatively simple intraperitoneal access, defect closure, and composite mesh fixation. This is also a reflection of the steep learning curve for advanced minimally invasive retromuscular surgery and the role of surgeon experience. Nevertheless, as suggested by our study and the national cohort study by Jensen et al. (2023), longer operation time does not necessarily translate to inferiority of the procedure, as it is compensated for by superior postoperative recovery, pain experience and patient satisfaction [20]. The initial operative time investment seems to result in better recovery and improved long-term function.

Postoperative complications were found to be comparable in both groups in our study. While seroma formation was more common in the PeTEP group, this is an anticipated but usually self-limiting complication of extensive retrorectus dissection that did not cause significant morbidity. We noted a higher incidence of postoperative ileus and mesh-related complications in the IPOM-Plus group, probably due to the physiological drawbacks of intraperitoneal mesh placement and visceral manipulation. There were no significant differences in surgical site infection and early recurrence, which reinforces the PeTEP approach's safety and feasibility. This is in line with the systematic review by Aliseda et al. (2022) which found that eTEP repair is a safe and feasible technique with satisfactory perioperative complications and short-term outcomes [21]. Therefore, despite the additional technical challenges, PeTEP does not seem to impact short-term safety.

This study has significant implications for decision-making in primary ventral hernia repair. Recurrence has long been the main outcome measure of interest in hernia surgery; nevertheless, with the growing interest in abdominal wall reconstruction, it is becoming clear that the other key factors a patient considers in their long-term satisfaction with surgery are pain-free mobility, return of core function, no bulge, and acceptable quality of life. So surgical repair should not only be based on recurrence but also on the anticipated level of recovery. For young, fit, and working patients, in whom abdominal wall function and early return to full activity are of particular significance, PeTEP offers considerable benefits. Returning the abdominal wall to its original

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biomechanics, with reduced pain and mesh-related sensations, could enhance patient satisfaction and quality of life.

This study has many strengths. It compares two novel minimally invasive approaches in a well-defined group of patients with primary umbilical and paraumbilical hernias and thus avoids the potential confounding factors associated with the inclusion of incisional or recurrent hernias. Moreover, the emphasis on functional outcomes rather than recurrence solely is an important addition to the existing body of literature and highlights the shift to more patient-centered outcomes in modern hernia surgery. However, some limitations should be noted. The study was a single-center, non-randomized, single-arm study of limited sample size, which may limit its generalizability and increase the risk of sampling bias. Moreover, we were unable to assess long-term results, such as chronic pain, mesh complications, and recurrence, which are essential for the longevity of the procedure, due to limited follow-up in the short postoperative period.

In summary, while both IPOM-Plus and PeTEP are safe and effective minimally invasive approaches to primary ventral hernia repair, the current study shows that PeTEP offers better short-term functional outcomes, with less postoperative pain, shorter hospital stay, quicker return to normal life and better abdominal wall functionality. Although PeTEP procedures have a longer operating time, the physiological benefits of anatomical reconstruction of the abdominal wall seem to compensate for increased technical complexity. This study provides evidence for PeTEP as the preferred option for patients for whom improved postoperative functional outcomes and quality of life is a key consideration. Prospective randomized studies with long-term follow-up and multiple points of patient-reported quality of life and functional outcomes are needed to confirm these results and provide a definitive guide to the selection of a technique.

5. CONCLUSION

This study shows that PeTEP (Preperitoneal Enhanced-view Totally Extraperitoneal Repair) technique is superior to IPOM-Plus regarding functional outcomes in the repair of primary ventral hernias, especially umbilical and paraumbilical hernias. Despite successful repair of the hernia, equivalent short-term complications and no difference in early recurrence, PeTEP consistently demonstrated superior recovery and patient-reported outcomes.

PeTEP patients reported significantly less pain, particularly in the immediate post-operative period, and a shorter length of stay in hospital and a significantly quicker return to normal activities. This suggests improved abdominal wall function and improved quality of life after surgery. PeTEP restores the anatomical structure and biomechanics of the abdominal wall by placing mesh in the retromuscular position, which contributes to better transmission of force and less foreign body sensation and chronic pain in contrast to intraperitoneal mesh placement in IPOM-Plus. However, despite IPOM-Plus being an improvement over conventional bridged IPOM with closure of the defect and decrease in postoperative bulging, the foreign body sensation of mesh placement in the peritoneal cavity may still lead to pain, mesh sensation and impaired function.

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Although a longer operative time is required for PeTEP due to the learning curve and technical aspects of the procedure, the benefits in terms of function far outweigh this disadvantage. The superior rehabilitation and patient satisfaction achieved with PeTEP make it an attractive procedure, especially in young and fit patients, those who are in the workforce, and those who exercise and engage in heavy manual labour.

Given these results, PeTEP should be given serious consideration as a minimally invasive surgical option for primary ventral hernia repair if quality of life and the ability to return to normal function is desired over convenience.

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