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Original Research Article

Comparison of Onlay versus Sublay Mesh Placement in Umbilical Hernia Repair: A Prospective Randomized Controlled Study

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Abstract

Background: Umbilical hernia repair is one of the most common surgical procedures worldwide. The optimal plane for mesh placement remains controversial, with both onlay and sublay techniques being widely practiced.

Methods: 124 patients with umbilical hernias (defect size 2-5 cm) were randomly assigned to either onlay (n=62) or sublay (n=62) mesh placement groups. Primary outcomes included operative time, postoperative pain scores, seroma formation, wound infection, and recurrence rates. Patients were followed for 24 months postoperatively.

Results: The mean operative time was significantly longer in the sublay group (78.4 ± 12.3 minutes) compared to the onlay group (54.2 ± 9.8 minutes, $p<0.001$). Postoperative pain scores at 24 hours were lower in the sublay group (4.2 ± 1.1 vs. 5.8 ± 1.3, $p<0.001$). Seroma formation occurred more frequently in the onlay group (29.0% vs. 11.3%, $p=0.012$). Wound infections were comparable between groups (8.1% vs. 6.5%, $p=0.704$). At 24-month follow-up, recurrence rate was significantly lower in the sublay group (3.2% vs. 14.5%, $p=0.028$).

Conclusion: Sublay mesh placement in umbilical hernia repair demonstrates superior outcomes with lower recurrence rates, reduced seroma formation, and decreased postoperative pain despite longer operative times. These findings support the preference for sublay technique in suitable patients.

Keywords: umbilical hernia, mesh repair, onlay technique, sublay technique, postoperative complications, hernia recurrence.

INTRODUCTION

Umbilical hernias represent approximately 10-15% of all abdominal wall hernias and affect both pediatric and adult populations [1]. While small umbilical hernias may be managed conservatively, defects larger than 2 cm typically require surgical intervention to prevent complications such as incarceration and strangulation [2]. The evolution of hernia repair has shifted from primary suture techniques to mesh-based repairs, which have demonstrated significantly lower recurrence rates [3]. The fundamental principle of mesh repair involves reinforcement of the abdominal wall defect with prosthetic material, but the optimal anatomical plane for mesh placement remains a subject of ongoing debate [4]. The two most commonly employed techniques are onlay mesh placement, where the mesh is positioned superficial to the anterior rectus sheath, and sublay (retromuscular or preperitoneal) placement, where the mesh is positioned deep to the rectus muscles or

in the preperitoneal space [5]. Onlay mesh placement offers technical simplicity and shorter operative times, making it an attractive option for many surgeons [6]. However, this technique has been associated with higher rates of seroma formation and wound-related complications due to the extensive subcutaneous dissection required [7]. Additionally, the onlay position may be mechanically disadvantageous as it does not benefit from intra-abdominal pressure contributing to mesh fixation [8].

Conversely, sublay mesh placement positions the prosthetic material in a well-vascularized plane, potentially promoting better tissue integration [9].

The sublay technique theoretically benefits from intra-abdominal pressure pushing the mesh against the abdominal wall, creating a mechanical advantage [10]. Recent meta-analyses have suggested superior outcomes with sublay placement in ventral hernia repairs, but specific data comparing these techniques exclusively in umbilical hernias remain limited [11].

Several retrospective studies have attempted to address this question, but the heterogeneity in patient populations, hernia sizes, and follow-up protocols has led to conflicting conclusions [12]. A systematic review by Holihan et al. identified the need for prospective randomized trials specifically evaluating mesh placement techniques in umbilical hernia repair [13]. Despite the high prevalence of umbilical hernias and the widespread use of mesh repair, there is a paucity of Level I evidence comparing onlay and sublay techniques specifically for this anatomical location. The unique anatomical characteristics of the umbilical region, including limited fascial overlap and proximity to skin, may influence outcomes differently than in other ventral hernia locations [14].

Aim of the study: This prospective randomized controlled trial was designed to compare the clinical outcomes, postoperative complications, and long-term recurrence rates between onlay and sublay mesh placement techniques in patients undergoing elective umbilical hernia repair.

Materials and Methods

Study Design and Setting: This prospective, randomized controlled trial was conducted at the Department of General Surgery.

Sample Size Calculation: Sample size calculation was based on an expected 15% difference in recurrence rates between the two groups, with alpha set at 0.05 and power at 80%. This yielded a minimum requirement of 56 patients per group. Accounting for a 10% dropout rate, we aimed to recruit 62 patients in each arm, totaling 124 patients.

Inclusion and Exclusion Criteria

Inclusion Criteria: Patients aged 18-70 years with primary umbilical hernias, defect size between 2-5 cm measured intraoperatively, American Society of Anesthesiologists (ASA) physical status classification I-III, and ability to provide informed consent.

Exclusion Criteria: Emergency presentations with incarceration or strangulation, recurrent umbilical hernias, multiple concurrent hernias requiring repair, active skin or systemic infection, pregnancy, morbid obesity (BMI >40 kg/m^2), chronic immunosuppression, malignancy, inability to attend follow-up visits, and patient refusal to participate.

Randomization and Blinding: Eligible patients were randomly assigned to either the onlay or sublay group using computer-generated random numbers in a 1:1 allocation ratio. Randomization was performed using sealed opaque envelopes opened in the operating room after induction of anesthesia. Due to the nature of surgical intervention, surgeons could not be blinded to the technique. However,

outcome assessors and data analysts were blinded to group allocation.

Surgical Techniques: All procedures were performed under general anesthesia by experienced surgeons (>50 hernia repairs annually). Prophylactic antibiotics (cefazolin 2g intravenously) were administered 30 minutes before incision.

Onlay technique: An elliptical incision around the umbilicus was made, and the hernia sac was dissected. The fascial defect was identified and reduced. The fascial edges were approximated with continuous polypropylene sutures. A lightweight polypropylene mesh (10×15 cm) was placed over the anterior rectus sheath with minimum 3-4 cm overlap in all directions and fixed with interrupted non-absorbable sutures. Subcutaneous drains were placed routinely.

Sublay technique: Similar skin incision and sac reduction were performed. The posterior rectus sheath was opened, and the retromuscular space was developed by blunt dissection. The fascial defect was closed with continuous polypropylene sutures.

A lightweight polypropylene mesh (10×15 cm) was placed in the retromuscular/preperitoneal plane with adequate overlap and fixed with interrupted absorbable sutures. The anterior rectus sheath was closed over the mesh. Drains were placed selectively based on extent of dissection.

Postoperative Management: All patients received standardized postoperative care including analgesics (paracetamol and NSAIDs with opioids as rescue medication), early mobilization within 6 hours, and prophylactic antibiotics for 24 hours. Drains were removed when output was <30 mL/24 hours. Patients were discharged when pain was controlled with oral medications and they were ambulatory.

Outcome Measures

Primary outcomes: Recurrence rate at 24 months, defined as clinically palpable or imaging-confirmed defect at the repair site.

Secondary outcomes: Operative time (skin incision to closure), intraoperative complications, postoperative pain assessed using Visual Analog Scale (VAS, 0-10) at 6, 12, 24, and 48 hours, seroma formation (clinically detectable fluid collection confirmed by ultrasonography), wound infection (based on CDC criteria), hematoma formation, hospital length of stay, time to return to normal activities, and patient satisfaction scores at 6 months.

Follow-up Protocol: Patients were evaluated at 1 week, 1 month, 3 months, 6 months, 12 months, and 24 months postoperatively. Clinical examination was performed at each visit. Ultrasonography was performed at 3, 12, and 24 months or when recurrence was suspected clinically.

Statistical Analysis: Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation and compared using independent t-tests. Categorical variables were expressed as frequencies and percentages and compared using chi-square test or Fisher's exact test as appropriate.

A p-value <0.05 was considered statistically significant. Intention-to-treat analysis was performed for all randomized patients.

Results

Patient Demographics and Baseline Characteristics: A total of 156 patients with umbilical hernias were assessed for eligibility. Of these, 32 patients were excluded (18 did not meet inclusion criteria, 9 declined participation, and 5 for other reasons). The remaining 124 patients were randomly allocated to onlay (n=62) or sublay (n=62) groups. During the study period, 3 patients in the onlay group and 2 patients in the sublay group were lost to follow-up. Complete 24-month follow-up

data were available for 119 patients (95.9%). The mean age of participants was 46.8 ± 12.4 years in the onlay group and 48.2 ± 11.9 years in the sublay group (p=0.516). Both groups were comparable in terms of gender distribution, body mass index, comorbidities, and hernia defect size (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	Onlay Group (n=62)	Sublay Group (n=62)	p-value
Age (years), mean ± SD	46.8 ± 12.4	48.2 ± 11.9	0.516
Male gender, n (%)	34 (54.8)	37 (59.7)	0.584
BMI (kg/m²), mean ± SD	28.3 ± 3.6	27.9 ± 3.8	0.542
Diabetes mellitus, n (%)	12 (19.4)	14 (22.6)	0.656
Hypertension, n (%)	18 (29.0)	21 (33.9)	0.555
Smoking, n (%)	15 (24.2)	13 (21.0)	0.661
ASA I/II/III, n	28/26/8	30/24/8	0.897
Defect size (cm), mean ± SD	3.2 ± 0.8	3.4 ± 0.9	0.198
Previous abdominal surgery, n (%)	22 (35.5)	19 (30.6)	0.561

BMI: Body Mass Index; ASA: American Society of Anesthesiologists; SD: Standard Deviation

Operative Outcomes: The mean operative time was significantly longer in the sublay group compared to the onlay group (78.4 ± 12.3 minutes vs. 54.2 ± 9.8 minutes, p<0.001). Intraoperative blood loss was minimal in both groups with no significant difference (45.3 ± 18.2 mL in onlay vs. 52.6 ± 21.4 mL in sublay, p=0.052). No major intraoperative complications occurred in either group. All procedures were completed successfully without conversion or modification of technique.

Postoperative Pain: Visual Analog Scale pain scores were significantly lower in the sublay group at all measured time points. At 6 hours postoperatively, the onlay group had a mean pain score of 6.8 ± 1.5 compared to 5.3 ± 1.4 in the sublay group (p<0.001). This difference persisted at 12 hours (6.2 ± 1.3 vs. 4.9 ± 1.2, p<0.001), 24 hours (5.8 ± 1.3 vs. 4.2 ± 1.1, p<0.001), and 48 hours (4.5 ± 1.2 vs. 3.1 ± 0.9, p<0.001). Total analgesic requirement was higher in the onlay group (142.5 ± 38.6 mg morphine equivalents vs. 98.4 ± 32.1 mg, p<0.001).

Postoperative Complications: Early postoperative complications are summarized in Table 2. Seroma formation was significantly more common in the onlay group (18 patients, 29.0%) compared to the sublay group (7 patients, 11.3%, p=0.012). Most seromas resolved spontaneously with conservative management, but 4 patients in the onlay group and 1 patient in the sublay group required aspiration. Wound infection rates were comparable between groups, occurring in 5 patients (8.1%) in the onlay group and 4 patients (6.5%) in the sublay group (p=0.704). All infections were superficial and resolved with antibiotics and local wound care without mesh removal. Hematoma formation occurred in 3 patients (4.8%) in the onlay group and 2 patients (3.2%) in the sublay group (p=0.648), all managed conservatively.

Table 2: Postoperative Complications and Short-term Outcomes

Outcome	Onlay Group (n=62)	Sublay Group (n=62)	p-value
Operative time (min), mean ± SD	54.2 ± 9.8	78.4 ± 12.3	<0.001
VAS pain score at 24h, mean ± SD	5.8 ± 1.3	4.2 ± 1.1	<0.001
Seroma, n (%)	18 (29.0)	7 (11.3)	0.012
Wound infection, n (%)	5 (8.1)	4 (6.5)	0.704
Hematoma, n (%)	3 (4.8)	2 (3.2)	0.648
Hospital stay (days), mean ± SD	2.8 ± 0.9	3.2 ± 1.1	0.034
Return to activities (days), mean ± SD	18.4 ± 4.6	16.2 ± 4.2	0.006
Chronic pain at 6 months, n (%)	8 (12.9)	3 (4.8)	0.109

VAS: Visual Analog Scale; SD: Standard Deviation

Hospital Stay and Recovery: Mean hospital length of stay was slightly but significantly shorter in the onlay group (2.8 ± 0.9 days vs. 3.2 ± 1.1 days, p=0.034). However, patients in the sublay group returned to normal activities sooner (16.2 ± 4.2 days vs. 18.4 ± 4.6 days, p=0.006).

Long-term Outcomes and Recurrence: At 24-month follow-up, the primary outcome of hernia recurrence showed significant differences between groups (Table 3). The onlay group had 9 recurrences (14.5%) compared to only 2 recurrences (3.2%) in the sublay group (p=0.028). All recurrences were confirmed by both clinical examination and ultrasonography.

The median time to recurrence detection was 14.5 months (range 8-22 months) in the onlay group and 16.0 months (range 13-19 months) in the sublay group.

Chronic pain (defined as pain persisting beyond 3 months) at 6-month follow-up was reported by 8 patients (12.9%) in the onlay group compared to 3 patients (4.8%) in the sublay group, though this difference did not reach statistical significance (p=0.109). Patient satisfaction scores at 6 months were significantly higher in the sublay group (8.6 ± 1.2 vs. 7.8 ± 1.6 on a 0-10 scale, p=0.002).

Table 3: Long-term Outcomes at 24-Month Follow-up

Outcome	Onlay Group (n=62)	Sublay Group (n=62)	p-value
Hernia recurrence, n (%)	9 (14.5)	2 (3.2)	0.028
Mesh infection, n (%)	1 (1.6)	0 (0.0)	0.315
Mesh migration, n (%)	2 (3.2)	1 (1.6)	0.558
Chronic pain (VAS >3), n (%)	8 (12.9)	3 (4.8)	0.109
Patient satisfaction (0-10), mean ± SD	7.8 ± 1.6	8.6 ± 1.2	0.002
Quality of life score, mean ± SD	82.4 ± 12.6	88.3 ± 10.8	0.006
Cosmetic satisfaction (0-10), mean ± SD	7.2 ± 1.8	8.1 ± 1.5	0.003

VAS: Visual Analog Scale; SD: Standard Deviation

One patient in the onlay group (1.6%) developed mesh infection requiring mesh removal at 8 months postoperatively.

No mesh infections occurred in the sublay group. Mesh migration, detected by ultrasonography, occurred in 2 patients (3.2%) in the onlay group and 1 patient (1.6%) in the sublay group (p=0.558), but none required intervention.

Discussion

This prospective randomized controlled trial provides valuable evidence comparing onlay and sublay mesh placement techniques specifically for umbilical hernia

repair. Our findings demonstrate that sublay mesh placement offers superior long-term outcomes with significantly lower recurrence rates (3.2% vs. 14.5%, p=0.028), reduced seroma formation (11.3% vs. 29.0%, p=0.012), and improved postoperative pain profiles despite requiring longer operative times.

The observed recurrence rate of 14.5% in the onlay group is consistent with previously reported rates in the literature [15]. Muysoms et al. reported recurrence rates ranging from 10-18% following onlay mesh repair in a multicenter study of ventral hernias [16]. Our sublay group's recurrence rate of 3.2% compares favorably with published data, where retromuscular mesh placement has demonstrated recurrence rates of 2-6% in medium-term follow-up [17].

The higher recurrence rate in the onlay group may be attributed to several biomechanical factors. Onlay mesh placement positions the prosthetic superficial to the fascia, where intra-abdominal pressure works against the repair rather than supporting it [4]. Additionally, the extensive subcutaneous dissection required for onlay placement may compromise tissue perfusion and wound healing, potentially affecting mesh integration [7]. In contrast, sublay positioning benefits from the intra-abdominal pressure pressing the mesh against the abdominal wall, creating a mechanical advantage that distributes forces more evenly across the repair [10].

The significantly higher rate of seroma formation in our onlay group (29.0% vs. 11.3%) aligns with findings from previous studies. Korenkov et al. reported seroma rates of 25-35% following onlay mesh placement in ventral hernia repairs [18]. The extensive subcutaneous dissection and creation of large tissue planes in the onlay technique likely contribute to increased fluid accumulation. The sublay approach, by preserving subcutaneous tissue integrity and minimizing dead space, appears to reduce this complication.

Postoperative pain outcomes favored the sublay technique across all measured time points, with statistically significant differences persisting through 48 hours postoperatively. This finding contrasts with the common perception that deeper dissection would result in more pain. The reduced pain in the sublay group may be explained by preservation of cutaneous nerve branches that traverse the subcutaneous tissue, which are more likely to be disrupted during extensive subcutaneous dissection in the onlay technique. These results support findings by Albino et al., who reported lower chronic pain rates with retromuscular mesh placement [11].

The longer operative time for sublay repair (78.4 ± 12.3 minutes vs. 54.2 ± 9.8 minutes) represents a trade-off for the improved outcomes. This additional time reflects the technical complexity of developing the retromuscular plane and achieving adequate mesh overlap in this space. However, the clinical significance of this difference must be weighed against the substantial benefits in recurrence reduction and complication rates. Similar operative time differences have been reported in comparative studies of mesh placement techniques [9].

Interestingly, despite longer operative times and slightly longer hospital stays in the sublay group, patients returned to normal activities significantly sooner (16.2 vs. 18.4 days, p=0.006). This seemingly paradoxical finding may be explained by reduced pain and lower complication rates, particularly seroma formation, which often delays return to activity. The higher patient satisfaction scores in the sublay group (8.6 vs. 7.8, p=0.002) further support the clinical relevance of these findings. Our wound infection rates were comparable between groups (6.5-8.1%) and consistent with published data for clean-contaminated hernia repairs [2]. The similarity in

infection rates suggests that the deeper dissection required for sublay placement does not increase infectious risk when appropriate prophylactic measures are employed.

The study has several strengths, including its prospective randomized design, standardized surgical techniques performed by experienced surgeons, comprehensive outcome assessment, and adequate follow-up duration. The 24-month follow-up period is appropriate for detecting the majority of hernia recurrences, as studies have shown that approximately 70% of recurrences manifest within the first two years [13].

Several limitations should be acknowledged. First, the single-center design may limit generalizability. Second, surgeon blinding was not possible due to the nature of surgical intervention, potentially introducing performance bias. Third, the 24-month follow-up, while adequate, may not capture all late recurrences, as some may manifest beyond this timeframe. Fourth, we did not evaluate the cost-effectiveness of the two approaches, which would be valuable for healthcare decision-making. Finally, our study included only primary umbilical hernias with defects between 2-5 cm, limiting applicability to larger or recurrent hernias.

The clinical implications of our findings are significant. While onlay mesh placement offers technical simplicity and shorter operative times, the substantially higher recurrence rate and increased early complications make it a less favorable option for most patients.

The sublay technique, despite requiring greater technical expertise and longer operative duration, provides superior long-term outcomes that justify its preferential use when anatomically feasible and surgeon expertise permits. These findings support recent guidelines suggesting retromuscular mesh placement as the preferred technique for ventral hernia repairs [12]. Future research should focus on long-term cost-effectiveness analyses comparing these techniques, assessment of outcomes beyond 24 months, and evaluation of quality of life measures using validated instruments. Additionally, studies examining the learning curve for sublay technique and its applicability in community settings would be valuable. Investigation of biomaterial characteristics and their interaction with different tissue planes may further optimize outcomes.

Conclusion

This prospective randomized controlled trial demonstrates that sublay mesh placement in umbilical hernia repair offers significant advantages over the onlay technique. Despite requiring longer operative times, sublay placement results in substantially lower recurrence rates, reduced seroma formation, decreased postoperative pain, and improved patient satisfaction at 24-month follow-up. The superior biomechanical properties and reduced complications associated with sublay mesh positioning support its adoption as the preferred technique for umbilical hernia repair in appropriate patients. Surgeons should consider these evidence-based findings when selecting mesh placement strategies, recognizing that the additional technical complexity and operative time of the sublay approach are offset by meaningful improvements in patient outcomes. These results contribute to the growing body of evidence supporting retromuscular mesh placement in ventral hernia surgery and should inform clinical practice guidelines and surgical training programs.

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