Section: General Surgery

Original Research Article

COMPARATIVE STUDY BETWEEN INLAY VERSUS SUBLAY VERSUS ONLAY MESH REPAIR IN PARAUMBILICAL HERNIA

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ABSTRACT

Background: Paraumbilical hernias are a common type of ventral abdominal wall hernia in adults, often requiring surgical repair. The choice of mesh placement technique—onlay, inlay, or sublay—plays a critical role in postoperative outcomes. This study compares these three techniques to evaluate their clinical efficacy, safety, and complication profiles. The objective is to compare and analyze the outcomes of inlay, onlay, and sublay mesh repair techniques in the surgical management of paraumbilical hernias with respect to operative time, hospital stay, postoperative pain, and complications. **Materials and Methods:** A prospective observational study was conducted involving 50 adult patients with primary paraumbilical hernia. Patients underwent mesh repair using one of three techniques: inlay (n=1), onlay (n=21), or sublay (n=28). Data on demographic characteristics, comorbidities, operative parameters, and postoperative outcomes were collected and analyzed using appropriate statistical methods. **Result:** The sublay group demonstrated significantly longer operative time (mean: 82.1 ± 6.4 min) compared to onlay (65.5 ± 4.2 min) and inlay (45 min). However, sublay repair was associated with shorter postoperative stay (mean: 7.4 ± 2.9 days) and fewer complications (e.g., wound infections, seroma, mesh exposure) compared to onlay and inlay. The recurrence rate was lowest in the sublay group. Pain scores were also lower in sublay repair, indicating better postoperative comfort. **Conclusion:** Sublay mesh repair offers superior outcomes in terms of reduced postoperative morbidity and shorter recovery compared to onlay and inlay techniques. Although technically more demanding, it is the most effective and preferred method for paraumbilical hernia repair based on the present study findings.

INTRODUCTION

Paraumbilical hernias are among the most common types of hernias in the abdomen, accounting for about 10–30% of all abdominal hernias in adults.[1] They happen because of a weakness or gap in the linea alba (the tissue near the belly button), allowing fat or organs to bulge through. Unlike umbilical hernias seen in babies, which often heal without surgery, paraumbilical hernias in adults usually need surgery because they tend to get bigger and can cause serious problems like trapping (incarceration), cutting off blood supply (strangulation), and intestinal blockage.[2] The treatment of paraumbilical hernias has changed greatly over time. Earlier, surgeons mostly used stitches (primary suture repair), but this had very high failure rates, with hernias coming back in 25–63% of cases.[3] In the 1950s, Usher and colleagues introduced the use of prosthetic mesh, which reduced recurrence rates significantly and made mesh-based, tension-free repair the standard.[4] Today, using mesh for hernia repair is widely accepted, with recurrence rates falling to around 1–10%, depending on the technique used.[5,6-15]

In the onlay method, the mesh is placed on top of the rectus sheath after closing the defect. It is simple and avoids damage to internal organs, making it easier for many surgeons. However, this method is associated with more wound problems like fluid collection (seroma), infections, and sometimes the mesh shifting from its place.[7] Also, the mesh may not

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integrate well with deeper layers, which might weaken the repair over time.

The sublay method (also called retrorectus or retromuscular repair) places the mesh between the back of the rectus muscle and its sheath or deeper near the peritoneum. This technique has several advantages: it protects the mesh from the outside environment, the body's own pressure helps hold the mesh in place, and it allows a wider area of coverage.[8,9] Studies and reviews suggest that sublay repairs have fewer complications and lower recurrence rates compared to other methods.[10,16-25]

Choosing the best method also depends on the patient. Factors like the size of the hernia, obesity, other illnesses, previous surgeries, and lifestyle must be considered.[11,12] In addition, the surgeon's experience and preference influence which technique is used, which can affect the results.[26-32]

Aim: The main aim of the study is to compare the outcome of the patient undergoing inlay.

MATERIALS AND METHODS

Study Design

- Prospective observational clinical study with longitudinal follow-up.
- Single-center surgical outcomes research design.

Study Setting

- Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital (GMKMCH), Salem, Tamil Nadu, India.
- Tertiary care teaching hospital with specialized hernia treatment facilities.

Study Duration

- 24-month period from July 2023 to July 2025.
- Patient recruitment phase: July 2023 to January 2025.
- Follow-up phase extending to July 2025 (minimum 6-month follow-up for all participants).

Sample Size Determination

- Sample size of 50 patients was calculated based on:
- Expected paraumbilical hernia prevalence of 15% among ventral hernias.
- Confidence level of 95% with a margin of error of 10%.
- Anticipated attrition rate of 10%.
- Power analysis conducted to ensure adequacy for detecting clinically significant outcome differences.

Patient Selection

Inclusion Criteria

- Adult patients aged 20-70 years.
- Primary paraumbilical hernia confirmed by both clinical examination and radiological assessment.
- Patients medically fit for elective surgery under general or regional anesthesia (ASA grade I-III).
- Willingness to participate and comply with follow-up protocols.

Exclusion Criteria

- Patients aged below 20 years or above 70 years.
- Recurrent paraumbilical hernia.
- Patients with complicated hernias requiring emergency surgery.
- Severe comorbidities contraindicating elective surgery (ASA grade IV or higher).
- Concurrent presence of other abdominal wall hernias requiring repair.
- Patients unable to provide informed consent or comply with follow-up protocols.
- Pregnancy or planned pregnancy during the study period.

Conflict of Interest

- All investigators declare no financial or non-financial conflicts of interes.

RESULTS

Fifty study participants were included in the study with an objective to compare the outcome of the patient undergoing Inlay, Sublay and Onlay mesh repair for paraumbilical hernia.

Table 1: Age distribution of the study participants

	Age in years
Mean	47.48
SD	12.65
Median	50.0
Minimum	19.0

The mean age of the participants was 47 + 12.65 years ranging from 19 to 70 years and majority of the participants were in the age group of 30 to 50 years. The table below depict the age distribution of the study participants.

Gender distribution of the study participants: Majority of the study participants were male 54% (n=27) and the remaining 46% (n=23) were females the table below depict the gender distribution among the study participants.

Table 2: Gender distribution of the study participants

Gender	Frequency	Percentage
Male	27	54.0
Female	23	46.0
Total	50	100.0

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Presenting complaints: All the study participants presented with complaints of swelling over para-umbilical region, and a majority of them had swelling in the supra-umbilical region (36%), followed by Infra-umbilical regions (28%). The table and figure below depict the presenting region of swelling among the study participants.

Comorbid illness: Of the study participants 9 (18%) reported to have diabetes militants, 6 (12%) individuals have systemic hypertension and 2 (4%) had coronary artery disease. The table below depict the distribution of comorbid illness among the study participants.

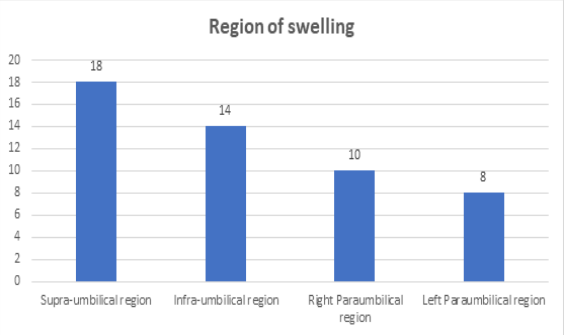

Figure 1: Region of presenting complaints.

Table 3: Comorbid illness

Comorbid illness	Frequency	Percentage
DM	9	18.0
SHT	6	12.0
CAD	2	4.0
HbsAg	1	2.0
Hypothyroidism	1	2.0
Cancer Cervix	1	2.0

Past surgical history: Majority of the study participants 92 % (n=46) had no previous surgical history. Of those who had previous surgical history one individual each had appendicectomy, Epigastric Hernia repair, Hysterectomy and Classical Caesarian section.

Length of hospital stay: Length of hospital stay was estimated from the date of admission and date of discharge of the study participants. The mean Length of hospital stay among the study participants was 14.6 + 6.6 days, ranging from 6 days to 38 days. The table below depict the Length of hospital stay (in days) among the study participants.

Table 4: Length of hospital stay among the study participants

	Length of hospital stay (in days)
Mean	14.6
SD	6.6
Median	13.0
Minimum	6.0
Maximum	38.0

Post-operative stay days: The post-operative stay days was estimated from the date of surgery and the date of discharge. The mean post-operative stay daysamong the study participants was 9.42 + 5.73 days, ranging from 2 days to 30 days. The table below depict the post-operative stay days among the study participants.

Table 5: Post-operative stay days among the study participants

	Post-operative stay days
Mean	9.42
SD	5.73
Median	8.0
Minimum	2.0
Maximum	30.0

Post-operative Pain score: The post-operative pain scores was assessed using VAS scores. The mean post-operative VAS score among the study participants was 3.68 + 1.5, ranging from 1 to 7. The figure below depict the post-operative pain scores among the study participants.

Post-Operative Complications: Majority of the study participants (84%) had uneventful post-operative period, 6% had wound gaping and mesh exit, 4% had seroma and surgical site infection. The table below depict the post-operative complications among the study participants.

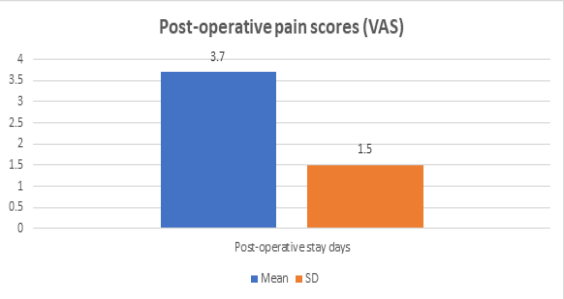

Figure 2: Post-operative pain scores among the study participants

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Table 6: Post-operative complications among the study participants

Post-operative Complications	Frequency	Percentage
Drain kept for 10 days	1	2.0
Seroma	2	4.0
Surgical site infection	2	4.0
Uneventful	42	84.0
Wound gaping, mesh exposed	3	6.0
Total	50	100.0

Group distribution as per the procedure underwent by the study participants: The study participants, based on the type of mesh repair they underwent, is classified into 3 groups, as shown in the table. 28 (56%) participants had SUBLAY mesh repair, 21 (42%) participants had ONLAY mesh repair and 1 (2%) had INLAY mesh repair.

Table 7: Group distribution as per the procedure

Type of Mesh repair	Frequency	Percentage
INLAY	1	2.0
ONLAY	21	42.0
SUBLAY	28	56.0
Total	50	100.0

Comparison of Operative time among the study groups: Operative time in minutes was estimated for all participants of all the three study groups. The mean operative time for INLAY group was 45 minutes, for ONLAY group, it was 65.5 + 4.2 minutes, ranging from 60 minutes to 75 minutes. Similarly, the operative time was highest among the three groups, in the SUBLAY group with 82.1 + 6.4 minutes ranging from 70 to 95 minutes. This difference in operative time among the study groups was statistically significant with a p-value<0.05, by ANOVA test statistics.

The table and figure below depict the operative time (in minutes) among the study groups and its association levels.

Table 8: Comparison of Operative time among the study groups

	Operative time in minutes				
	Mean	**SD**	**Minimum**	**Maximum**	**p-value**
INLAY (n=1)	45.0	-	45.0	45.0	<0.0001*
ONLAY (n=21)	65.5	4.2	60.0	75.0	
SUBLAY (n=28)	82.1	6.4	70.0	95.0	
Total	74.4	10.8	45.0	95.0	

*p-vale< 0.05- Statistically significant

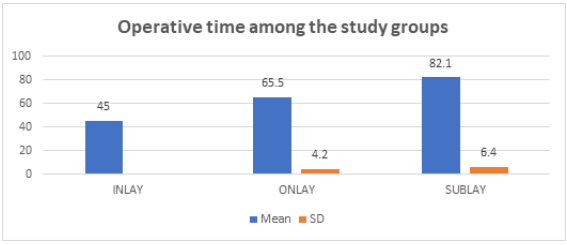

Figure 3: Comparison of Operative time among the study groups

Comparison of Length of hospital stay among the study groups: Length of hospital stay in days was estimated for all participants of all the three study groups. The mean length of hospital of stay was highest in the INLAY group (18 days). The mean length of stay in the ONLAY group was 17.95 + 8.2 days, ranging from 8 to 38 days. The mean length of hospital stay was lowest in the SUBLAY group, with 12.0 + 3.54 days, ranging from 6 to 21 days. This difference in length of hospital stay among the study groups was statistically significant with a p-value<0.05, by ANOVA test statistics.

The table below depict the length of hospital stay (in days) among the study groups and its association levels.

Table 9: Comparison of Length of hospital stay among the study groups

	Operative time in minutes				
	Mean	**SD**	**Minimum**	**Maximum**	**p-value**
INLAY (n=1)	18.0	-	18.0	18.0	<0.0001*
ONLAY (n=21)	17.95	8.2	8.0	38.0	
SUBLAY (n=28)	12.0	3.5	6.0	21.0	
Total	14.6	6.6	6.0	38.0	

*p-vale< 0.05- Statistically significant

Post-operative stay days in hospital: Post-operative stay days required was estimated for all participants of all the three study groups. The mean post-operative stay days was highest in the ONLAY group (12.1 + 7.5 days), ranging from 5 to 30 days. The mean post-operative stay days in the INLAY group was 8 days,

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and similarly the mean post-operative stay days was lowest in the SUBLAY group, with 7.4 + 2.9 days, ranging from 2 to 15 days. This difference in post-operative stay days among the study groups was statistically significant with a p-value<0.05, by ANOVA test statistics.

DISCUSSION

This present prospective observational study was conducted to compare the outcomes of three different mesh repair techniques such as Inlay, Onlay, and Sublay among patients who were presented and diagnosed with primary paraumbilical hernia. A total of 50 patients were enrolled at a tertiary care center in Tamil Nadu. The outcome variables included operative time, hospital stay, postoperative pain, and complication rates.[33-40]

Age Distribution: Participants were mostly aged 30–50 years (50%), with no statistically significant difference in age distribution among INLAY, ONLAY, and SUBLAY groups (p = 0.693). Raghuveer et al and Mohamed and Rabie included comparable age groups (30–60 years), and both studies reported no significant age-related variation in outcome across mesh types. Alobaidi and Alammar also documented similar age distribution.[41-60]

Gender Distribution: There was no statistically significant gender difference among groups (p = 0.520); males comprised 54% of the total study population. Memon et al and Jagtap et al also reported no influence of gender on surgical outcomes between mesh types. Zia et al found a similar male predominance but no gender-based difference in outcomes.[61-66]

Region of Defect: Supra-umbilical hernias were most frequent (36%). There was no statistically significant difference in defect region distribution across the groups. Mohamed and Rabie,[59] and Issa et al,[64] did not specifically stratify results based on defect region, but both acknowledged paraumbilical/supraumbilical predominance. Raghuveer et al,[57] included multiple ventral hernia types with uniform distribution, and this observation is consistent with our study's intergroup variation.

Comorbidities

In our study we have observed that Diabetes mellitus (18%) and hypertension (12%) were the most common comorbidities and there were no significant differences in comorbidity distribution across groups (DM p = 0.089; HTN p = 0.091; CAD p = 0.958). Babar et al,[74] and Martins et al,[67] found that comorbidities like DM and HTN did not significantly influence outcomes between mesh groups. Hassan et al,[75] also reported similar comorbidity prevalence with no significant intergroup association with complications.

Previous Surgical History: 92% of participants had no prior surgical history. Distribution of previous surgeries (appendicectomy, hysterectomy, etc.) was similar across groups (p = 0.824). Issa et al,[64] and Patidar et al,[77] did not observe prior surgeries influencing mesh outcomes significantly, supporting the non-significant findings in your study. Memon et al,[63] also reported balanced previous surgical history across their comparative groups.

Defect Size

The most common defect size was 3 cm (40%). The intergroup difference in defect size was statistically non-significant (p = 0.892). Goyal et al,[71] and Raghuveer et al,[57] included similar defect sizes and reported no significant association between defect size and complication rates. Zia et al. [66] also observed uniform efficacy across different defect sizes in both sublay and onlay groups.

Type of Mesh Repair: SUBLAY repair was performed in 56% of patients, ONLAY in 42%, and INLAY in only 2%, which limited conclusions regarding INLAY outcomes. Jagtap et al,[61] and Memon et al,[63] also compared sublay, onlay, and inlay repairs but noted inlay was less preferred due to higher complication rates.

Operative Time: The operative time was significantly longer for the SUBLAY group (82.1 ± 6.4 min) compared to ONLAY (65.5 ± 4.2 min) and INLAY (45 min), with a statistically significant p-value <0.0001. Dharmendra and Vijaykumar,[58] similarly reported longer operative time in sublay repair (70.8 ± 10.5 min) compared to onlay (62.6 ± 10.1 min, p=0.01). Mohamed and Rabie [59] also observed increased time for sublay (70 ± 18.5 min) vs. onlay (50 ± 12 min). Heteta et al,[72] documented a more pronounced difference (sublay: 111.9 min vs. onlay: 85.6 min, p<0.05), attributing this to the technical demand of sublay repair.

Length of Hospital Stay: The average hospital stay was significantly lower in the SUBLAY group (12.0 ± 3.5 days) compared to the ONLAY (17.95 ± 8.2 days) and INLAY (18.0 days) groups, with statistical significance (p = 0.004). This indicates that sublay mesh repair facilitated earlier discharge and faster post-operative stabilization. Raghuveer et al,[57] found that sublay repairs were associated with a shorter average hospital stay (4.8 days) compared to onlay (6.68 days), aligning with our findings despite the numerical difference. Zia et al,[66] also demonstrated significantly reduced hospital stays in the sublay group (2.46 ± 0.78 days) versus onlay (5.32 ± 1.12 days), with a statistically significant p-value of 0.036. Issa et al,[64] supported this observation, with the majority of sublay patients experiencing early recovery and shorter inpatient duration. Despite longer operative time, the sublay technique contributes to more rapid post-operative recovery and earlier hospital discharge, likely due to fewer complications and less wound morbidity.

Post-Operative Stay: Post-operative hospital stay calculated from the day of surgery to discharge was lowest in the SUBLAY group (7.4 ± 2.9 days), followed by INLAY (8.0 days), and highest in the ONLAY group (12.1 ± 7.5 days). The difference was statistically significant (p = 0.014). Heteta et al,[72]

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observed similar findings, with median post-operative duration being shorter in sublay (3.75 days) compared to onlay (5.75 days; p = 0.0014), attributing faster recovery in sublay to fewer seromas and infections. Boțianu et al,[70] highlighted significantly earlier drain removal and shorter post-op stays in sublay repairs due to their retromuscular mesh positioning, which reduces serous fluid accumulation and tissue irritation. Babar et al,[74] also reported a higher complication-free recovery rate in the sublay group (86.7% vs. 56.7%) leading to quicker discharge.

Post-Operative Pain: ONLAY repair was associated with the least post-operative pain (mean VAS: 2.4 ± 0.74), followed by INLAY (4.0) and SUBLAY (4.6 ± 1.2). The difference was highly significant (p = 0.0001). The low VAS scores in the ONLAY group may reflect less tissue dissection or effective analgesic strategies. Zia et al,[66] found sublay repair to be associated with significantly lower pain scores (VAS: 3.58 ± 1.44) than onlay (VAS: 6.01 ± 2.26), which contrasts with our findings. Jagtap et al,[61] reported similar results, with sublay patients experiencing lower day-3 pain (VAS: 3.13) than those in the onlay group (3.61; p = 0.002). Goyal et al,[71] also supported reduced pain perception in sublay due to deeper mesh placement, leading to less nerve irritation and superficialinflammation. Our deviation from literature may be due to differences in surgical technique, perioperative analgesia, or patient pain thresholds.

Post-Operative Complications: The complication rate was lowest in the SUBLAY group (only 2 patients with surgical site infection), while ONLAY had the highest, including all cases of wound gaping, mesh exposure, and seroma. INLAY had no recorded complications. Although the pattern was clinically relevant, the association was statistically non-significant (p = 0.229). Raghuveer et al,[57] observed significantly fewer complications in sublay repairs, including seroma (6.52%) and wound infection (4.35%) compared to onlay (21.3% and 19.2%, respectively). Mohamed and Rabie,[59] reported complications in only 2% of sublay patients, compared to 16% seroma and 6% wound infection in the onlay group Alobaidi and Alammar,[60] noted that sublay repair was superior with fewer seromas (3.33% vs. 20%), infections (1.66% vs. 10%), and zero recurrence.

The present study provides a comparative evaluation of inlay, onlay, and sublay mesh repair techniques in paraumbilical hernia surgery. Our findings indicate that while the sublay technique is associated with a significantly longer operative time, it offers superior outcomes in terms of reduced hospital stay, shorter postoperative duration, and fewer complications. The onlay technique demonstrated the lowest postoperative pain scores, albeit with a higher incidence of seroma and wound-related issues. Inlay repair, although requiring the least operative time, was underrepresented and could not be conclusively evaluated.

These results align with existing literature where sublay mesh placement consistently shows favorable profiles in reducing complications and recurrence while maintaining functional outcomes. Importantly, the differences in baseline variables such as age, gender, comorbidities, defect size, and prior surgical history were statistically insignificant across groups, reinforcing the validity of attributing outcome differences to the mesh repair technique itself. Therefore, sublay mesh repair emerges as a clinically effective and safer option, particularly when balanced against recovery metrics and complication rates.

CONCLUSION

This prospective observational study involving 50 patients with para-umbilical hernia compared outcomes of three mesh repair techniques—SUBLAY (56%), ONLAY (42%), and INLAY (2%). The groups were comparable in baseline characteristics, ensuring outcome differences were likely due to repair type. The mean participant age was 47.48 ± 12.65 years, with a male predominance (54%). Supra-umbilical defects (36%) and diabetes mellitus (18%) were the most common region and comorbidity, respectively.

Key outcome comparisons revealed that SUBLAY had significantly longer operative time but resulted in significantly shorter hospital and post-operative stay. ONLAY was associated with significantly lower post-operative pain. While SUBLAY showed fewer post-operative complications, the difference was not statistically significant. Due to minimal INLAY representation, conclusions for this group remain inconclusive. Overall, SUBLAY appeared superior in reducing complications and hospital stay, whereas ONLAY was preferable for post-operative pain management.

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