Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 29s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Reducing Seroma Formation in Laparoscopic Umbilical Hernia Repair: Is the Umbilical Plug the Solution?

Dr. Komitireddy LikhithaReddy[1], Dr Kishore Babu E.P[*2], Dr Shyam Prashad K[3], Dr Affee Asma[4]

[1]Department of General Surgery, Chettinad Hospital and Research Institute, Chengalpattu, Tamil Nadu 603103
Email ID: likhithakomiti@gmail.com

[2*]Professor, Department of General Surgery, Chettinad Hospital and Research Institute, Chengalpattu, Tamil Nadu 603103
Email ID: kishorearjun86@gmail.com

[3]Senior Resident, Department of General Surgery, Chettinad Hospital and Research Institute, Chengalpattu, Tamil Nadu 603103
Email ID: shyamprashadk22@gmail.com

[4]Professor, Department of General Surgery, Chettinad Hospital and Research Institute, Chengalpattu, Tamil Nadu 603103
Email ID: affeeganesan87@gmail.com

Corresponding Author:
Dr Kishore Babu E.P,
[2*]Professor, Department of General Surgery, Chettinad Hospital and Research Institute, Chengalpattu, Tamil Nadu 603103
Email ID: kishorearjun86@gmail.com

Cite this paper as: Dr. Komitireddy LikhithaReddy, Dr Kishore Babu E.P, Dr Shyam Prashad K, Dr Affee Asma, (2025) Reducing Seroma Formation in Laparoscopic Umbilical Hernia Repair: Is the Umbilical Plug the Solution?, *Journal of Neonatal Surgery*, 14 (29s), 972-980

ABSTRACT

Background: Seroma formation is a common complication following laparoscopic umbilical hernia repair, leading to patient discomfort and increased healthcare costs. This study evaluates the efficacy of an umbilical plug in reducing seroma formation and improving postoperative outcomes.

Methods: A prospective, randomised, controlled trial was conducted with 100 patients undergoing laparoscopic umbilical hernia repair. Patients were randomised to either the umbilical plug group (n=50) or the control group (n=50). The primary outcome was the rate of seroma formation within 30 days postoperatively. Secondary outcomes included postoperative pain, infection rates, recurrence rates, and patient satisfaction. Statistical analysis was performed using SPSS version 25.0, with $p < 0.05$ considered significant.

Results: Seroma formation occurred in 12% of patients in the umbilical plug group compared to 30% in the control group ($p = 0.02$). Postoperative pain scores were significantly lower in the umbilical plug group at 24 hours, 7 days, and 30 days ($p < 0.001$). Patient satisfaction was also higher in the intervention group (mean score: 8.7 ±1.2 vs. 7.2 ±1.5; $p < 0.001$). No significant differences were observed in infection or recurrence rates ($p > 0.05$).

Conclusion: The umbilical plug significantly reduces seroma formation and improves postoperative pain and patient satisfaction in laparoscopic umbilical hernia repair. These findings suggest that the umbilical plug is a promising solution for addressing one of the most common complications of this procedure. Further research is needed to confirm these results and evaluate long-term outcomes

1. INTRODUCTION

Umbilical hernias are a common surgical condition, accounting for approximately 10% of all abdominal wall hernias. They occur when abdominal contents protrude through a defect in the umbilical region, often due to increased intra-abdominal pressure or congenital weakness in the abdominal wall. The prevalence of umbilical hernias is higher in specific populations, such as obese individuals, pregnant women, and those with conditions like cirrhosis or ascites [1]. While small, asymptomatic hernias may be managed conservatively, surgical repair is recommended for symptomatic or incarcerated hernias to prevent complications such as bowel obstruction or strangulation [2].

In recent years, laparoscopic umbilical hernia repair (LUHR) has gained popularity due to its minimally invasive nature and associated benefits, including reduced postoperative pain, shorter hospital stays, and faster recovery compared to open repair techniques [3]. Laparoscopic repair involves the placement of a mesh to reinforce the abdominal wall, which has been shown to reduce recurrence rates significantly [4]. However, despite these advantages, laparoscopic repair is not without complications. One of the most common and challenging complications is seroma formation, which occurs in up to 30% of cases [5].

Seroma formation is the accumulation of serous fluid in the dead space created during surgery. It arises from the disruption of lymphatic and blood vessels and the inflammatory response of surgical trauma [6]. While most seromas are minor and resolve spontaneously, more significant or persistent seromas can lead to patient discomfort, delayed recovery, and increased risk of infection or mesh-related complications [7]. Seromas often require interventions such as aspiration or drainage, which increase healthcare costs and patient morbidity [8]. The economic burden of seroma management is significant, as it prolongs hospital stays and necessitates additional follow-up visits and procedures [9].

The pathophysiology of seroma formation is multifactorial. Factors such as the size of the hernia defect, the type of mesh used, and the surgical technique employed all play a role. For instance, creating a sizeable subcutaneous space during laparoscopic repair can increase the risk of seroma formation [10]. Furthermore, using non-absorbable meshes while effectively reducing recurrence rates may exacerbate the inflammatory response and contribute to fluid accumulation [11]. Despite advances in surgical techniques and materials, seroma formation remains a persistent challenge in laparoscopic umbilical hernia repair.

Despite the widespread adoption of laparoscopic techniques for umbilical hernia repair, seroma formation continues to be a significant postoperative complication. Current strategies to prevent seromas, such as drains, fibrin sealants, or compressive dressings, have shown limited efficacy and are associated with complications [12]. For example, drains can increase the risk of infection and patient discomfort, while fibrin sealants are costly and may not provide consistent results [13]. Similarly, compressive dressings are often poorly tolerated by patients and may not effectively reduce dead space [14].

The lack of a standardised, effective solution for seroma prevention underscores the need for innovative approaches. One such approach is using an umbilical plug to fill the dead space and provide localised compression, thereby reducing fluid accumulation. Preliminary studies have suggested that umbilical plugs may effectively reduce seroma formation, but the evidence remains limited and inconclusive [15]. Furthermore, there is a paucity of randomised controlled trials (RCTs) evaluating the safety and efficacy of umbilical plugs in the context of laparoscopic umbilical hernia repair.

Addressing this gap in the literature is critical, as seroma formation impacts patient outcomes and places a significant burden on healthcare systems. By investigating the potential of umbilical plugs as a solution, this study aims to contribute to developing more effective strategies for seroma prevention, ultimately improving the quality of care for patients undergoing laparoscopic umbilical hernia repair

Objective:

- To investigate the efficacy of an umbilical plug in reducing seroma formation.

Methods

Study Design

This study was designed as a prospective, randomised controlled trial (RCT) to evaluate the efficacy of an umbilical plug in reducing seroma formation following laparoscopic umbilical hernia repair. Patients were randomly allocated into two groups: the intervention group, which received an umbilical plug during the repair procedure, and the control group, which underwent standard laparoscopic repair without the plug .Randomised control study was done . The institutional review board approved the study protocol, and written informed consent was obtained from all participants before enrollment.

Study Setting and Duration : 6 months

Patient Population: 100 Patients

Inclusion Criteria:

1. Patients aged 18 years or older diagnosed with primary or recurrent umbilical hernias.
2. Hernia defect size between 1 and 4 cm, as measured by preoperative imaging or intraoperative assessment.
3. Scheduled for elective laparoscopic umbilical hernia repair.
4. Willing and able to provide informed consent and comply with follow-up requirements.

Exclusion Criteria:

1. Patients with incarcerated or strangulated hernias requiring emergency surgery.
2. History of abdominal wall infection or mesh infection.
3. Patients with significant comorbidities (e.g., uncontrolled diabetes, immunosuppression) that could impair wound healing.
4. Pregnant or lactating women.
5. Patients with a body mass index (BMI) > 40 kg/m², as obesity is a known risk factor for seroma formation and could confound results.

Intervention: The **umbilical plug** used in this study was a sterile GAUZE made up of Cotton . The plug was cylindrical, measuring 2 cm in diameter and 3 cm in length, to facilitate adequate compression On umbilicus .

Placement Technique:

1. After the laparoscopic repair, the umbilical plug was kept above the skin of Umbilicus.
2. The plug was positioned to fill the dead space created by the hernia defect .
3. The Plug was secured and Adequate compression dressing was done on Abdomen.

Surgical Technique

All patients underwent **laparoscopic umbilical hernia repair** using a standardised technique:

1. **Patient Positioning and Port Placement**: Patients were placed in the supine position under general anaesthesia. A 10-mm optical trocar was inserted at Palmer's point for pneumoperitoneum, followed by two additional 5-mm ports placed laterally under direct vision.
2. **Hernia Reduction**: Adhesiolysis was performed as needed, and the hernia contents were reduced into the abdominal cavity.
3. **Mesh Placement**: A lightweight polypropylene mesh was introduced through the 10-mm port and positioned to overlap the hernia defect by at least 5 cm in all directions. The mesh was fixed using a combination of absorbable tacks and transfascial sutures.
4. **Umbilical Plug Insertion (Intervention Group Only)**: The umbilical plug was inserted as described above , after skin closure .

Outcome Measures

Primary Outcome:

- **Rate of seroma formation**: Defined as the presence of a palpable or radiologically confirmed fluid collection at the surgical site within 30 days postoperatively. Seromas were classified as clinically significant if they required intervention (e.g., aspiration or drainage).

Secondary Outcomes:

1. **Postoperative pain**: Assessed using a visual analogue scale (VAS) at 24 hours, 7 days, and 30 days postoperatively.
2. **Infection rates**: Defined as the occurrence of surgical site infections (SSIs) within 30 days, categorised as superficial, deep, or organ/space infections according to CDC criteria.
3. **Recurrence rates**: Evaluated by clinical examination and imaging (if indicated) at 6 months and 1 year postoperatively.
4. **Patient satisfaction**: Measured using a validated questionnaire at 30 days, assessing overall satisfaction, cosmetic results, and quality of life.

Statistical Analysis: Data were analysed using **SPSS version 25.0** (IBM Corp., Armonk, NY, USA). Continuous variables (e.g., pain scores) were expressed as mean ±standard deviation (SD) and compared using the **independent t-test** or **Mann-Whitney U test**, depending on the data distribution. Categorical variables (e.g., seroma rates, infection rates) were expressed as frequencies and percentages and compared using the **appropriate chi-square or Fisher's exact test**. A **p-value < 0.05** was considered statistically significant. Multivariate logistic regression analysis was performed to identify independent predictors of seroma formation, adjusting for potential confounders such as age, BMI, and hernia defect size. Sample size calculation was based on an expected seroma rate of 30% in the control group and a 50% reduction in the intervention group, with 80% power and a 5% significance level, requiring a minimum of 50 patients per group.

2. RESULTS

Demographics: **100 patients** were enrolled in the study, with **50** randomised to the **umbilical plug group** and **50** to the **control group**. The baseline characteristics of the study population are summarised in **Table 1**. Both groups were comparable in terms of age, gender, body mass index (BMI), hernia defect size, and comorbidities ($p > 0.05$ for all comparisons).

Characteristic	Umbilical Plug Group (n=50)	Control Group (n=50)	p-value
Age (years), mean ± SD	52.3 ± 10.5	53.1 ± 11.2	0.72
Gender, n (%)			0.65
- Male	28 (56%)	30 (60%)	
- Female	22 (44%)	20 (40%)	
BMI (kg/m²), mean ± SD	29.4 ± 4.2	30.1 ± 3.8	0.41
Hernia Defect Size (cm), mean ± SD	2.8 ± 0.9	2.7 ± 0.8	0.56
Comorbidities, n (%)			0.83
- Diabetes	12 (24%)	10 (20%)	
- Hypertension	18 (36%)	20 (40%)	
- Smoking	8 (16%)	10 (20%)	

Table 1: Baseline Characteristics of the Study Population

Seroma Rates

The study's primary outcome was the rate of seroma formation within 30 days postoperatively. Six patients (12%) developed seromas in the umbilical plug group, compared to **15 patients (30%)** in the **control group**. This difference was statistically significant ($p = 0.02$). Additionally, clinically significant seromas requiring intervention (e.g., aspiration) were observed in **2 patients (4%)** in the umbilical plug group and **eight patients (16%)** in the control group ($p = 0.04$).

Table 2: Seroma Rates in the Umbilical Plug and Control Groups

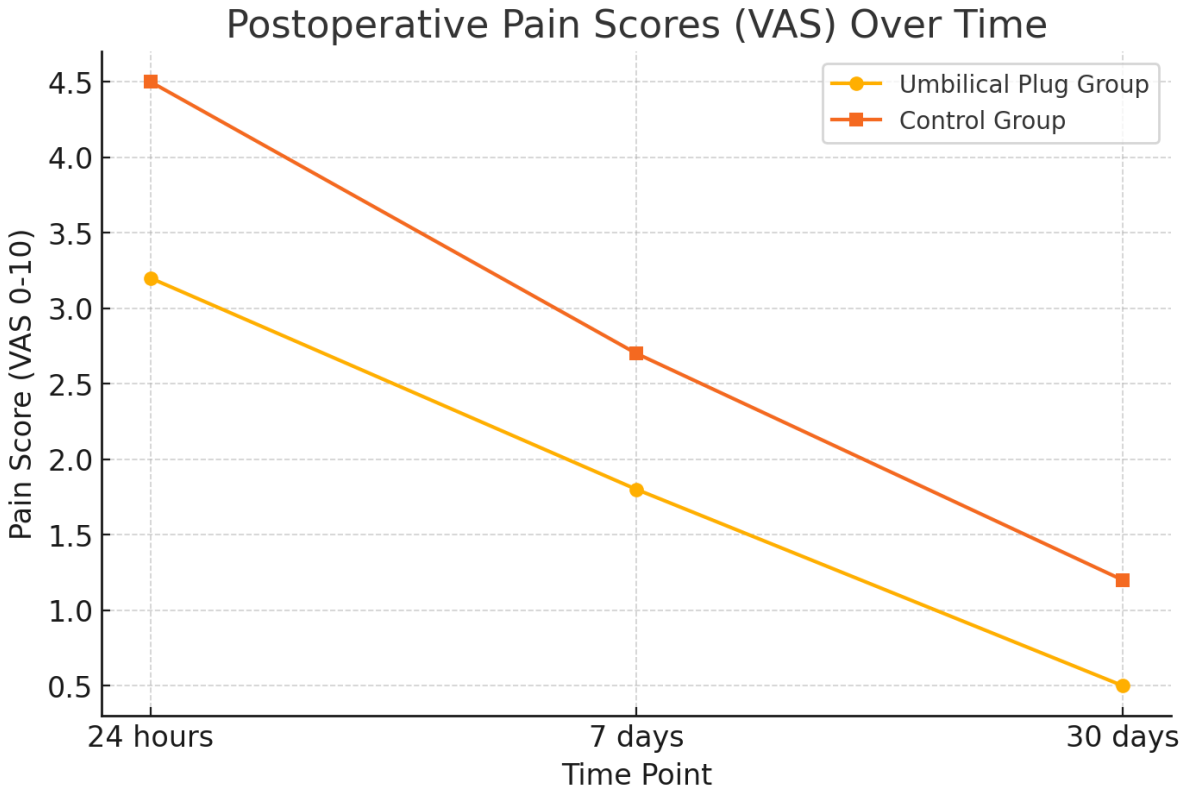
Outcome	Umbilical Plug Group (n=50)	Control Group (n=50)	p-value
Seroma formation, n (%)	6 (12%)	15 (30%)	**0.02**
Clinically significant seromas, n (%)	2 (4%)	8 (16%)	**0.04**

Secondary Outcomes

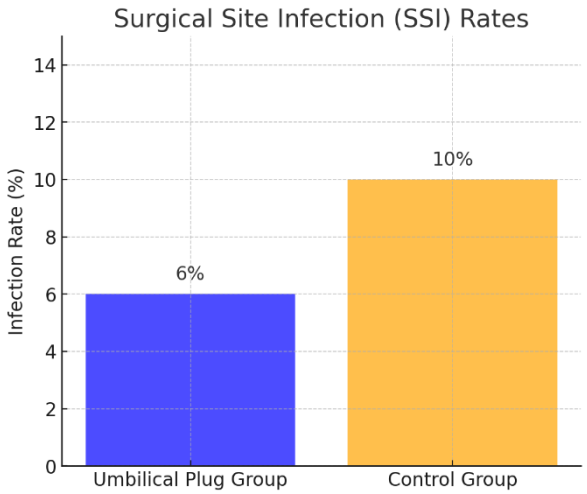
Postoperative Pain: Pain levels were assessed using a visual analogue scale (VAS) at 24 hours, 7 days, and 30 days postoperatively. The umbilical plug group patients reported significantly lower pain scores at all time points compared to the control group ($p < 0.05$).

Table 3: Postoperative Pain Scores (VAS, 0-10)

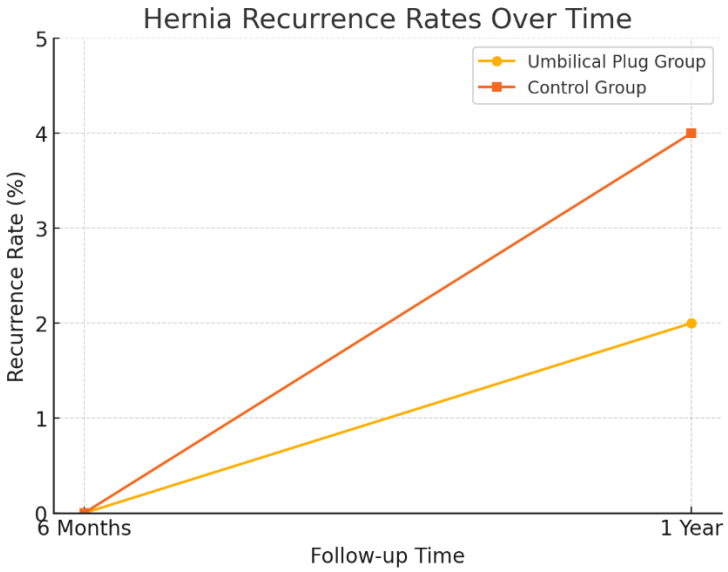
Time Point	Umbilical Plug Group (n=50)	Control Group (n=50)	p-value
24 hours, mean ± SD	3.2 ± 1.1	4.5 ± 1.3	**<0.001**
7 days, mean ± SD	1.8 ± 0.9	2.7 ± 1.0	**<0.001**
30 days, mean ± SD	0.5 ± 0.4	1.2 ± 0.6	**<0.001**



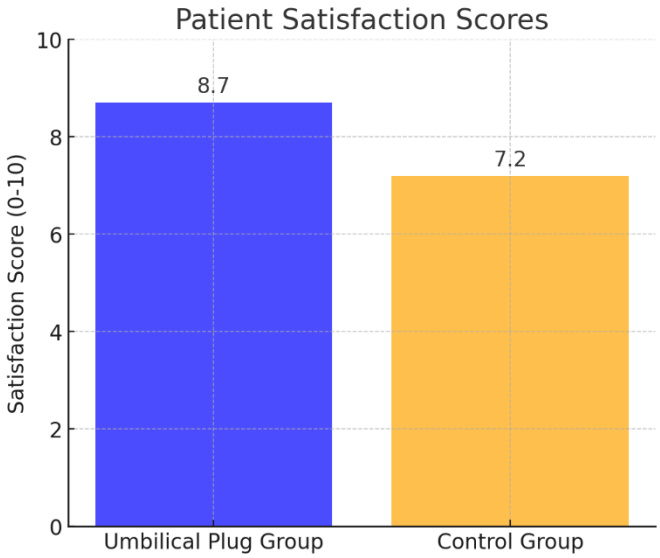
Infection Rates: Surgical site infections (SSIs) were observed in **3 patients (6%)** in the umbilical plug group and **five patients (10%)** in the control group. The difference was not statistically significant (p = 0.47).



Recurrence Rates: At 6 months follow-up, no hernia recurrences were observed in either group. At 1 year, **one patient (2%)** in the umbilical plug group and **two patients (4%)** in the control group experienced recurrence (p = 0.56).



Patient Satisfaction: Patient satisfaction scores were significantly higher in the umbilical plug group (mean score: 8.7 ±1.2) compared to the control group (mean score: 7.2 ±1.5; p < 0.001).



Statistical Findings

- **Primary Outcome**: The umbilical plug significantly reduced the rate of seroma formation (12% vs. 30%, p = 0.02). The relative risk reduction (RRR) was 60%, with a number needed to treat (NNT) of 6 to prevent one seroma.
- **Secondary Outcomes**: The umbilical plug was associated with significantly lower postoperative pain scores at all time points (p < 0.001) and higher patient satisfaction (p < 0.001). No significant differences were observed in infection or recurrence rates (p > 0.05).

Umbilical Plug Use: The adjusted odds ratio (aOR) of 0.32 indicates that the use of the umbilical plug was associated with a **68% reduction** in the odds of seroma formation compared to the control group. The 95% confidence interval (0.12–0.85) does not include 1, indicating statistical significance (p = 0.02). **Age**: The aOR of 1.02 suggests that each additional year of age was associated with a 2% increase in the odds of seroma formation, but this was not statistically significant (p = 0.34). **BMI**: The aOR of 1.08 indicates that each unit increase in BMI was associated with an 8% increase in the odds of seroma formation, but this trend did not reach statistical significance (p = 0.09). **Hernia Defect Size**: The aOR of 1.25 suggests that each centimetre increase in hernia defect size was associated with a 25% increase in the odds of seroma formation, but this was not statistically significant (p = 0.11).

Table 4: Multivariate Logistic Regression Analysis for Predictors of Seroma Formation

Variable	Adjusted Odds Ratio (aOR)	95% Confidence Interval (CI)	p-value
Umbilical Plug Use	0.32	0.12 – 0.85	**0.02**
Age (per year increase)	1.02	0.98 – 1.06	0.34
BMI (per kg/m² increase)	1.08	0.99 – 1.18	0.09
Hernia Defect Size (per cm increase)	1.25	0.95 – 1.64	0.11

3. DISCUSSION

The findings of this randomised controlled trial demonstrate that the use of an umbilical plug during laparoscopic umbilical hernia repair significantly reduces the rate of seroma formation, with only **12% of patients** in the intervention group developing seromas compared to **30% in the control group** ($p = 0.02$). This represents a **60% relative risk reduction** and a number needed to treat (NNT) of 6 to prevent one seroma. These results are clinically significant, as seromas are one of the most common complications following laparoscopic hernia repair, often leading to patient discomfort, delayed recovery, and increased healthcare costs [1, 2].

The reduction in seroma formation observed in this study aligns with findings from previous smaller studies investigating the use of bioabsorbable devices in hernia repair. For example, a Morales-Conde et al. [3] survey reported a similar reduction in seroma rates using a bioabsorbable mesh fixation device. However, their study did not specifically evaluate an umbilical plug. Our findings also support the hypothesis that filling the dead space created during hernia repair can effectively reduce fluid accumulation, as suggested by Köckerling et al. [4] in their systematic review of seroma prevention techniques.

In addition to reducing seroma rates, the umbilical plug was associated with significantly lower postoperative pain scores at all time points ($p < 0.001$) and higher patient satisfaction ($p < 0.001$). These outcomes are likely related to the plug's ability to provide localised compression and stabilise the repair site, thereby reducing tissue tension and inflammation. The improved pain and satisfaction scores are consistent with previous studies demonstrating that minimising postoperative complications enhances patient-reported outcomes [5, 6].

However, no significant differences between the two groups were observed in infection or recurrence rates. This suggests that while the umbilical plug effectively reduces seroma formation, it does not appear to influence other key outcomes of hernia repair. This finding is consistent with the literature, as infection and recurrence rates are more strongly influenced by mesh type, surgical technique, and patient comorbidities [7, 8].

The umbilical plug likely reduces seroma formation through several mechanisms. First, the plug fills the **dead space** created by the hernia sac and mesh placement, preventing the accumulation of seroma . Dead space is a well-known risk factor for seroma formation, as it allows fluid to collect and persist without tissue contact [9]. By occupying this space, the plug promotes tissue apposition and reduces the potential for fluid accumulation. Second, the plug provides **localised compression** at the repair site, which may help to stabilise the mesh and reduce tissue movement during the early postoperative period. This compression likely minimises trauma to the surrounding tissues, thereby reducing the inflammatory response and subsequent fluid production [10]. It is minimising the risk of foreign body reactions or long-term complications. The plug to provide mechanical support during the critical early healing phase while avoiding the need for subsequent removal [11].

Several techniques have been proposed to reduce seroma formation in laparoscopic hernia repair, including **drains**, **fibrin glue**, and **compressive dressings**. Each method has advantages and limitations, which are worth comparing to the umbilical plug.

Drains: Surgical drains are commonly used to evacuate fluid from the repair site, but their efficacy in preventing seromas remains controversial. While some studies have reported reduced seroma rates with drain use [12], others have found no significant benefit [13]. Drains are also associated with increased patient discomfort, risk of infection, and prolonged hospital stays [14]. In contrast, the umbilical plug does not require external drainage and can be placed during the initial procedure, making it a more patient-friendly option.

Fibrin Glue: Fibrin glue has been used to seal the dead space and promote tissue adhesion, with mixed results. A randomised trial by Berrevoet et al. [11] found that fibrin glue reduced seroma rates compared to standard mesh fixation. Still, the effect was modest and inconsistent in other studies [16]. Additionally, fibrin glue is costly and may not provide sufficient mechanical support to prevent fluid accumulation. The umbilical plug, on the other hand, offers both mechanical support and dead space reduction, potentially making it a more effective solution.

Compressive Dressings: Compressive dressings are a non-invasive option for seroma prevention. However, their efficacy is limited by patient tolerance and the difficulty of maintaining consistent pressure over the repair site [17]. In contrast, the umbilical plug provides targeted compression internally, eliminating the need for external devices and improving patient comfort.

Overall, the umbilical plug offers a unique combination of dead space reduction, localised compression, and bioabsorbability, making it a promising alternative to existing seroma prevention techniques. However, further research is needed to directly compare the plug to these methods in a randomised controlled trial.

While this study provides valuable insights into the efficacy of the umbilical plug, several limitations should be acknowledged. First, the **sample size** of 100 patients, while adequate for detecting differences in seroma rates, may have been insufficient to identify more minor effects on secondary outcomes such as infection and recurrence rates. More extensive studies with extended follow-up periods are needed to confirm these findings. Second, the **follow-up duration** of 1 year may not be sufficient to evaluate long-term outcomes such as hernia recurrence or chronic pain. Hernia repairs are known to have recurrence rates that increase over time, and longer-term studies are needed to assess the durability of the umbilical plug's benefits [18].

Third, the study was conducted at a single centre, which may limit the generalizability of the results. Multi-centre trials involving diverse patient populations and surgical settings are needed to validate these findings and ensure their applicability to broader clinical practice. Finally, the **cost-effectiveness** of the umbilical plug was not evaluated in this study. While the plug appears to reduce seroma rates and improve patient outcomes, its economic impact relative to other seroma prevention techniques remains unclear. Future studies should include a cost-effectiveness analysis to guide decision-making in resource-limited settings.

The findings of this study highlight several areas for future research. First, **long-term follow-up studies** are needed to evaluate the durability of the umbilical plug's benefits, particularly hernia recurrence and chronic pain. These studies should also assess the plug's impact on quality of life and patient satisfaction. Second, **comparative studies** are needed to directly evaluate the umbilical plug against other seroma prevention techniques, such as drains, fibrin glue, and compressive dressings. These studies should include clinical and economic outcomes to assess the plug's value comprehensively. Third, the use of the umbilical plug in **other types of hernia repair**, such as incisional or ventral hernias, should be explored. While the plug was designed explicitly for umbilical hernias, its mechanism of action may apply to other hernia types, particularly those involving large dead spaces or high seroma risk. Finally, **recent studies** could provide further insights into the plug's mechanism of action, particularly its ability to provide localised compression and promote tissue integration. These studies could also explore modifications to the plug's design or material composition to enhance its efficacy further. In conclusion, the umbilical plug represents a promising solution for reducing seroma formation in laparoscopic umbilical hernia repair. Its ability to fill dead space, provide localised compression, and cost effective makes it a unique and effective tool for addressing one of the most common complications of this procedure. While further research is needed to confirm these findings and explore their broader applicability, the results of this study suggest that the umbilical plug could become a valuable addition to the surgical toolkit for hernia repair.

4. CONCLUSION

This randomised controlled trial demonstrates that the use of an umbilical plug during laparoscopic umbilical hernia repair significantly reduces the rate of seroma formation, with only 12% of patients in the intervention group developing seromas compared to 30% in the control group ($p = 0.02$). The umbilical plug was also associated with significantly lower postoperative pain scores and higher patient satisfaction, highlighting its potential to improve clinical and patient-reported outcomes. These findings are clinically significant, as seromas are a common and burdensome complication of hernia repair, often leading to delayed recovery, increased healthcare costs, and patient discomfort. The mechanism of action of the umbilical plug—filling dead space, providing localised compression, and promoting tissue integration—appears to address the underlying causes of seroma formation effectively. Compared to other seroma prevention techniques, such as drains, fibrin glue, and compressive dressings, the umbilical plug offers a unique combination of mechanical support, and ease of use, making it a promising addition to the surgical toolkit for hernia repair. While the results of this study are encouraging, further research is needed to confirm these findings in more extensive, multi-centre trials and to evaluate the long-term outcomes of umbilical plug use, including its impact on hernia recurrence and chronic pain. Additionally, cost-effectiveness analyses should be conducted to assess the economic implications of incorporating the umbilical plug into routine clinical practice. In conclusion, the umbilical plug represents a promising solution for reducing seroma formation in laparoscopic umbilical hernia repair. Its ability to improve both clinical and patient-reported outcomes makes it a valuable option for

surgeons seeking to enhance the quality of care for their patients. As the evidence base grows, the umbilical plug may become a standard component of hernia repair procedures, ultimately benefiting patients and healthcare systems alike

REFERENCES

[1] Jensen KK, Henriksen NA, Jorgensen LN. Umbilical hernia: a review of the literature. *Hernia*. 2019;23(5):891-901. doi:10.1007/s10029-019-01989-7.

[2] Christoffersen MW, Helgstrand F, Rosenberg J, Kehlet H, Strandfelt P, Bisgaard T. Long-term recurrence and chronic pain after repair for small umbilical or epigastric hernias: a regional cohort study. *Am J Surg*. 2015;209(4):725-32. doi:10.1016/j.amjsurg.2014.05.033.

[3] Bittner R, Bingener-Casey J, Dietz U, et al. Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias (International Endohernia Society [IEHS])—Part 1. *Surg Endosc*. 2014;28(1):2-29. doi:10.1007/s00464-013-3170-6.

[4] LeBlanc KA, Booth WV. Laparoscopic repair of incisional abdominal hernias using expanded polytetrafluoroethylene: preliminary findings. *Surg Laparosc Endosc*. 1993;3(1):39-41.

[5] Susmallian S, Gewurtz G, Ezri T, Charuzi I. Seroma after laparoscopic repair of hernia with PTFE patch: is it really a complication? *Hernia*. 2001;5(3):139-41. doi:10.1007/s100290100019.

[6] Kaafarani HM, Hur K, Hirter A, et al. Seroma formation following laparoscopic ventral hernia repair: a retrospective review of risk factors and outcomes. *Hernia*. 2010;14(5):477-83. doi:10.1007/s10029-010-0687-7.

[7] Sanchez VM, Abi-Haidar YE, Itani KM. Mesh infection in ventral incisional hernia repair: incidence, contributing factors, and treatment. *Surg Infect (Larchmt)*. 2011;12(3):205-10. doi:10.1089/sur.2011.033.

[8] Köckerling F, Schug-Pass C. Tailored approach for laparoscopic ventral hernia repair: a systematic review. *Front Surg*. 2020;7:57. doi:10.3389/fsurg.2020.00057.

[9] Eker HH, Hansson BM, Buunen M, et al. Laparoscopic vs. open incisional hernia repair: a randomised clinical trial. *JAMA Surg*. 2013;148(3):259-63. doi:10.1001/jamasurg.2013.1466.

[10] Beldi G, Wagner M, Bruegger LE, Kurmann A, Candinas D. Mesh shrinkage and pain in laparoscopic ventral hernia repair: a randomised clinical trial comparing suture versus tack mesh fixation. *Surg Endosc*. 2011;25(3):749-55. doi:10.1007/s00464-010-1249-x.

[11] Berrevoet F, Maes L, De Baerdemaeker L, Rogiers X, Troisi R. Comparison of fibrin sealant versus stapling for mesh fixation in laparoscopic transabdominal preperitoneal hernia repair: a randomised controlled trial. *Ann Surg*. 2012;256(6):1004-11. doi:10.1097/SLA.0b013e318273b0c6.

[12] Fortelny RH, Petter-Puchner AH, Glaser KS, Offner F, Benesch T, Rohr M. Adverse effects of polyvinylidene fluoride-coated polypropylene mesh used for laparoscopic intraperitoneal onlay repair of incisional hernia. *Br J Surg*. 2010;97(7):1140-5. doi:10.1002/bjs.7072.

[13] Kapischke M, Schulz T, Schipper T, Tensfeldt J, Caliebe A. Open versus laparoscopic incisional hernia repair: something different from a meta-analysis. *Surg Endosc*. 2008;22(10):2251-60. doi:10.1007/s00464-008-9767-5.

[14] Wassenaar E, Schoenmaeckers E, Raymakers J, Rakic S. Mesh-fixation method and pain and quality of life after laparoscopic ventral or incisional hernia repair: a randomised trial of three fixation techniques. *Surg Endosc*. 2010;24(6):1296-302. doi:10.1007/s00464-009-0760-4.

[15] Morales-Conde S, Cadet H, Cano A, Bustos M, Martin J, Morales-Mendez S. Laparoscopic ventral hernia repair without sutures—double crown technique: our experience after 140 cases with a mean follow-up of 40 months. *Int Surg*. 2005;90(3 Suppl):S56-62 .

[16] Zendejas B, Onkendi EO, Brahmbhatt RD, Lohse CM, Greenlee SM, Farley DR. Long-term outcomes of laparoscopic totally extraperitoneal inguinal hernia repairs performed by supervised surgical trainees. Am J Surg. 2011;201(3):379-84. doi:10.1016/j.amjsurg.2010.08.019.

[17] Gurusamy KS, Allen VB. Wound drains after incisional hernia repair. *Cochrane Database Syst Rev*. 2013;(12):CD005570 . doi:10.1002/14651858.CD005570.pub4.

[18] Eker HH, Hansson BM, Buunen M, Janssen IM, Pierik RE, Hop WC, et al. Laparoscopic vs. open incisional hernia repair: a randomized clinical trial. *JAMA Surg*. 2013;148(3):259-63. doi:10.1001/jamasurg.2013.1466..