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Original Article

A comparative study of three-dimensional and polypropylene meshes in Laparoscopic Transabdominal Preperitoneal inguinal hernia repairs

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Abstract

Introduction: Inguinal hernia repair is a common surgical procedure that results in different patient outcomes. This study compared outcomes of laparoscopic Transabdominal Preperitoneal (TAPP) inguinal hernia repairs using three-dimensional (3D) mesh and polypropylene mesh.

Material and Methods: A descriptive-analytical study was conducted on patients with inguinal hernia referred to Imam Hossein Hospital, Tehran, Iran. This study selected two groups of 40 people who underwent TAPP laparoscopy using 3D meshes and polypropylene by convenience sampling method. Based on medical records, demographic and clinical data of patients and outcomes after surgery were recorded. Mann-Whitney U, Chi-Square, and Fisher Exact tests were performed to evaluate the variables' associations. All data was analyzed using SPSS (Version 16.0) and boxplots were designed using GraphPad Prism, version 8.0.1. The significant level was considered less than 0.05.

Results: The mean age of individuals in the 3D mesh and polypropylene mesh groups was 53.10±8.72 and 53.15±13.69 years, respectively, and in both groups, 32 (80%) patients were male. The pain mean scores in the 3D group were significantly higher than in the polypropylene group (5.5 vs 4.5, P=0.004). The median surgical time in the polypropylene group was significantly lower than in the 3D group (40.0 vs 42.5 min, P=0.041). The walking time among the 3D group (5.0, IQR: 5.0 to 6.0 hours) was significantly higher than in the polypropylene group (5.0, IQR: 4.0 to 5.8 hours; P=0.025). Moreover, the duration of hospital stay and the incidence of postoperative complications, such as ecchymosis, seroma, foreign body sensations, numbness, and neuralgia, were not significantly different between the two studied groups (P>0.05). The infection and hernia recurrence were not observed in either group.

Conclusion: The study indicated that 3D mesh in laparoscopic TAPP hernia repair may lead to slightly higher postoperative pain and longer surgery time. However, it did not significantly affect complications or hernia recurrence.

Keywords: Inguinal Hernia, Surgical Mesh, Hernia Repair

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Introduction

Inguinal hernia repair is a highly prevalent surgical procedure worldwide, with over 20 million patients undergoing this intervention yearly (1). Inguinal hernias, constituting around 75% of all hernias, predominantly affect the inguinal region, with indirect hernias being the most prevalent subtype. These hernias exhibit a nine-fold higher incidence in men and are also commonly observed in women (2).

Over the past two centuries, various techniques have been documented for correcting inguinal hernias, ranging from the pioneering Marcy repair to the significant advancement of the Bassini repair, culminating in the modern approach of laparoscopic inguinal hernia repair (3). Laparoscopic hernia repair has witnessed remarkable progress in repair techniques, mesh options, and mesh fixation methods, leading to revolutionary advancements. While complications have decreased with this approach, concerns persist regarding hernia recurrence, postoperative groin pain, seroma formation, and various mesh-related complications like mesh shrinkage and displacement (4,5).

The use of mesh in laparoscopic inguinal hernia repair, specifically the transabdominal preperitoneal (TAPP) technique, has increased in popularity. However, the expanding range of mesh choices has made selecting the most suitable material challenging (6,7). Polypropylene, polyester, and polytetrafluoroethylene (PTFE) are notable non-resorbable mesh materials commonly used in inguinal hernia repair (8). Polypropylene mesh has gained extensive usage in laparoscopic hernia repairs. It consists of prolene fibers arranged in a mesh structure with varying pore sizes. Polypropylene mesh is categorized into heavy weight (90 to 100 gm/sq meter), medium weight (45 to 50 gm/sq meter), and lightweight (less than 45 gm/sq meter) based on its material density and surface area (9,10).

The drawbacks of flat mesh sheets in laparoscopic repairs have spurred the development of three-dimensional (3D) mesh. This innovative mesh design aims to offer anatomical conformity, simplified positioning, fixation-free application, decreased postoperative pain, and a reduced occurrence of chronic post-herniorrhaphy groin pain and hernia recurrence (11,12). Despite advancements in mesh options, there is still a lack of consensus on the ideal mesh type that consistently yields favorable outcomes in hernia repair procedures(13–15). This scarcity of conclusive evidence highlights the need for a comprehensive study to compare the effects of different mesh types on surgical outcomes. In this study, we evaluated the effectiveness and patients' outcomes of performing two methods of laparoscopic inguinal hernia repairs (3D mesh and polypropylene mesh) in patients with inguinal hernia.

Material and Methods

A descriptive-analytical study was conducted on 80 patients with inguinal hernia referred to the Imam Hossein Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran, from 2023 to 2024. The study was approved by the ethical committee of the Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.RETECH.REC.1402.860). All subjects were informed about the details and purpose of the study and gave their written informed consent to participate. Patients in the age group of 18 to 65 years, of both genders, with unilateral or bilateral inguinal hernia, were included in the study.

Exclusion criteria included hernia with obstruction, strangulation, peritonitis, active malignancy, pregnancy, history of other surgeries in the inguinal region, immunodeficiency, uncontrolled diabetes, chronic lung disease, chronic cough, any condition precluding the use of general anesthesia or laparoscopy, and those who did not wish to participate. The convincing sampling method collected 40 patients with laparoscopically TAAP inguinal hernia repair using medium-weight 3D mesh and 40 individuals

with laparoscopically TAAP inguinal hernia repair using medium-weight polypropylene mesh. A radiologist measured the hernia size for all patients through ultrasound, which a single surgeon performed, and a radiologist assessed all surgeries. A visual analog scale (VAS) assessed postoperative pain levels. All patients received general anesthesia according to the standard protocol, supervised by an anesthesiologist. Prophylactic antibiotics (1 gram of cefazolin intravenously) were administered one hour before surgery, and a Foley catheter size 14 was placed after general anesthesia. A surgeon performed the TAPP laparoscopic procedure following the standard protocol (16). Postoperatively, patients were given 400 mg Ibuprofen every eight hours for two days to manage pain. All patients' demographical and clinical data were recorded through face-to-face interviews, on the phone, or from patient's medical records. The data included age, gender, body mass index (BMI), smoking status, type of hernia (primary or recurrent), unilateral or bilateral hernia, indirect/direct and femoral hernia (IDF), hernia size, intraoperative and postoperative events, such as postoperative pain (6 hours, 24 hours, 7th day, 1st, 3rd, 6th month), surgery duration, time to walking, surgical complications of patients including ecchymosis, seroma (first, 7th, 13th day), infection, foreign body sensation (3rd month), numbness of the surgical area (3rd month), neuralgia (3rd month), hernia recurrence (3rd month), and length of hospital stay, was recorded. In the present study, categorical variables were presented as frequency (percentage) and continuous variables as mean ±standard deviation (SD) or median [interquartile range (IQR)]. The normality assumption for the continuous variables was examined using the Shapiro–Wilk test. Differences in continuous and categorical variables between polypropylene mesh and 3D mesh groups were analyzed using the Mann-Whitney U, Chi-Square, and Fisher Exact tests. Data analysis was carried out using SPSS for Windows, version 16.0 (SPSS Inc., Chicago, IL, USA), and boxplots were depicted using GraphPad Prism, version 8.0.1 (GraphPad Prism Software Inc., San Diego, CA, USA). The significant level was considered less than 0.05.

Results

The mean age of the participants was 53.13 ±11.41 years, and the mean BMI was 26.70±3.38 kg/m2. The mean age of individuals in the 3D and polypropylene groups was 53.10±8.72 and 53.15±13.69 years, respectively. The mean BMI was 26.48±2.36 kg/m2 and 26.92±4.17 kg/m2 in 3D and polypropylene groups. About 80.0% of each group's participants were male, 22.5% were smokers, 70.0% had a one-sided hernia, and 77.5% had a primary hernia. The mean size of the hernia was 1.48±0.45 cm, and the mean hernia size of individuals in the 3D and polypropylene groups was 1.58±0.38 and 1.38±0.49 cm, respectively Table 1. The median pain score in the 3D group (5.5, IQR: 5.0 to 6.0) was significantly higher than in the polypropylene group (4.5, IQR: 4.0 to 6.0; P=0.004) Table 2 and Figure 1. The median of surgery time in the 3D group (42.5, IQR: 36.3 to 50.0 min) was significantly higher than in the polypropylene group (40.0, IQR: 35.0 to 45.0 min; P=0.041). The walking time in the 3D group (5.0, IQR: 5.0 to 6.0 hours) was significantly higher than in the polypropylene group (5.0, IQR: 4.0 to 5.8 hours; P=0.025). The hospital stay was not significantly different between the two groups (P=1.000). As presented in Table 3, there were no significant differences in the incidence of postoperative complications, such as ecchymosis (7.5 vs. 10.0%, P=1.000), seroma (20.0 vs. 22.5%, P=0.785), foreign body sensations (12.5 vs. 10.0%, P=1.000), numbness (10.0 vs. 12.5%, P=1.000), and neuralgia (7.5 vs. 12.5%, P=0.712) between polypropylene and 3D groups. In addition, infection was not observed in both groups. There was no hernia recurrence in either group Table 3.

Table 1. Baseline characteristics of study participants

Variables	Total (n=80)	Group	
		Polypropylene (n=40)	3D (n=40)
Age (years), (mean ±SD)	53.13 ±11.41	53.15 ±13.69	53.10 ±8.72
Sex, n (%)			
Male	64 (80.0)	32 (80.0)	32 (80.0)
Female	16 (20.0)	8 (20.0)	8 (20.0)
BMI (kg/m^2), (mean ±SD)	26.70 ±3.38	26.92 ±4.17	26.48 ±2.36
Smoking, n (%)			
No	62 (77.5)	31 (77.5)	31 (77.5)
Yes	18 (22.5)	9 (22.5)	9 (22.5)
One/Two-side hernia, n (%)			
One-side	56 (70.0)	32 (80.0)	24 (60.0)
Two-side	24 (30.0)	8 (20.0)	16 (40.0)
IDF hernia, n (%)			
I	36 (45.0)	12 (30.0)	24 (60.0)
D	36 (45.0)	20 (50.0)	16 (40.0)
F	4 (5.0)	4 (10.0)	0 (0)
I/D	4 (5.0)	4 (10.0)	0 (0)
Type of hernia, n (%)			
Primary	60 (77.5)	36 (90.0)	24 (60.0)
Recurrent	20 (22.5)	4 (10.0)	16 (40.0)
Size of hernia (cm), (mean±SD)	1.48 ±0.45	1.38 ±0.49	1.58 ±0.38

BMI: Body Mass Index; IDF: Indirect/direct and femoral; SD: Standard Deviation

Table 2. Comparison of continuous outcome variables between polypropylene and 3D groups

Variables	Polypropylene (n=40)	3D (n=40)	P-Value
	Median [IQR]	Median [IQR]	
Postoperative Pain (using VAS)	4.5 [4.0 to 6.0]	5.5 [5.0 to 6.0]	0.004
Surgical Time (Min)	40.0 [35.0 to 45.0]	42.5 [36.3 to 50.0]	0.041
Walking time (H)	5.0 [4.0 to 5.8]	5.0 [5.0 to 6.0]	0.025

IQR: Interquartile Range; VAS: Visual Analogue Scale; The P-values are based on the Mann–Whitney test.

Table 1. Baseline characteristics of study participants

Variables	Polypropylene (n=40)	3D (n=40)	P-Value
	n (%)	n (%)	
Ecchymosis	3 (7.5)	4 (10.0)	1.000‡
Seroma	8 (20.0)	9 (22.5)	0.785†
Infection	0 (0)	0 (0)	N/A
Foreign body sensations	5 (12.5)	4 (10.0)	1.000‡
Numbness	4 (10.0)	5 (12.5)	1.000‡
Neuralgia	3 (7.5)	5 (12.5)	0.712‡
Hernia Recurrence	0 (0)	0 (0)	N/A
Hospital stay			
1 day	39 (97.5)	39 (97.5)	1.000‡
2 days	1 (2.5)	1 (2.5)	

N/A: Not Applicable; † Chi-square test; ‡ Fisher exact test

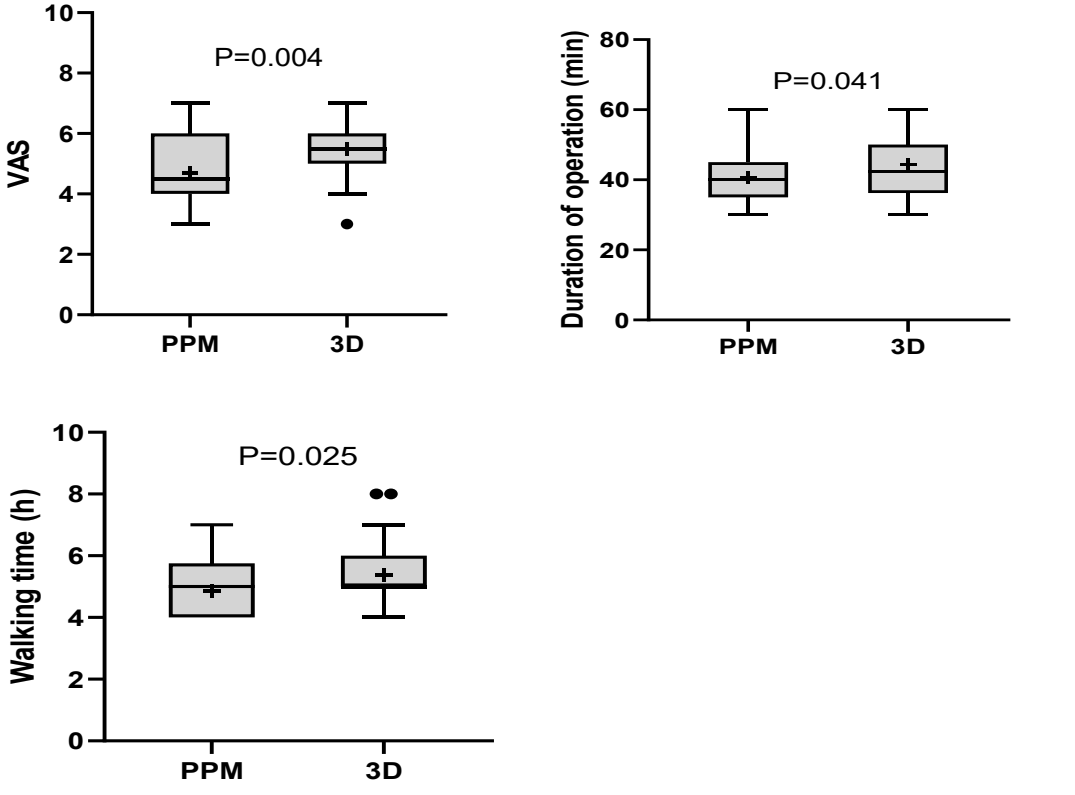

Figure 1. Comparison of continuous outcome variables between polypropylene and 3D groups. Note. The box plot shows the minimum, first quartile (Q1); median, third quartile (Q3); and maximum values. The black dots show the outliers (●); The plus sign (+) represents the mean; VAS: Visual Analogue Scale; The P-values are based on the Mann–Whitney test.

Discussion

The primary goals of hernia repair surgery include minimizing intraoperative and postoperative complications, ensuring a successful repair, reducing recurrence rates, enabling a swift return to normal activities, maintaining cost-effectiveness, and achieving improved cosmetic results (17). Using biomaterials is crucial for inguinal hernia repair, as prosthetic materials significantly reduce the recurrence rates of these repairs (18). The choice of mesh type for hernia repair is often dictated by the surgeon's preference and economic considerations (19).

International research has emphasized the critical role of prosthesis selection in hernia repair, suggesting that the type of mesh used may substantially impact outcomes more than the surgical technique itself (20). In this study, we compared the effectiveness and outcomes of 3D and polypropylene meshes in laparoscopic TAPP for inguinal hernia repair. Our findings provided valuable insights into the performance of these two mesh types in laparoscopic TAPP, illuminating their respective advantages and limitations. One of the notable findings of this study was the significant disparity in postoperative pain scores between the 3D and polypropylene groups, with the 3D group showing a higher median pain score. Mir IS et al. reported an immediate severe postoperative pain rate of 1.88% in total extraperitoneal (TEP)/TAPP hernia repair using medium-weight 3D mesh (21).

Conversely, Chalkoo et al. observed postoperative pain in 9.23% of cases in TEP repair with polypropylene mesh (22). Mohamed et al. found that the incidence of chronic pain was similar between the 3D mesh and polypropylene groups in laparoscopic inguinal hernia repair (23). Rashid et al. noted a lower incidence of severe immediate postoperative pain in the 3D mesh group during TEP/TAPP repair with lightweight polypropylene and 3D mesh, based on the need for intravenous analgesics per day, although the difference did not reach clinical significance. Moreover, most patients in both groups experienced either no or mild pain, effectively managed with oral analgesics (10). Pain perception is inherently subjective and can vary significantly among individuals and between genders due to differences in pain thresholds. The decreased postoperative pain observed with the 3D mesh may be due to the absence of sutures or tacks needed for flat mesh implantation. This omission helps to avoid nerve entrapment, potentially leading to less postoperative pain (24). The increased incidence of immediate postoperative pain with the 3D mesh could be attributed to the larger size of inguinal hernias in the 3D mesh group, as compared to the polypropylene group, with average measurements of 1.58 ± 0.38 cm and 1.38 ± 0.49 cm, respectively. Our study also noted that the duration of laparoscopic TAPP procedures using 3D mesh was longer than that of polypropylene. In contrast, Rashid et al. found that the operative time was shorter in the 3D mesh group compared to the polypropylene group in their study on TEP/TAPP repairs (10). Additionally, a prospective randomized controlled trial has shown that TAPP laparoscopy with 3D mesh offers significant advantages, such as a shorter operation time than 2D high-definition laparoscopy (25). Another significant observation is the discrepancy in walking time between the two groups, with the 3D group showing a considerably longer median walking time than the polypropylene group. Mohamed et al. indicated that the 3D group had fewer movement restrictions than others in their study (23). In contrast, Hou et al. found no significant difference in movement limitations between the two groups (12). It is crucial to interpret the clinical relevance of this difference in walking time with caution, as it may not significantly affect overall patient recovery and functionality. Our study found no recurrence or infection in any of the patients. Consistent with this, Winchester et al., using conventional polypropylene mesh, reported no recurrence in patients during a 10-month follow-up (26). Similarly, Mir et al., using 3D mesh and a

12-month follow-up, also reported no recurrence in any patients (21). Recurrence of inguinal hernia has been documented in instances where 3D and polypropylene meshes were employed for repair (27–29). A comparative analysis of lightweight 3D and polypropylene mesh in TEP/TAPP laparoscopic inguinal hernia repairs in adults revealed that both groups experienced recurrence at 18 months, with rates of 3.3% in the 3D mesh group and 6.7% in the polypropylene group, indicating no statistically significant difference in recurrence rates between the two groups (10).

It is worth noting that recurrence rates can fluctuate based on various factors, including patient characteristics, surgical technique, mesh type, and the duration of follow-up. Ongoing monitoring and additional research are essential to assess the long-term outcomes and recurrence rates linked to different mesh materials and repair methods in inguinal hernia repair. Also, our study found no significant differences in hospital stay or the occurrence of complications such as ecchymosis, seroma, foreign body sensations, numbness, and neuralgia between the 3D and polypropylene groups. Similarly, a prospective comparative study examining laparoscopic extraperitoneal repair for inguinal hernia using lightweight polypropylene and 3D mesh detected no significant differences in postoperative seroma formation, chronic groin pain, length of hospital stay, and sensory impairment between the two groups. Additionally, both mesh repair techniques showed no recurrence after the three-month follow-up period (30).

One of the strengths of this study is the comparison of outcomes between two types of medium-weight 3D and polypropylene meshes in laparoscopic TAPP for inguinal hernia repair, which has rarely been explored in previous research. However, there are some limitations to consider. First, the sample size was relatively small, which may restrict the generalizability of the findings. Future studies with larger cohorts are necessary to confirm our results. Second, the follow-up duration was relatively brief, and future research needs to examine longer-term outcomes, including recurrence rates.

Conclusion

The findings indicated that 3D mesh may result in slightly higher postoperative pain and longer surgical durations but did not significantly affect complications or hernia recurrence outcomes. Further research and long-term follow-up are suggested to assess the cost-effectiveness and long-term consequences of using 3D mesh in hernia repairs.

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Conflict of Interests

The authors declare that they have no competing interests.

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