Anatomical meshes compared with standard flat polypropylene meshes in laparoscopic TAPP inguinal hernia repair

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Introduction
Chronic pain after hernia repair is a well-known complication and can be expected in 4–6% of patients undergoing transabdominal preperitoneal (TAPP) repair, with deleterious effects on daily activities and quality of life. Mesh-based chronic pain usually results from shrinkage and adhesions formation. Pain can be attributed to the type of the mesh inserted as well as the techniques of its fixation.

Objectives
The authors compare between anatomical mesh and standard flat prolene mesh regarding their effects on chronic postoperative pain. The authors also evaluate fixation using tacks and its effect on chronic postoperative inguinodynia.

Patients and methods
This is a randomized prospective cohort study of 200 patients undergoing TAPP repair with either anatomical meshes or flat prolene meshes. The authors randomized patients to either groups by closed envelop technique. Average age was 34.52 ± 9.63 years, and 83% of patients were males and 17% were females. Patients were evaluated on the seventh day, first month, sixth month, and first year. All patients were evaluated through questionnaires and detailed physical examination. Study outcomes included postoperative pain evaluated through visual analog scale (VAS) scores, seroma formation, and other operative morbidities. The correlation between number of tacks inserted and postoperative pain was also evaluated. Secondary outcomes include mean operative time and mean hospital stay.

Results
Mean VAS scores were statistically lower (P<0.05) in anatomical mesh group compared with flat mesh group. This difference started from the first evaluation visit (seventh day) and persisted till the last visit (after 1 year). Seroma formation was comparable between both groups (P>0.05). A fair relationship between the number of tacks inserted and incidence of postoperative pain was found (adjusted coefficient of determination, adjusted R^2=0.362). Mean operative time and mean hospital stay were significantly lower in anatomical mesh group (P<0.05).

Conclusion
Anatomical meshes reduce the incidence of postoperative inguinodynia. This effect starts early in postoperative period and persists over the first year. Traditional operative metrics as mean hospital stay and operative time were also better in anatomical group without any increase in operative complications.

Keywords:
anatomical, fixation, flat mesh, inguinodynia, tacks

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Introduction

Inguinal hernia is defined as protrusion of the contents of abdominal cavity through a defect in fascia transversalis above the inguinal ligament [1]. The lifetime risk of inguinal hernia is thought to be around 27% in men and 3% in women [2]. Inguinal hernia repair improves quality of life and prevents disability. One study showed that hernia repair was able to avoid 5.41 disability life years per patient treated [3]. Subsequently, around 20 million hernioplasties are performed annually around the world [4]. Since the first laparoscopic hernia repair performed by Ger *et al.* in 1990, the laparoscopic approach has gained much popularity and acceptance among the practitioners and the field has undergone huge changes in repair techniques, mesh types, and fixation methods [5].

Chronic pain after hernia repair is a well-known complication and remains an important measure of the outcome. The risk factors for chronic pain reported in the literature include young age patients, female sex, presence of chronic pain preoperatively, recurrent hernia, open-type repair, presence of penetrating mesh, resection

of cremasteric muscle, and the experience together with the learning curve of the performing surgeon [6]. Open techniques, in contrast to laparoscopic ones, seem to be more traumatic resulting in more peripheral nerve injuries and scarring of the anterior abdominal wall [7]. Laparoscopic approaches itself may cause nerve injury to nervous cutaneous femoris lateralis; however, this risk seems to be avoidable with the correct operating techniques [8]. Postoperative pain could be expected in 4–6% of patients undergoing transabdominal preperitoneal (TAPP) inguinal hernia repair with mesh [9].

Mesh-associated chronic pain is a well-known postoperative complication. Meshes may cause rigidity, adhesion formation, and shrinkage [10]. Initial repair techniques focused on using two-dimensional flexible meshes and fixation was a constant step in operative procedures, probably because of concerns that two-dimensional meshes may migrate in the three-dimensional contoured space of the groin [11]. Polypropylene meshes are permanent and hydrophobic. They promote a local inflammatory response with subsequent cellular infiltration and reduction of its size [12]. Best fixation methods are still debated. One study found higher risk of seroma formation with tack fixation when compared with no fixation (2.1 vs. 0.7%) [6]; however, the effect on pain is still to be debated [13,14]. Anatomically oriented meshes were introduced and brought the advantages of less tacks usage and ease of placement, which led to less operative times [15].

We aim to compare between the standard flat prolene meshes and anatomical mesh regarding scores of postoperative pain and seroma formation. We also examine the relation between number of tacks inserted and incidence of postoperative pain. We also examine some traditional operative metrics such as operative time, mean hospital stay, and recurrence rates.

Materials and methods

Study design and setting

This is a randomized prospective cohort study to assess the differences between anatomical mesh and flat prolene mesh regarding postoperative pain, seroma formation, and other operative morbidities. Traditional operative metrics such as operative time, hospital stay, and number of tacks were also evaluated. We randomized patients to group by closed envelop technique. This study took place between February 2018 and February 2021. All the procedures were TAPP repairs and were performed in El-Demerdash Hospital, Ain Shams University Specialized Hospital, Dar El-Fouad-Madinat Nasr, Dar El-Fouad. A total of 200 patients (166 males and 44 females) were enrolled. All the patients were followed as outpatients. All the surgeries were performed by the same well-trained experienced surgical team and pain scores were evaluated by qualified well-trained residents for postoperative pain scores. We recorded on visual analog scale (VAS score), with 0 being the least possible score and 10 the highest possible score. Postoperative pain was classified as no pain (VAS score 0), mild pain (VAS score 1–3), moderate pain (VAS score 4–6), and severe pain (VAS score >6).

Inclusion criteria

(1) Age above 18 years.
(2) All the patients who were having clinically, detected direct or indirect inguinal hernia.
(3) Patients with either unilateral or bilateral inguinal hernia.

Exclusion criteria

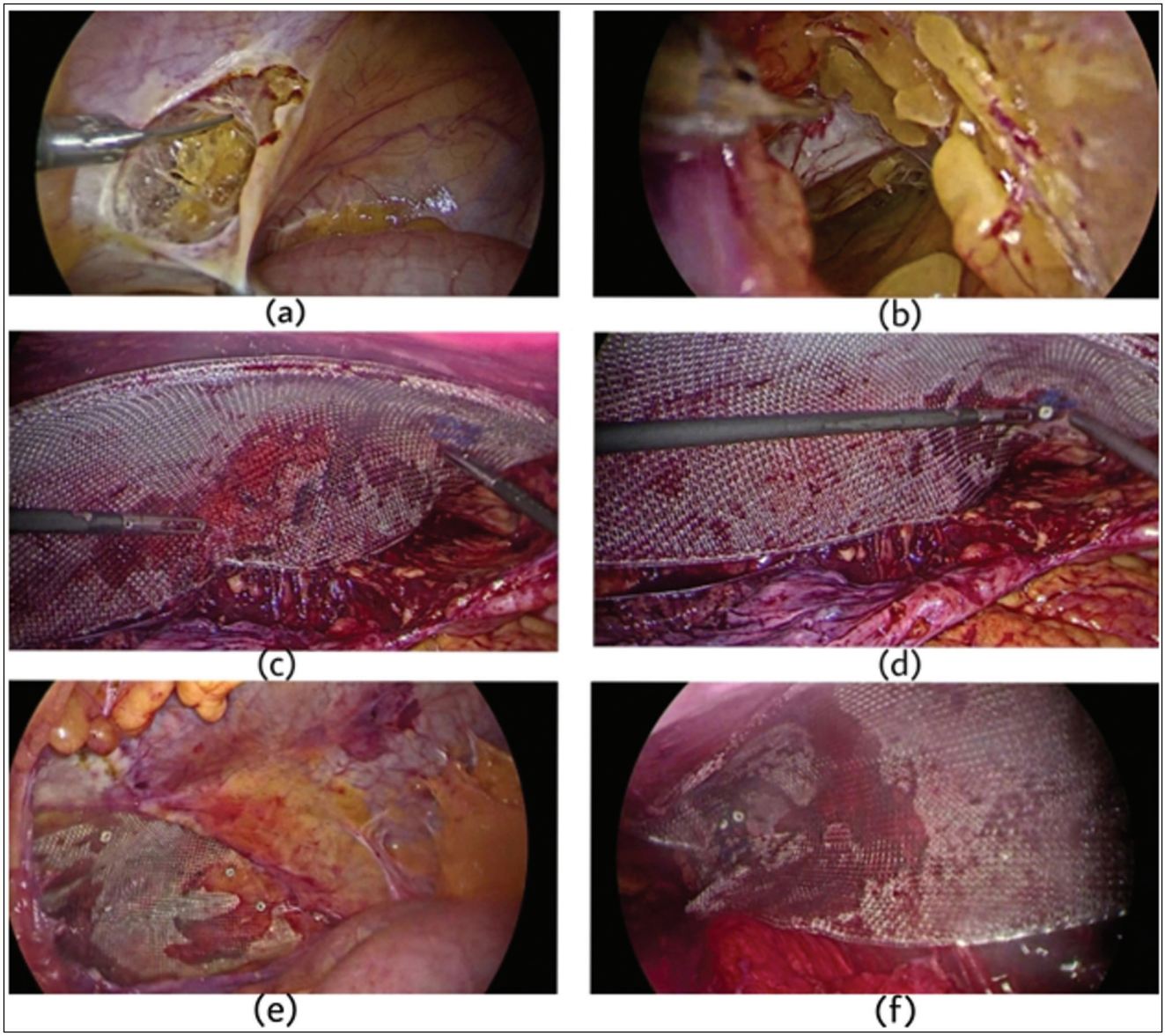
(1) Patients who are under 18 years.
(2) Patients with recurrent inguinal hernias.
(3) Open type hernioplasties.
(4) Patients who are unfit for laparoscopic surgery.

Operative details

All surgical procedures were performed by a single investigator. TAPP repair was done in all patients under general anesthesia. A single dose of ceftriaxone was given during induction of anesthesia. Pneumoperitoneum was created with Veress needle at 15 mmhg CO_2. We inserted 12-mm umbilical trocar and two 5-mm trocars lateral to rectus sheath at the lower abdomen. Inferior epigastric artery was identified and secured, and we confirmed the diagnosis of direct/indirect hernia. We started incising peritoneum 2 cm lateral to anterior superior iliac spine, and medial limit of dissection was retropubic with 1–2 cm. The peritoneum was routinely dissected off anterior ramus of the pubis, vas, and gonadal vessels. Peritoneum reflected and preperitoneal space entered and dissected. Cord lipomas when encountered were excised or reduced. Fat was dissected from fascia transversalis as needed. Hernial sac was reduced and not excised, and spermatic cord and gonadal vessels were identified and preserved.

After creating adequate preperitoneal pocket, we started inserting the mesh. In all, 100 patients received anatomical meshes (large size, 10.8 × 16 cm) and 100 patients received flat prolene meshes (10 × 12 cm). Mesh was deployed through the 10-mm trocar and adequately placed in the preperitoneal space according to original design specifications. We tried to use a minimal number of tacks. Application of tacks between ductus deferens and testicular vessels (which is known as “triangle of dome”) and lateral to structures of spermatic cord below ilio-pubic tract (which with

Figure 1



(a) The beginning of dissection at anterior superior iliac spine. (b) Pubic tubercle and medial limits of dissection. (c) Placing mesh in its plane. (d) Tack fixation of pubic tubercle. (e, and f) Anatomical meshes positioned in its anatomical plane with the use of minimal umber of tacks.

lateral femoral cutaneous nerve are known as "square of doom") were strictly avoided. At least one or two tacks were used for fixation in pubic tubercle and single lateral tack was used, if no more were required. Peritoneum flaps were closed using the tacks. For anatomical mesh fixation, we used nonabsorbable tacks permanent fixation system that allows strong long-term repair with minimal tissue damage. We avoided applying tacks over or in proximity of bones and blood vessels (Fig. 1a–f).

Study outcomes and data collection

All the 200 cases were reviewed as outpatients at the 7th day, 1st month, 6th month, and 1 year after the surgery. Data collection was done through a face-to-face interviewing and physical examination.

(1) Postoperative pain scores were recorded on VAS score, with 0 being the least possible score and 10 the highest possible score. Postoperative pain was classified as no pain (VAS score 0), mild pain (VAS score 1–3), moderate pain (VAS score 4–6), and severe pain (VAS score >6).
(2) Postoperative seroma formation, wound infection, and urinary retention were evaluated through a detailed physical examination.
(3) Secondary outcomes such as operative time and the length of hospital stay were also evaluated.

Statistical analysis

Data entry was done through Microsoft EXCEL spreadsheet. All continuous variables were expressed

as mean±SD. Frequency data were summarized as percentages. For continuous variables, we used unpaired *t*-test. Assumptions of normality and equal variances were checked first. Comparison of categorical data was done through χ^2 test for proportions and all frequencies were represented as percentages. Linear regression was done by ordinary least squares method. Tabulation and data analysis was done through R core team 2020 and IBM SPSS statistics 27. All *P* values less than 0.05 were considered as statistically significant.

Results

In our study in 200 patients, 166 (83%) patients were males, and 34 (17%) patients were females. The average age for both groups was 34.52 ± 9.63 (range 21:51) years. In all, 160 (80%) patients were operated on for indirect inguinal hernia (80 in anatomical mesh group and 80 in flat prolene mesh group), 40 (20%) patients were operated for direct inguinal hernia (20 in anatomical mesh group and 20 in flat prolene mesh group), 158 (79%) patients had a unilateral hernia (78 patient in anatomical mesh group and 80 in flat prolene mesh group), and 42 (21%) patients had bilateral hernia (22 in anatomical mesh group and 20 in flat prolene mesh group). Table 1 gives a summary about patients' characteristics.

Regarding postoperative pain, Table 2 compares between percentages of postoperative pain scores between anatomical mesh group and flat prolene mesh group at the 7th day, 1 month, 6th month, and 1 year.

Mean VAS score on the 7th postoperative day was found to be 1.9 ± 1.38 in anatomical mesh group, compared with 3.81 ± 2.1 in flat mesh group, which was statistically significant (*P*=0.0001). We followed our patients again after 1 month, and mean VAS score decreased to 1.28 ± 1.39 in anatomical mesh and to 2.51 ± 1.76 in flat mesh group; however, the difference between the means was also statistically significant (*P*=0.0001). At 6 months, 66% of the anatomical mesh group reported that they were pain-free, in comparison with only 25% in flat group. Mean VAS scores for anatomical mesh group at 6 months was 0.41 ± 0.62, and mean VAS scores for flat mesh was 1.7 ± 1.35 (*P*=0.0001). At 1 year, the mean VAS scores started to plateau when compared with the previous results (0.34 ± 0.48 for anatomical mesh and 1.2 ± 1.1 for flat mesh); however, the difference between mean values was still statistically significant (*P*=0.0001) (Diagram 1).

Regarding seroma formation, at 7th day, 6 (6%) patients had seroma formation in anatomical mesh group and 6 (6%) patients at flat mesh group (*P*>0.05). At 1 month, this dropped to 4 (4%) patients in anatomical mesh group and 3 (3%) patients in flat mesh group; however, the difference between both was statistically insignificant (*P*>0.05). At 6 months no patients in anatomical group still had seroma (0%) compared with 1 (1%) patient in flat mesh group (*P*>0.05). At 1 year, no patients had seroma in both groups (0%).

Three (3%) patients in flat mesh group developed urinary retention compared with none (0%) in anatomical mesh

Table 1 Baseline characteristics of the patients

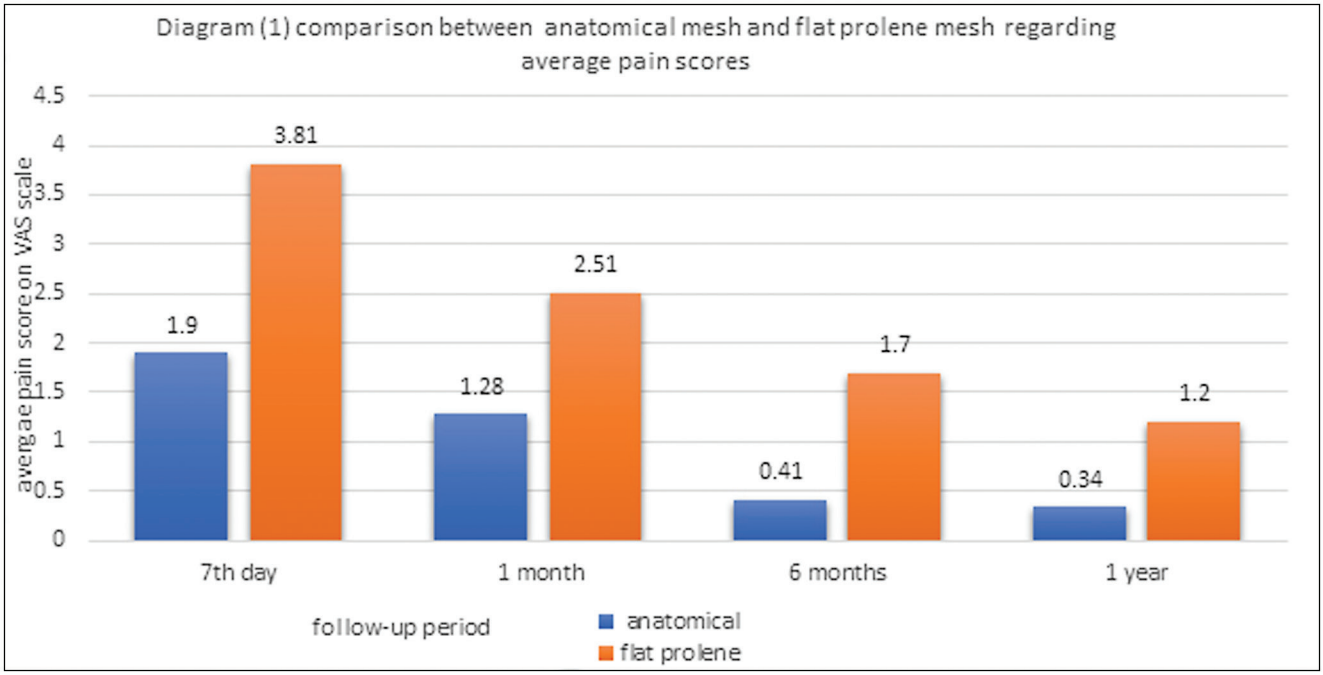
	Anatomical mesh	Flat prolene mesh	Total
Number	100	100	200
Age (average)	33.64 ± 10.4	35.4 ± 8.8	
Sex			
Male	82	84	166 (83%)
Female	18	16	34 (17%)
Laterality			
Unilateral	78	80	158 (79%)
Bilateral	22	20	42 (21%)
Type of hernia			
Direct	20	20	40 (20%)
Indirect	80	80	160 (80%)

Table 2 Percentages of postoperative pain

	No pain VAS score 0		Mild pain VAS score (1–3)		Moderate pain VAS score (4–6)		Severe pain VAS score (>6)	
	Anatomical (%)	Flat prolene (%)	Anatomical (%)	Flat prolene (%)	Anatomical (%)	Flat prolene (%)	Anatomical (%)	Flat prolene (%)
7th day	0	10	87	35	13	41	0	14
1 month	30	20	54	47	16	33	0	0
6 months	66	25	34	70	0	5	0	0
1 year	66	35	34	65	0	0	0	0

VAS, visual analog scale.

Diagram 1



Comparison between anatomical and prolene mesh regarding average pain scores.

group; however, this was not statistically significant (P>0.05) Taking into consideration the sample size, one (1%) patient developed hematuria and one (1%) patient developed intra-abdominal hematoma in flat mesh group compared with none (0%) in anatomical mesh group (P>0.05). Two (2%) patients developed wound (port site) infection in anatomical mesh group, and no one developed wound infection in flat mesh group (0%); however, this was not statistically significant (P>0.05). Two (2%) patients in anatomical mesh group developed recurrence compared with four (4%) patients in flat mesh group; however, this was not statistically significant (P>0.05).

Regarding traditional operative metrics, the mean operative time in anatomical group was 65.7 ± 6.03 min and the mean operative time in flat mesh group was 69.7 ± 8.56 min. This difference between means was statistically significant (P<0.0001) reflecting less technical difficulties and ease of placement compared with traditional meshes. The mean hospital stay in anatomical mesh arm was 19.68 ± 8.27 h compared with 29.16 ± 5.97 h in flat mesh group (P<0.0001).

A total of 75 patients in anatomical mesh group (75%) needed only two tacks for fixation and 25 (25%) patients needed three tacks. A minimum of four tacks were needed in flat mesh group and this occurred in only 10 (10%) patients, whereas 20 (20%) patients needed five tacks, 31 (31%) patients needed six tacks, 20 (20%) patients needed seven tacks, and 19 (19%) patients needed eight tacks. Mean number of tacks in anatomical group was 2.25 compared with 6.18 in flat mesh group. This was statistically significant (P<0.0001). Diagram 2 shows number of tacks inserted in each group.

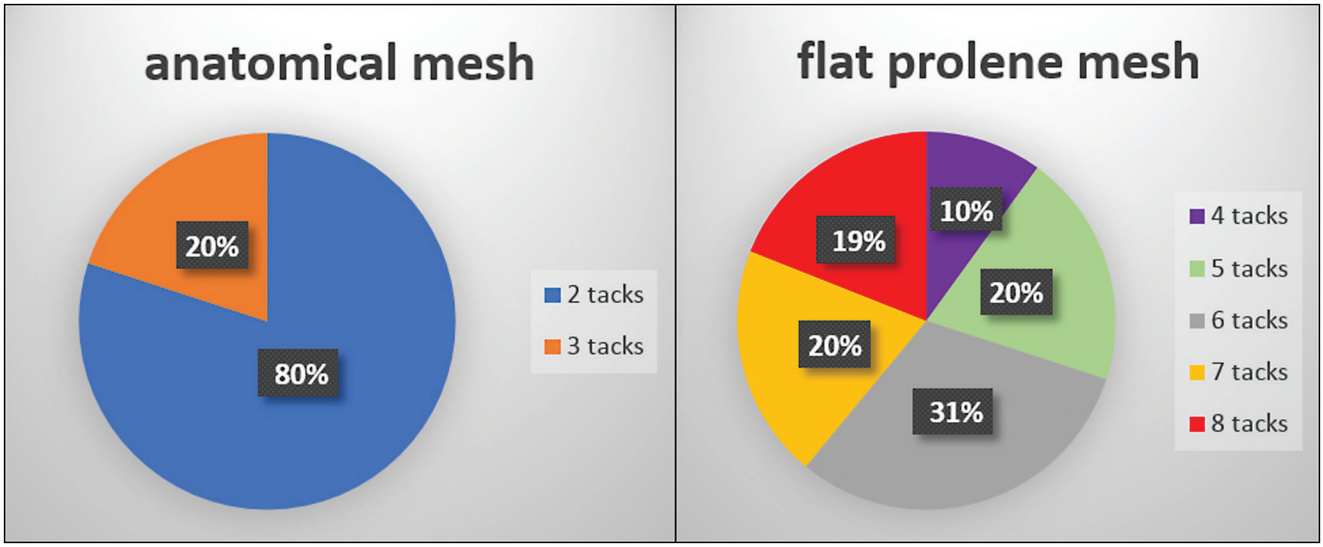
When we plotted the mean VAS for every patient over the follow-up period against number of tacks, the correlation has been shown to be statistically significant (P<0.001) with coefficient of determination R^2 being 0.365 and adjusted R^2 being 0.362. This means that 36.2% of the variability in VAS scores among patients can be directly attributed to number of tacks inserted (Diagram 3).

Regarding recurrence rates, recurrence occurred in 2 (2%) in 100 person-years follow-up in anatomical mesh group compared with 4 (4%) in 100 person-year follow-up in flat prolene mesh group; however, the difference was not statistically significant (P>0.05).

Discussion

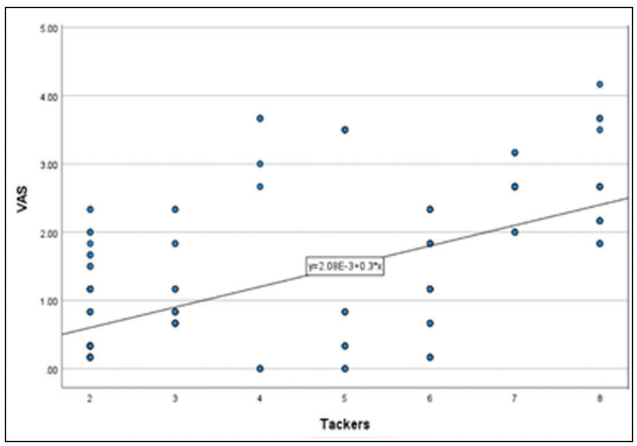
In this prospective cohort study of 200 patients with inguinal hernia, either unilateral or bilateral, direct or indirect, evaluated over 1 year, we found a significant reduction of postoperative pain in anatomical group compared with flat prolene group over the study period. This effect started from the 7th postoperative day and persisted till the end of first year. Operative time was significantly less in anatomical group compared with flat prolene mesh, reflecting the ease of placement and less technical demanding of the contoured mesh. Hospital stay was also significantly less in anatomical

Diagram 2



Number of tacks inserted in each group.

Diagram 3



Visual analog scale scores compared with number of tackers.

group. This can be translated to rapid return to normal activities after surgery. The number of tacks needed to fix the meshes was significantly less in anatomical group, which may help reducing the prevalence of postoperative pain in laparoscopic hernia surgery.

With the advent of the so-called tension-free techniques, the problem of recurrence has been substantially solved; however, chronic pain after surgery is now receiving more attention. Kehlet and Aasvang [16] showed that a 5–10% of the patients reported a deleterious effect on daily activities and pain-related sexual problems occurred in up to 2% of young men in his study population. Nienhuijs *et al*. concluded that around 11% of operated patients suffered chronic pain after mesh-based inguinal hernia repair. More than quarter of the patients in this study had moderate to severe pain with a debilitating effects on daily-leisure life [17,18]. The pain after TAPP is thought to be related to ligamentous insertions around pubic tubercle, and maybe related to fixation process. This is on contrary to open approaches that results in neuropathic pain arising from nerve irritation [19].

The type of prothesis used in mesh-based surgery and its relation to postoperative pain was a matter of continuous debate. Horstmann *et al*. [20] examined the effect of reducing polypropylene amount on functional outcomes and quality of life measures after TAPP procedure. They concluded that lower postoperative complications and better quality of life can be anticipated by reducing the amount of polypropylene in the used meshes. There are numerous variations regarding fiber diameter and fiber count classifying mesh materials into heavyweight or lightweight; however, there was no consensus on the classification details. A meta-analysis of 2310 patients undergoing inguinal hernia repair with either heavyweight or lightweight meshes showed less incidence of postoperative pain in lightweight meshes with no difference regarding recurrence rates [21]. However, 2D meshes are more liable for shrinkage and migration in three-dimensionally contoured space of the groin, increasing postoperative pain [11]. The introduction of anatomical meshes allowed better conformation to the inguinal anatomy. Its shape and contour minimized buckling and eased its positioning in inguinal region, possibly with minimal amount of fixation [19]. In our study, pain score was significantly lower in anatomical mesh group at 7th day and the effect persisted till the end of first year of follow-up.

Regardless prothesis material, the method of its fixation is still a matter of debate, suturing, stapling,

and tacking leads to tissue perforation with subsequent inflammatory process and neurovascular bundles injury, which may a provoking step in development of chronic pain [12]. Mesh fixation was introduced first to minimize the risk of recurrence; however, Gutlic *et al*. [22] found no difference regarding recurrence rates between fixation and no fixation techniques. The guidelines of International Endohernia Society recommend no mesh fixation in TAPP repair performed for types LI, II and MI, II (EHS classification). The use of fixation is recommended in larger defects such as LIII and MIII [23].

Multiple meta-analyses compared the use of penetrating mesh fixation (including tacks) with fixation using glue. The use of penetrating fixation led to more chronic postoperative pain when compared with glue fixation [24,25]. This underpins the value of reducing penetrating fixation to minimum. Unfortunately, this evidence is mostly of low or moderate quality. On contrary to these results, Sajid *et al.* [13] did not find a significant difference in the rates of postoperative pain between tack fixation and nonfixation methods. Anatomical meshes with its shape and durability allow for minimum fixation. In our study, most patients in anatomical mesh group needed only two tacks in 80% of patients and three in 20% of patients. This is compared with a minimum number of four tacks in flat prolene mesh group in 10% of the patients, five tacks in 20%, six tacks in 31%, six tacks in 20%, and seven tacks in 19% of the patients. The adjusted coefficient of determination (adjusted R^2) was found to be 36.2%, suggesting a direct relationship between number of tacks inserted and the incidence of postherniorrhaphy inguinodynia.

In our study, most patients were discharged home within the first day in anatomical group (mean hospital stay 19.68 ± 8.27 h). This is compared with the results published by Mir *et al.* [19] where 88.67% of the patients were discharged on the first day. Patients treated with flat prolene mesh in our studied stayed in hospital for 29.16 ± 5.97 h, which was statistically significant. Recurrence rates in our study after 3 years of follow-up were truly comparable with the results shown by Pokorny *et al.* [26] where the cumulative 3-year recurrence rate was 4.7%.

Limitations of our study included limited access to the data regarding baseline characteristics of the patients and moderate sample size.

Conclusion

Anatomical meshes were able to reduce the incidence of postoperative inguinodynia. This effect started on seventh day postoperatively and persisted till the end of first year in follow-up. Seroma formation was not higher in anatomical group when compared with flat prolene mesh. Traditional metrics such as operative time and hospital stay were better in anatomical group when compared with flat prolene mesh. Anatomical mesh paves the way for a better quality of life after hernioplasties and reduces the incidence of postoperative inguinodynia.

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Nil.

Conflicts of interest

No conflict of interest.

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