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Retromuscular Mesh Repair Using Fibrin Glue: Early Outcomes and Cost-effectiveness of an Evolving Technique

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Background: Retromuscular hernia repairs (RHRs) decrease hernia recurrence and surgical site infections but can cause significant pain. We aimed to determine if pain and postoperative outcomes differed when comparing suture fixation (SF) of mesh to fibrin glue fixation (FGF).

Methods: Patients undergoing RHR (n = 87) between December 1, 2015 and December 31, 2017 were retrospectively identified. Patients received SF of mesh (n = 59, 67.8%) before the senior author changing his technique to FGF (n = 28, 32.2%). These 2 cohorts were matched (age, body mass index, number of prior repairs, mesh type, defect size, and wound class). Outcomes were analyzed using a matched pairs design with multivariable linear regression.

Results: Two matched groups (21 FGF and 21 SF) were analyzed (45.2% female, average age 56 years, average body mass index 34.7 kg/m^2, and average defect size 330 cm^2). Statistical significance was observed for FGF compared with SF: length of stay (3.7 versus 7.1 days, $P = 0.032$), time with a drain (17.2 versus 27.5 days, $P = 0.012$), 30-day postoperative visits (2 versus 3, $P = 0.003$), pain scores (5.2 versus 3.1, $P = 0.019$) and activity within the first 24 hours (walking versus sitting, $P = 0.002$). Operative time decreased by 23.1 minutes ($P = 0.352$) and postoperative narcotic represcription (3 versus. 8 patients, p=0.147) also decreased. Average cost for patients receiving SF was $36,152 compared to $21,782 for FGF ($P = 0.035$).

Conclusions: Sutureless RHR using FGF may result in decreased pain when compared with a matched cohort receiving SF, translating to enhanced recovery time, shortened hospital stay, and decreased costs. *(Plast Reconstr Surg Glob Open 2019;7:e2184; doi: 10.1097/GOX.0000000000002184; Published online 11 April 2019.)*

INTRODUCTION

Ventral hernias (VHs) are prevalent, resulting in over 400,000 repairs and $3.2 billion annually.[1] A substantial improvement to VH repair (VHR) was the introduction of the retromuscular hernia repair (RHR) utilizing large transfascial suture bites by Rives et al[2] and Stoppa et al[3] in the 1970s. Recent studies have shown that placement of mesh in the retrorectus space has led to decreased recurrence rates[4,5] and surgical site infections (SSIs).[6]

Despite these successes, VHs still have a significant impact on morbidity, healthcare costs, and quality of life.[7,8] Patients experience significant postoperative pain[9] leading to decreased activity levels[10] and increased hospital length of stays (LOS).[11] Recent studies have aimed to identify and mitigate factors associated with postoperative pain, including location of mesh placement,[4] combinations of suture and mesh techniques,[7] preoperative identification of high-risk patients,[12] and the use of fibrin fixation for mesh placement.[13–15] Of these, fibrin fixation appears to be extremely promising, allowing for an ideal hernia repair without causing the pain typically associated with large transfascial bites.

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Fibrin sealants, such as Tisseel (TISSEELTM: Baxter Healthcare Corp, Deerfield, Ill.), are made up of fibrinogen and thrombin; this combination allows for fibroblast proliferation and hemostasis. Ultimately, this leads to fibrinolysis and incorporation of the mesh into the surrounding tissue.[15] In their preliminary investigations, Chevrel and Rath did not intend for fibrin glue (FG) to be used on its own, but rather as an adjunct to the principal suture fixation (SF).[16] In 2009, Canziani et al[14] described decreased postoperative pain at 1 year and short LOS in a group of 40 patients who underwent recurrent incisional hernia repair with mesh. More recently, Weltz et al[13] reported reduced pain at 6 months postoperatively with FG using mesh in the retromuscular position.

To date, no study has compared 2 matched groups to assess early postoperative outcomes, cost-effectiveness, and quality of life between SF and sutureless mesh repair using FG. We hypothesized that the FG fixation (FGF) group would experience lower pain score and increased activity levels at 24 hours resulting in shorter LOS, less postoperative visits, and lower costs compared with the SF group.

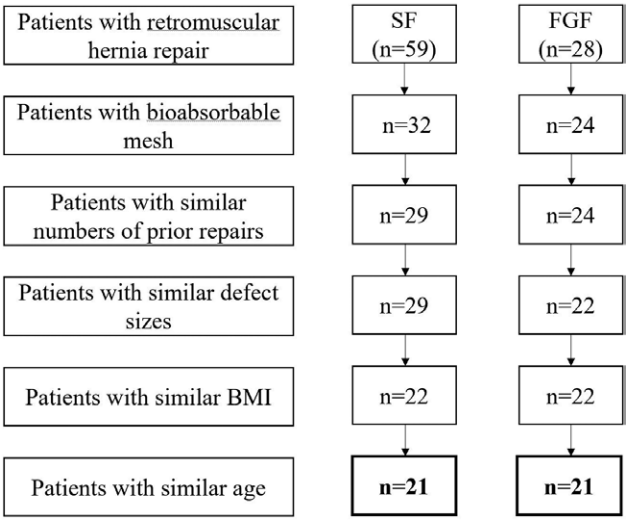

Fig. 1. Matching process using a constrained distance hot deck imputation procedure based on a hierarchy of variables, resulting in 21 patients in each group. Comparative statistics for these variables can be seen in Tables 1 and 2.

METHODS

Data Source and Patient Selection

After receiving approval from the University of Pennsylvania institutional review board (Protocol #828952), we retrospectively identified all patients that underwent VHR with mesh placement between July 1, 2015 and December 31, 2017 by the senior author. Of the 132 patients who underwent VHR during this time period, 87 received mesh in the retrorectus position. These patients were then separated into 2 groups based on the method of mesh fixation (SF or FGF) and matched using a constrained distance hot deck imputation procedure[17] based on a hierarchy of variables: type of mesh, location of mesh, number of prior VHR, defect size, age, and body mass index (BMI) as seen in Figure 1.

Patient demographics (age, gender, and BMI), comorbidities (hypertension, diabetes, smoking, and number of prior hernia repairs), and perioperative factors [type of mesh, location of mesh, wound class,[18] defect size, case length, transversus abdominis release (TAR), open anterior component separation, number of drains, concurrent surgical procedures (including panniculectomies and use of an epidural)] were collected for all patients.

Operative Technique for FGF

An RHR and addition of a TAR as described by Novitsky et al,[19] where necessary, are performed in all cases. The posterior rectus sheath is closed with interrupted figure-of-eight or running and interrupted monofilament absorbable suture (Fig. 2A). The tension in the anterior sheath is assessed. If there is minimal tension, a sponge is used to ensure that the closed posterior sheath and surrounding rectus muscle is free of moisture so as to optimize the effectiveness of the FG (Fig. 2B). Next, before introduction of the mesh, FG is sprayed on to the anterior surface of the posterior sheath and the posterior surface of the anterior sheath/rectus complex (Fig. 2C). The mesh is then tailored to sit in the retromuscular defect with a "hand-in-glove" fit, and additional FG is sprayed (Fig. 2D). In total, 10–20 ml of FG is used per case. The anterior rectus fascia is then closed with two #1-sized continuous slowly absorbable sutures. The anterior soft tissue is closed in multiple layers. At least one drain is left in place above the mesh and the patient is given instructions to keep a running diary of drain outputs. Once a drain output is less than 30 ml for 24 hours, patients are instructed to come in to the office to have that drain pulled by the surgeon or physician extender.

Outcomes and Statistical Analysis

Primary outcomes of interest were pain scores at 24 hours (based on a 0–10 visual analogue scale), activity scores at 24 hours (from the Braden assessment),[20] and hospital LOS. Secondary outcomes included time to the last drain being removed, number of 30-day postoperative visits, seroma, nonhealing incisional wound,[21] SSI, number of patients requiring additional narcotic prescriptions after discharge from the hospital, costs associated with the hernia repair, and quality of life assessment using the Hernia-related quality of life survey (HerQLes).[22] Costs related to the hernia repair were obtained from the institution's Department of Finance. HerQLes scores were collected 4–6 weeks before surgery and then 12 weeks postoperatively. Scores were converted to a 100-point scale using a Rasch model, indicating improved quality of life with a higher score.[22]

Univariate analyses for preoperative and intraoperative variables included McNemar's tests for nominal variables and Student's t tests or Mann-Whitney U tests for continuous variables. Postoperative outcomes were calculated using Fisher's exact and chi-square tests for categorical variables and Student's t tests and Mann-Whitney U tests for continuous variables (including cost and quality of life). Multivariable linear regression models were constructed for all 3 primary outcomes with covariates identified if they had a P value <0.1 during univariate analysis.

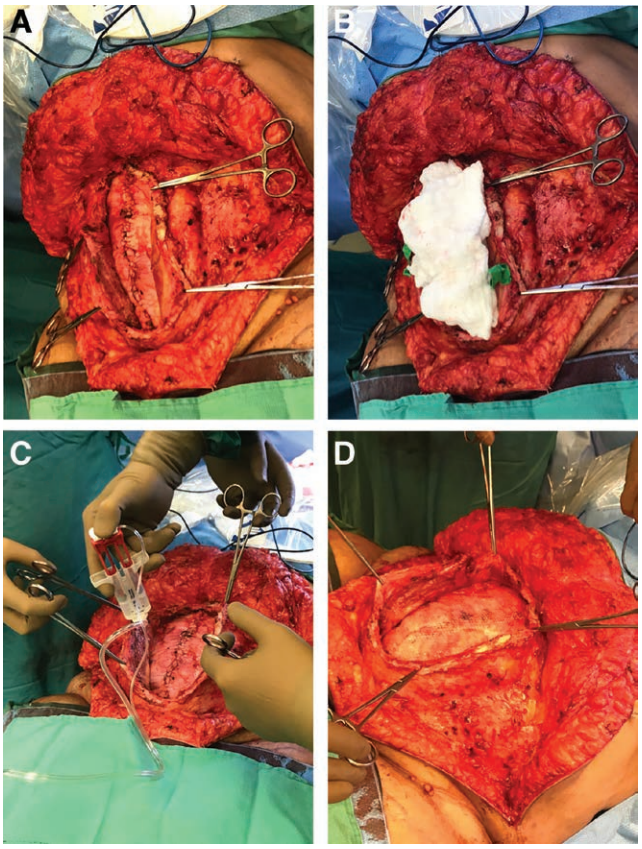

Fig. 2. Operative technique. A, Closure of posterior sheath. B, Drying fascia with a sponge. C, Spraying FG before introduction of mesh. D, Inset of mesh before respraying FG.

All tests were 2-sided and a *P* value less than 0.05 was used to define statistical significance. All statistical analyses were performed using StataCorp. 2017. *Stata Statistical Software: Release 15* (StataCorp LLC, College Station, Tex.).

RESULTS

Patient Preoperative Variables

After patients were matched as detailed in Figure 1, there were 21 patients who received FGF and 21 patients who received SF during the study period. Average follow-up was 28 weeks (range 4–80 weeks). Average age (56.0 years SF versus 56.6 years FGF, $P = 0.89$), BMI (35.4 kg/m^2 SF versus 34.0 kg/m^2 FGF, $P = 0.57$), number of females (47.6% SF versus 42.9% FGF, $P = 0.83$), number of prior repairs ($P > 0.99$), presence of hypertension (HTN) (71.4% SF versus 57.1% FGF, $P = 0.31$), and history of smoking (47.6% SF versus 28.6% FGF, $P = 0.42$) were not statistically different between the 2 groups (Table 1).

Table 1. Preoperative Variables of Patients Receiving SF or FGF of Mesh

	Total (n = 42)	SF (n = 21)	FGF (n = 21)	*P*
Females, n (%)	19 (45.2%)	10 (47.6%)	9 (42.9%)	0.83
Age (y)	56.3 (±13.0)	56.6 (±11.9)	56.0 (±14.4)	0.89
BMI (kg/m^2)	34.7 (±8.2)	35.4 (±8.8)	34.0 (±7.8)	0.57
No. prior repairs, n (%)				>0.99
0	21 (50.0%)	11 (52.4%)	10 (47.6%)	
1	14 (33.3%)	7 (33.3%)	7 (33.3%)	
2+	7 (16.7%)	3 (14.3%)	4 (19.0%)	
Hypertension, n (%)	27 (64.3%)	15 (71.4%)	12 (57.1%)	0.31
Diabetes, n (%)	11 (26.2%)	8 (38.1%)	3 (14.3%)	0.08
Smoking history	16 (38.1%)	10 (47.6%)	6 (28.6%)	0.42

Number of prior repairs defined by any previous ventral or incisional hernia repairs.

Intraoperative Details

Table 2 shows the intraoperative characteristics of both groups. All patients received an RHR with bioabsorbable mesh. Wound class, number of TARs, panniculectomies, concomitant procedures, and epidural use were not statistically different. Additionally, case times and average defect sizes were similar between the 2 groups. Statistical significance was seen for the average number of drains used (2.4 in SF compared with 1.4 in FGF, $P = 0.003$) and for the number of open anterior component separations in each groups (6 in SF and 4 in FGF, $P = 0.035$).

Postoperative Outcomes

Postoperative outcomes recorded in Table 3 show a statistically significant difference between SF and FGF with improved 24-hour pain scores (3.1 FGF versus 5.2 SF, $P = 0.019$), improved 24-hour activity scores (occasionally walking FGF versus sitting in a chair SF, $P = 0.002$), shorter hospital LOS (3.7 days FGF versus 7.1 days SF, $P = 0.032$), decreased 30-day postoperative visits (1.9 FGF versus 3.1 SF, $P = 0.003$), and decreased time to last drain removal (17.2 days FGF versus 27.5 days SF, $P = 0.012$). Seroma, SSI, and nonhealing incisional wounds were not statistically different between the 2 groups. Multivariable linear regression showed that FGF of mesh remained as an independent predictor of improved 24-hour pain scores ($P = 0.024$) and 24-hour activity scores ($P = 0.028$) but was not significant for hospital LOS. However, improved 24-hour activity scores did have an association with shorter hospital LOS ($P = 0.004$) (Table 4).

Of 42 patients, 31 (73.8%) (15 FGF and 16 SF) completed the pereoperative and postoperative quality of life surveys, revealing no statistically significant differences between the 2 groups (Table 4). Average total costs ($21,782 FGF vs $37,960 SF, $P = 0.017$) and average hospital charges ($109,543 FGF versus $176,800 SF, $P = 0.033$) were significantly different between the 2 groups (Table 3).

DISCUSSION

After introducing FG into his practice on June 30, 2017, the senior author has used this technique in the majority of his RHR. Short-term results assessing the utility of FG appear to provide a safe and cost-effective alternative to SF of mesh in open abdominal RHR. Patients who did not receive SF were more likely to be walking instead of sitting and reported less pain at 24 hours postoperatively. The group of patients that received FGF spent an average of 3.4 days less in the hospital, were drain-free 10 days earlier, and required one less 30-day post-operative visit—all contributing to decreased cost and improved recovery. These results

Table 2. Intraoperative Variables of Patients Receiving SF or FGF of Mesh

	Total (n = 42)	SF (n = 21)	FGF (n = 21)	*P*
RHR, n (%)	42 (100%)	21 (100%)	21 (100%)	>0.99
Bioabsorbable mesh, n (%)	42 (100%)	21 (100%)	21 (100%)	>0.99
Wound class				>0.99
1	33 (78.6%)	16 (76.2%)	17 (81.0%)	
2	5 (11.9%)	3 (14.3%)	2 (9.5%)	
3	2 (4.8%)	1 (4.8%)	1 (4.8%)	
4	2 (4.8%)	1 (4.8%)	1 (4.8%)	
Defect size (cm^2)	330.1 (±185.8)	334.1 (±179.0)	326.0 (±196.7)	0.89
Case length (min)	205.0 (±79.2)	216.5 (±75.7	193.4 (±82.8)	0.35
Open anterior component separation, n (%)	10 (23.8%)	6 (28.6%)	4 (19.0%)	0.035
TAR, n (%)	16 (38.1%)	8 (38.1%)	8 (38.1%)	0.38
No. drains placed during surgery (mean)	1.9 (±1.1)	2.4 (±0.9)	1.4 (±1.0)	0.003
Panniculectomy, n (%)	20 (47.6%)	11 (52.4%)	9 (42.9%)	>0.99
All concomitant surgery, n (%)	24 (57.1%)	13 (61.9%)	11 (52.4%)	>0.99
Use of epidural, n (%)	33 (78.6%)	16 (76.2%)	17 (81.0%)	>0.99

RHR, retromuscular hernia repair; TAR, transversus abdominis release.

Table 3. Postoperative Outcomes, Healthcare Costs, and Healthcare Charges for Patients Receiving SF or FGF of Mesh

	Total (n = 42)	SF (n = 21)	FGF (n = 21)	*P*
24-h pain score (0–10)	4.2 (±3.0)	5.2 (±3.1)	3.1 (±2.5)	0.019
24-h activity score[1–4]	2.5 (±0.9	2.0 (±1/1)	2.9 (±0.4)	0.002
LOS (d)	5.4 (±5.3)	7.1 (±7.0)	3.7 (±1.6)	0.032
No. 30-day postoperative visits (#)	2.5 (±1.4)	3.1 (±1/6)	1.9 (±0.8)	0.003
Time to last drain being removed (d)	22.8 (±12.6)	27.5 (±15.4)	17.2 (±4.3)	0.012
Repeat narcotic prescription, n (%)	11 (26.2%)	8 (38.1%)	3 (14.2%)	0.27
Seroma, n (%)	3 (7.1%)	3 (14.3%)	0	0.23
SSI	3 (7.1%)	2 (9.5%)	1 (4.8%)	>0.99
Nonhealing incisional wound, n (%)	3 (7.1%)	2 (9.5%)	1 (4.8%)	>0.99
Total healthcare costs ($)	29,674 (±22,080)	37,960 (±28,604)	21,782 (±7,978)	0.017
Total hospital charges ($)	141,863 (±100,220)	176,800 (±131,009)	109,543 (±39,172)	0.033

Twenty-four hour pain scores are based on a visual analog scale, with a higher number associated with increased pain. Twenty-four hour activity score is based on the Braden Assessment scale (1, bedrest; 2, sitting in a chair; 3, walks occasionally; 4, walks frequently).

indicate the utility of FG in the short term, but there are potential drawbacks of not using SF (such as hernia recurrence or mesh migration). Thus, we are continuing to follow these 2 patient groups over the next 2 years.

When considering sutureless RHR, an argument can be made to avoid fixation of the mesh completely. In fact, a study in 2015 showed that using self-gripping meshes may also decrease pain.[23] To our knowledge, no direct comparison of self-gripping mesh to FGF of mesh has been conducted. Because an open anterior approach for RHR was used in all cases (as opposed to a posterior laparoscopic approach), the dissection plane was likely larger and potentially had higher likelihood for dislodgment of the mesh. As such, the senior author used FG in this study to ensure that the mesh remained in place during the initial healing period while still safeguarding against mesh displacement.

In 1997, Chevrel and Rath[24] published their technique describing the use of FG along with sutures for fascial reinforcement of onlay mesh repairs. Almost 20 years later, the first case series describing fixation of mesh using FG alone in an onlay position was published, citing potential advantages that include less operative time, less technical difficulty, and less long-term pain.[25] In 2009, Canziani et al[14] described the first series of patients to undergo sutureless positioning of a retromuscular preperitoneal mesh fixed only with FG and demonstrated decreased pain and a 3-day LOS, although there was no control group for comparison.

Our study reported an average LOS in FGF patients of 3.7 days, which is supported by previous publications describing a range of 3–5.7 days in patients receiving FGF for RHR.[13,14] Factors that may contribute to this advantage include significantly lower pain and increased activity by those undergoing FGF. The shortest postoperative time point used by these studies was 1 week after surgery for pain scores and 1 month for activity. Our study is the first to compare both pain and activity levels between the 2 groups at 24 hours postoperatively while also assessing these factors 12 weeks after the operation through the HerQLes questionnaire. Although we were unable to calculate morphine equivalents due to limitations of our electronic medical record (EMR), the visual analog scale (VAS) used in our study is well established and has been cited as a uniform method for documenting patient pain.[26] The more comprehensive assessment of pain and activity at 2 separate time points in our study further suggests that these factors contribute to shorter hospitalization and lower healthcare costs. Other factors have also been cited as decreasing hospital LOS, including the use of minimally invasive techniques[27] and use of enhanced recovery after surgery (ERAS) protocols.[28] No laparoscopic or robotic cases were performed in our study and no ERAS protocols were implemented at our institution during the study period, but the senior author typically does await return of bowel function before discharging patients. Furthermore,

Table 4. Multiple Linear Regression Model Utilizing All Variables That Had a *P* Value <0.1 in Univariate Analyses as Covariates and the Primary Outcomes (24-hour Pain Score, 24-hour Activity Score, and Hospital LOS) as Dependent Variables

Covariates	Coefficient (Standard Error)	95% Confidence Interval	*P*
24-h Pain Score (0–10)			
Diabetes	−1.30 (±1.10)	[−3.52, 0.94]	0.25
Open anterior component separation	−0.23 (±0.63)	[−1.51, 1.05]	0.71
No. drains placed during surgery	0.20 (±0.55)	[−0.92, 1.32]	0.72
FGF	−2.32 (±0.99)	[−4.33, −0.32]	0.024
24-h activity score[1–4]			
Diabetes	0.12 (±0.29)	[−0.48, 0.72]	0.68
Open anterior component separation	−0.33 (±0.17)	[−0.68, 0.01]	0.06
No. drains placed during surgery	−0.21 (±0.15)	[−0.51, 0.09]	0.16
FGF	2.69 (±0.26)	[1.99, 3.40]	0.028
Hospital LOS			
Diabetes	0.95 (±1.80)	[−2.70, 4.60]	0.60
Open anterior component separation	−1.55 (±1.06)	[−3.71, 0.61]	0.16
No. drains placed during surgery	1.18 (±0.91)	[−0.67, 3.02]	0.20
FGF	0.30 (±1.79)	[−3.34, 3.94]	0.87

pain control methods were standardized (including use of an epidural) between both groups.

Quality of life after RHR using FGF is essential to consider in addition to surgical outcomes. Weltz et al[13] are one of the few to report quality of life metrics in this population when they conducted the first head-to-head evaluation of SF versus FGF alone in the retromuscular position analyzed operative outcomes along with quality of life. In their study, the Carolinas Comfort Scale was administered preoperatively and at 1 and 6 months postoperatively. Results showed that at 6-month follow-up, patients in the SF group were 12 times more likely to report chronic pain than patients in the FGF group. Although similar to our study with regards to fixation technique, the type of mesh used was variable between the 2 comparison arms. Our study controlled for mesh type and also ensured that several other factors including age, BMI, number of prior repairs, and defect size were similar between the 2 patient groups to limit any confounding effects. After employing this rigorous matching strategy, our group did not detect a significant difference in quality of life at 12 weeks postoperatively, although we did employ a different quality of life tool. The HerQLes questionnaire was chosen for use in our study because it does not have mesh-specific questions (like the Carolinas Comfort Scale) which can often be confusing to patients when they are filling out the survey preoperatively. The lack of significant improvements in quality of life outside of the pain level may not be representative of the true impact that FGF is having on patients receiving RHR.

Although not explicitly discussed in quality of life surveys, the cost that patients incur during their treatment

Table 5. Quality of Life for Patients Receiving SF and FGF of Mesh Broken Down by Preoperative, Postoperative, and Difference in Preoperative and Postoperative Scores Using the HerQLes Questionnaire

	Total (n = 31)	SF (n = 16)	FGF (n = 15)	*P*
Preoperative score, mean (SD)	50.0 (±25.1)	48.3 (±27.2)	51.8 (±23.4)	0.70
Postoperative score	74.2 (±26.0	77.2 (±20.9)	71.0 (±30.9)	0.52
Difference between preoperative and postoperative score	24.3 (±25.8)	29.0 (±23.8)	19.2 (±27.8)	0.30

can play a large part in satisfaction with their surgery. Tisseel has been cited to cost approximately $50 per mL.[29] To our knowledge, the only study to perform cost analysis of Tisseel in open VHR reported an average cost of $995.78 per case,[30] but did not provide a robust cost analysis.[13,30,31] Factors that provide a cost-benefit using Tisseel as elucidated by our study were not considered in this prior study due to confounding factors mentioned by the authors that kept patients in the hospital well after resolution of their surgical issues. Our study suggests that an important factor in reducing costs of hospitalization is a shorter LOS, which appears to be driven by less pain and shorter time to achieve a higher level of physical activity. Despite a reported cost-savings of $16,178 shown in our study, follow-up studies to assess the amount of costs ultimately recovered by the hospital system for the 2 groups studied would aid to further assess any impact on realized profit margin.

Our study was limited in its retrospective design and sample size, which in the scope of this study was necessary to ensure rigorous matching of the 2 cohorts. The short-term follow-up was an accepted limitation to this study as our goal was to report early outcomes and potential practicality of this technique. Due to the senior author performing all cases in this study, it is possible that the improvements in postoperative outcomes are not solely attributable to FG and that refinement of operative strategy and postoperative care played a role. Furthermore, although the 2 groups were rigorously matched, there is a selection bias because patients before June 30, 2017 may have been appropriate candidates to receive FG, but the senior author had not introduced FG into his practice at that time. However, by studying the results of a single surgeon's results, bias regarding operative technique and application of Tisseel was mitigated. Additionally, by limiting the study to the senior author, we were able to assess quality of life data as his patients are routinely asked to fill out these questionnaires. Although quality of life data were not available for all patients in our study, the 73% completion rate is comparable to other studies using the HerQLes survey.[32] Finally, this study focuses on short-term results of using FG in RHR. Although the most important outcome regarding incisional hernia (IH) is recurrence, this study is the initial step in assessing if FG may be a suitable alternative to using SF. Our hope is that this study will allow for a future prospective study to study long-term recurrence rates of FG in light of the fact that other postoperative outcomes are similar, whereas LOS and costs are decreased.

CONCLUSIONS

FG provides a safe and cost-effective alternative to SF of retromuscular mesh and is associated with decreased postoperative pain and increased activity in the short term. Future studies in the form of prospective randomized clinical trials are imperative to assess both subjective and objective long-term outcomes of FG mesh fixation.

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