

A Novel Use of Fully Absorbable Phasix™ Mesh for Laparoscopic Inguinal Hernia Repair

Abdullah Aldohayan, FRCS Glas, Fahad Bamehriz, MBBS, MD, SBC,
Ghanem Khalid Alghamdi, MBBS, Rana Ahmed AlJunidel, MBBS, Mohannad AlBalawi, MBBS,
Abdullah Zakaria Aldhayan, Omar Mohammed AlShehri

ABSTRACT

Background and Objectives: An inguinal hernia is usually repaired with synthetic nonabsorbable mesh, resulting in collagen formation, chronic inflammation, and fibrosis, with significantly reduced hernia recurrence. However, chronic pain may affect the quality of life. Poly-4-hydroxybutyrate (P4HB) mesh was introduced to minimize complications, and starts to degrade in 12–18 months. This study assesses the consequences and results of patients undergoing transabdominal preperitoneal (TAPP) inguinal hernia repair using P4HB mesh (Phasix™, C.R. Bard Inc., Murray Hill, NJ, USA).

Methods: We performed a pilot study of laparoscopic TAPP repair for inguinal hernias using P4HB mesh in 15 patients (14 male and one female) with an average age of 55.8 y, and an average body mass index of 27.4 kg/m². We assessed the recurrence rate and patients' chronic pain for 30 months, with institutional review board approval (E-19–3735). The study was conducted from January 2016 to July 2017 in Medical City, King

Saud University. We measured postoperative pain, reactions, mesh sensation, discomfort, and recurrence.

Results: In 15 patients, we encountered no recurrence or mesh sensation, except in one patient, who experienced mild chronic inguinal pain for one year, without activity restrictions.

Conclusion: Laparoscopic TAPP inguinal hernia repair using P4HB mesh is safe for combined, direct (medial), and indirect (lateral) inguinal hernia, with no recurrence. P4HB absorbable mesh caused less chronic pain and discomfort. Longer follow-up, more patients and 15 patients repaired using synthetic mesh are necessary to assess the utility of P4HB for inguinal hernia repair globally.

Key Words: Phasix, P4HB, TAPP, Inguinal hernia.

Department of Surgery, College of Medicine, Medical City, King Saud University (all authors).

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Address correspondence to: Prof. Abdullah Aldohayan, Department of Surgery, College of Medicine, Medical City, King Saud University/King Khalid University Hospital Surgery Department, P.O. Box 7805, Riyadh 11472, Riyadh, Kingdom of Saudi Arabia, E-mail: adohayan@ksu.edu.sa/adohayanss@gmail.com.

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INTRODUCTION

Synthetic mesh has routinely been used for hernia repair since its introduction. Polyethylene (Dacron) and polypropylene meshes were used in previous decades.^{1,2} Klinge et al. popularized the usage of polypropylene for tension-free inguinal herniorrhaphy.³ The sequelae of herniorrhaphy with synthetic mesh may include chronic pain. Mesh shrinkage, chronic inflammation, and mesh fixation are possible causes of chronic pain,^{4,5} and the degree of chronic inflammation and shrinkage may be the primary causes of chronic pain.^{3,4} Using less foreign material will decrease chronic inflammation and its sequelae.⁶ Additionally, an inflammatory tissue reaction to mesh may occur for years, resulting in scar formation, which may induce chronic pain.⁷

Lightweight meshes are also used in hernia repair.⁴ Indeed, lightweight polypropylene mesh induces less scar tissue.⁷ In a meta-analysis of inguinal herniorrhaphy, Lichtenstein et al. indicated that lightweight mesh and very lightweight mesh resulted in significantly less chronic pain.⁸

In addition to using synthetic mesh in inguinal herniorrhaphy, there are opportunities for using absorbable materials.⁸ Surgeons have used biological mesh in inguinal

Table 1.
Sociodemographic Characteristics of Participants

Patient Characteristics (n = 15)	Frequency n (%)	
Age	≤ 51	6 (40 %)
	52 – 65	4 (26.7 %)
	≥ 66	5 (33.3 %)
	Mean Age	54.8
Gender	Male	14 (93.3 %)
	Female	1 (6.7 %)
Body Mass Index	18 - 24	4 (26.7 %)
	24.01 – 30	8 (53.3 %)
	30.01 – 35	3 (20 %)
Site	Unilateral	10 (66.7 %)
	Bilateral	5 (33.3 %)
Hernia Type	Direct	2 (13.3 %)
	Indirect	8 (53.3 %)
	Both	5 (33.3 %)
Side	Right	5 (33.3 %)
	Left	5 (33.3 %)
	Bilateral	5 (33.3 %)
Complications (n = 2/15)	Seroma	1 (50 %)
	Hematoma	1 (50 %)

herniorrhaphy with strattice, surgisis, and tachosil showing promising results.⁹ However, the high cost, religious or social factors, and fast absorption impede its utilization. For identifying meshes free of complications, the horizon shines with synthetic resorbable meshes. Also, the fear of recurrence casts a wide shadow for the introduction of synthetic absorbable meshes, Gore BioA, and TIGR used as transit scaffolds for collagen growth promising less chronic pain.^{8,9} However, the fear of high recurrence is a barrier to the application of absorbable mesh in direct inguinal hernia repair.⁷

Absorbable synthetic meshes involve different polymers, including trimethylene carbonate, polylactide, polyglycolide, and poly-4-hydroxybutyrate (P4HB).^{10–14} The ad-

vantages of these polymers include elimination of allergic reactions, disease transmission, and religious objections to the use of human tissues or animal-derived materials.¹⁵ Recently, the 12–18 month mesh absorption time of P4HB has allowed identification of ideal materials for hernia repair.¹⁵ The knitted permanent synthetic mesh pattern is applied to compromise Phasix™ (C.R. Bard Inc., Murray Hill, NJ, USA).^{9,14–15} Laboratory trials of biomaterials have identified an absorbable monofilament, P4HB, used in Phasix™, for hernia repair. P4HB meshes have shown promising results in animal trials for different medical applications,^{14,15} and have high tensile strength and flexibility. Recently, P4HB mesh has been used for ventral hernia repair, with promising or favorable outcomes.¹⁶ This study aims to evaluate the recurrence and chronic postoperative pain in transabdominal preperitoneal (TAPP) inguinal hernia repair using P4HB mesh (Phasix™), and to broaden this mesh’s use in laparoscopic hernial repair.

MATERIALS AND METHODS

This is a pilot study of all patients who underwent laparoscopic TAPP hernia repair. The study protocol was approved by the Institutional Review Board of Medical City, King Saud University, in Saudi Arabia (approval number: E-19–3735, 10 March 2019). Inguinal hernia repair was performed by one surgeon. From January 2016 to July 2017, we recruited 15 patients who met our inclusion criteria; these were (1) aged 18–84 y, (2) diagnosed with a primary inguinal hernia, (3) medically fit for general anesthesia, and (4) suitable for laparoscopic TAPP procedure using a 15 ' 15 cm Phasix™ mesh. The patients’ information and hernia characteristics were recorded for analysis at the University Medical City, King Saud University. All patients had clinical follow-ups at the outpatient clinic two weeks after discharge, after six and 12 months in the first year, and annually thereafter. At each visit, the patients were assessed for pain and wound complications, including infection, seroma, hematoma, and recurrence; all complications and instances of recurrence were recorded. Chronic pain was defined as pain which did not respond to analgesia for more than three months.

RESULTS

In total, 15 patients underwent inguinal hernia repair with P4HB mesh. The mean age of patients was 54.8 y, and the average body mass index was 27.2 kg/m2. Two patients had direct hernias, five patients had both direct and indirect hernias, and eight patients had indirect inguinal her-

Table 2.
Frequency of Pain with Phasix™

Variables (n = 15)	Chi-square (df)	
	Mesh Type	
	Variable	Phasix™
Postoperative pain	No pain	n = 10 (66.7 %)
	Pain	n = 5 (33.3 %)
Pain after one week	No pain	n = 9 (60 %)
	Pain	n = 6 (40 %)
Pain after one month	No pain	n = 13 (86.7 %)
	Pain	n = 2 (13.3 %)
Pain after three months	No pain	n = 15 (100 %)
	Pain	n = 0 (0 %)
Pain after six months	No pain	n = 15 (100 %)
	Pain	n = 0 (0 %)
Pain after one year	No pain	n = 11 (91.7 %)
	Pain	n = 1 (8.3 %)
Pain after two years	No pain	n = 3 (100 %)
	Pain	n = 0 (0 %)

nias. Thirteen of the patients were male; one was female. One patient developed a recurrence (Table 1). The mean follow-up was more than 30 months. One patient developed a seroma, and one a hematoma. There were no signs of recurrence at follow-up (Table 3), and no patients reported severe pain. Only one patient reported mild pain at follow-up (Table 2). All patients were able to return to regular activities within 10 days, and reported no awareness of the foreign body over the mesh site. All patients were entirely satisfied with the operation.

DISCUSSION

The main finding of this study was that P4HB mesh (Phasix™) is a feasible and viable alternative to current

mesh products for use in inguinal hernia repairs, and demonstrates safe and effective clinical outcomes. Indeed, Inguinal hernias represent some of the most common surgical problems worldwide.^{1,2} Initially, synthetic nonabsorbable polymer products, such as polypropylene, were used because of their various advantageous physical properties,¹⁷ including their inherent tensile strength, flexibility, and ease of cutting with surgical tools. In addition, synthetic mesh is readily integrated into the surrounding local tissues, effectively augmenting and re-enforcing the native abdominal wall,^{17,18} consequently, reducing hernia recurrence rates dramatically.¹⁸ However, these same mesh products, such as polypropylene, are shrinkable, which could cause chronic pain and stiffness of the abdominal wall. The occurrence of chronic pain increased substantially and became the most frequent undesired side effect of hernia repair.^{5,18}

The ideal mesh is absorbable, and supports the hernial defect with collagen.^{18,19} Subsequently, second-generation mesh products were developed to be lighter, thinner, and manufactured with larger pores than their predecessors.⁶ Primary clinical studies demonstrated that these lightweight meshes generated fewer foreign body reactions, and had better bio-compatibility.⁶ A large number of meta-analyses have demonstrated the superiority of lightweight mesh over heavyweight mesh in reducing the risk of chronic pain and foreign body awareness.¹⁶ In contrast, other studies reported no differences between the two classes of mesh in terms of the outcomes mentioned above.²⁰ Nevertheless, these results were often flawed because of the discrepancies in the methodologies or techniques used to evaluate or measure outcomes.¹⁷⁻¹⁹

Recently, biologically derived meshes were introduced as potential alternatives to synthetic meshes. However, these bio-meshes also have disadvantages, including the variability of the donor dermis tissue quality and the possibility of eliciting unpredictable patient-specific immune responses.^{8,9} Their microporous structure also slows the

Table 3.
Recurrence Reported at Follow-up

Recurrence (n = 15)	Variable	1 week	1 month	3 months	6 months	1 year	2 years
	No Recurrence	n = 15 (100 %)	n = 15 (100 %)	n = 15 (100 %)	n = 15 (100 %)	n = 15 (100 %)	n = 15 (100 %)
	Recurrence	0	0	0	0	0	0
Median follow-up							

Table 4.
Time to Absorption

Name of Mesh	Absorbable Time	Type of Materials	Manufacturer
TIGR® Matrix	4 – 36 min	Lattice glycolide, trimethylene carbonate, trimethylene carbonate and lattice	Novus Scientific
GORE® BIO-A®	6 min	Acids: polyglycolide, 10- carbonate trimethylene	Gore Medical
Phasix™	12 – 18 min	Poly-4-hydroxybutyrate (scott roth)	C.R. Bard Inc.

Min, minutes.

local tissue integration and neovascularization. However, the biological mesh degrades within three months, which may be enough to provide good support for collagen formation, and to prevent recurrence and higher costs.^{8,9} Other developers have devised another type of mesh, the TIGR® Matrix, which provides both enhanced initial support to prevent premature recurrence, and long-term support from enabling native abdominal tissue to remodel and bear loads after degradation of the mesh.⁷ This mesh comprises a combination of two copolymer fibers with different chemical constitutions and resorption times. The first fiber comprises two-fifths of the matrix by weight, and is made of polyglycolide, polylactide, and polytrimethylene. In contrast, the second fiber comprises 60% of the matrix by weight, and has the same components as the first, without the polyglycolide molecules. This variation in composition confers to the first fiber a much shorter-lived strength that dwindles to half of its maximum in six weeks, as opposed to the second fiber, which loses half of its strength in the span of six months. Overall, these composite mesh materials are expensive in comparison to synthetic meshes, and are associated with increased direct costs to health facilities, limiting their usage to specific surgical scenarios. Moreover, the mesh is recommended only for lateral hernia (indirect inguinal hernia) repair. In contrast, we used Phasix™ for direct and indirect inguinal hernia without recurrence, and absorption commenced within 12 months, which is sufficient for the deposition of maturation of collagen.⁷ In light of the above, P4HB is a novel, fully absorbable, naturally occurring monofilament, which is fully absorbed in 12–18 months. In the preclinical trial on procaine mode, P4HB exhibited desirable characteristics for hernia repair, including markedly increased robust stiffness, amplified suture retention, tear-resistance, and ball-burst strength.^{14,15} We hypothesize that this quality facilitates a smooth and gradual transfer of the load into the natural abdominal tissues, reducing the risks of premature load transfer and recurrence.

Meanwhile, on the cellular level, P4HB demonstrated minimal to mild fibrosis and inflammation in host tissues. It also induced mild neovascular responses in host bodies and evoked an immune reaction that was predominated by mononuclear cells, rather than giant cells. Overall, P4HB may cause less chronic pain following hernia repair.¹⁵ In this medium-sized case series, we present the midterm outcomes of 15 patients who underwent laparoscopic inguinal hernia repair with a Phasix™ mesh. We performed a classical TAPP procedure and affixed the mesh using tackers. Our group uses tackers instead of fibrin glue because of concerns regarding the glue’s ability to affix the mesh to the pubic bone, and we have not encountered a similar study using synthetic absorbable mesh in TAPP repair. No hernia recurrence was detected during follow-up, and only one patient reported chronic postoperative pain, which was mild and had no negative effect on daily routines. We anticipate an increase in the likelihood that their pain will resolve with complete resorption of the mesh material.

There is abundant literature investigating the prevalence of pain and discomfort following hernia repair, with quoted high figures and other parameters, such as quality of life, during follow-up. The ambiguity of pre-existing data, combined with the utilization of mainly subjective pain scales, diminishes the value of direct comparison between studies.^{17,18} However, a recently published study using P4HB mesh in ventral hernia repair showed that subjects experienced minimal recurrence during the three-year follow-up period, and reported minimal pain.⁹ Meanwhile, laparoscopic placement using Phasix™ mesh has been reported, and we are the first study to report its use in laparoscopic inguinal herniorrhaphy. This mesh was technically difficult to handle intraoperatively. We required a different technique to insert the mesh in a 5-mm incision using the principle of patent no. US,9,204,955 B2. In a critique of our paper, we have not encountered chronic severe pain in one year. However,

performing more repairs with different meshes and comparing the outcome is necessary. Additionally, the limitation of the present study are: 1) small sample size; 2) short term follow-up of the patients; 3) telephone follow-up might have given inconsistent results.

CONCLUSION

Despite the limitations of the study, we have grounds to conclude that Phasix™ is a feasible and viable alternative to current mesh products for use in inguinal hernia repairs, and demonstrates safe and effective clinical outcomes.

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