



# Polyvinylidene Fluoride Prosthetic Reinforcement in Abdominal Wall Hernia Surgery

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**Received:** 6 February 2024 ♦ **Accepted:** 16 May 2024 ♦ **Published:** 30 June 2024

**Citation:** Ivanov IA, Mitev DB. Polyvinylidene fluoride prosthetic reinforcement in abdominal wall hernia surgery. *Folia Med (Plovdiv)* 2024;66(3):356-360. doi: 10.3897/folmed.66.e120418.

## Abstract

**Introduction:** Surgical repair of the anterior abdominal wall hernia is the most common intervention in general surgery practice. The introduction of synthetic prostheses reduces the frequency of recurrences, but in many cases, they are associated with complications that could seriously impair the quality of life of patients. To reduce perioperative complications, we introduced in our practice innovative prostheses made of a highly inert polymer, polyvinylidene fluoride (PVDF), and conducted an observational study.

**Aim:** To compare the postoperative results of using PVDF prosthetic material to the standard polypropylene mesh and to evaluate the applicability of the new material in daily surgical practice.

**Materials and methods:** Over a two-year period, 34 operations were performed using PVDF meshes, with characteristics varying depending on the operative technique and anatomical region of the hernia defect.

**Results:** With a median follow-up of 8 months, no recurrences or early complications occurred in patients with an expressed comorbidity

**Conclusions:** PVDF offers comparable advantages to other synthetic prosthetic materials due to its improved biostability, minimal tissue reaction, limited shrinkage, and lack of stiffness after integration.

## Keywords

hernia surgery, polyvinylidene fluoride

## INTRODUCTION

An abdominal wall hernia consists of a protrusion of intra-abdominal tissue through a fascial defect in the abdominal wall. Inguinal hernias are the most common abdominal type of hernias accounting for approximately 75% of all hernias. Almost a third of men are diagnosed with an inguinal hernia in their lifetime. The highest incidence in adults is after 50 years of age. Only 3% of women will develop an inguinal hernia. In the United States, the annu-

al incidence of an inguinal hernia is 315 per 100,000, and surgical repair of inguinal hernias accounted for more than 48 billion dollars in 2005 health care expenditures.<sup>[1]</sup> The 'tension-free' mesh technique, which was pioneered by the Lichtenstein Hernia Institute in 1984, is currently considered the gold standard of hernia repair by the American College of Surgeons. In this procedure, the repair is accomplished by covering the opening of the hernia with a patch of mesh, instead of sewing the edges of the hole together.<sup>[2]</sup> The prosthetic repair of abdominal wall hernias has become

an integral component of surgery. Meanwhile, about 1 million meshes are implanted world-wide per year.<sup>[3]</sup> The possibility of a tension-free repair and the lowered recurrence rate make the use of prosthetic meshes the most common choice for abdominal wall repair, despite the mesh-related complications. The currently available non-absorbable polymer prostheses are made of polypropylene (PP), polyethylene-terephthalate (PET), or polytetrafluoroethylene (ePTFE), though all of them have some disadvantages.<sup>[4]</sup> The introduction of new materials seems to be advisable. Polyvinylidene fluoride (PVDF) meshes are thought to have advantages in terms of textile properties, morphological stability, and chemical stability, as well as reduced tissue response, making them a potential replacement for other materials in abdominal wall hernia repairs.<sup>[5]</sup> We have been using PVDF prostheses in our practice since 2018.

## AIM

The current study sought to compare the postoperative outcomes of using PVDF prosthetic material to those of using standard polypropylene mesh, as well as to assess the new material's applicability in daily surgical practice.

## MATERIALS AND METHODS

An observational study with a clinical follow-up and a questionnaire was conducted on 66 male patients, divided into two groups: those who had anterior abdominal wall reconstruction with PVDF mesh or polypropylene mesh. The mean BMI of the patients was 32.1 kg/m<sup>2</sup> and the mean defect width was 6 cm (IQR 2-14). A non-inferiority analysis was performed. A survey was conducted on subjective complaints in the early and late postoperative period. Data were analyzed using the Mann-Whitney U-test. In the late postoperative period, it was conducted in terms of discomfort and/or pain around the operative incision using the Mankoski scale.<sup>[6]</sup>

## RESULTS

Over a two-year period, 34 operations were performed using PVDF prosthetic meshes and 32 were with polypropylene meshes. PVDF meshes were with textile characteristics corresponding to the operative technique and the anatomical area of the hernia defect. At an average follow-up of 8 months, no recurrences were observed. One patient with several comorbidities developed postoperative hematoma that was treated conservatively and observationally. The absence of discomfort and local stiffness was found in most of the patients with PVDF group in the late postoperative period measured by the scale of Mankoski (**Table 1**).

Non-inferiority analysis with a focus on the difference between the conventional treatment (PP) and new treat-

**Table 1.** Results of the conducted survey according to the Mankoski Pain Scale eight months postoperatively

Mankoski Pain Scale	PVDF	Polypropylene	Total (n)
0	17	7	24
1	10	16	26
2	6	9	15
3	1	0	1
4 or more	0	0	0
Total number	34	32	66

ment (PVDF) was conducted with a confidence interval of 95%. The Mann-Whitney U analysis was undertaken. The resulting U value was 406.5; the z-score was 1.75776. The result was  $p=0.0392$ , with statistical significance of values of  $p<0.05$ .

## DISCUSSION

Hernia surgery was associated with a number of complications and recurrences, and it was widely regarded as unsuccessful until the end of the nineteenth century, when Bassini adapted and improved the MacEwen plasty. Bassini's new method is now widely accepted in the surgical community due to its positive results. His initial results of 3.1% recurrence and 2.4% mortality rate contrast sharply with the leading clinic at the time, T. Billroth's, which reported 31% recurrence and 6% mortality.<sup>[7]</sup> Despite the introduction of many innovations in the first half of the 20th century such as the introduction of silver (Witzel 1900) and steel (Babcock 1929) suture materials, steel mesh (Babcock 1952), nylon sutures (Melick 1942), and mesh (Aquaviva 1944), a breakthrough in results did not occur until 1955.<sup>[8]</sup> Then Usher began experiments and subsequently introduced into clinical practice mesh prosthesis from Marlex, an ethylene polymer, subsequently processed into polypropylene, which, unlike the original product, could be sterilized in an autoclave. In the 1960s, about 20% of all mesh plastics were performed with polypropylene prostheses, then the use of polypropylene suture materials in abdominal and cardiovascular surgery began.<sup>[9]</sup> Currently, polypropylene is the most widely used prosthetic material in hernioplasty. As experience with the various polymers in clinical practice accumulates, rarer polymer-related complications and those occurring after a long period of time are observed. The main progress in the PP meshes of the first generation are the changes in their texture and the introduction in 1998 of 'light' large-pore meshes.<sup>[10]</sup> Reports of easy iatrogenic damage, erosion, loss of properties over time, as well as the strong tissue reaction it causes, lead to a search for alternatives to polypropylene as a widely used material.<sup>[11]</sup>

PVDF is a highly non-reactive fluoropolymer that is known for its resistance to solvents, acids, UV, and gamma

and beta radiation. In medical industry, it has long been used in measuring technology, e.g. in the western blot, due to its inertness towards amino acids and proteins. In search of an alternative to polypropylene as a suture material, PVDF sutures were experimented with and subsequently put into practice.<sup>[12]</sup> In vitro and in vivo studies have shown that PVDF retains its tensile strength, does not stretch, is not easily damaged by surgical instrumentation, and exhibits minimal erosion rates compared to polypropylene. One study compared PVDF and polypropylene in vitro, under conditions of potentiating hydrolysis, and in vivo in thoracic aortic anastomoses. A strength loss of 46.6% was found for polypropylene, with only 7.5% loss for PVDF<sup>[13]</sup> (Fig. 1).

The utilization of PVDF meshes in hernia repair procedures has been associated with a remarkably subdued biological response. This phenomenon was particularly noteworthy following the introduction of commercially available PVDF meshes in 2002.<sup>[14]</sup> In contrast to traditional materials such as polyester and polypropylene, PVDF demonstrates superior resistance to hydrolysis and degeneration.<sup>[15]</sup> This heightened inertness of the PVDF mesh makes it a promising material for hernia repair with favorable biostability, lowered bending stiffness and a minimum tissue response. Therefore, we can conclude that the PVDF is at least as good for use as a prosthetic material in anterior abdominal wall reconstructions as the classically widely used PP. The use of PVDF mesh is an accepted treatment method by the surgical community but more studies with longer follow-up periods are needed to validate its advantages and disadvantages in terms of recurrence rate and postoperative complications.

## CONCLUSION

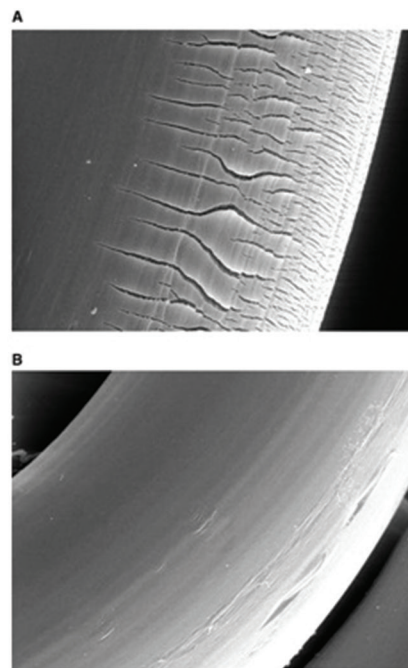
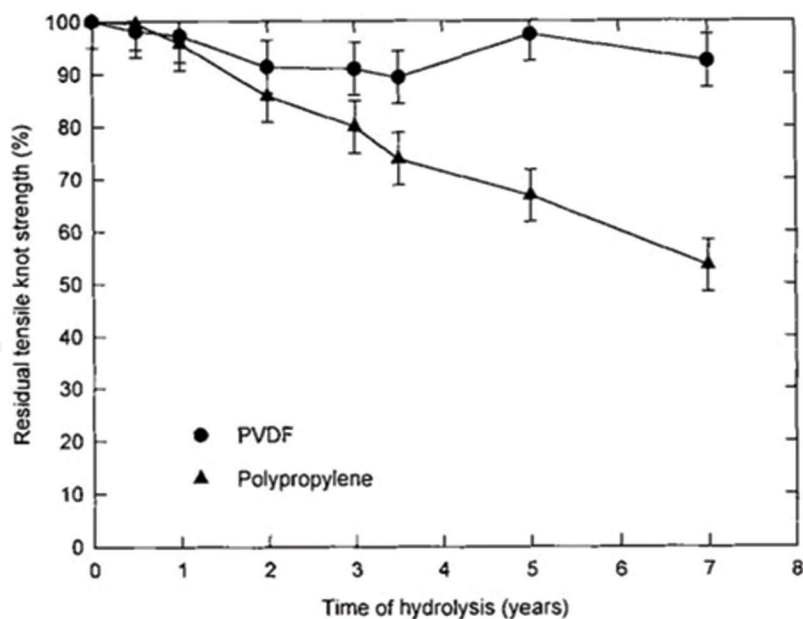
For surgical interventions of hernias of anterior abdominal wall, the use of prosthetic materials is a common requirement for effective surgical reconstruction with low recurrence rates. Hernia meshes crafted from polyvinylidene fluoride (PVDF) have emerged as a compelling alternative of polypropylene material prostheses. This is attributed to the inert properties of PVDF which endows it with enhanced resistance to hydrolysis and degeneration when juxtaposed with established materials like polyester and polypropylene. The enhanced biostability, minimal tissue reaction, limited shrinkage, and lack of stiffness after integration result in comparable advantages of PVDF in relation the standard polypropylene mesh. We can expect the integration of PVDF meshes into mainstream surgical practices for hernia repair. They show comparable results with PP meshes but also have numerous potential advantages that require validation through large, randomized trials with long-term patient follow-ups.

## Acknowledgements

The authors have no support to report.

## Funding

The authors have no funding to report.



**Figure 1.** Residual strength of PVDF and polypropylene sutures with identical other characteristics, over a period of 7 years under conditions simulating in vivo hydrolysis.

## Competing Interests

The authors have declared that no competing interests exist.

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# Армирование протезов поливинилиденфторидом при хирургии грыжи брюшной стенки

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Дата получения: 6 февраля 2024 ♦ Дата приемки: 16 мая 2024 ♦ Дата публикации: 30 июня 2024

Образец цитирования: Ivanov IA, Mitev DB. Polyvinylidene fluoride prosthetic reinforcement in abdominal wall hernia surgery. Folia Med (Plovdiv) 2024;66(3): 356-360. doi: 10.3897/folmed.66.e120418.

## Резюме

**Введение:** Хирургическое лечение грыжи передней брюшной стенки является наиболее распространённым вмешательством в общей хирургической практике. Внедрение синтетических протезов снижает частоту рецидивов, но во многих случаях они связаны с осложнениями, которые могут серьёзно ухудшить качество жизни пациентов. Для снижения периоперационных осложнений мы внедрили в нашу практику инновационные протезы из высокоинертного полимера поливинилиденфторида (ПВДФ) и провели наблюдательное исследование.

**Цель:** Сравнить послеоперационные результаты использования протезного материала ПВДФ со стандартной полипропиленовой сеткой и оценить применимость нового материала в повседневной хирургической практике.

**Материалы и методы:** За двухлетний период было проведено 34 операции с использованием сеток ПВДФ, характеристики которых различались в зависимости от оперативной техники и анатомической области грыжевого дефекта.

**Результаты:** При медианном наблюдении в течение 8 месяцев рецидивов или ранних осложнений у пациентов с выраженной сопутствующей патологией не наблюдалось.

**Заключение:** ПВДФ предлагает сопоставимые преимущества по сравнению с другими синтетическими протезными материалами благодаря своей улучшенной биостабильности, минимальной реакции тканей, ограниченной усадке и отсутствию жёсткости после интеграции.

## Ключевые слова

грыжесечение, поливинилиденфторид