Histološke prednosti dvo-komponentne fibrinske mreže (TachoSil) v primerjavi s polipropilensko mrežo po vstavitvi pod mišični sloj in nad transverzalno fascijo v podganah

Histological advantages of two-component fibrin mesh (TachoSil) compared with polypropylene mesh after placement in the inguinal region in laboratory rats

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Izvleček

Operacije hernije so ena izmed najbolj pogostih operacij tako v veterinarski kot človeški medicini in na voljo je široka izbira glede mreže, ki jo kirurgi uporabljajo za popravo transverzalne fascije. Primerjali smo dvo-komponentno fibrinsko mrežo TachoSil in polipropilensko mrežo pri rekonstrukciji transverzalne fascije po vstavitvi pod mišični sloj in nad transverzalno fascijo pri podganah. Podganam vrste Fischer je bila vstavljena ali polipropilenska ali fibrinska mrežica pod mišični sloj in nad transverzalno fascijo. 30 dni po posegu so bile podgane žrtvovane, fibrinska ploščica z mrežicama je bila odstranjena ter poslana na histološko analizo. Ugotovili smo, da so podgane z dvo-komponentno mrežico imele manj pooperativnih komplikacij, ter manjšo prisotnost vnetnih celic, kar je povezano z večjo verjetnostjo za uspešno popravilo hernije.

Abstract

Hernia repair surgeries are among the most common procedures in both veterinary and human medi-cine, with various mesh options available for surgeons repairing the transversalis fascia. This study compared a variant of two-component fibrin mesh (TachoSil) and polypropylene mesh in reconstruct-ing the transversalis fascia by placing them in the inguinal region in Fischer laboratory rats. Specifically, the TachoSil or fibrin mesh was implanted into the groin region of Fischer rats, and after 30 days of mesh placement, the rats were sacrificed, the fibrous plate with either inserted mesh removed, and the tissue sent for histological analysis. The results showed that, compared with the polypropylene mesh, the implanted TachoSil mesh resulted in fewer postoperative complications and lower inflammatory cell presence.

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INTRODUCTION

The two-component fibrin net is widely used today for various indications and was first introduced in surgery in the early 1990s. Initially, this mesh consisted of equine collagen, bovine thrombin, aprotinin, and human fibrinogen. Over time, animal-derived components were replaced with human-derived components, and the latest generations, including the one we used in our study (TachoSil) no longer contain bovine components. To date, four randomized clinical studies have demonstrated the effectiveness of said two-component fibrin mesh (TachoSil) in liver, urological, and thoracic surgeries [1-6]. The physical and mechanical properties of this mesh are particularly noteworthy. Wet TachoSil mesh is approximately 2.5 times more elastic than the dry version, allowing it to adhere precisely to tissues and organs, move smoothly over surfaces, and withstand extreme stretching and stress [7]. However, polypropylene mesh remains the most commonly used prosthetic implant in abdominal hernia surgery due to its strength and integration into surrounding tissue. Although this integration is desirable because the mesh forms a solid fibrous plate that prevents recurrence, it can also cause severe inflammatory reactions and solid adhesions during scar formation [8]. New biomaterials are continually being developed to reduce the inflammatory response. Such materials have played a key role in the implantable device industry. New biomaterials with built-in anti-inflammatory properties have already shown significant success, reducing both inflammation and adhesive interactions [9]. It has been hypothesized that reducing the amount of polypropylene in the mesh can lower the inflammatory response during the postoperative period. The severity of the inflammatory response to the foreign body type cells and production of scar tissue depend on the structure of the incorporated material. Meshes with reduced polypropylene content, greater elasticity, and larger pores may offer significant advantages [10-12]. Despite the clear benefits of biomaterials, the use of prosthetic meshes in hernia surgery remains widespread. The primary reasons include the lack of definitive evidence, concerns about erosion into visceral organs, formation of adhesions, and chronic groin pain [13]. Meshes should prioritize the safety and long-term reliability of existing implants, especially with dominant scar formation and good tissue integration. However, this is not the case, as findings from animal models using "heavy" polypropylene meshes, have shown complications such as seromas, infections, mesh compression, and migration.

MATERIALS AND METHODS

This research was conducted using Fischer strain rats in the Laboratory for Medical Biology at the Faculty of Medicine, University of Zagreb, (Zagreb, Croatia) between 2006 and 2008.

A total of 78 rats (38 female, 49%; 40 male, 51%) were included, all 3 months old and weighing between 300 and 350 g. The animals were divided into two groups: the first group [N = 40; 23 males (57.5%) and 17 females (42.5%)] was treated with a polypropylene mesh measuring 2 × 1.5 cm^2 inserted into the groin region above the transversalis fascia, whereas the second group [N = 38; 29 males (76.3%) and 9 females (23.7%)] was treated with a 2 × 1.5 cm^2 two-component fibrin mesh (TachoSil sealant matrix, Corza Medical GmbH, Austria) inserted into the same region (Fig. 1).

Procedure

The rats were first shaved and their skin disinfected with alcohol, after which they were then anesthetized using ether and placed in the supine position. Next,

Figure 1. *Fisher rats in laboratory conditions.*

Figure 2. *Sacrificed rats after fibrotic plaque removal.*

a 3-cm skin and subcutaneous incision was made in the groin region, exposing the muscular layer through careful preparation with scissors. Depending on the group, either the polypropylene or TachoSil mesh was then placed below the muscle layer and above the transversalis fascia. The wounds were closed using Michel's clips (Fig 2.), after which the animals were allowed to recover under standard conditions and monitored for 30 days. The postoperative variables we observed included bleeding, hematoma, wound and implant infections, and mobility within the first 24 h and after 24 h. After 30 days, the animals were sacrificed and tissue specimens collected for histological analysis at the Department of Pathology and Cytology, Clinical Hospital Merkur Zagreb (Fig. 3). Histological analysis included measuring the presence of leukocytes and foreign-body cells using microscopy.

Statistical analysis

The data, including presence of leukocytes and foreign body cells, were analyzed using descriptive statistics, including arithmetic mean, standard deviation, median, and range. The chi-square test was applied to compare qualitative characteristics such as inflammation and the presence of foreign body type cells. For smaller samples, Fisher's exact test was used. As the data did not follow a Gaussian distribution, quantitative comparisons between the polypropylene and fibrin groups were conducted using the Mann–Whitney U test for two independent samples.

RESULTS

In the first group of animals (40 rats treated with polypropylene mesh), bleeding and hematoma in the wound were observed in six (15.0%) and four (10.0%) animals within the first 24 h and after 24 h, respectively. Wound and implant infections occurred in two (5.0%) animals. Mobility was recorded in 20 (50.0%) and 8 (20.0%) animals in the first 24 h and after 24 h, respectively. Importantly, in the second group of animals (38 rats treated with TachoSil mesh) bleeding and hematoma in the wound were not recorded at any time point nor were implant (mesh) infections observed. Finally, mobility in the first 24 h was observed in 32 (84.2%) animals, whereas mobility after 24 h was observed in 6 (15.8%) animals.

Figure 3. *Fibrotic plaque tissue after removal for histological analysis, containing either polypropylene or TachoSil mesh.*

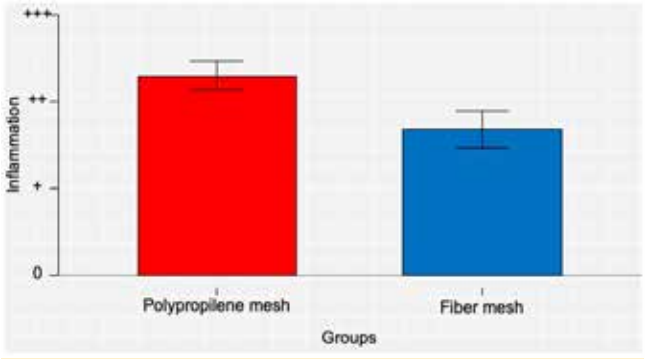

Figure 4. *Distribution of groups based on the presence of inflammation. +, Poor; ++, moderate; +++, strong.*

Table 1: Distribution of animals by presence of Inflammation

			Inflammation			Total
			+	++	+++	
Groups	Polypropylene Mesh	Number Of Individuals	1	26	13	40
		% Groups	2,5%	65,0%	32,5%	100,0%
		% Inflammation	5,9%	59,1%	76,5%	51,3%
	Fibrin Mesh	Number Of Individuals	16	18	4	38
		% Groups	42,1%	47,4%	10,5%	100,0%
		% Inflammation	94,1%	40,9%	23,5%	48,7%
Total		Number Of Individuals	17	44	17	78
		% Groups	21,8%	56,4%	21,8%	100,0%
		% Inflammation	100,0%	100,0%	100,0%	100,0%

Histological analyses

The results of histological analyses of the presence of inflammatory and foreign body type cells, are displayed graphically and in tables 1, 2 and 3. The results of the fibrous plate analysis indicated most rats treated with TachoSil mesh had moderate or less inflammation, as measured by the presence of leukocytes in the histological tissue. This finding highlighted the advantage of using the TachoSil mesh over the polypropylene mesh (Fig. 4 and Tables 1 and 3). Most rates with the polypropylene mesh also had a significantly higher presence of foreign body type cells than those with TachoSil mesh (Table 2).

DISCUSSION

This study compared variables related to complications and fibrous plaque formation following the implantation of either polypropylene or fibrin mesh in the inguinal region of rats. The results indicated a clear advantage of the two-component fibrin mesh compared with the polypropylene mesh. The statistical analysis revealed a significant difference in inflammation levels and presence of foreign body type cells, with the fibrin mesh group showing fewer postoperative complications in the two-component fibrin mesh rat group.

The polypropylene group exhibited abundant chronic inflammatory infiltrates, including lymphocytes, plasma cells, eosinophilic granulocytes, and mast cells. In contrast, the TachoSil mesh group showed only mild inflammatory infiltration (Fig. 4 and Tables 1 and 3). Additionally, the number of foreign body type cells were significantly higher in the polypropylene group compared with the TachoSil group (Table 2). This shows a significant favor in terms of postoperative healing in the TachoSil group, which in turn means a greater chance of a successful hernioplasty repair with a smaller chance of hernia recurrence.

The extensive chronic inflammatory response in the polypropylene group indicated poorer healing and less favorable implant outcomes. Conversely, the reduced presence of foreign body type cells and inflammation in the TachoSil group suggested that the two-component fibrin mesh was a more biologically compatible material compared with the polypropylene mesh which again leads to a greater chance of a successful repair.

Table 2. Distribution of animals based on the presence of foreign body type cells

			Foreign Body Type Cells			Total
			+	++	+++	
Groups	Polypropylene Mesh	Number Of Individuals	1	24	15	40
		% Groups	2,5%	60,0%	37,5%	100,0%
		% Foreign Body Type Cells	4,8%	57,1%	100,0%	51,3%
	Fibrin Mesh	Number Of Individuals	20	18	0	38
		% Groups	52,6%	47,4%	0%	100,0
		% Foreign Body Type Cells	95,2%	42,9%	0%	48,7%
Total		Number Of Individuals	21	42	15	78
		% Groups	26,9%	53,8%	19,2%	100,0%
		% Foreign Body Type Cells	100,0%	100,0%	100,0%	100,0%

Table 3: Presence of inflammation in the stady gruops

		Groups		Total
		Polypropylene Mesh	Fibrin Mesh	
Inflammation	+	1	16	17
	++	26	18	44
	+++	13	4	17
Total		40	38	78

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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