Original article

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COMPARATIVE ANALYSIS OF GRAFT STRUCTURE RETRACTION AND TISSUE INTEGRATION OF UROGYNECOLOGY SYNTHETIC GRAFTS - AN EXPERIMENTAL STUDY

Milan Potić

Although many synthetic grafts have been considered chemically and physically inert, stabile and non-immunogenic, none of them is actually bioinert. Inflammatory reaction is necessary for the reparation process and collagen deposition, however, it can lead to graft retraction, erosion and adhesions. The aim of this experimental study was to analyze and compare the influence of graft structure on both retraction and tissue integration into urogynecology synthetic grafts.

Six different urogynecology synthetic graft types, after scan electronic microscope analysis, were used for the reparation of abdominal wall defect in Wister rats. After three and six weeks the influence of graft structure on tissue integration and retraction was compared.

Largest pores were recorded in the multifilament with polyglactine group (1.06 mm^2) compared to the almost ten times smaller pores in the monofilament collagen coated group (0.08 mm^2). Prominent retraction was recorded for the titanium coated polypropylene after six weeks (18.78%) compared to the multifilament polypropylene (10.88%). Tissue integration into monofilament grafts presented the steady rate with maximum of up to 25.3% for the low weight polypropylene after six weeks. Retraction rates were inversely dependent on graft filament thickness after six weeks. Filament thickness influenced significantly the tissue integration.

Retraction of urogynecology synthetic grafts was 10.88-18.78%. Tissue integration into urogynecology synthetic grafts was 18-25.3%. Retraction rates and tissue integration were inversely dependent on the graft filament thickness.

Key words: tissue integration, retraction, synthetic grafts. *Acta Medica Medianae 2014;53(4):5-9.*

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Introduction

The search for the ideal biocompatible synthetic material dated from 1950 when Cumberland and Scales studied the materials used in ventral hernia surgery. Although many synthetic grafts have been considered chemically and physically inert, stabile and non-immunogenic, none of them is actually bioinert (1). Inflammatory reaction is necessary for the reparation process and collagen deposition, but can lead to graft retraction, erosion and adhesions. The intensity of the inflammatory reaction is intensified with the increase of contact surface (2). Pore size is also important for fibroblast infiltration, flexibility and tissue integration (2). According to the valid Amid classification, synthetic materials are divided into four groups: macropore, micropore, macropore with multifilament structure and submicropore (3).

The aim of this experimental study was to analyze and compare the influence of graft structure on both retraction and tissue integration into urogynecology synthetic grafts.

Materials and methods

Six different urogynecology synthetic polypropylene grafts were analyzed; two mono-filaments: Prolene mesh (Ethicon, UK, 85g/m^2) in further text high weight polypropylene(HWPP), Gynecare gynemesh (Ethicon, UK, 43g/m^2) in further text light weight polypropylene (LWPP), two multifilaments: Surgipro multifilament (Tyco, Belgium, 97g/m^2) in further text multifilament polypropylene (MPP), Vypro II mesh (Ethicon, UK, 25 g/m^2) in further text multifilament with polyglactine (MPPG) and two coated grafts: collagen-coated Sepra mesh (Genzyme, USA, 96 g/m^2) in further text collagen coated polypro-pylene (CPP) and titanium coated Titanized mesh (GFT, Deutschland, 16 g/m^2) in further text titanized polypropylene

(TPP). Ten samples were gold-coated (sputter method for five minutes) and analyzed on scan electronic microscope in the Institute for biomedical research of Faculty of Medicine in Nis. Approximate pixilation method (three random sites) was used for determining the filament thickness and pore size. The graft thickness was measured with digital micrometer. Mean values and standard deviation were calculated.

Experimental study was carried out at the Institute for biomedical research of the Faculty of Medicine in Niš, on 144 male Wister rats weighing 250-300gr. Animals were divided into groups (n= 24) according to the graft type used later on. Rats were anesthetized by subcutaneous injection on 0.3ml 10% Ketamidor (Richter, Austria) calculated according to the body mass. Full thickness abdominal wall defect (20x25mm) with respect to the peritoneum was repaired (overlay technique) with standardized (25x30m) grafts overlapping the defect by at least 2.5m. Subcutis and skin were closed using the single suture Vicryl 3/0 and graft fixed with 5/0 prolene suture. After the postoperative recovery animals were housed with free access to food and water. Animals were checked for complications daily for the first week and then weekly until the sacrifice. The animals were sacrificed by lethal Ketamidor overdose after three and six weeks. After the sacrifice, the entire abdominal wall was dissected en block including the graft and at least 3cm of neighboring tissue (explant). All samples were photographed (Nikon D 90,12 Mpix) on a stand position for graft shrinkage evaluation (approximate pixelation).

Also, three random measurements over the explants were taken to determine the tissue integration. Comparative analysis of structure, retraction and tissue integration was done.

Statistical analysis was performed with Statistica 4,5; StatSoft, Tulsa, OK, USA (Linear correlation test, Kruskal Wallis test followed by Man-Whitney U test). Values $p<0,05$ were considered statistically significant.

Results

Figure 1. presents the scan electronic microscope images of tested samples. Urogynecology synthetic graft types, pore size and filament thickness are presented in Table 1. The largest pore size was recorded in the MPPG group (1.06 mm^2) while at the same time the smallest pores were recorded in the CPP group (0.08mm^2). MPP presented significantly lower pore size than the monofilaments. HWPP, LWPP and TPP had comparable pore size. Filament thickness was maximal in the MPP group (0.259mm). Graft thickness presented significant differences with HWPP 0,65mm and TPP 0,28mm.

In our study, graft infection and seroma development were not noted. Graft retraction results are presented in Figure 2. Retraction level was comparable for all samples with LWPP recording the maximum retraction after three weeks (11.93%). After six weeks maximal retra-ction rate was in the TPP group(18.78%) compa-red to the minimal retraction recorded in the MPP group (10.88%).

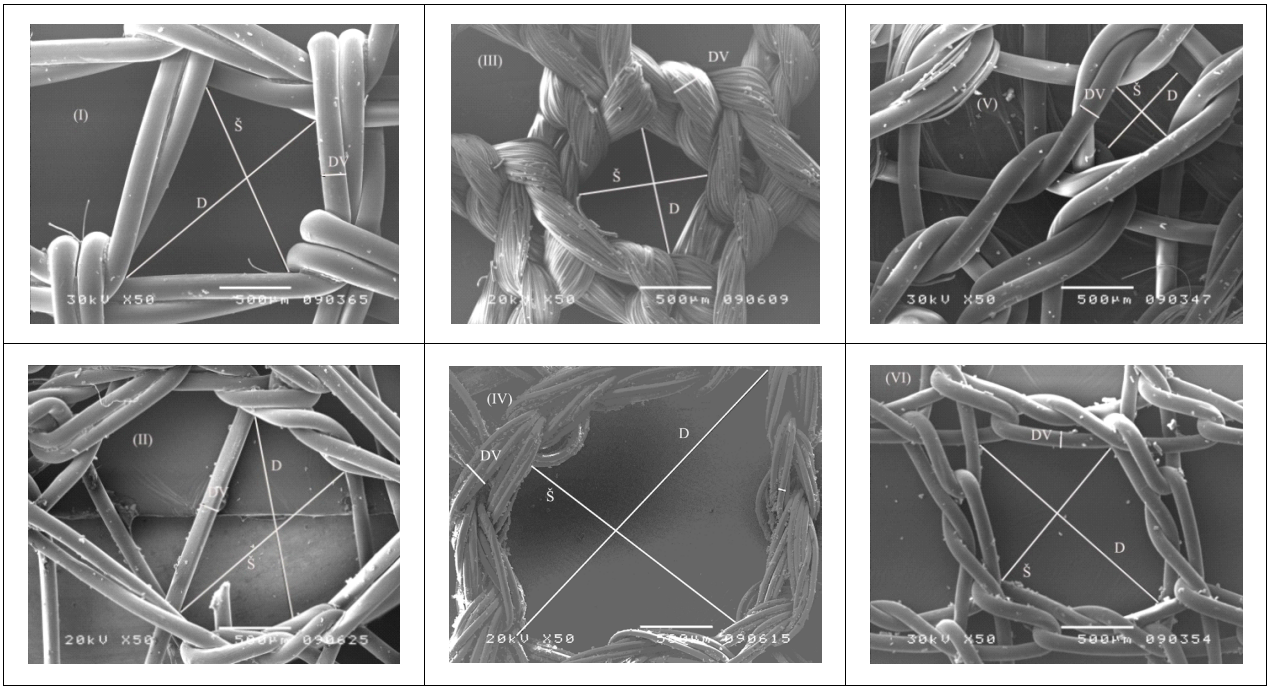

Figure 1. Scan electron microscope graft images (50/1)
(I-HWPP, II-LWPP, III-MPP, IV-MPPG, V-CPP, VI-TPP, Š-pore size, D-pore length, DV-filament thickness)

Table 1. Basic graft characteristics

Commercial name	Pore size (mm^2)	SD	Filament thickness (mm)	SD	Thickness	SD
TVT (HWPP)	0.570	0.020	0.086	0.009	0.650	0.010
Prolift (LWPP)	0.490	0.010	0.068	0.013	0.430	0.020
Surgi multi (MPP)	0.190	0.010	0.259	0.002	0.440	0.010
Vypro II (MPPG)	1.060	0.080	0.190	0.005	0.340	0.020
Colag coat (CPP)	0.080	0.030	0.077	0.003	0.630	0.020
Titan coated (TPP)	0.460	0.030	0.048	0.007	0.280	0.010

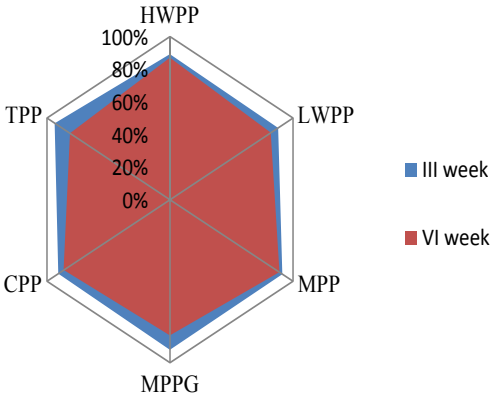

Figure 2. Graft retraction rates

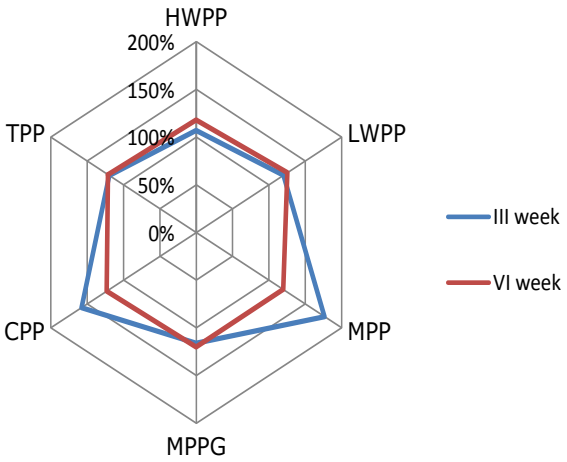

Figure 3. Tissue integration rates

Tissue integration results are presented in Figure 3. Monofilament grafts recorded a steady rate of tissue integration with maximum of up to 25% for LWPP after six weeks. After three weeks MPP and CPP had slightly higher tissue integration compared to other explants. The differences between MPP and LWPP ($p<0.01$), and between CPP and MPPG ($p<0.021$) were significant. After six weeks there was no difference in tissue integration. The maximum tissue integration of 25.3% was recorded in the LWPP group, while HWPP recorded 18%. After three weeks retraction was not influenced significantly by filament thickness or pore size ($p=0.479$; $p=0.63$). After six weeks retraction rates were inversely influenced by filament thickness ($p<0.05$). Pore size had no influence on retraction after six weeks ($p=0.065$), whereas filament thickness had significant influence ($p<0.001$).

After three weeks filament thickness influenced tissue integration significantly ($p<0.01$). The maximum tissue integration was recorded in the multifilament group. After six weeks filament thickness significantly influenced tissue integration as well ($p<0.05$).

Discussion

Experimental studies present a glimpse at the tissue integration and graft behavior not seen in the human population treatment. The basic theoretical assumption of inflammatory reaction, collagen deposition and their structural changes can be quantified only in experimental studies.

Some studies reported serum formation and graft infection (4) not seen in our study. Retraction rates presented comparable results in the groups after three weeks. The assumption is that the reparation process is still in the inflammatory stage with definitive collagen deposition yet to come. After six weeks, retraction rates were higher with maximum recorded of just below 20% comparable to other study reports (5-9). The inversely influenced filament thickness on retraction is also important. Other studies reported significantly lower retraction rates (10) but with graft placement over the intact fascia. One of the most prominent researchers reports that the LWPP had lower retraction rates due to induction of weaker immune response (11), which is in keeping with our results. Some of the study reports have comparable results to our study with similar methodology (11,12). Graft configuration of thinner filaments reduces the surface for foreign body reaction reducing also the final retraction and complications thus providing adequate support (13). This is probably the reason for favoring the LWPP by many authors (14-16). Multifilaments had lower retraction rates due to significantly thicker filaments.

Tissue integration or infiltration was prominent in the multifilament's group after three weeks. It is the multifilament structure that is responsible for the intensity of the inflammatory reaction (17-19). Multifilament structure is responsible for many complications in other studies as well (20). Tissue integration correlated significantly with filament thickness after six weeks. Comparative analysis of retraction and tissue integration classified the MPPG and LWPP in the same group according to the results. Having in mind that the reabsorbable component participates with 50%, less foreign material is left behind after the healing process, which results in lower complication rate (20). Coating the polypropylene with collagen and titanium has not been proved to be successful. The titanium coating is particularly associated with shorter postoperative course, which is also influenced by light weight of polypropylene (21).

The search for the ideal biomaterial lasts almost two decades. The multifilament and monofilament grafts proved to be a stabile support with complications yet to be summarized. The future perspective might lie in the semireabsorbable grafts providing the adequate support and leaving less foreign material behind.

Conclusion

Urogynecology synthetic grafts used in urogynecology show significant differences in pore size and filament as well as graft thickness. Retraction rates for urogynecology synthetic grafts is 10.88-18.78%. Tissue integration into urogynecology synthetic grafts is 18-25.3%. Retraction rate and tissue integration are inversely proportional to filament thickness.

Acknowledgment

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KOMPARATIVNA ANALIZA STRUKTURE STEPENA RETRAKCIJE I TKIVNE INTEGRACIJE SINTETSKIH GRAFTOVA KOJI SE KORISTE U UROGINEKOLOGIJI-EKSPERIMENTALNA STUDIJA

Milan Potić

Pored toga što se mnogi sintetski materijali smatraju hemijski i fizički inertnim, stabilnim i neimunogenim, nijedan od njih nije apsolutno biološki inertan. Inflamatorna reakcija neophodna je za željeni proces fibroze, međutim, kao njen rezultat nastaju neželjeni efekti sakupljanja grafta, erozije i adhezija. Cilj rada bio je utvrditi uticaj strukturnih karakteristika sintetskih graftova koji se koriste u uroginekologiji na tkivnu integraciju i stepen sakupljanja graftova nakon tkivne integracije.

Nakon analize elektronskom mikroskopijom, korišćeno je šest različitih vrsta polipropilenskih materijala koji se koriste u uroginekologiji je za reparaciju defekta prednjeg trbušnog zida Wistar pacova. Nakon tri i šest nedelja, upoređivan je uticaj strukture graftova na retrakciju i tkivnu integraciju graftova.

Najveća površina pora zabeležena je u grupi multifilamentnog polipropilena sa glaktinom (1.06mm^2), dok je, istovemeno, gotovo deset puta manja površina pora zabeležena kod kolagenom obloženog polipropilena (0.08mm^2). Najviši stepen retrakcije zabeležen je u grupi titanijumom obloženog polipropilena nakon šest nedelja (18.78%), u odnosu na najmanji stepen u grupi multifilamentnog polipropilena (10.88%). Tkivna integracija u monofilamentne graftove postepeno je rasla, sa maksimumom od 25.3% za polipropilen niske težine nakon šest nedelja. Stepen retrakcije bio je obrnuto srazmeran debljini vlakana polipropilenskih graftova nakon šest nedelja. Debljina vlakana pokazala je statistički značajan uticaj na stepen tkivne integracije.

Retrakcija polipropilenskih graftova koji se koriste u uroginekologiji iznosi 10,88-18.78%. Tkivna integracija u polipropilenske graftove iznosi 18-25.3%. Stepen retrakcije i tkivne integracije obrnuto je srazmeran debljini vlakana sintetskih graftova. *Acta Medica Medianae 2014; 53(4):5-9.*

Ključne reči: *tkivna integracija, retrakcija, sintetski graftovi*