Comparative study of fibrosis induced by Marlex®, Parietex Composite®, Vicryl® and Ultrapro® meshes[1]

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Abstract

Purpose: To evaluate the fibrosis induced by four different meshes: Marlex®, Parietex Composite®, Vicryl® and Ultrapro®.
Methods: Histological cutouts of abdominal wall were analyzed with polarized light 28 days after the meshes implants and colorized by picrosirius to identify the intensity of collagen types I and III, and their maturation index.
Results: When the four groups were compared, the total collagen area analyzed was bigger in groups A and D, with no difference between them. The collagen type I density was bigger in group A, with an average of 9.62 ± 1.0, and smaller in group C, with an average of 3.86 ± 0.59. The collagen type III density was similar in groups A, B and C, and bigger in group D. The collagen maturation index was different in each of the four groups, bigger in group A with 0.87, group B with 0.66, group D with 0.57 and group C with 0.33 (p = 0.0000).
Conclusion: The most prominent fibrosis promotion in the given meshes was found on Marlex® (polypropylene mesh) and the Parietex Composite® (non-biodegradable polyester); the collagen maturation index was higher in the Marlex® mesh, followed by Ultrapro®, Parietex Composite® and Vicryl® meshes.
Key words: Abdominal Wall. Hernia. Fibrosis. Collagen. Surgical Mesh.0

■ Introduction

Incisional hernia, also called ventral hernia or eventration, consists in the protrusion of viscera through orifices or abdominal wall areas weakened due to trauma or surgical incisions[1]. It is considered that one out of ten patients who had a laparotomy will develop incisional hernia[2]. It is also estimated that approximately 50% of those hernias take place in the first couple of years after the surgery and up until 74% throughout the first three years[3,4]. From 1950 forth, after the introduction of the meshes usage by Usher and Wallace, this practice was intensified, which represented a great step for the ultimate treatment and the recurrence rate decrease[5].

The mesh works as a prop and the fibrosis formation around its lines and pores guarantees the incorporation into the tissues. The fibroplasia process consists in a harmonious and coordinated sequence of cell and molecular events which interact in order to promote the damaged tissue repair and reconstruction.

The most deployed material is still polypropylene since it has been proven to be the responsible for the boost in the abdominal wall strength, however its high porosity leads to an intense inflammatory reaction with fibrosis ensued by elasticity loss[6]. One major issue lies in the intraperitoneal adherences, which might be the reason for intra or extra-hospital attendance with situations ranging from chronic pelvic pain, intestinal obstruction and women's infertility to intestinal strangling and necrosis (under high rates of morbidity and mortality). Furthermore, the difficulties and damage risks when eventual abdominal interventions are necessary are to be incurred[7,8].

Hence, an ideal material for the procedure, which must result in fair resistance to traction with no carcinogenic potential and chemically inert (bereft of infection potential), being also capable of developing sufficient inflammatory reaction and not to cause rejection, is searched. Moreover, it is also highly important to ensure it won't trigger any allergies or hypersensitivities besides being rather low-cost and able to resist to the mechanical stress, enabling the sterilization and, last but not least, its incorporation to the host[9-16].

Many strategies have been applied to try and avoid the complications. One option would be narrowing down the usage of polypropylene in meshes or making use of absorbable materials, which would promote an initial tension and then would be absorbed, soothing the local inflammatory process and the foreign body reaction[16]. It is worth bringing up that the polypropylene mesh associated with polyglecaprone 25 was created with the purpose of leading to a reaction 65% milder in the organism as compared with traditional meshes and offering a gain about four times bigger on the resistance to the abdominal pressure[17]. In regards of the mesh made of polyglactin 910 filaments, totally absorbable, Gaertner *et al.*[13] reckoned that its usage leads to the formation of adherences, although those had a smaller area as compared to synthetic prostheses. Other studies suggested that the eventual related complications could be avoided as per this selection[10] since, for such meshes, the inflammatory foreign body reaction has shown to be diminished as compared to other materials. In comparative studies on the collagen-coated, non-biodegradable polyester, it was demonstrated that the adherences promotion occurred more enduringly than on the polypropylene mesh. Nevertheless, concerning the involved surface, a smaller adherence area as related to polypropylene was found, whence the conclusion was that the collagen layer is more efficient on the adherence avoidance. Therefore, this work aspires to the histologic comparison of the intensity of the fibrosis induced by Marlex®, Parietex Composite®, Vicryl® an Ultrapro® meshes.

■ Methods

Ethical analysis

Histological cutouts obtained from abdominal walls with adherences, kept in paraffin blocks and brought from a previous work analyzed and approved by the Animal Ethics Committee/Biological Sciences Department, number 802 of June 12th, 2014, were scrutinized.

The meshes, with dimensions of 10 x 20 mm, were implanted in a standardized intraperitoneal fashion and secured on the corners of the meshes with polypropylene 5.0 and the knots were placed extraperitoneally.

Polypropylene (Marlex®), polypropylene associated with polyglecaprone 25 (Ultrapro®), collagen-coated polyester (Parietex Composite®) and polyglactin 910 (Vicryl®) meshes were attached to the abdominal wall in intraperitoneal position and evaluated after 28 days. On this evaluation, the abdominal walls which contained the mesh were dried and the adherences formed were kept in paraffin blocks. The walls that were given the polypropylene (Marlex®) mesh were branded as group A; the ones that were given the polypropylene associated with polyglecaprone 25 (Ultrapro®) mesh, group B; the ones that were given the polyglactin 910 (Vicryl®) mesh, group C; and the ones that were given the collagen-coated polyester (Parietex Composite®), group D. Among the blocks, the chosen were 5-micrometer-thick histological cutouts, which were displayed in slides. In order to recognize, classify and quantify the fibrosis, the Sirius Red F3AB dye, with acid, strong collagen-reagent features, was used. The examination under polarized light allows the verification of birefringence because its molecules mate to the collagen fibrils in a way that they remain parallel. The localization of different colors and the birefringence intensity with the biochemical distribution of collagen types I and III provide means of tissue differentiation. Collagen type I shows thick fibers, strongly birefringent, in shades of yellow or red; whereas type III shows thin fibers, weakly birefringent and in shades of green[15].

The pictures were shot with a camera Sony® CCD101 and transmitted to the colored monitor Trinitron Sony®, then frozen and digitalized as per the lens TCX®. They were analyzed by the Image-Plus® 4.5 for Windows® program via Media Cybernetics® on a microcomputer.

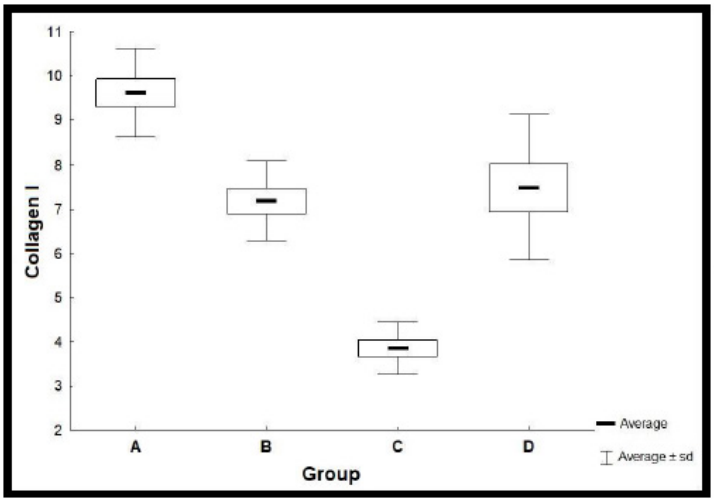
From each cutout, ten fields were read and once the percentages of each collagen type were identified, they were averaged out. Afterwards, an average was also obtained from each one of the scrutinized walls. The relation collagen I/collagen III has enabled the acknowledgement of its maturation index.

Statistical analysis

The data were tabulated and submitted to statistical analysis. For the comparison amongst the groups about the collagen variables, the analysis of variance model (ANOVA) was made use of as a factor. For the comparison of the groups by two, the test used was the Least Significant Difference (LSD). It was established $p \leq 0.05$ or 5% as a level for the nullity hypothesis rejection. The data were analyzed with the computational program IBM® SPSS Statistics v.20.

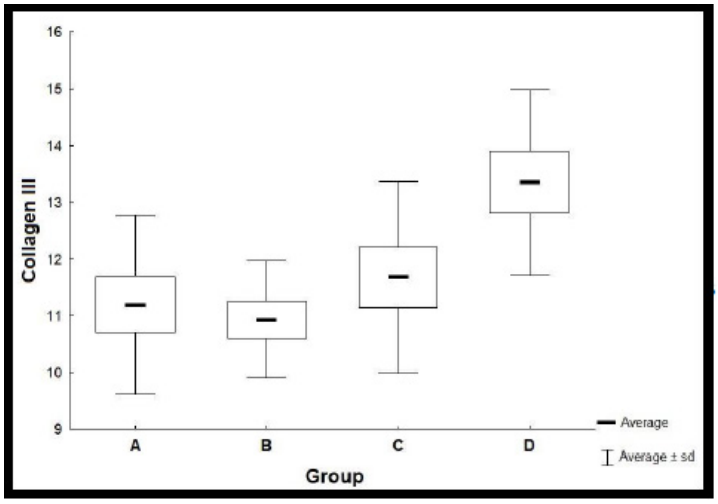
■ Results

The abdominal walls which presented the greatest collagen concentration were the ones that were given the polypropylene meshes, followed by the ones that were given collagen-coated polyester: respectively groups A and D. The walls that received polypropylene associated with polyglecaprone 25 showed comparatively lower concentration, and the lowest concentration was found on the walls that were given polyglactin 910 (Figures 1 to 3).



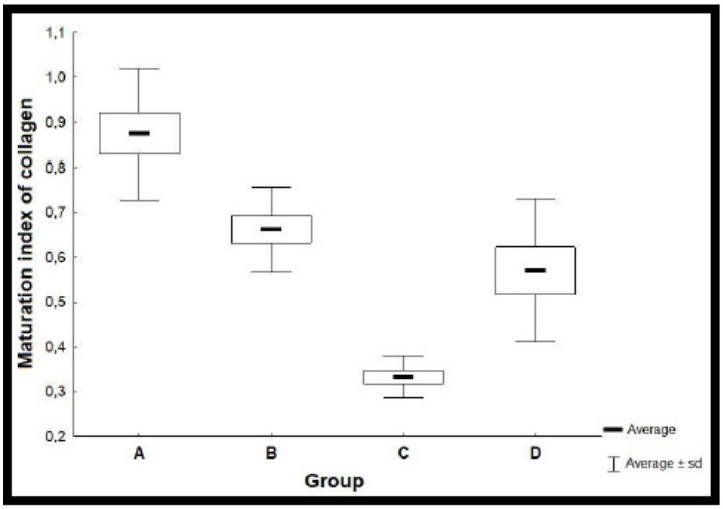
Groups	Col I
A x B x C x D	0.000
A x B	0.000
A x C	0.000
A x D	0.000
B x C	0.000
B x D	0.551
C x D	0.000

Figure 1 – Collagen I concentration in histological cutouts in four groups.



Groups	Col III
A x B x C x D	0.006
A x B	0.697
A x C	0.473
A x D	0.004
B x C	0.271
B x D	0.001
C x D	0.021

Figure 2 - Collagen III concentration in histological cutouts in four groups.



Groups	IMC
A x B x C x D	0.000
A x B	0.000
A x C	0.000
A x D	0.000
B x C	0.000
B x D	0.102
C x D	0.000

Figure 3 – Maturation index of collagen in histological cutouts in four groups.

■ Discussion

The classic incisional hernia treatment has been the correction of the fault without tension making use of meshes which, with the advent of the surgery by laparoscopic means, clung to the abdominal wall. Inasmuch as on one hand we have the perks of an earlier return to the activities and fewer abdominal wall infection occurrences, on the other hand new complications such as intraperitoneal adherences, fistulas, obstructions and infertility, besides the technical difficulties when new interventions are needed[5-11] were also found. These complications derive from the viscera rate of adherence to the wall, the foreign body reaction and the possibility of internal hernias formation. The physiological cicatrization reaction, mediated by inflammation and repair, is responsible for the prostheses integration, resulting in inflammatory cells infiltration and connective tissue deposition[25].

The acute inflammatory reaction leads to an increase in the capillary permeability as well as in the leakage of exudate high in fibrinogen, whence fibrin deposition ensues[26]. The latter is the responsible for the signalization of inflammatory cells, culminating in the adhesion of the two of the serous surfaces, with fibroblasts infiltration, collagen deposition and neovascularization. The whole phenomenon begins in the surgical operation and ends five to seven weeks later[10].

The technological enhancement has created prostheses with absorbable layers to inhibit the adherences. The polypropylene mesh is swathed by a dense fiber optic tissue. The fibrosis derives from the local reaction to the lesion itself and to the presence of the mesh[28]. It is the outcome of a chain of cell and molecular events the tissue repair process consists of[29-31] and its intensity depends on the inflammatory activity[32,33]. Another prosthesis, partially absorbable, is made of low-density filaments and polypropylene and polyglecaprone 25 (Ultrapro®). The polypropylene layer is incorporated and the polyglecaprone is reabsorbed within about 90 days. In a study carried out with rabbits, when polypropylene, Ultrapro® and Proceed® were applied in intraperitoneal position, there was no significant difference regarding the adherence area (p=0.134) and the inflammatory reaction, fibrosis and mesothelial reaction was similar in the three groups[9].

Trials recorded on literature have shown controversial results. Bringman *et al.*[28], working with rabbits which polypropylene, Ultrapro® and Proceed® meshes were applied on, documented that the presence of adherence, inflammatory reaction and fibrosis was similarly intense. Klinge *et al.*[27] set rats polypropylene and polyglactin meshes and reported that their association contributed to the fibrosis. Pereira-Lucena *et al*.[30] also set rats polypropylene and polyglactin meshes and stated that the latter resulted in lower collagen deposition as well as its lower maturation index. Gaertner *et al.*[13] studied, in rats, many types of meshes. According to them, the polyglactin mesh offered the lowest collagen concentration and the polypropylene mesh, the highest concentration, whereas Parietex Composite® resulted in an intermediate concentration.

In the present experiment it was noted that the Marlex® mesh developed the most fibrosis, followed by Parietex Composite®. This result might be explained by the fact that the Marlex® mesh consists of non-absorbable material and it maintains the foreign body reaction. The same is found on the Parietex Composite® mesh because it is composed by a layer of polyester, an unabsorbable material able to keep the foreign body reaction, although it contains a collagen coat which should be in contact with the viscera. This film should be absorbed and deteriorated via neutrophil collagenase within approximately 30 days[31]. This way, lesser fibrosis intensity and adherences formation would show. Throughout the study hereby presented, it

was observed that the polypropylene (Marlex®) mesh developed the most fibrosis and showed a maturation index higher than the Ultrapro® mesh (p =0.0000). This might have been led by the fact that the Ultrapro® mesh presents an absorbable component, polyglecaprone 25, all over its weft. The polyglactin was the one to show the least collagen density and the lowest maturation index, very likely due to its absorbable composition. These results undergird the ones previously documented by Gaertner *et al.*[13].

■ Conclusion

Amongst the analyzed meshes, the ones that promoted most fibrosis were the polypropylene (Marlex®) and non-biodegradable polyester (Parietex Composite®); the maturation index was higher on the polypropylene (Marlex®) mesh, followed by polypropylene together with polyglecaprone 25 (Ultrapro®), non-biodegradable polyester (Parietex Composite®) and polyglactin 910 (Vicryl®).

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