MATERIALE PLASTICE
https://revmaterialeplastice.ro
https://doi.org/10.37358/Mat.Plast.1964

Impact of Polypropylene Sutures Phisical Properties on Lymphaticovenous Anastomosis in Lymphedema Patients

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Abstract: *Polypropylene is a material recognized for its tensile properties, as well as for the stability of its chemical structure, an important element that has allowed the use of this material on a large scale, in a wide range of fields of activity, especially in the medical field. This study aims to highlight the structural properties of polypropylene, which contribute to improving the prognosis of vascular microsutures, through the comparative analysis of the results obtained after performing lymphatico-venous anastomosis in lymphedema patients. The research was focused on analyzing the importance of the diameter of the polypropylene thread and its tensile properties on the patency of the lymphatic anastomosis, through the comparative analysis of two groups of patients who benefited from micro-vascular sutures. The database was made up of a group of 82 patients divided into two groups who benefited from supermicrosurgical interventions by using polypropylene thread 11.0 (37 cases involving 148 anastomoses), respectively 12.0 (45 cases involving 180 anastomoses). The results of the research revealed that the group of patients who benefited from microvascular anastomoses using 12.0 poly-propylene thread recorded both better anastomosis patency rates and a significantly reduced rate of complications due to the rejection reaction of the suture material, under the conditions a significantly reduced tensile strength.*

Keywords: *polypropylen, lymphaticovenous anastomosis, tensile properties, lymphedema*

1. Introduction

Polypropylene is widely used in the plastics industry, as well as in the medical field in the form of implantable devices, due to its chemical and physical characteristics, being characterized by an increased resistance of prosthetic structures in the context of minimal stimulation of the local immune response [1]. Its linear polymer structure and the physical properties characteristic of this class of compounds give it versatility, having applications in wide areas both as a plastic material and in the form of fiber in most fields of use of plastic materials [2-4].

The main properties of polypropylene are represented by: chemical stability, rigidity, durability, increased tolerance to thermal variations, variable flexibility depending on diameter and translucency [5].

In this context, polypropylene shows increased resistance under stress conditions, being ideal for use in the medical field, especially in prosthetic devices, as well as as a suture material. Increased resistance and flexibility are the main properties that have allowed the use of polypropylene to make suture threads of different diameters [6,7]. The increased capacity of tensile strength facilitates the realization of complex sutures of tendinous structures with a high degree of mobility and maximum gravitational load. At the same time, the increased flexibility of the polypropylene chains allows the production of suture materials with a very small diameter, which facilitates the performance of microsurgical sutures of the lymphatic vessels, representing an important advantage from the financial point of view in the national

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healthcare system [8-11].

Depending on the form of presentation, polypropylene (Figure 1) has different melting point values, in copolymer form the temperatures are significantly lower (135-159^{o}C), compared to the homopolymer form whose structure degrades between 160 and 165^{o}C [12].

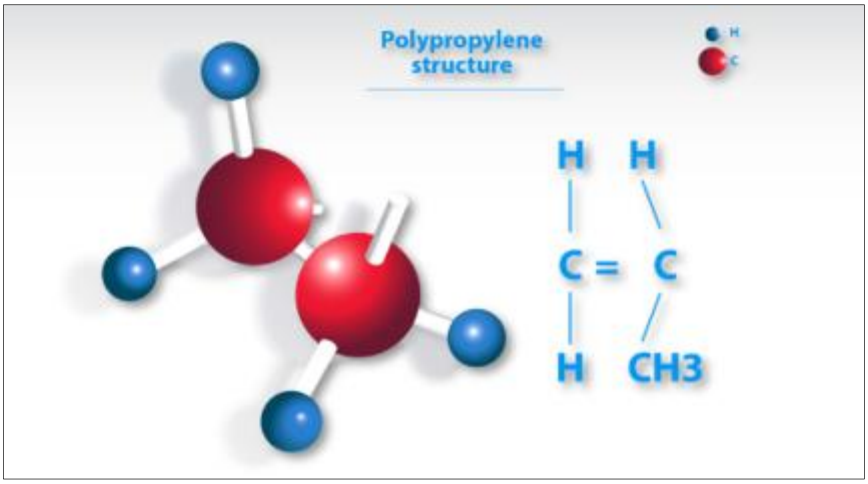

Figure 1. Polypropylene chemical structure

Polypropylene has a low weight, an element that has significantly contributed to the increase in its use in the plastics industry, as well as in the medical field. The density of polypropylene also varies depending on the form of presentation, its values being between 0.904 g/cm^3 and 0.908 g/cm^3 in the case of homopolymer, so that the copolymer structure reaches an even lower value, between 0.898 and 0.900 g/cm^3 [13-15].

Regarding the chemical resistance of polypropylene, it maintains its structure in contact with dilute and concentrated acids, as well as in the presence of alcoholic substances and bases. Property that represents an indisputable advantage of using polypropylene in the medical field, considering the complexity of the chemicals used in this field. Also, polypropylene is characterized by a good resistance to the action of aldehydes, ketones and esters, having a reduced resistance to contact with aromatic and halogenated hydrocarbons, as well as in the presence of oxidizing agents [16].

Polypropylene retains its chemical and structural properties in contact with water, as well as in wet environments, a property that has allowed its use on a large scale in the medical industry, as a resistant prosthetic material in the form of meshes for the treatment of hernias, as well as as a suture material in in order to make tendinous and microvascular sutures [17-18]. The chemical structure also allows it to keep its electrical and mechanical properties under the conditions of changing ambient temperature, at the same time having an increased resistance to steam sterilization.

The main disadvantages of polypropylene are represented by poor adhesion of pigments, increased sensitivity to the action of UV radiation, reduced resistance to the action of high temperatures in contact with metals, as well as rapid degradation in the presence of chlorinated solvents [19-20]. However, by using additives, a large part of these disadvantages have been overcome.

The use of polypropylene sewing threds represents a standard in the field of plastic surgery, due to their physical properties, being used in neoplastic pathology, microsurgery and reconstructive surgery [21].

The comparative analysis of polypropylene with nylon, another material frequently used in the medical field, reveals a better resistance and elasticity of polypropylene, as well as an increased efficiency in the production process due to the advantages given by the ease of injection molding [22].

The aim of this study is to highlight the structural properties of polypropylene threads and their impact on the prognosis of vascular microsutures. A comparative analysis of the results was obtained after performing lymphaticovenous anastomosis in lymphedema patients.

2. Materials and methods

In order to carry out the study, 12-0 and 11-0 (Figure 2) polypropylene sutures were used, the lymphaticovenous anastomosis being performed under optical magnification. In order to obtain relevant results, threads from the same manufacturer were used, having the same technical specifications, the only differentiating criterion being that represented by the thickness of the suture material. The specific chemical structure of these suture threads is represented by synthetic linear polyolefin, composed of an isotactic crystalline stereoisomer of polypropylene.

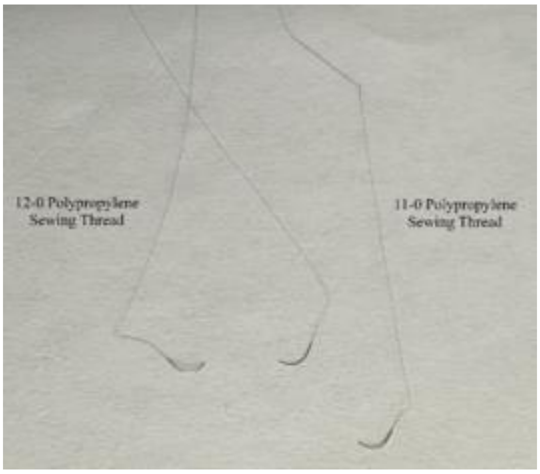

Figure 2. Comparative analysis of polypropylene sutures

2.1. Study inclusion criteria

The group of patients was divided into two groups: 45 patients (Group I) benefited from micro-vascular sutures made with 12.0 polypropylene threads, and the second group was made up of 37 patients (Group II) for the anastomoses that were used suture threads 11.0.

Regarding the total number of anastomoses performed in the first group of patients, 180 micro-surgical anastomoses were performed, so that the second group benefited from 148 anastomoses.

In both groups, pigmented threads were used, thus facilitating the visualization of the quality of the anastomoses, the traction marks at the level of the thread, as well as the quality of the knots, viewed from the perspective of flexibility influenced by the thickness of the thread used.

The distribution by age groups of the two groups respected the median of 50 years, with group I including patients aged between 29 and 74 years, for group II to register age values between 35 and 78 years. In the general group, patients aged between 29 and 78 years were included (Figure 3), so that the differences between the results obtained by using the two thicknesses of the suture threads, in the context of a wide spectrum of vascular fragility, could be analyzed , considering criteria such as: resistance, reliability and versatility specific to these medical devices.

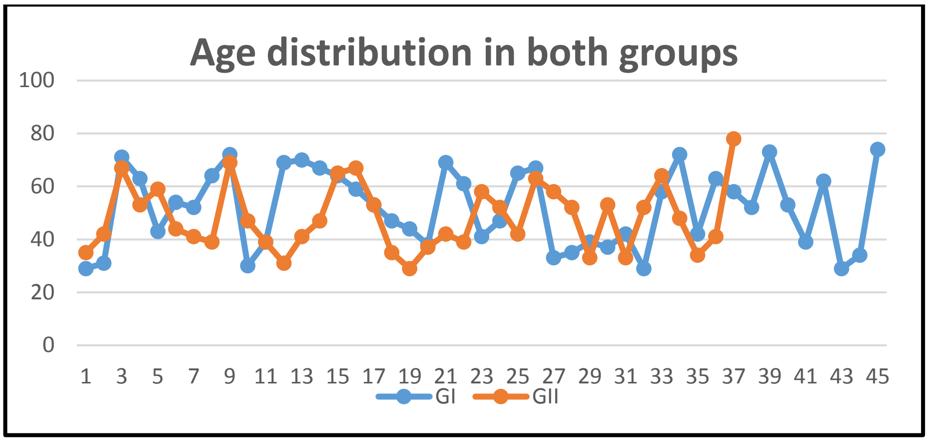

Figure 3. Age distribution in each group of patients

The gender distribution of the two groups was influenced by the increased incidence rate of lymphedema in the female population, the ratio per se in group I being 2:1 (F:M), so that in group II the value of the ratio was 3:1.

2.2. Main topics of the study

The study focused on the comparative analysis of the following indicators: the fragility of the suture material, objectified by the breakage rate of the suture threads during the performance of microsurgical sutures, the flexibility of the sutures by the qualitative analysis of the anastomoses and suture knots, the traumatization of the vascular wall objectified by the breach or its complete section determined by the specific hardness of the two sizes of threads used. The integration rate of the suture material, objectized by the patent of the anastomoses 7 and 14 days after the sutures were performed, the rate of immediate foreign body type complications as an indicator of the integration capacity of polypropylene according to size, as well as the success rate of surgical interventions by analyzing the patent 3 months after performing microsurgical sutures by using ICG.

3. Results and discussions

Regarding the comparative analysis of the fragility of the suture material, objectized by the breakage rate of the suture threads during the performance of microsurgical sutures, the analysis of intraoperative incidents revealed that there is no statistically significant difference between the two sizes of threads used.

In group I, three suture thread breakage (STB) incidents were identified, two of which were identified at the needle-polypropylene junction, one being associated with traction against a resistance, represented by the anchoring in the autostatic spacer. In group II, two intraoperative incidents were noted, in both cases the rupture was located at the level of the needle-wire junction.

Regarding the deformation of the polypropylene thread (DID) during surgical maneuvers, highlighted by imprinting and flattening, in the group of patients who benefited from microsurgical suture with 12-0 polypropylene thread, a significantly higher rate of this indicator was highlighted in 13 cases, compared to 6 in the case of group I.

The analysis of the flexibility of the suture threads (FST depending on the diameter was performed by studying the quality of the vascular anstomoses as well as the static properties of the suture knots.

In group I, made up of patients who benefited from microsurgical sutures using 12-0 propylene threads, the high rate of anastomosis quality was noted, viewed from the perspective of the uniform tension and distribution of tension at the level of the suture lines, revision of the anastomoses being necessary in 3 cases out of the 45 performed surgeries (Figure 4).

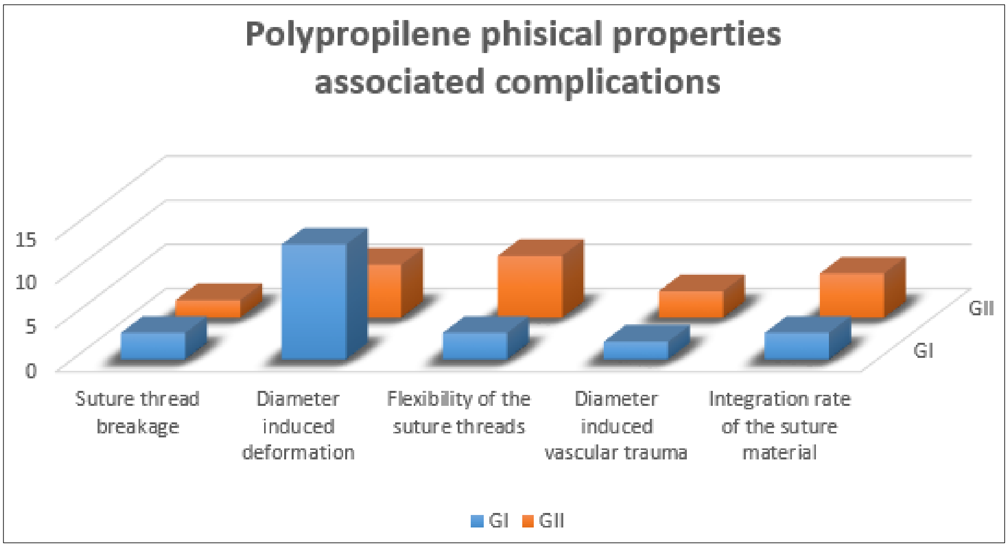

Figure 4. The impact of the physical properties of polypropylene on the rate of complications

In group II, in the context of the use of the 11-0 polypropylene thread, its greater thickness was associated with a rate of revision of the anastomoses of 7/37 resolved cases.

The study of the trauma rate of the vascular wall (DIVT), objectified by the breach or its complete section, revealed the fact that in study group I, the complete sectioning of the vascular wall at the passage of the suture thread was identified in 2 cases.

The analysis of the incidents identified in group II of patients showed a decreased rate of incidents, breach of the vascular wall that required the revision of the anastomosis, being identified in 3 cases.

Although polypropylene is a material with a high degree of flexibility, the analysis of the results obtained from the testing of this indicator, revealed that the rate of incidents of this type is significantly increased in the case of patients who benefited from microsurgical sutures using polypropylene thread 11- 0, compared to the group of patients who benefited from the suture using the 12-0 thread .

The physical and chemical properties of polypropylene have allowed the access of this polymer in a multitude of areas of the plastics industry. The flexibility, versatility and stability of the chirmic formula represented without a doubt the main advantages that were the basis of this phenomenon. Its wide-scale use in the medical industry was based on the minimal stimulation of the immune system and the low rate of local foreign body reactions (Figure 5).

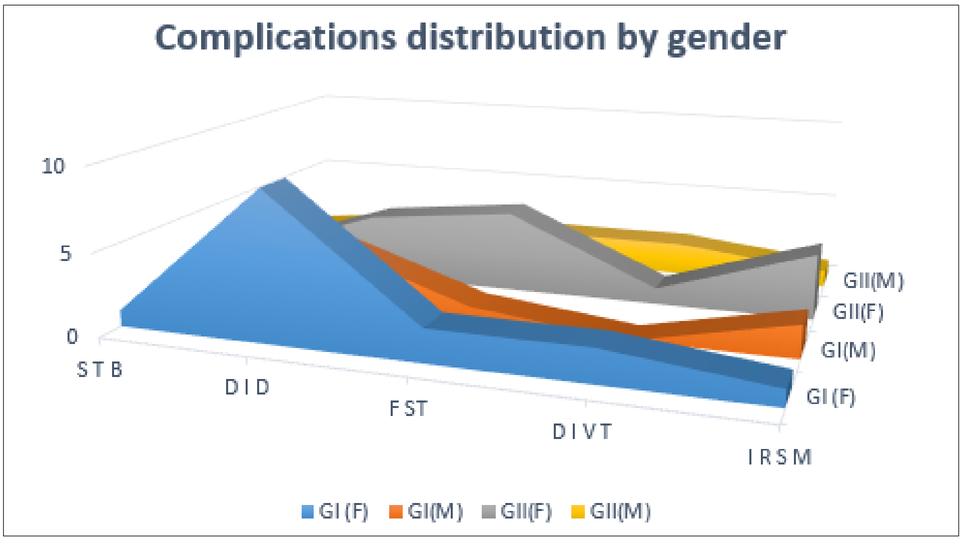

Figure 5. The impact of polypropylene properties on the rate of complications in both gender groups

The integration rate of the suture material (IRSM), objectiveized by the patent of the anastomoses at 7 and 14 days after the sutures were performed, recorded a value of 93.33% at 7 days within Group I, a value that was maintained at analysis performed at 14 days. In study group II, the suture material integration rate was 89.18%, its value dropping to 81.62% at 14 days.

Regarding the rate of immediate complications of the foreign body type as an indicator of the integration capacity of the polypropylene depending on the size of the suture threads used, in both studied groups no such adverse reactions were identified, the stability of the polymer and its inert structure contributing to a good integration of the prosthetic material.

The analysis of the success rate of surgical interventions by studying the patent 3 months after the performance of microsurgical sutures revealed similar values in the two studied groups.

In group I, made up of 45 patients, who benefited from 180 microsurgical anastomoses using 12-0 polypropylene thread, the results at 3 months were considered satisfactory by both the attending physicians and the patients involved in the study. In group II, made up of 37 patients who benefited from 148 anastomoses, 2 cases were identified, which required surgical reintervention or conservative methods to improve the functional result of the primary surgical intervention.

4. Conclusions

This work aimed to analyze the differences exerted by the physical and chemical properties of polypropylene depending on the size of the suture thread, in the case of its use in the medical field, in order to perform microsurgical sutures.

The results of the research reveal the fact that the differences in flexibility, fragility, tensile capacity and hardness of polypropylene, specific to different sizes of suture threads, influence the success rate of microsurgical interventions by increasing the rate of intraoperative, immediate and remote postoperative complications and incidents.

In the studied group, the group of patients who benefited from microsurgical sutures using 12-0 polypropylene thread recorded better results from the perspective of all the analyzed indicators.

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Manuscript received: 10.01.2024