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The Surface of Various Types of Surgical Sutures by Scanning Electron Microscopy

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Abstract: Using scanning electron microscopy – SEM, 165 various samples of surgical sutures, including 75 monofilament and 80 multifilament sutures were studied. SEM revealed varying degrees of defects on surface of sutures. They became more frequent when knots were tied, found in 4 cases of monofilament sutures - 5.3% and 8 cases of multifilament sutures - 10%. SEM is one of the most reliable methods for evaluating suture defects that may cause surgical complications.

Keywords: SEM, Surgical Sutures, Defects, Knots, Monofilament, Multifilament

1. Introduction

The progress of modern medicine, and, in particular, its intervention methods, is substantially associated with the development and wide application of various synthetic materials; suture materials comprise notable part among these materials. During the last decades the prompt progress of surgery, especially cardiovascular, became possible in many respects due to the development and wide introduction of new types of suture materials. Modern suture material allows significantly facilitating, speeding up and securing procedure of intervention. In fact, many surgical interventions became possible due to the advent of new types of surgical sutures [4], [6], [14].

At present, there is a large choice of different surgical sutures of various manufacturers. Different types and brands of sutures have different popularity with surgeons of various specializations and this is stipulated by a number of demands placed on one or another type of a suture material. In general, it can be said that the chosen material should allow adequately realizing short and long term tasks, an outcome influenced by a row of factors [4], [9], [15], and the physical and chemical structure of sutures play the main role in it. Studying and revealing advantages and limitations of existing surgical sutures is an important step in creating new types of modern suture materials.

The integration of synthetic and natural suture material into the recipient's tissues and the tissue reactions on them are well-enlightened issues in the literature [7], [9], [12], [15]. However, we could find only few works related to studies of spatial structure, relief of material and studies of the interaction between materials and tissues in three-dimensional aspect. The mentioned tasks can be achieved with the use of scanning electron microscopy (SEM) [3], [8].

The purpose of this work was to compare spatial structure and micro-relief of various surgical sutures and knots with the technique of scanning electron microscopy.

2. Materials and Methods

We examined different types of original (not used) surgical sutures along with their atraumatic needles and knots formed by the sutures, belonging to different trademarks and manufacturers (Table 1). There were 165 samples in total, including monofilaments - 75 and multifilaments- 80. The sutures were after being removed from packaging, were cut into pieces, knotted and mounted on aluminum wafers with the electrically conductive glue (through all the steps they were handled in sterile surgical gloves). The samples then were ion sputtered gold with IB-3 (Hitachi). Samples were than studied and photographed with a scanning electron microscope S-405A, (Hitachi) at accelerating voltage of 15 kV.

Table 1. *Studied suture brand names.*

Name of firm-manufacture, country	Name of suture (trade-mark)
KIM, Russia	AKKI
B/Braun, Germany	Premilene, Syntofil
Dr. Hammer&Co, HowmedicaInc., Germany- Sweden	Teflon-Polyester, Vitalon
Surgaloy, USA	Surgidac, Biosin, Surgipro, MonosoftPolisorb
Devis&GeckMonofil Inc., USA	Novafil, Ti-Cron, Dexon II, Maxon, Cotton, Surgilene
Ethicon, Scotland	EthibondExel, Ethibond Extra, Mersilene, Prolene

3. Results

All synthetic surgical sutures can be divided into two groups - the monofilaments and the multifilament sutures. So called, braided sutures are the prevailing type among the latter groups.

The surface of monofilaments sutures, as a rule, have longitudinal strips that are better visualized at higher magnifications. Sometimes, due to the tears of the surface layers, it is possible to see disruptions of surface integrity, appearing in the form of fins (Figures 1, 2). However, tying knots of monofilament sutures resulted in the formation of more expressed defects in form of deep tears, both transverse and longitudinal.

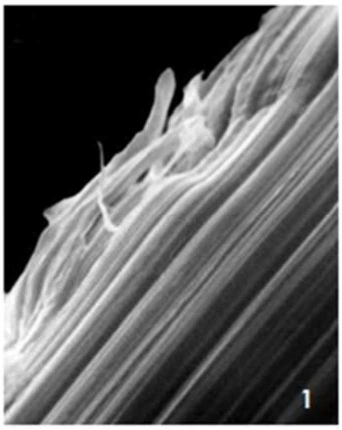

Figure 1. *PREMILENE. Blue nonabsorbable polypropylene monofilament. (B/Braun). Knot, x1000.*

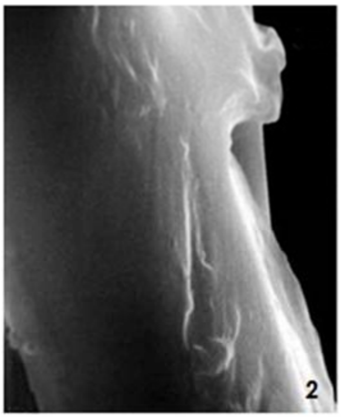

Figure 2. *SYNTOFIL. Green nonabsorbable coated braided polyester. (B/Braun), Suture surface x4000.*

SEM of multifilament sutures at low magnification showed no obvious defects on their surface.

However, larger magnification allows, in individual cases, identifying a number of surface defects on the multifilament sutures. They are concluded in the roughness of the filament surface, grooves, and protuberances (Figures 3, 5). Often, the adjacent filaments have jumpers between them (Figure 4).

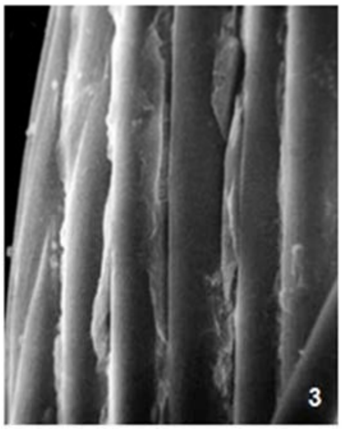

Figure 3. *TEFLON. Green nonabsorbable Teflon-polyester. (Dr. Hammer & Co. Howmedica Inc), x1000.*

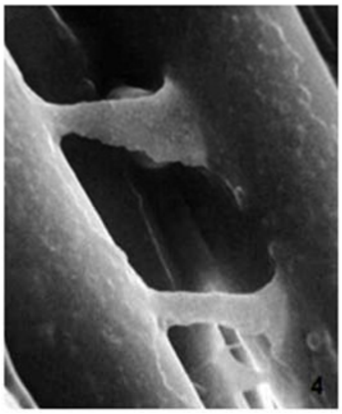

Figure 4. *TEFLON. Green nonabsorbable Teflon-polyester. (Dr. Hammer & Co. Howmedica Inc), x3000.*

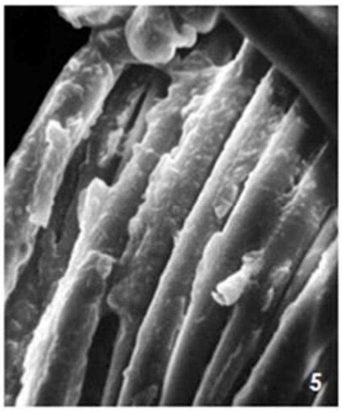

Figure 5. *POLYSORB. Braidedlactomer 9-1. (Surgalloy). Knot, x1000.*

The obvious and hidden defects of filaments become apparent when tying them in knots.

Typically, the surface defects are less frequent on the knots made of monofilament sutures (Figures 6, 7, 8), or they are less significant than those found in multifilament sutures.

Figure 6. *PREMILENE. Blue nonabsorbable polypropylene monofilament. (B/Braun). Knot x60.*

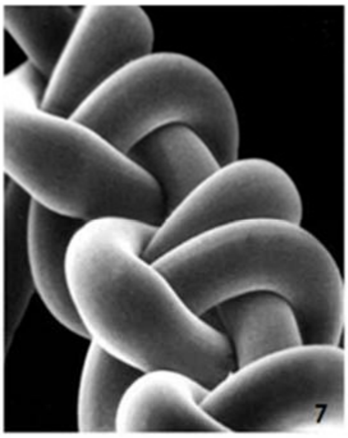

Figure 7. *MONOSOFT. Blacknonabsorbable, nylon (polyamide) monofilament. (Surgalloy). Knot x100.*

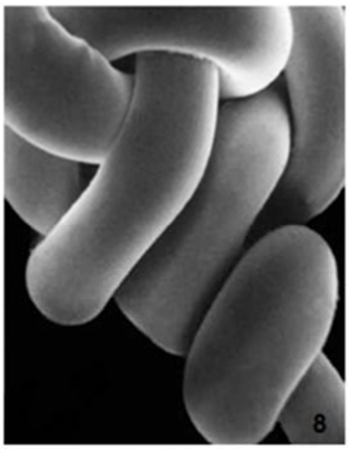

Figure 8. *SURGILENE. Blue nonabsorbable monofilament polypropylene. (Davis & Geek Monofil Inc.). Knot. x100.*

However, in certain observations (4 samples -5.3%) tying knots resulted in significant disruption of the integrity of sutures: they consisted of longitudinal delamination of filaments (Figure 9) and transverse tears (Figure 10).

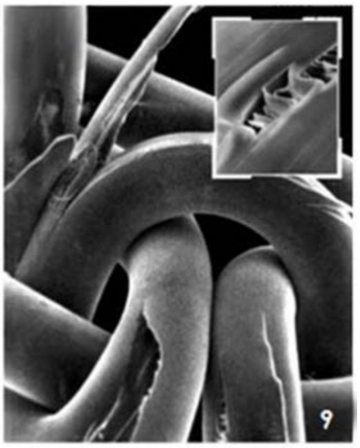

Figure 9. *BIOSIN. Synthetic absorbable glycomer 631. (Surgalloy). Knot, x60. Inset- x600.*

Figure 10. *MAXON. Absorbable monofilament from polygluconate. (Davis & Geek Monofil Inc.) Knot. x60.*

As a rule, SEM examination of knots made of multifilament sutures reveals that not many of knots would contain defects (Figures 11, 12), or they form small insignificant excrescences on the surface (Figure 13).

Figure 11. *SURGIDAC. Green nonabsorbable polyester. (Surgalloy). Suture surface, x200. Inset -knot x60.*

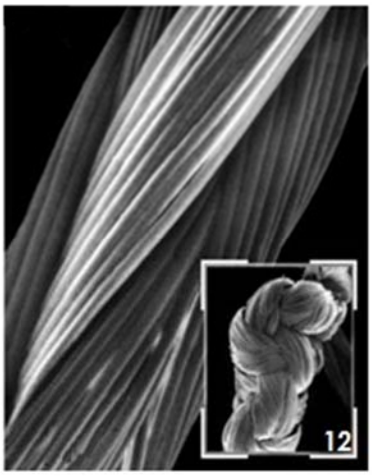

Figure 12. *MERSILENE. Black nonabsorbable braided polyester. (Ethicon Inc). Suture surface x100. Inset –knot x60.*

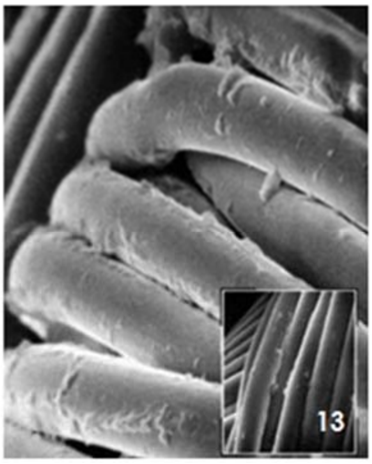

Figure 13. *SYNTOFIL. Green nonabsorbable coated braided polyester. (B/Braun). Knot x500. Inset - same.*

Some samples of knots made of multifilament sutures (8 samples - 10% of cases) reveal various defects, particularly obvious at high magnification. They represent the appearance of calluses, tears, and depressions (Figures 14, 15, 16) as well as the fusion of filaments together (Figure 14).

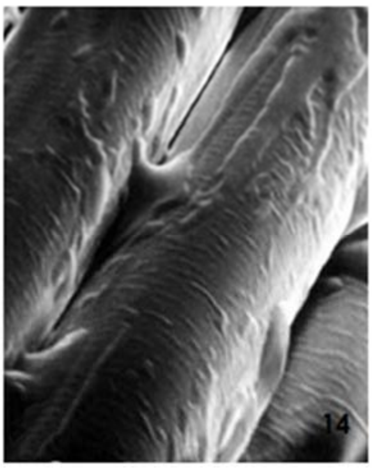

Figure 14. *DEXON II. Absorbable, braided polyglycolicacid with polycaprolate. (Davis & Geek Monofil Inc.). Knot x4000.*

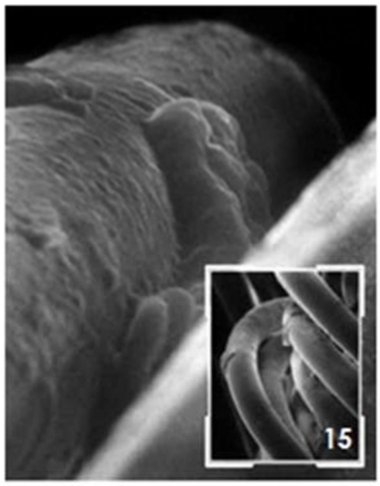

Figure 15. *MERSILENE. Black nonabsorbable braided polyester. (Ethicon Inc). Knot 10000.*

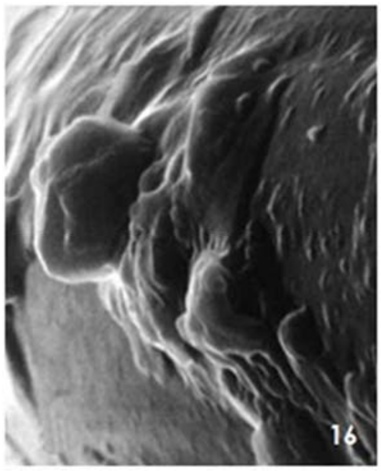

Figure 16. *ETHIBOND EXTRA. Green nonabsorbable braided polyester, coated by polybutilate. (Ethicon Inc). Surface of knots. x4000.*

The study of impregnated with silicone braided sutures revealed that after knots being made these materials have deformations in form of numerous knolls of different sizes and shapes on their surface. The volume and linear sizes of knots vary also, knots formed from braided sutures approximating more to a flat sphere, while the knots from monofilament sutures form cylindrical or cone-shaped structures.

4. Discussion

Since the 50's, more works were devoted to the problem of sutures in surgery, as it turned out, that the suture material is practically a "miniprothesis" or a foreign body (the single one for the vast majority of operations), which remains in the tissues. It is natural that the quality, chemical composition, and structure of the material depends on the reaction of tissue to its implantation, and ultimately, often, the result of the operation. [4], [7], [9].

In general, the main factors considered in the selection of a suture include the tensile strength, durability, tissue reactivity, and the intrinsic material characteristics which determine ease of use and knot palpability [4], [7]. Monofilament sutures have the proven benefit of minimal tissue reaction [13], [17] and a lower rate of infection [5], while braided polyester has the advantage of maintaining tensile strength over time. [2], [10]

SEM study of sutures demonstrates that apparently similar, at first glance, and homogenous synthetic materials become rather different from each other, and have various defects. Moreover, the mentioned defects can be revealed before sutures started to be used. As a rule, this is usually varying degrees of a disintegration of filaments in sutures and disrupted integrity of surface, which was considerably more notable in knots and ranged from insignificant deformation to complete destruction. Braided absorbable sutures are mostly exposed to disintegration processes, while synthetic monofilaments – least.

Stability and strength of knots significantly depend on the degree of engagement of suture loops with each other and the ability to preserve the form. The lesser volumes of knots formed from braided sutures are conditioned by their higher elasticity and therefore better cohesion between its loops. Microrelief of suture surface, besides elasticity, play a noticeable role in it; in this aspect, the braided sutures are more advantageous than monofilaments. [1], [16]

The initial defects or damages arising in the course of use of sutures reduces the period of the adequate functioning of synthetic materials, increase the degree or risk of their destruction.

Suture material used in the cardiovascular surgery may directly be in contact with blood flow in the lumen of heart and vessels. Accordingly, before suture integrates into the tissue, its surface microrelief and physical-chemical properties may also be a source of thrombosis (or microthrombosis). In these terms, the disrupted surface of sutures may serve to the emergence of specific for implants complications, including violations of general and local hemodynamics, thrombosis or microthrombosis [11].

It seems that morphologic analysis of specific features of sutures and careful study of particular batches synthetic materials before their use may prevent or reduce the risk of various complications.

5. Conclusions

Some of the original suture materials have initial structural defects, which become more evident in knots. More often these defects are found in multifilament sutures, as compared to monofilament sutures. The structural defects are thought to be the cause of inadequate functioning of sutures and of various early and late postoperative complications. However, higher flexibility of multifilament sutures allow forming smaller size knots from them, which seems to be an obvious advantage, in terms of reducing turbulent flow and trombogenicity of sutures.

SEM can be used for objective visualization of suture material for assessment of its condition before and after use.

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