
Morphological Foundations of Facelift Using APTOS Filaments

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1. Introduction

Correction of earlier involutional changes of the face, in the first place facial skin ptosis, encounters some difficulties. On the one hand, these changes are not serious enough to serve as an indication for radical aesthetic surgery. On the other hand, traditional minor surgical interventions fail to ensure well-apparent beneficial effect.

Moreover, many women are reluctant to undergo extensive surgery since it entails prolonged rehabilitation which may sometimes take one and a half months to be completed.

No wonder, many plastic surgeons tend to resort to a combination of minor invasive interventions that are apt to significantly shorten the rehabilitation period and are possible to perform in an outpatient setting.

2. Materials and methods

Recent years witnessed wide implementation into clinical practice of aesthetic surgery of an effective, atraumatic method of treatment of facial involutional alterations – lifting of the soft tissues with the help of specially designed “APTOS” threads [1, 4, 5, 6, 7, 8].

The method is based on the use of specially designed polypropylene APTOS filaments and is recommended for managing moderate involutional changes in the facial soft tissues and local face lifting. One side of an APTOS thread bears barbs that extend forward in the direction of its movement through the tissue, on the other side the barbs extend backward, i.e. in the opposite direction. Barb length - 1 mm, barb angle thickness could vary from 30 to 50 degree depending on the barb resistance force. Such a design ensures that the filament gently glides through soft tissues in a desired direction but resists drawing in the opposite one, i.e. remains fixed as appropriate. As a result, subcutaneously implanted filaments keep

in place the lifted facial tissues uniformly drawn into puckers, do not allow them to slip down, and thus maintain a new facial contour.

However, until now it remains unknown how the APTOS threads behave within the tissues in time and what are the local and morphological processes maintaining the tension and creating the rejuvenating effect.

In an attempt to clarify the mechanism of tissue reactions to subcutaneous implantation of APTOS filaments, an experimental study of the resulting morphological changes was undertaken at the A.V. Vishnevsky Institute of Surgery. A group of 20 white rats was used as a model from which 72 tissue samples were obtained for histological studies [3]. Morphological findings were compared with the results of examination of tissue samples following implantation of smooth polypropylene filaments to another group of animals that served as control.

The material for histological analysis included implants, their capsules, and the surrounding tissues.

Relative vascular bed density (RVBD) at different time intervals after implantation was estimated and compared with RVBD of intact rats to evaluate changes of blood supply to the tissues surrounding implanted polypropylene filaments [2].

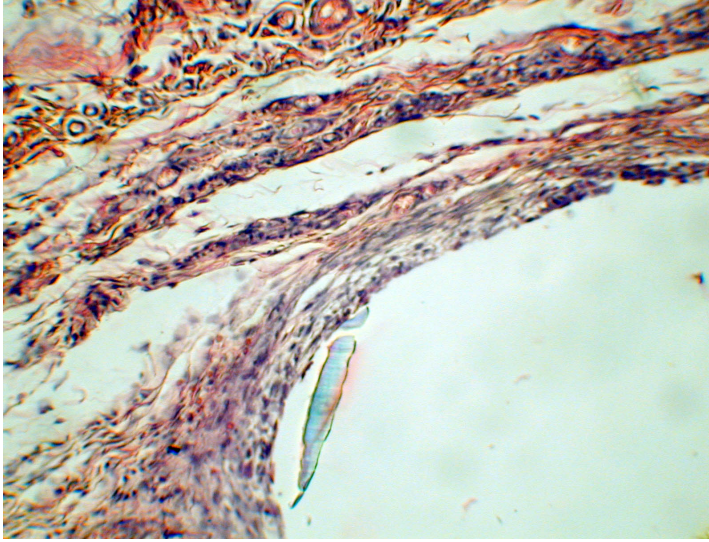
Relative vascular bed density was calculated by the following standard formula

$$RVBD = \frac{\text{Number of points in the blood vessel field}}{\text{Total number of points in the examined field}} \times 100\%$$

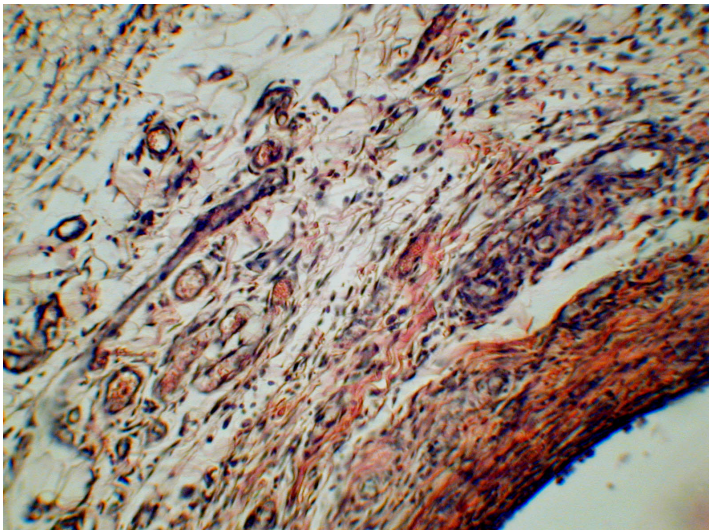
3. Results and discussion

On day 3 after subcutaneous implantation, the filament was found to be isolated from the surrounding tissue mass by an immature connective tissue capsule (fig. 1a) the lateral sides of which gave rise to connective tissue bands. The capsule wall was much thicker close to the barbs than near the smooth thread portions. Also, the capsule wall facing epidermis was significantly thicker than its remaining part, probably due to mechanical pressure exerted by the integumentary tissues on the filament and the capsule developing around it. Such variability of the capsule wall thickness is considered to be beneficial for the final face lifting effect and improve its stability.

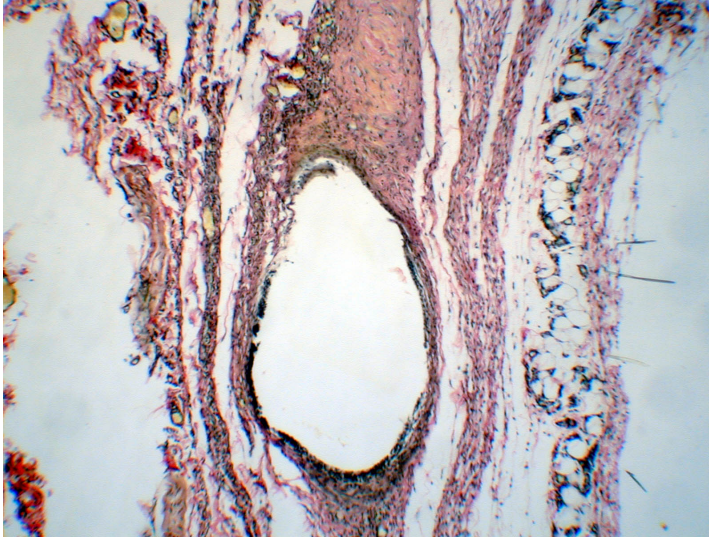
The histological study revealed marked hyperemia of the microvascular bed. It was especially pronounced where barbs rose from the shaft of the thread. The barbs looked braided with tissue cells. The inner capsule layer at the base of the barbs was composed of fibroblasts dominated by young cells. Connective tissue bands growing from the capsule wall were readily apparent as well as inflammatory reaction that resulted in fibroblast accumulation around the barbs and thickening of the capsule wall where it faced epidermis. There were practically no signs of inflammation in the form of infiltration around the implanted filaments.



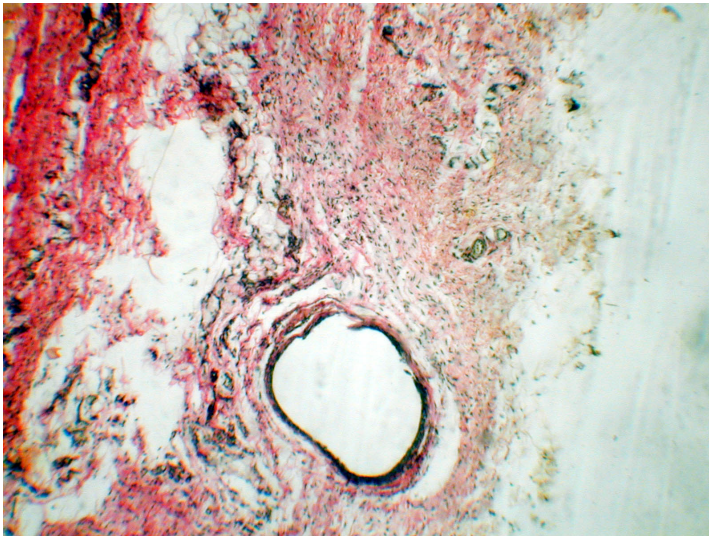
a



b



c



d

a - 3 days after implantation. Cellular elements predominate over fibrous ones, the number of microvessels increases (x100); b - 7 days after implantation. The capsule has a bilayer structure, persistent hyperemia develops due to marked vasodilation (x100); c-7 days after implantation. Connective tissue bands can be seen arising from the upper poles of the capsule (x40); d - 7 days after implantation (x40)

Figure 1. Microphotographs of the capsule surrounding APTOS filament (a-c) and smooth polypropylene thread (d). Van-Gieson pyrofuchsin staining

The structure of the capsule surrounding a smooth polypropylene filament on day 3 after implantation was not substantially different from that formed around a barbed APTOS filament. Only the wall thickness was smaller, being 19.25 mem on the side facing epidermis and 23.5 mem on the side facing the subcutaneous fat layer. A thinner capsule around smooth filaments was due to the absence of barbs and the respective less injurious effect of the implanted material.

The shape of the capsule developing after the implantation of both APTOS and smooth filaments was that of a rhombus. However, the capsule around smooth filaments gave out no connective tissue bands arising from their lateral walls.

On day 7, the capsules around APTOS filaments became thicker due to a rise in the number of collagen fibres. Each capsule exhibited two distinct layers characterized by different cell to collagen fibre ratio (fig. 1b):

1. inner layer enclosing the filament and dominated by young cells and
2. outer layer in which collagen fibres predominated.

The capsules assumed the rhomboid shape while their lateral apices gave rise to connective tissue bands that became thinner as the distance from the capsule increased (fig. 1c). The total length of a band (the capsule wall inclusive) was 886 mem, the width ranged from 108 to 187 mem. The capsules remained well-vascularized despite a progressive rise in the number of collagen fibres within 7 days after filament implantation. The capsule walls were penetrated by a large number of capillary vessels, microvascular hyperemia persisted both in the immediate proximity to the filaments and at a certain distance from them. No signs of pyogenic inflammation could be seen.

The outer capsule layer, although rather thin, always contained a large number of capillary-type vessels.

Isolated lymphoid and plasma cells as well as swollen fibroblasts were readily apparent close to microvessels. The amount of blood congestion in the microvascular bed decreased with the distance from the filament.

The thickness of the capsule formed around a smooth polypropylene filament by day 7 after implantation was 17.75 mem on the side facing epidermis and 17.25 mem on the side facing the subcutaneous fatty layer. Lateral walls were as thick as 54.5 and 25 mem (fig. 1c).

On the whole, the major morphological characteristics of the tissues surrounding smooth filaments on day 7 after implantation underwent significantly smaller modification compared with the tissues responding to APTOS filaments.

On day 40, further thickening of the capsule wall around both the shaft and the barbs of APTOS filaments took place; however, the capsule development was not completed. The capsule wall facing epidermis was significantly thicker than that facing the subcutaneous fat layer (58 and 18.75 mem, respectively). Connective tissue bands arising from the capsule walls, shafts and barbs of APTOS filaments became thicker and longer than before. Simul-

taneously, the number of microvessels increased. Most of them underwent hyperemia, but no signs of exudation were documented.

A peculiar morphological finding on day 40 was parallel bands composed of connective tissue fibres and extending towards the subcutaneous fat layer. According to micrometric measurements, the bands were from 5,000 to 8,000 μm long and from 900 to 300 μm wide. They occupied a total area of 4,200 μm^2 .

Characteristic changes in loose connective tissue close to the implanted filaments included:

- an increased number of vessels in the microcirculatory system (arterioles, venules, pre- and postcapillaries, and capillaries) compared with tissues located farther from the implants;
- microvessels looked overfilled with blood, i.e. had an open lumen, any time after the implantation of APTOS filaments; in other words, implantation induced persistent hyperemia and therefore stimulated blood supply to the tissues surrounding APTOS filaments;
- fibroblasts of loose connective tissue had enlarged nuclei and plasma volume and finely dispersed chromatin which suggested a functionally active state.

Staining with toluidine blue revealed an increased number of mast cells in the loose connective tissue layer surrounding APTOS filaments. These cells were concentrated in perivascular space of the microcirculatory system (fig. 2).

The tissue response to smooth polypropylene filaments on day 40 after their implantation was not significantly different from that to APTOS filament. However, the capsule

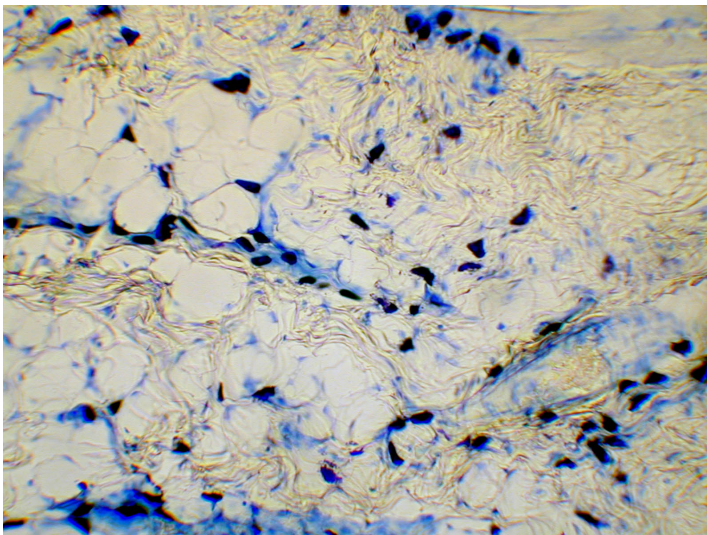


Figure 2. Microphotograph showing accumulation of mast cells around APTOS filament. Staining with toluidine blue (x 40)

developing around smooth polypropylene threads had thinner walls and matured quicker than around APTOS filaments, evidently due to less severe irritating effect on the tissues.

The capsule wall thickness varied from 52,5 mem on the side facing epidermis to 42.75 mem on the side facing the subcutaneous fat layer. The lateral walls of the capsule were approximately 400 mem thick. The width of the middle part of the lateral walls was around 136.75 mem. Tissues surrounding smooth filaments contained an increased number of microvessels, but hyperemia and vascularization were less pronounced than around APTOS filament.

On day 90 after the implantation of APTOS filaments, the inner capsule layer was composed of functionally active cells, each containing a large amount of cytoplasm. The outer layer consisted of collagen fibres and a small number of fibrocytes (fig. 3a).

Fibrous capsule structures and similar structures of the surrounding tissue merged into one another giving rise to a continuous network.

In the course of time, the fibrous capsule became more and more tightly integrated with the surrounding tissue which promoted solid fixation of the implanted filaments. Both the shaft and the barbs of the filaments were braided with fibrous tissue structures. The capsule wall near the barbs was thicker but less mature than around the shaft of the filaments; it contained more cellular elements than fibrous ones. Simultaneously, the number of mast cells increased. Giant cells close to the filaments were very rare and localized near the barbs.

Smooth polypropylene filaments had better developed capsules than APTOS filaments on 90 days after implantation. Fibrous elements in their walls predominated over cellular ones. The capsules displayed neither inflammatory reaction nor signs of resorption. Tissue vascularization in the immediate proximity to smooth polypropylene threads was less pronounced than around APTOS filaments.

The capsule had a rhomboid shape. However, unlike the capsule around APTOS filaments, it gave out no laterally extending connective tissue bands. This confirms that smooth polypropylene threads are unsuitable for facelift.

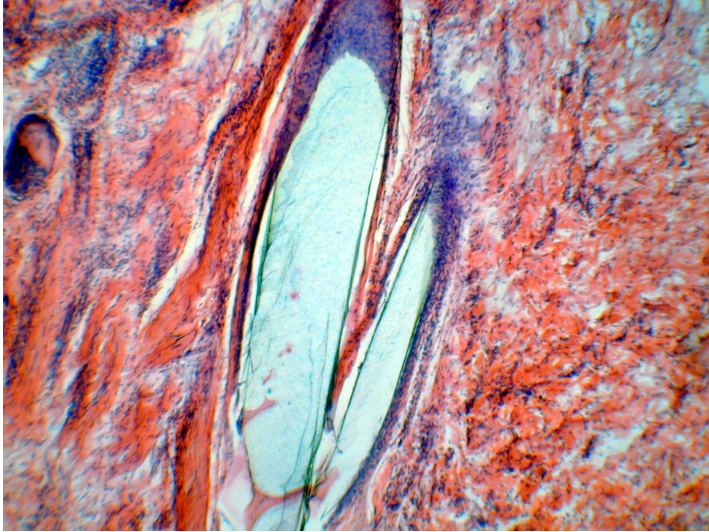
On day 210 after implantation, the connective tissue capsule around APTOS filaments continued to develop having the wall thickness of 39.6 and 35.4 mem on the sides facing epidermis and subcutaneous fat layer, respectively.

The capsule became thinner, fibroblasts underwent conversion into fibrocytes, collagen fibres predominated over cellular elements. Capsular fibrous structures merged with the fibrous structures of the surrounding tissue, i.e. their further integration occurred.

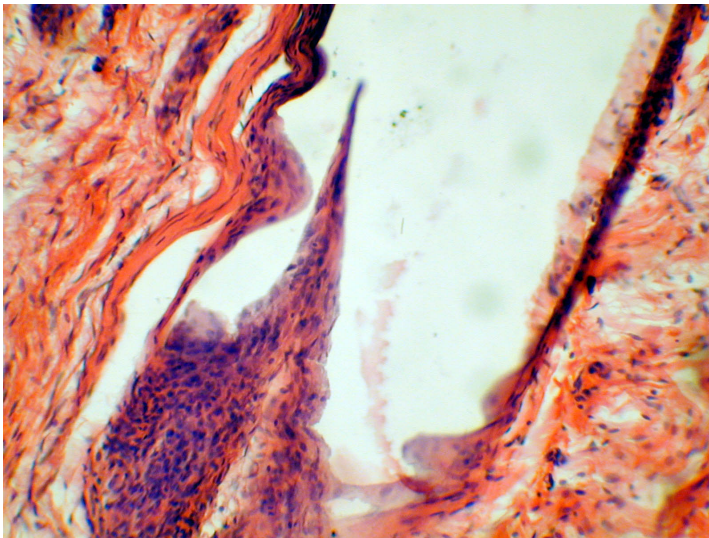
The capsule around filament barbs looked less mature than around the shaft (fig. 3b) due to irritating effect of the former on the adjacent tissue.

No giant cells indicative of resorptive macrophagal reaction could be seen in the capsule.

Prolonged period of capsule development around barbs ensured stronger adhesion between implanted filaments and the surrounding soft tissues (fig. 4a).



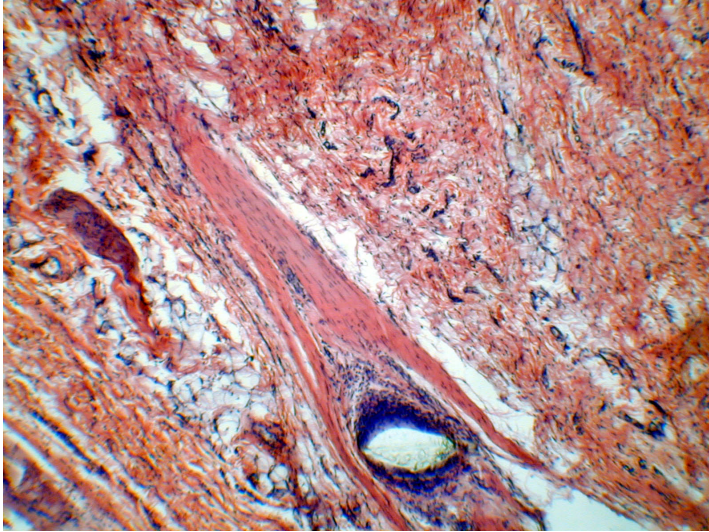
a



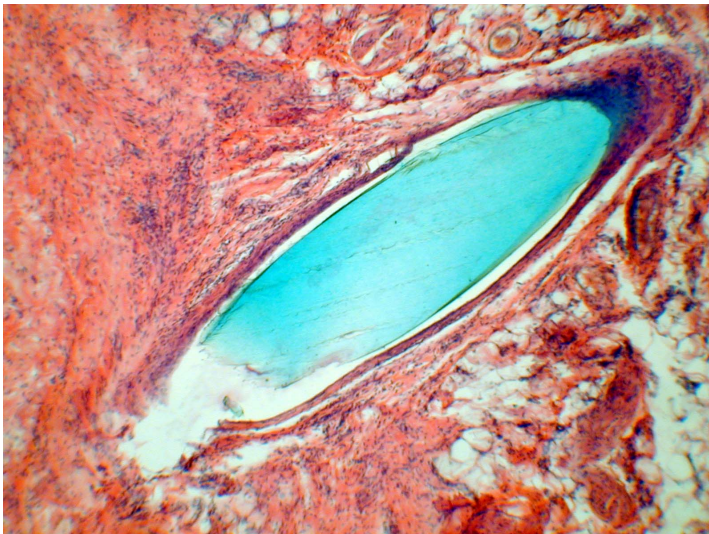
b

a - 90 days after implantation. The capsule wall around the barb is much thicker than around the shaft. Cellular elements predominate (x 40); b - 210 days after implantation. The capsule wall around the shaft is thin and contains few cells. The capsule around a barb contains many cellular elements (x 40)

Figure 3. Microphotographs of the capsule surrounding APTOS filament and its barb. Van-Gieson pyrofuchsin staining (a-b)



a



b

a - the capsule gives rise to well-apparent connective tissue bands. Collagen biosynthesis continues (x 40); b - the capsule contains few cellular elements throughout its length. Cellular elements in the right top corner show themselves as a result of oblique section across the filament and the surrounding capsule (x 40)

Figure 4. Microphotographs of the capsule surrounding a barb of APTOS filament (a) and a smooth polypropylene thread (b) 210 days after implantation. Van-Gieson pyrofuchsin staining

The capsule wall thickness around the barbs varied from 150 to 54.2 μm , the lateral walls were 220 μm long and 133 μm wide.

The structure of the capsule that developed around smooth polypropylene thread by day 210 after implantation was practically identical with that of the capsule around APTOS filament, but its maturation was about to be complete, and fibrous elements predominated over cellular ones (fig. 4b).

A study of blood supply to the tissues surrounding implanted filaments based on the estimation of relative vascular bed density has demonstrated its 20% increase on day 3 after implantation of APTOS filaments compared with only 6% in case of smooth polypropylene threads (a 8.1 and 7.9% rise, respectively from the baseline level in intact rats).

A maximum increase of the relative vascular bed density occurred on day 40 after implantation (11.0 and 9.1% in tissues surrounding barbed filament and smooth thread, respectively).

In the course of further follow-up, the relative vascular bed density remained constant in the tissues surrounding both APTOS filaments and smooth polypropylene threads.

4. Conclusions

To summarize the results of comparative histological study of the soft tissues surrounding implanted filaments, the following conclusions can be drawn:

- Collagen biosynthesis begins earlier and ends later after the implantation of APTOS filaments than after the implantation of smooth polypropylene threads; moreover, it is more extensive and involves a greater tissue volume in the former case.
- Fibrous capsule around the filament shaft and barbs gives rise to connective tissue bands that extend towards epidermis and subcutaneous fatty layer and merge with connective tissue fibres of these tissues.
- Tissues surrounding APTOS filaments contain much more microvessels than tissues enclosing smooth threads where the microcirculatory system extends but insignificantly.
- Microvessels formed after the implantation of APTOS filaments have an open lumen. This feature referred to as «phenomenon of persistent hyperemia» can be seen at any time after the implantation, unlike the case of smooth polypropylene threads when hyperemia occurs only in the early postimplantation period.
- Barbs of APTOS filaments are enclosed in their own connective tissue capsule having significantly thicker walls than the capsule around the shaft of the filament. This greatly contributes to solid fixation of APTOS filaments in the surrounding tissues.
- A capsule around the barbs is less mature than around the shaft of the filament. This suggests a stronger stimulatory effect of the barbs on the surrounding tissues which in

turn accounts for prolonged collagen biosynthesis and thus promotes fixation of both the filaments and the lifted tissues.

- Tissues surrounding APTOS filaments contain mast cells, the number of which remains virtually constant throughout the postimplantation period. These cells contribute to vasodilation in the microcirculatory system and transportation of hyaluronic acid to the tissues around the filaments. The number of mast cells in the tissues surrounding smooth polypropylene threads is significantly smaller.
- Implantation of APTOS filaments induces no phagocytic reaction.
- The relative microvascular bed area increases by 26% after the implantation of APTOS filaments leading to a marked improvement of local tissue oxygenation and blood supply. Implantation of smooth polypropylene threads causes a much smaller increase of relative vascular bed density.

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