Development of a surgical suture for the delivery of active substances to the wound area: Mechanical properties

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Summary

New surgical sutures are developed for the targeted delivery of active substances to the wound area, where the main carrier of these substances would be nanofibers. This work forms part of this development, focusing on investigating the mechanical properties of various developed sutures in relation to their intended applications. Mainly tensile, bending and creep behavior in the context of exposure of samples to environment simulating wound-milieu are investigated.

Introduction

Effective wound healing requires not only mechanical closure of the tissue, but also targeted delivery of bioactive substances to support the healing process and prevent infections. Conventional surgical sutures primarily serve a mechanical function and lack the ability to actively contribute to tissue regeneration. Incorporating nanofiber-based carriers into sutures offers a promising strategy for localized and controlled delivery of therapeutic agents directly to the wound site.

Methods

Tensile (maximum force, elongation at break and initial modulus: sample length 250 mm, deformation rate 100 %·min-1, winding jaws), bending (bending stiffness: ring-loop bending under static load) and creep (tensile creep strain: load 2,5 N) characteristics of suture prototypes were measured in the context of a simulated wound environment. To simulate the wound environment, two buffers were used: carbonate (pH 9, 37°C, 14 days) to simulate a chronic wound and phosphate (pH 7.2, 37°C, 14 days) to simulate a healthy healing wound. In the simulation of the effect of the wound environment, the influence of static suture loading was also included (2.5 N [1,2]).

In terms of tested suture prototypes, two sutures with a central monofilament and a nanofiber-based shell (central: polycaprolactone, RWTH Aachen; shell: nanofiber, polycaprolactone, AC electrospinning, TUL), one suture with a central monofilament without a nanofiber-based shell (central: polycaprolactone, RWTH Aachen) and a control suture - the Monolac surgical suture (monofilament, Glycolide-ε-Caprolactone, EP 2, violet, Chirana T. Injecta, Ltd., CZ) were tested.

Results and Discussion

The first set of tests indicated several findings that were essential for the development of a novel surgical suture.

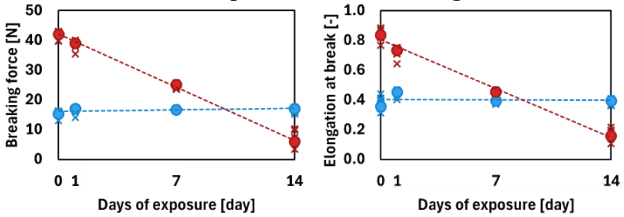

Figure 1: Graph of breaking force and elongation at the break of the suture prototype with nanofibers (blue) and Monolac suture (red) after exposure to a medium simulating healthy wound (circles = medians; crosses= measured values; linear regression; *n=7 – 18*)

All our suture prototypes showed practically no signs of degradation within fourteen days of exposure to the environments simulating healthy (Fig. 1) or chronic wound (data not shown), while the control resorbable Monolac suture showed a significant decrease in the monitored mechanical characteristics. At the same time, relatively low breaking forces in the dry state of the suture prototypes at the beginning of the experiment were measured.

Conclusions

Based on the findings related to degradation rates and mechanical properties, further suture prototype will be developed. The next phase of development will focus on modifying the central monofilament, whose composition plays a key role in the degradation of the developed surgical sutures.

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References

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