News Release

Title

A highly elastic absorbable monofilament suture fabricated from poly(3-hydroxybutyrate-co-4-hydroxybutyrate)

Key Points

- This product is an absorbable monofilament suture fabricated from poly(3-hydroxybutyrate-co-4-hydroxybutyrate), a novel biodegradable material, using pure domestic technology.
- It is an innovative suture that is rich in elasticity, flexibility, and biocompatibility, and has the advantage of a small knot size that is less likely to untie, as well as medium to long-term bioabsorbability.
- It is a safe alternative to existing absorbable monofilament sutures, with farreaching potential applications.

Summary

The research group led by Atsuhiko Murayama, an assistant professor at the Graduate School of Medicine, Nagoya University, and including assistant professor Hidemasa Yoneda and professor Michiro Yamamoto, as well as special appointed professor Hitoshi Hirata of the development of personalized medical technologies, aims to develop a highly elastic absorbable monofilament suture made of polyhydroxyalkanoate (PHA), a novel biodegradable material, in a joint industry-academia research project with Mitsubishi Gas Chemical Company, Inc. and Kono Seisakusho Co., Ltd. Through this research, it was found that this prototype has high stretchability and flexibility that is not found in existing products, and its feature of having a small and secure knot. Furthermore, because it is slowly hydrolyzed within the body, the period during which the tensile strength decreases by half is approximately four months, and there is a possibility that inflammation around the suture site may not occur easily. Based on these results, this new suture is expected to be an improved medical device that reduces stress during wound closure for both the surgeon and the patient.

Absorbable monofilament sutures have a smooth surface, good tissue passage, and are resistant to infection. However, compared to blade sutures, they lack flexibility, which makes it difficult to handle them and the knot may loosen easily. Materials such as polylactic acid and polyglycolic acid are used, but the challenges of handling and knot security have not been solved.

P(3HB-co-4HB), a copolymer of 3-hydroxybutyrate and 4-hydroxybutyrate, is a biodegradable plastic synthesized in microbial bodies that has high biocompatibility, and has also attracted attention in the field of biomedical engineering. However, no medical devices using P(3HB-co-4HB) have been developed so far due to technical barriers in synthesis, purification, and spinning processes. Our research team has overcome these barriers through a technological breakthrough and succeeded in creating an absorbable monofilament suture with unique characteristics using this new material. It is expected to be particularly effective in suturing soft and fragile tissues. This research was supported by AMED under Grant Number JP21ym0126010. This research achievement was published in the electronic edition of the academic journal "Scientific Reports" on February 25, 2023.

Research Background

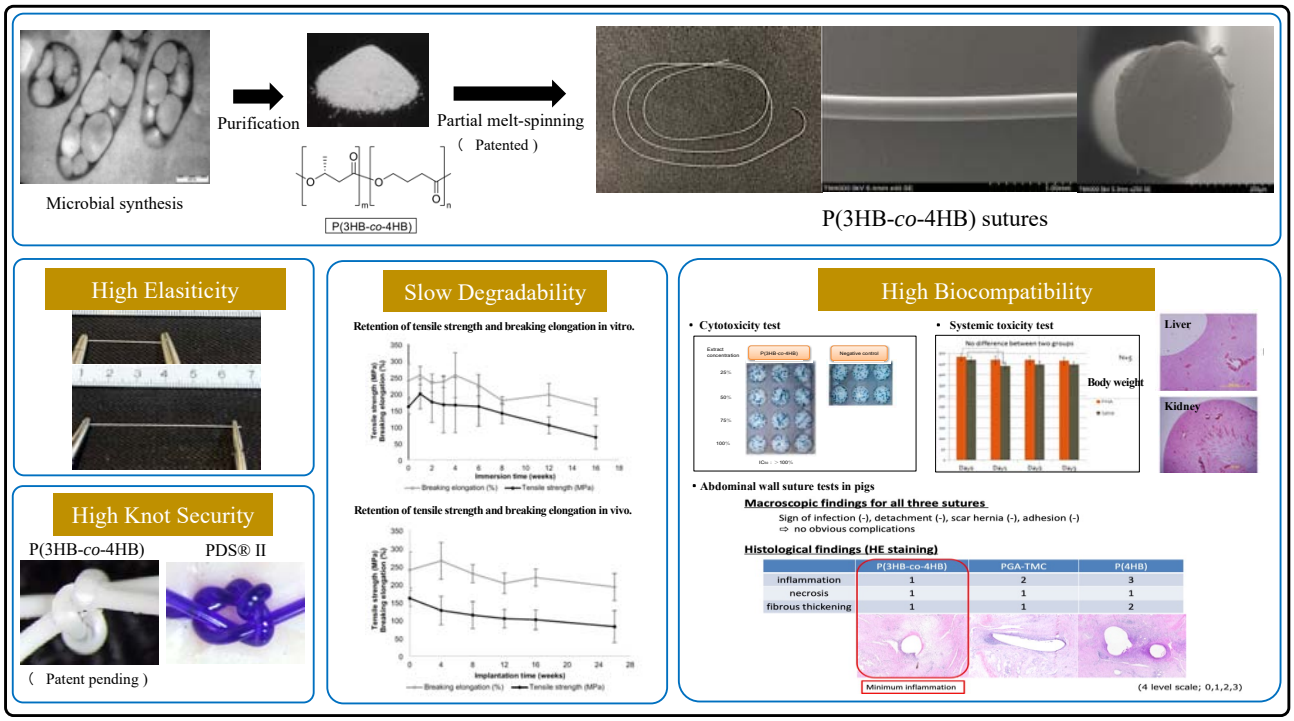
Surgical sutures are classified into monofilament sutures and braided sutures, each of which is further classified into bioabsorbable and non-bioabsorbable. For subcutaneous buried sutures, bioabsorbable monofilament sutures are preferred due to their smooth surface reducing tissue damage and to avoid residual foreign bodies. However, existing products lack flexibility and have some problems with knot security and knot size. Bioabsorbable monofilament sutures with superior knot security and operability have been in demand among many surgeons, and their development has been sought for some time. On the other hand, although the bioabsorbable monofilament suture market is large in scale, a few overseas products dominate the market, and in the current situation, our country also relies on foreign-made products.

PHA is a biodegradable plastic mainly synthesized by microorganisms using glucose as a carbon source. Hydroxy acids such as 3HB and 4HB, which are produced by its degradation, are widely present in living organisms, including humans, and have high biocompatibility as they ultimately decompose into water and carbon dioxide. Although medical devices using P(4HB) have already been launched, they have not yet overcome the challenges of existing products. On the other hand, it has been known that changing the ratio of 3HB and 4HB results in flexible properties, but it has been technically difficult to maintain a constant copolymerization ratio and stably cultivate high molecular weight polymers, and there have also been challenges in the spinning process. Therefore, medical devices using P(3HB-co-4HB) have not been developed so far. Our research team has independently established a purification method and spinning process for P(3HB-co-4HB), and succeeded in producing a

prototype of absorbable sutures with both a certain strength and flexibility.

Research Results

First, we compared the physical properties of this prototype to those of existing products, including tensile strength, elongation at break, elastic modulus, and molecular weight. While it was weaker in strength, we found that when stretched, it can extend to approximately twice its initial length and return close to its initial length when the force is released. We then conducted degradation tests in vitro and in vivo in rats to confirm changes in physical properties. The strength of the suture after 16 weeks in vivo was maintained at 63% of its initial value, and it was found to degrade more slowly than existing products. We also evaluated the knot size and stability of the prototype, finding that the knots were significantly smaller and less likely to untie than those of existing products. Furthermore, we performed abdominal wall suture tests in pigs to evaluate the prototype's performance. At 7 weeks after suturing, there was no clear separation or infection at the suture site, and no abdominal wall hernias were observed. HE staining of the surrounding abdominal wall tissue suggested that inflammation was less pronounced than with existing products.



Research Summary and Future Perspective

Based on these results, it can be concluded that this product is an innovative absorbable suture with rich elasticity, flexibility and biocompatibility, and has the advantage of a small knot size that is less likely to untie, as well as medium to long-term bioabsorbability. It is a safe alternative to existing absorbable monofilament sutures and can be widely applied, particularly in the

suturing of fragile soft tissues. In the future, it may be possible to create threads that do not require ligation by changing their shape. Furthermore, it is also envisioned that P(3HB-co-4HB) could be applied not only as a suture material but also for flexible tissue reconstruction devices such as artificial ligaments and nerves, thus expanding its potential applications in medical devices.

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Authors: Atsuhiko Murayama[1], Hidemasa Yoneda[1], Akira Maehara[2], Noriyuki Shiomi[2], Hitoshi Hirata[3]
Affiliations:
[1]Department of Human Enhancement & Hand Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan
[2]Mitsubishi Gas Chemical Company, Incorporated Niigata Laboratory, Niigata, Japan
[3]Department of Personalized Medical Technology, Nagoya University Graduate School of Medicine, Nagoya, Japan

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