An Analysis of Off-Target Toxicity in a Fiber-Reinforced Polyurethane Composite

Michael Langworthy, MD – Chairman of Orthopaedics
Southcoast Health System

ABSTRACT

Fiber-reinforced polyurethane composites, which are both fully bio-absorbable and fully biodegradable under ambient conditions, would be ideal material for orthopaedic fracture fixation. There have been a multitude of attempts to manufacture-engineer absorbable fixation and scaffolds for use in orthopaedics. However, mechanical strength of the structures, as well as inflammatory response, have continued to be an issue.

A fiber-reinforced polyurethane composite, which was both fully bio-absorbable and fully biodegradable under ambient conditions, has been developed specifically to address fracture fixation. Compared to traditional materials, which are either high strength or fully degradable, a fiber-reinforced polyurethane composite is stable under ambient conditions but slowly hydrolytically breaks down in hydrated parts of the body. The fiber reinforcements are selected from a group of glass compositions that dissolve in aqueous media.

To determine whether the fiber-reinforced polyurethane composite or its degradation products elicit an off-target toxicity, evaluation was performed.

METHODS

Twenty adult rabbits were selected with IRB approval. Under intravenous sedation, the rabbits had one of their intra-articular hind knees exposed via a medial para-patella approach. A 2.5 mm drill bit was then used to drill a femoral intramedullary hole up to the meta-diaphysis. A 2 mm polymeric rod consisting of fiber-reinforced polyurethane was then introduced into the medullary canal of the femur. The knee was then closed with absorbable suture.

The animals were monitored for two months, as the cellular and molecular effects of inflammation were thought to have peaked during this time frame. At the end of two months, none of the animals exhibited any gross untoward effects from the implanted devices. At two months the animals were euthanized and bone tissue, liver, spleen, lungs, and kidney tissue were harvested for histologic analysis for off target toxicity. Micro CT was also performed to evaluate for endosteal and periosteal reaction of the bone and periosteum to the polyurethane composite as well as its degradation products.

All of the samples were analyzed by a board certified pathologist. Of the tissues provided and analyzed, there was no off-target toxicity in any of the specimens. The micro-CT analysis of the retrieved specimens did not reveal either bone or periosteal toxicity to the implanted polymeric rod or its degradation products (Fig 1-6).

DISCUSSION

A fiber-reinforced polyurethane composite, which was both fully biodegradable and bio-absorbable, was tested via an animal model with no apparent clinical untoward effects for the animal while it was alive. Histological and CT analysis of multiple organ systems did not reveal any identifiable or specific off target toxicity. This fiber reinforced polyurethane composite appears to be safe as to local application and systemic response.

SIGNIFICANCE

Fiber-reinforced polyurethane composites for use in orthopaedic and other medical applications would be a revolutionary technological breakthrough. Previous bio-composite attempts have had limitations in strength as well as both local and systemic off-target toxicity. A strong and safe fiber-reinforced polyurethane composite would be a welcome addition to the surgical as well as implant armamentarium.

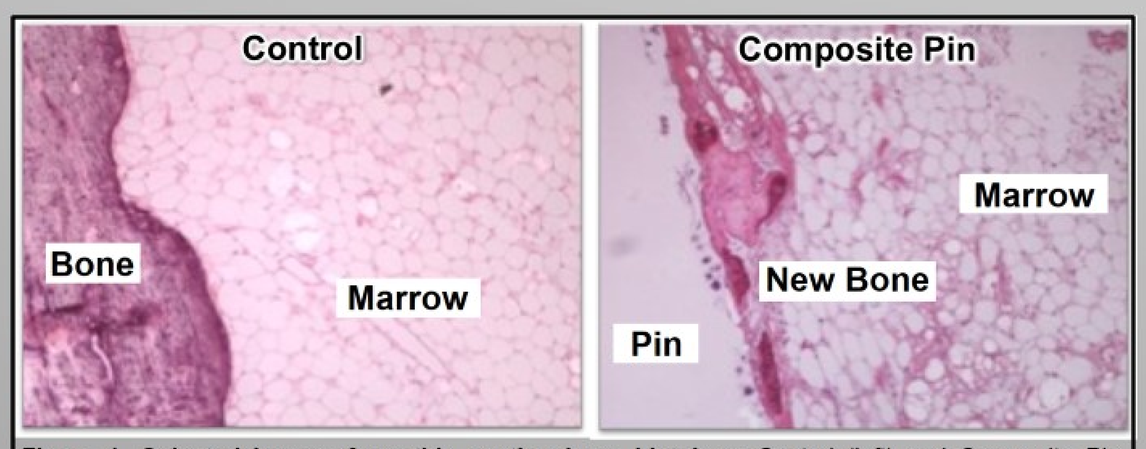

Figure 1. ***Selected images from thin section bone histology.*** Control (left) and Composite Pin (right). The response to the biocompsite pin (right) shows very little marrow reaction from the presence of the pin.

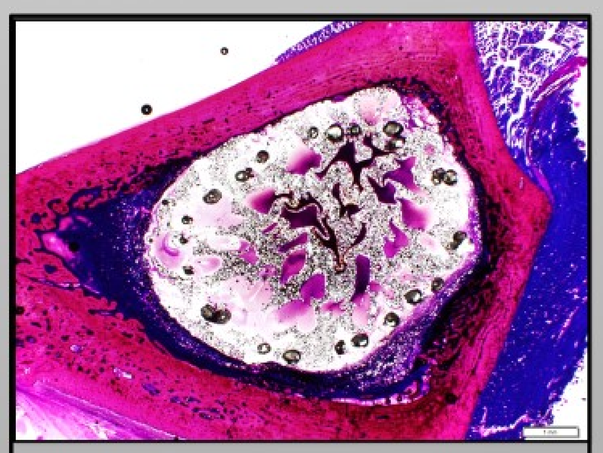

Figure 4. Histologic cross section of femur demonstrating no endosteal reaction to the polymer

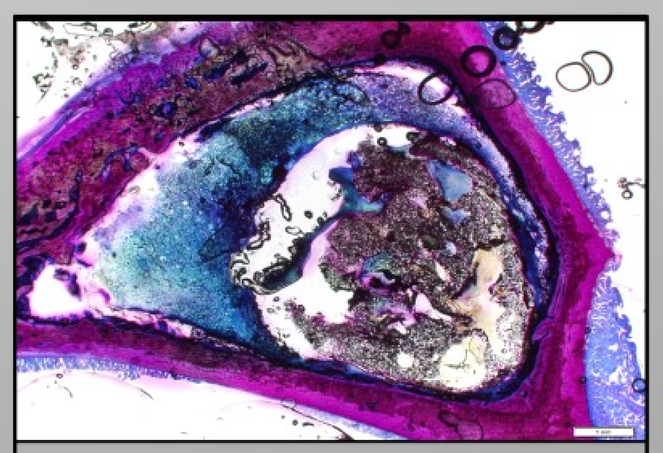

Figure 5. Histologic cross section of femur demonstrating no pereosteal reaction to polymer

A. Control

B. Composite Pin

Figure 2. ***Radiographs of rabbit femurs at the time of harvest.*** A (PCL-15, Control),and B (PCL-16) Matrix. There are no remarkable features or irregularities. An outline of the biocomposite pin can be seen in PCL 16.

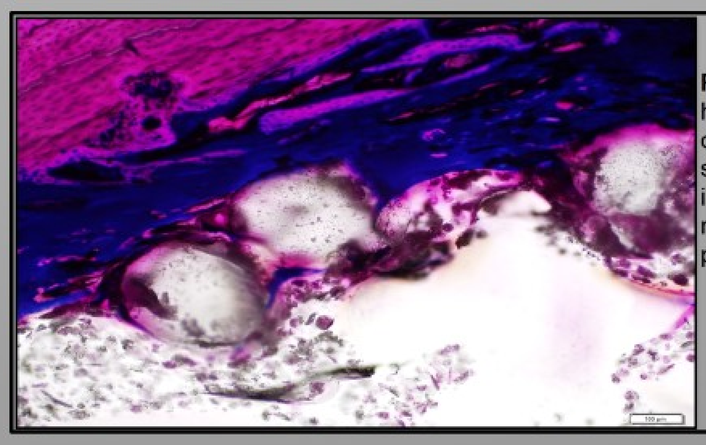

Figure 6. Magnified histologic picture demonstrating no significant inflammatory reaction of endosteal polymer interface

Implants provided by 206 Ortho, Inc. *www.206ortho.com*