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CHARACTERIZATION AND AGEING OF BRAIDED CARBON FIBER/PEEK BONE PLATES

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INTRODUCTION: Fractures in human limbs are often treated by internal fixation with stainless steel bone plates. Although these bone plates are strong and highly biocompatible, they have a very high resistance to bending (bending stiffness), because the elastic modulus of steel is 10 times that of bone. This higher bending stiffness leads to stress shielding, resulting in bone resorption, and potentially causing bone refracture upon plate removal. A bone plate with a lower bending stiffness, but a similar strength and biocompatibility to steel could potentially reduce stress shielding problems. One group of materials that match these criteria are polymer matrix composites, such as carbon fiber reinforced poly-ether-ether-ketone (CF/PEEK). However, the effects of body fluids on the mechanical properties of CF/PEEK are still relatively unknown and are thus investigated in this study.

METHODS: The CF/PEEK bone plates used for these experiments had the same dimensions as standard AO steel bone plates for the human shinbone, except for the thickness, which was 15 percent lower[1]. 9 specimens were aged in a 0.9% saline solution at 40°C (simulated body environment) for several days to a few months. The specimens were then mechanically tested in 3 and 4 point bending tests to measure bending stiffness and strength. Changes in weight, bending strength and bending stiffness were monitored, using both destructive (static and fatigue) and non-destructive bending tests. Scanning electron microscopy (SEM) was used to investigate failure mechanisms in destructive tests.

RESULTS: The specimen weight increased by around 0.25 weight percent during 12 weeks in saline solution at 40°C. Bending stiffness and strength in the aged specimens remained unchanged at around the pre-aged values of 0.85 Nm/deg and 10.2 Nm, respectively (Fig. 1). Fatigue testing showed that the fatiguing behavior remained unaffected by the ageing process. In addition, SEM images showed no different failure modes for different ageing conditions, indicating that no chemical changes occurred during the experiments.

DISCUSSION & CONCLUSIONS: Braided CF/PEEK shows a high chemical resistance to saline solution at body temperature. Both bending stiffness and strength remained unaffected during the ageing experiments, thus fulfilling one of the essential requirements for any implant material.

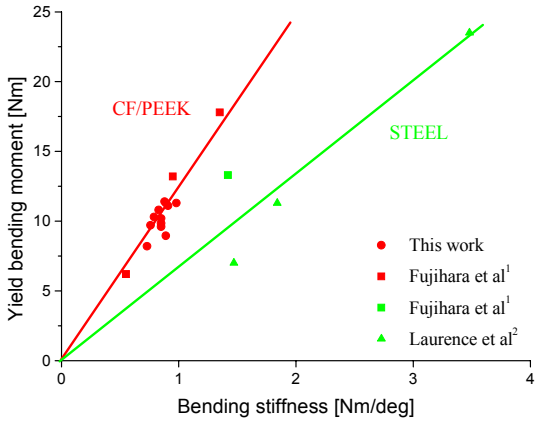

Fig. 1: Comparison of yield bending moment and bending stiffness of steel and CF/PEEK bone plates, showing that for any given bending strength, the stiffness of CF/PEEK bone plates is only half that of steel.

Results from this study show that the thinner braided CF/PEEK bone plates have a similar strength to steel bone plates but have half the bending stiffness. The lower stiffness should reduce stress shielding, while a thinner bone plate could make the implantation process easier. Thus braided CF/PEEK is a suitable material for constructing bone plates and should be further investigated for this application.

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