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Optimisation of composite bone plates for ulnar transverse fractures

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Abstract

Metallic bone plates are commonly used for arm bone fractures where conservative treatment (casts) cannot provide adequate support and compression at the fracture site. These plates, made of stainless steel or titanium alloys, tend to shield stress transfer at the fracture site and delay the bone healing rate. This study investigates the feasibility of adopting advanced composite materials to overcome stress shielding effects by optimising the geometry and mechanical properties of the plate to match more closely to the bone.

An ulnar transverse fracture is characterised and finite element techniques are employed to investigate the feasibility of a composite-plated fractured bone construct over a stainless steel equivalent. Numerical models of intact and fractured bones are analysed and the mechanical behaviour is found to agree with experimental data. The mechanical properties are tailored to produce an optimised composite plate, offering a 25% reduction in length and a 70% reduction in mass. The optimised design may help to reduce stress shielding and increase bone healing rates.

Keywords: Ulna; Bone plates; mechanical properties; composites; finite element analysis

1. Introduction

Diaphyseal fractures (transverse to bone shaft) of the ulna are sometimes treated with internal fixations such as bone plate/screw systems to provide support to the fractured bone and to assist healing. These plates are designed to stabilise the fracture and to restrict further damage, by bringing the broken bone ends together and fixing them using neutral and compression screws. This fixation enhances the primary and secondary bone healing rates (Aro and Chao, 1993). In the last decade, there has been scientific development in surgical devices and techniques to improve patient comfort (in terms of post-surgical biomechanical movements), accelerate rate of healing and introduce bio-adaptive implant designs (i.e. lessening damage to neighbouring bone tissues). Titanium (Ti) and stainless steel (SS) alloys are commonly adopted for orthopaedic trauma fixation devices, but stress shielding, reduced