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DESIGNING CARBON-POLYESTER BRAIDS FOR LIGAMENTS

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ABSTRACT

Ligament prostheses are highly load-bearing structures that are subjected to both quasi-static and impact loading. They are expected to have a long service life without undergoing excessive creep. In addition, in vivo trials are very expensive and take a very long time. In view of this, numerical simulation techniques were developed in the present work to simulate the structural response of the ligaments. Non-linear load-deformation behaviour of a braided ligament was predicted based on the stress-strain relationships of constituent yarns of carbon and polyester. Tensile and transverse stresses were computed in order to establish failure criteria. A cyclic fatigue test scheme that maintains a desired load-amplitude is described here. This test scheme does not need expensive servo-hydraulics and hence can be used to test a large number of samples simultaneously to expedite a product development cycle.

Keywords: ligaments, anterior cruciate ligament, braid, carbon fiber. Polyester

INTRODUCTION

Ligaments are very important restraining members in the musculoskeletal system. According to the Oxford Dictionary, a "ligament" is a short band of tough flexible fibrous connective tissue linking bones together. Skeletal joints are kinematically constrained and stabilized by ligaments to minimise the transverse displacements while maintaining the rotational movements. Ligaments are subjected to shock-loads during sports and exercise programs sometimes resulting in rupture. In recent years, sports related injuries are on an increase as a result of populations participating in sporting activities well into their middle ages. As a result, prosthetic devices are used increasingly in joint rehabilitation.

Ligaments are essentially tensile structural members and hence offer very little resistance in compression. Hence, several ligaments are involved in stabilizing a joint. The natural ligament is made-up of aligned networks of collagen microfibrills giving high strength (2160N in the case of the ACL of a young adult). However, the key feature in the 'design' of the natural ligament is the presence of 'crimp', which is analogous to the crimp present in textile structures. The natural ligaments exhibit strain-hardening behaviour with a low initial modulus.