IX. Ligaments and Tendons

Ligaments Proteoglycans and Interactions with Collagen

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Sponsor: National Institutes of Health
(National Institute of Arthritis, Diabetes, and Digestive and Kidney Diseases)

Normal skeletal function is determined, to an important extent, by the integrity of ligaments and tendons. Several orthopaedic diseases (e.g., congenital clubfoot, idiopathic scoliosis, congenital hip dislocation) involve either abnormal contraction or relaxation of ligaments, while in other conditions, abnormalities of ligamentous structures are suspected. Ligament injuries are common in many active sports and in situations involving strenuous physical exercise. However, therapeutic regimes prescribed during recovery from these injuries are mostly empirical, since the molecular organization of ligaments and tendons is poorly understood. In particular, the interactions of collagen with proteoglycans and with other components of the intercellular matrix, and the function of these interactions in determining the properties of the tissues, are largely unknown.

We plan to study, using in vitro model systems and electron microscopy, the effect of well characterized proteoglycans, which we have extracted from bovine and canine ligaments, on the kinetics of formation of collagen fibrils and on their properties. We also plan to study the effect of the presence or absence of proteoglycans on the maturation of collagen and formation of the cross-links. Using affinity chromatography methods, we will study the binding of proteoglycans to different collagen types. By enzymatically and chemically modifying the proteoglycans, we hope to clarify which parts of the molecules are more important in the interactions. We also plan to purify and characterize some matrix glycoproteins which have been detected in animal ligaments during preliminary work and to study their possible interactions with other matrix macromolecules.

The long-term goals are: (i) to study molecular defects which may be at the basis of the pathogenesis of disease processes involving contraction, relaxation, or loss of functional strength of ligaments; and

(ii) to study molecular changes occurring during exercise and aging. Toward the partial fulfillment of these goals, we will study human ligaments obtained at the time of corrective surgery from patients with idiopathic scoliosis and congenital clubfoot. We also will examine their collagen, proteoglycan, and glycoprotein content, types, and extent of collagen cross-linking■

Development of Synthetic Replacement Fibro-Osseous Pulleys

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Sponsor: National Institutes of Health
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The fibro-osseous pulleys of the digital flexor mechanism may be adversely affected by trauma or disease, resulting in bow-stringing of the tendon, loss of digital flexion, and poor joint motion. Replacement of these pulleys with biological or synthetic materials would be clinically useful to the surgeon (i) when the pulley is traumatically absent, (ii) at surgical tendolysis when the pulley also is incorporated in the fibrous adhesions, and (iii) at tendon grafting when the pulley is incorporated in the fibrous adhesions. Previously used synthetic materials (Dacron, Silastic) did not have biomechanical properties that were adequate for the substitution of pulleys in the human hand. Replacement pulleys must be technically easy to place, compatible with surrounding tissues to minimize scar formation, and have immediate maximum strength so that mobilization of the digit can be instituted in the immediate postoperative period.

We are developing and evaluating a synthetic pulley in the nonhuman primate that has anatomical characteristics similar to the human. We are pursuing a relatively long-term study in the monkey to determine if a synthetic pulley made of woven monofilament nylon (Nitex) is comparable to a replacement pulley made of biological materials. The pulleys are being evaluated with respect to (i) the limitation to tendon gliding by restrictive adhesions, (ii) the functional competency of the replacement pulley, (iii) the integrity of the flexor mechanism structures (pulley, tendon, bone) and (iv) the biomechanical properties of the pulley in relation to the intact mechanism■