MECHANICAL PROPERTIES OF DIFFERENT ANATOMICAL SITES OF THE BONE-TENDON ORIGIN OF THE LATERAL EPICONDYLE

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Introduction:
Based on clinical and surgical evidence, microtear, microfailure or partial failure at the bone-tendon junction or musculo-tendinous junction, most often occurring within the origin of the extensor carpi radialis brevis, acts as the initiator of epicondylitis 1,2. Biomechanical studies have demonstrated that forceful exertions can produce stress concentrations on tendons and adjacent tissues that correspond with the sites of injury 3,4.

The present study was undertaken to evaluate the effect of the direction of applied load and displacement rate on the mechanical properties (ultimate tensile strength, failure strain, energy absorption and linear stiffness) of bone-tendon specimens of the rabbit humeral epicondyly. Because the common extensor tendon and its insertion site are viscoelastic and are not homogeneous, but rather a composite material 5,6, it was hypothesized that different directions of load application and different displacement rate would result in different mechanical responses and failure patterns in tendons and at the bone-tendon junction.

Materials and Methods:
Thirty-six New Zealand white rabbits (seventy-two common extensor tendon specimens) of similar ages and both sexes, weighing 3.5 to 4.5 kilograms, were used. Each animal was sacrificed using and intracardiac injection of sodium pentobarbital and both forelimbs were disarticulated. The tendon specimens (of similar ages and both sexes, weighing 3.5 to 4.5 kilograms) were studied.

The bone-tendon specimens were prepared by removing the humerus and the extensor carpi radialis brevis tendon. The bone-tendon specimens were mounted with bone cement in an electrical conduit 10 mm in diameter. Custom-designed devices attached to the MTS machine to change the elbow flexion angle (45°, 90° and 135°).

Tensile tests were performed on the MTS machine. Prepared specimens were mounted with bone cement in an electrical conduit 10 mm in diameter. Custom-designed devices attached to the MTS machine were used to change the elbow flexion angle (45°, 90° and 135°).

Strain measurements in tendon and bone were recorded using two differential variable reluctance transducers (DVRT) which were fixed to the tendon and bone in a straight line representing the loading direction. Two ultra fine wires were separately welded to the top surface of the DVRT in the tendon and the bottom surface of the DVRT in the bone to establish the gauge length for the bone-tendon complex. The strain for the bone-tendon complex was obtained using a video motion analysis system, consisting of COHU solid state camera, AL16, fitted with a Monocular/45 Field microscope, JVC video tape recorder, HR-6700U and Sony monitor, to record changes of the gauge length between the two wires.

Results:
The ultimate tensile strength for the specimens tested at 135° had 20% and 40% of specimens failed at the bone-tendon junction. The bone-tendon specimens in tensile tests showed two failure modes: tendon failure and failure at the bone-tendon junction without bone avulsion. All specimens at 135° and most specimens at 90° showed a tendon failure for both displacement rates. At 45°, 20% and 40% of specimens failed at the bone-tendon junction at the 10 mm/min and 100 mm/min displacement rates, respectively.

Discussion/Conclusion:
In conclusion, the direction of applied tensile load and the displacement rate should be very important parameters to consider when investigating the biomechanical properties of the bone-tendon unit of the epicondyle. Based on this study, the common extensor tendon and its insertion site on the humeral epicondyle had different mechanical responses to the testing conditions. It appears that the differences in ultimate tensile strength, failure strain, energy absorption and linear stiffness are a consequence of varying the loading direction and strain rate of the tendon across the bone-tendon junction. In future studies, the fatigue response to a series of elbow flexion angles will be investigated.

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Reference: