IN VIVO EVALUATION OF ANKLE LIGAMENT FORCES USING A FIBER OPTIC TRANSDUCER

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INTRODUCTION: Successful injury prevention, treatment and rehabilitation require a clear understanding of ligament function and forces acting on these ligaments, especially for injuries to the lateral ankle ligaments, which are very common in many kinds of sports. Several authors (Bahr et al. 1998; Renström, et al., 1988; Sauer et al., 1978) investigated forces or tensile strength of the ligament talofibulare anterior (LTFA) in vitro. There is, however, a lack of information of investigations with direct measurement of forces in this structure. The aim of this study was to apply a fiber optic transducer in vivo in order to register forces in the LTFA during different natural movements of the ankle joint under varied load conditions.

METHODS: The technical principle of the optic fiber transducer is based on the modulation of light (820nm) as a result of compression of the optic fiber in which the light is transmitted. This method was introduced by Komi et al. (1996) for measurements of tendon forces in vivo. The system consists of three parts: a light emitter, an optic fiber (0.6mm diameter) and a light receiver with amplifier. A detailed description is given elsewhere (Komi et al.,1996). Pre-experimental studies have been carried out in order to find an optimal fiber position with minimum harm to surrounding soft tissue. Three freshly frozen ankle specimens were treated by an orthopedic surgeon to determine the best implantation procedure. In vivo the investigation was performed with one subject under local anaesthesia of the left ankle joint. Active and passive range of motion (ROM) was recorded using twin axis electrogoniometers (Penny & Giles, Blackwood, UK). Axial load of the ankle joint was measured by a Kistler force plate (Kistler, Winterthur, CH). External or internal calibration of the optic fiber signal (voltage to force) was not possible. Therefore, the data from the optic fiber sensor were normalized to the average value of the ligament tension observed in both leg stance.

RESULTS: The signal from the optic fiber was reproducible from a set of repeated measurements. The result of increased axial load to the ankle was an increase in the fiber signal. During active ROM, the highest values from the sensor were recorded for a combination of inversion and plantar flexion. During maximum subtalar eversion, the signal was also increased. Dynamic load (walking, hopping) showed increased values compared to the unloaded condition.

DISCUSSION: It could be shown, that the optic fiber in the LTFA was sensitive to motion and load changes to the ankle joint. From increased voltage of the sensor, an increase in the ligament force could be concluded. For functional interpretation, the model of helical motion of the talus with respect to the calcaneus can be employed. With this model the highest loading of LFTA could be related to inversion/eversion movements of the subtalar joint.

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