CAN CAPSULAR SHRINKAGE STABILISE THE ANTEROINFERIOR GLENOHUMERAL JOINT?

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Introduction The use of thermal energy on soft tissues has been employed since the beginning of last century. Traditional methods often resulted in significant damage due to tissue overheating beyond the denaturation threshold of type I collagen. Laser and radiofrequency systems have been developed that allow for controlled tissue heating. Clinical indications for their use have increased, despite a lack of studies that specifically address the nature of their effects. Thermal shrinkage of the shoulder capsule in the treatment of glenohumeral instability has been proposed. This study sought to determine the effect of thermal energy treatment on the mechanical properties and histologic appearance of the anteroinferior glenohumeral joint capsule using cadaveric shoulders placed in the “at risk” position of abduction and external rotation.

Materials and Methods: The anteroinferior capsule was isolated in 6 unmatched fresh frozen cadaveric shoulders (average age 65 years). The humerus was divided midshaft, and the coracoid process and clavicle were removed. The shoulders were mounted in 80 degrees of glenohumeral abduction and 90 degrees of external rotation relative to the plane of the scapula [1]. Testing was performed on an MTS 858 Materials Testing Machine (MTS Systems Corporation, Minneapolis, MN). The humeral head was translated anteriorly at 25mm per minute until a preset end-point load of 150N. Testing comprised of a consecutive series of loading sequences after successive thermal treatments of the capsule using the Mitek VAPR-T Thermal Electrode System (Mitek Products, Ethicon Inc, Westwood, MA) at 20 watts for 10 seconds. The testing apparatus was immersed in 0.9% NaCl and the tissue treated using a sweeping motion. Four treatments were applied and the loading sequence repeated after each treatment. The stiffness in the toe (30-50 N) and linear regions (90-110N) of the load deformation curves was determined. Analysis of variance was used to compare the effect of progressive treatments.

Three additional anteroinferior capsules were obtained to examine the effects of successive treatments on histological appearance. H&E staining was also performed on the capsule from each shoulder tested mechanically to determine the histologic changes and assess damage. Crimp angle, collagen fibres size, and degree of cellularity were qualitatively graded.

Results The capsule following shrinkage became thicker and less pliable. Macroscopic shrinkage was not observed considering the positioning of the samples in abduction and external rotation which tensions the anteroinferior capsule. Thermal energy treatment revealed a trend towards increased tissue stiffness after 1 or 2 treatments (10 to 20 seconds). The increase in stiffness was lost with successive treatments and decreased in 5 of the 6 specimens tested. This effect was more pronounced at lower loads (between 30N and 50N), in the toe region of the load-displacement curves (figure 1).

A progressive tissue disorganisation occurred with increasing treatment time with loss of crimp angle, cellular destruction, and areas of fibre fusion. Successive treatments increased the depth of damage and loss of cellular detail.

Discussion Thermal shrinkage is a well-described phenomenon however recommendations concerning power levels and treatment time and their effects are lacking. The aim of capsular shrinkage is to improve joint stability. The mechanical properties of the tissues must be able to withstand physiological forces without further damage. In theory, shrinkage of the glenohumeral joint capsule in selected patients could decrease capsular laxity and increase joint stability.

Tibone et al performed a cadaveric study to examine glenohumeral joint translation after arthroscopic, nonablative, thermal capsuloplasty using a laser [2]. Anterior and posterior translation was decreased after Ho:YAG laser treatment of the anterior capsuloligamentous structures. However, the applied loads were small (15N and 20N) and the shoulder was not placed in the “at risk position”. The present study examined the effects of thermal energy treatment on the shoulder in abduction and external rotation. In this position the only restraint to an anteriorly directed force on the humeral head is the remaining capsule. This was chosen to maintain a constant length of the capsular tissues with each successive treatment. Non-destructive loading to 150 N was chosen to simulated daily activities. The treatment power selected (20W) is most commonly used in clinical practice.

The initial thermal treatment increased the stiffness of the load-deformation curve but was not statistically significant. Subsequent shrinkage treatments resulted in a deterioration in stiffness and led to severe alterations in the tissue ultrastructure. This suggests a threshold for treatment time above which the tissue may become weakened unduly. Placement of the shoulder in abduction and external rotation tightens the anteroinferior complex. Initial tissue tension as well the inherent degree of laxity may play a role in the effectiveness of thermal treatment. This study is however limited in sample size. The effectiveness of capsular shrinkage to reduce shoulder instability has yet to have firm biomechanical support and may be dependent in part, on the quality of the capsule.