EFFECT OF ATROPHY ON OPTIMAL POST-OPERATIVE SHOULDER IMMOBILIZATION POSTURES FOLLOWING SIMULATED SURGICAL REPAIR OF SUPRASPINATUS TEARS

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INTRODUCTION
Rotator cuff tears are highly prevalent, afflicting approximately 20% of the population [1]. Rotator cuff tears often lead to atrophy of the injured muscle(s), which has been associated with poor functional outcomes [2]. Surgical repair is commonly performed, followed by a period of shoulder immobilization by means of an orthosis. The purpose of the immobilization is to protect the integrity of the repair during the immediate post-operative period. There is, however, no consensus on the best postures for post-operative shoulder immobilization, and furthermore, the effect, if any, of muscle atrophy on the postures. The purpose of this work was to simulate supraspinatus tears with varying degrees of muscle atrophy to determine the effect of atrophy on optimal post-operative shoulder immobilization postures.

METHODS
A musculoskeletal model of the shoulder complex (AnyBody Technology, Denmark) was simplified for this study to incorporate just the scapula, humerus and rotator cuff muscles. Six muscle paths represented each rotator cuff muscle, namely supraspinatus (SS), infraspinatus, subscapularis and teres minor. Each muscle path was represented by a Hill-type muscle-tendon actuator.

Full thickness SS tears were simulated by reducing the length of the SS tendon by 5 to 20 mm. The reduction in tendon length or gap length represented tendon retraction and removal during surgery. The cross sectional area of the SS muscle was reduced by up to 40% to represent varying levels of muscle atrophy. For each tear condition the optimal post-operative immobilization posture was determined, defined as the posture in which 1) the stress in the SS was minimized to protect the repair; 2) elevation of the humerus was minimized to ensure the resulting posture was practical; 3) stresses in the uninjured tendons were maintained below an upper limit to ensure integrity of these tendons; and 4) the posture of the humerus was within anatomical limits. To allow for better visualization of the results complete upper limb configuration was determined, assuming elbow flexion of 90° and the scapulohumeral rhythm of [3].

RESULTS
For full thickness SS tears without atrophy the optimal post-operative immobilization postures were with the humerus in external rotation, with the plane of elevation close to the scapular plane, while the angle of humerus elevation increased with gap length from 28° to 55°. For all gap lengths, as muscle atrophy was increased the angle of humerus elevation decreased. For example for a gap length of 15 mm the angle of elevation decreased from 46° to 38° as the cross sectional area of the SS was decreased by 10 to 40% (Figure 1).

DISCUSSION AND CONCLUSIONS
For SS tears the optimal post-operative shoulder immobilization postures were dependent on both the gap length and the degree of muscle atrophy. As gap length increased the angle of humerus elevation increased. In effect, higher angles of elevation were required to protect the more severe injuries. However, the opposite relationship was found for atrophy. As the level of muscle atrophy increased the required angle of humerus elevation decreased. This result is at first counter-intuitive; high atrophy represents a severe injury for which you could expect high humerus elevation to protect the repair. However, atrophy reduces the cross sectional area of the muscle. As a result the muscle becomes more compliant and can be extended further under the same level of force, therefore lower elevation angles can be tolerated. In conclusion, gap length and atrophy should both be considered when selecting a post-operative shoulder immobilization posture.

REFERENCES