AN EXPERIMENTAL SHOULDER MODEL SIMULATING POSTOPERATIVE PHYSIOTHERAPY FOR PRIMARY STABILITY TESTING OF FRACTURE REFIXATION

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INTRODUCTION

The postoperative rehabilitation protocol four weeks after shoulder hemiarthroplasty applies an active full range of motion for abduction and for internal/external rotation [1]. The risk of secondary fracture dislocation in that early phase still exists unless the bone is not healed. In contradiction to that high range of motion during physiotherapeutic exercises, experimental biomechanical analysis analyzing the primary stability of refixation uses a semi-constrained or fixed humerus by applying unidirectional muscular forces to the rotator cuff [3, 4]. Our goal was therefore to build a physiologic shoulder testing device according to the rehabilitation protocols and to derive hurtful loading patterns during rehabilitation.

METHOD

An experimental shoulder simulator applied active rotator cuff muscle forces of m.supraspinatus and m.deltoideus, m.infraspinatus/teres minor and m.subscapularis (two segments). Range of motion was chosen according to clinical physiotherapy protocols (Table 1).

Literature	Thoracohumeral (TH) Abduction	Internal/External Rotation
Christoforakis [1]	140° (flexion)	30 ext. rot.
Brems [5]	140° (elevation)	40 ext. rot.

Table 1: Kinematic protocol 4 weeks post- operative.

Loading scenario A applied 20 cycles of thoracohumeral abduction, ranging from 15° to 140°. Loading scenario B applied 20 cycles of internal/external rotation in a range of +/- 30° for a fixed abduction angle at 45°. A and B resulted in a similar maximum GH contact force of around 550N at maximum angulation. Rotational speed of 15°/s was achieved for both loading scenarios.

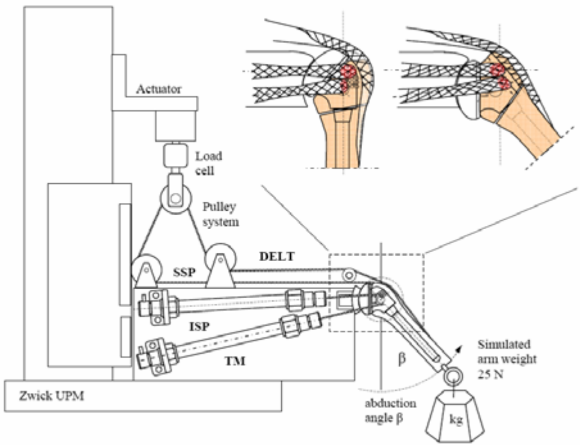

Figure 1: Physiological load application at the rotator cuff muscles applying abduction and internal/external rotation.

The four-part fracture model made of artificial bone (Last-a-foam®, FR6715, ASTM F1839) was refixated by a titanium cable (Ø1.5mm) oriented in a figure-of-eight fashion according to the AO-guidelines incorporating all three fragments and the prosthesis to guarantee rotational and tensional stability. Cable prentension of 40N was applied by a tensioner (Königssee Implantate GmbH). Interfragmentary distances of the greater tuberosity to the shaft and the lesser tuberosity to the shaft were measured by an optical 3-D topometry surface scanning (optoTop, Breukmann GmbH).

RESULTS AND DISCUSSION

The greater tuberosity-to-shaft distance increased with the amount of cycles for both loading profiles A and B, followed by a flattening of the migration curve. Loading profile A, performing single plane abduction, revealed a higher migration rate (0.93+/-0.25mm) in comparison with internal int./ext. rotation (0.42+/-0.22mm) after 20 cycles. No interfragmentary distance between greater and lesser tuberosity was detected, the lesser tuberosity-to-shaft distance revealed data in the similar range.

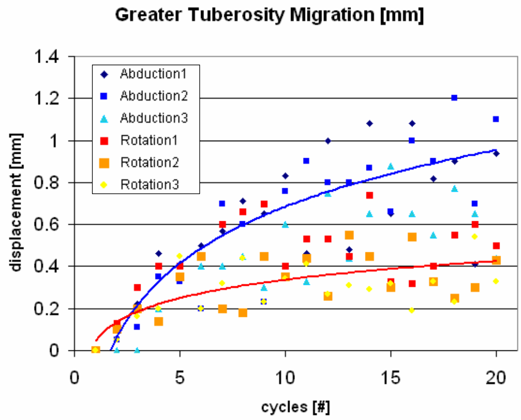

Figure 2: Regression curves (blue: abduction, red: rotation) display the mean tuberosity-to-shaft migration.

CONCLUSIONS

Cyclic thoracohumeral abduction until 90° leads to a higher displacement of the greater tuberosity relative to the shaft than internal/external rotation at fixed abduction angle. The risk of a potential secondary dislocation in physiotherapy is increased performing full abduction compared to int/ext. rotation at a specific abduction angle.

ACKNOWLEDGEMENT

We gratefully acknowledge ISB Dissertation Grant 2007.

LITERATURE

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