J Shoulder Elbow Surg (2013) 22, 971-978

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Is failure of tuberosity suture repair in hemi-arthroplasty for fracture mechanical?

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Background: Tuberosity suture repair in hemiarthroplasty for fracture carries risk of malunion giving poor results. Is failure mechanical or biochemical? We investigated the mechanical aspect with repetitive loading in cadaveric repairs.

Materials and methods: Tests were carried out in line with U.K. Human Tissue Authority regulations. A 4-part fracture was created in 8 cadaver shoulders by osteotomizing the tuberosities. A standard hemi-arthroplasty implant was cemented in at correct height and retroversion, and standardized repairs applied. Initial firmness of repair was confirmed by attempting to manually displace the tuberosities with a forceps in multiple planes. All pre-stress tests showed 0 mm movement. Repairs were then subjected to cyclical tension on the cuff musculature and simultaneous gleno-humeral motion for 8000 cycles. The tuberosities were reprobed with a forceps to record any movement.

Results: Defining repair failure as the ability to manually displace a tuberosity more than 3 mm, every specimen failed: 100% failure (exact 95% confidence interval 65.2-100% due to sample size). Movements of at least 1 cm were commonly observed. The sutures were loose but had never snapped. Sutures were noted to dig into the tendon and cut partially through bone. Collapse of cancellous bony volume led to looseness and migration of the sutures.

Conclusion: Suture repair of tuberosities has mechanical weaknesses; failure may be a mechanical phenomenon.

Level of evidence: Basic Science Study, Biomechanics.

Keywords: Suture repair; tuberosity; hemiarthroplasty; proximal humerus fracture

We investigated the use of suture repair for the tuberosities in hemiarthroplasty for 4-part fractures, by examining cadaveric repairs after repetitive loading tests. Sutures are the most popular repair tool currently. A variety of repair patterns using sutures or cables is currently available[2]; however, tuberosity "disappearance" with repairs is common and touted as the prime cause for failure.[1,3-5,8,10-17] In some studies, biochemical lysis[3] of the tuberosities has been

Investigational Review Board approval was not required for this study. This study was carried out in line with the Human Tissue Act (HTA) 2004 under the HTA license held at Brighton and Sussex Medical School (license no. 12098).

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1058-2746/$ - see front matter © 2013 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2012.09.002

commented upon as associated with poor results after secondary arthroplasty. The aim of this study was to analyze the mechanical tolerance of traditional repairs and seek possible causes for failure.

Materials and methods

Tests were carried out in line with U.K. Human Tissue Authority regulations. Eight fresh frozen cadaver shoulders were employed. The average age of the specimens at death was 64.8 years (range, 53-86), and there was no history of previous shoulder problems. There were 5 male specimens and 3 female. After allowing to thaw at room temperature for 36 hours, each specimen was stripped of all soft tissue (skin, external musculature, and neurovascular structures), leaving only the rotator cuff musculo-tendinous units and the underlying capsular and joint structures. The cuff was inspected for signs of any degenerative tearing and all specimens were intact except for a 3-mm full thickness tear of supraspinatus in 1 (specimen 4). The clavicle segments were removed at the acromio-clavicular joint. The coracoid and acromion processes were osteotomized to allow subsequent unimpeded filming of the tuberosity repair sites during testing.

Creation of a 4-part fracture in each specimen

The humerus stump was impaled on a vertical iron rod. At a point 5-mm posterior to the biceps tendon, an oscillating saw was used to make a 5-mm deep vertical cut in the greater tuberosity and the supraspinatus tendon was split superiorly. From the lower margin of the bone cut, transverse 5-mm deep cuts were made both anteriorly to the lower margin of the subscapularis tendon insertion and posteriorly to the lower margin of the teres minor insertion. The oscillating saw was then directed from the vertical cut, both anteriorly and posteriorly, to remove 2 tuberosity fragments. The posterior consisted of greater tuberosity alone. The anterior fragment consisted of 5 mm of greater tuberosity, bicipital groove, and lesser tuberosity. The biceps tendon was removed (Fig. 1). The tuberosity fragments were measured for thickness at their superior and inferior halves. Tuberosity thicknesses were an average of 5.7 mm for the greater tuberosity and 5.9 mm for the lesser. Greater and lesser tuberosity segments with their attached tendons were displaced sufficiently to dislocate the humeral head.

Establishing height and retroversion

An osteotome was placed atop the highest point of the humeral head and held perpendicular to the shaft. The vertical distance from the osteotome to the cut margin of the humeral midshaft was recorded. This measurement was later used to cement in the prosthesis at correct height. Viewing the humeral head from the top, a straight metallic instrument was placed along a line from the center of the humeral shaft to the center of the humeral head circumference. Using this as a guide, the retroversion of the native humeral head was marked on the humeral shaft outer circumference, establishing a retroversion mark for the prosthesis.

The humeral head was then osteotomized and removed. The calcar was comminuted deliberately to simulate fracture conditions (Fig. 2). A transverse 3.5-mm hole was made in good bone generally about 2 cm below the transverse osteotomy sites and

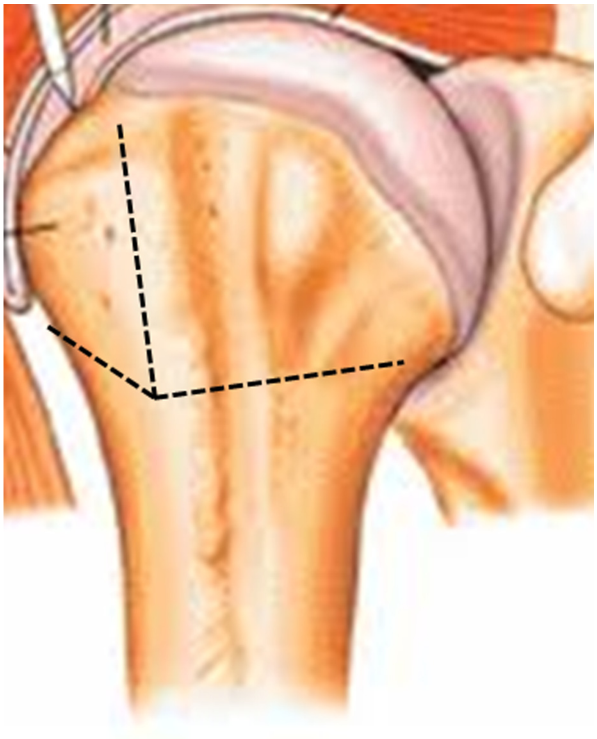

Figure 1 Line diagram showing the osteotomy cuts used to make a 4-part fracture.

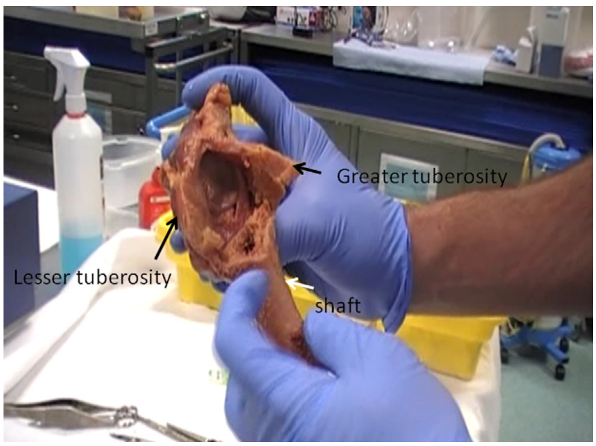

Figure 2 Typical "fracture bed" after osteotomising the tuberosities and removing the humeral head.

two Ethibond No. 5 sutures (Ethicon, Livingston, West Lothian, Scotland) placed for later figure-of-8 repairs. An Aequalis fracture prosthesis (Tornier Orthopaedics, St Ismier, France) was then cemented into the humeral shaft with Palacos® cement (Heraeus Medical, Wehrheim, Germany) and set at the height and retroversion previously measured. Two well-spaced, transverse, Ethibond No. 5 sutures (Ethicon) were carefully placed at the cuff -bone margin of infraspinatus and teres minor insertions, and around the prosthetic neck, to form the greater tuberosity cerclage.

Two well-spaced sutures were placed around both tuberosities. Care was taken to apply sutures at the cuff-bone interface, to make sure the passage around the prosthetic neck was smooth and