J Shoulder Elbow Surg (2014) 23, 151-158

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Evaluation of the role of glenosphere design and humeral component retroversion in avoiding scapular notching during reverse shoulder arthroplasty

Julien Berhouet, MD*, Pascal Garaud, Luc Favard, MD, PhD

François Rabelais University, Trousseau Hospital, Tours University Hospital Center, Orthopaedics and Trauma Department, Chambray-les-Tours, France

Background: Scapular notching is a common observation during radiological follow-up of reverse shoulder arthroplasty. The purpose of this study was to evaluate the effect of glenosphere design and humeral component retroversion on movement amplitude in the scapular plane and inferior scapular impingement.

Materials and methods: The Aequalis Reversed Shoulder Prosthesis (Tornier) was implanted into 40 cadaver shoulders. On the glenoid side, 8 different combinations were tested:

36-mm glenosphere: centered (standard), eccentric, with an inferior tilt, or with the center of rotation (COR) lateralized by 5 or 7 mm; and

42-mm centered glenosphere: used alone or with the COR lateralized by 7 or 10 mm.

The humeral component was positioned in 0°, 10°, 20°, 30°, and 40° of retroversion. Maximum adduction and abduction were measured when inferior impingement and superior impingement, respectively, were detected.

Results: The average increase in abduction amplitude was 10° and inferior impingement occurred 18° later with a 42-mm glenosphere, especially when it was lateralized by 10 mm, relative to a 36-mm centered glenosphere ($P < .05$). These 2 combinations provided a 28° increase in the movement amplitude in the scapular plane. Positioning of the humeral component in 10° or 20° of retroversion or in anatomical retroversion was most effective at avoiding inferior impingement but had less effect on abduction range of motion (except with the 42-mm glenosphere).

Conclusion: Our study confirmed published results with various glenosphere designs but was unique in describing the effect of humeral retroversion on scapular impingement. Inferior scapular notching can be most effectively prevented by using large-diameter glenospheres with lateralized COR and by making sure to replicate the patient's native humeral retroversion.

Level of evidence: Basic Science Study, Biomechanics, Cadaver Model.

Keywords: Reverse shoulder arthroplasty; glenoid modularity; humeral version; scapular notching

The reverse shoulder prosthesis developed by Grammont[8] in 1985 is now the preferred treatment option in older patients with cuff tear arthropathy. The survival rate in this indication has been reported to range from 89% to 91% at 10 years.[9,18] The most common radiological complication with this implant is the occurrence of notching in the scapular pillar, which has been reported in 56%

*Reprint requests: Julien Berhouet, MD, François Rabelais University, Trousseau Hospital, Tours University Hospital Center, Orthopaedics and Trauma Department, 2A Ave. de la République, 37170 Chambray-les-Tours, France.

E-mail address: julien.berhouet@gmail.com (J. Berhouet).

1058-2746/$ - see front matter © 2014 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2013.05.009

to 96% of cases.[2,3,20,23,24,28,31] However, the clinical consequences of scapular notching are not clear. Some authors[22,24] have reported that the Constant score and active forward flexion are altered in cases of grade 4 notching (Sirveaux classification). Others found no deterioration in the functional outcome at the same grade.[16-18] Nevertheless, notching results in true bone loss; the potential risk of loosening is difficult to accept.

Various solutions have been proposed to get around this problem. One is to provide less medialization of the center of rotation (COR). Frankle[6] used a glenosphere that was more than a half-sphere. No scapular notching was observed after an average follow-up of 33 months. Kalouche[14] and Valenti[29] proposed an implant by which the COR was lateralized by 8.5 mm. No scapular notching was evident after an average follow-up of 36 months. On the basis of this observation, a bone graft lateralization technique called BIO-RSA (bony increased-offset reverse shoulder arthroplasty) was proposed by Boileau.[1,2] With this technique, the scapular notching rate was reduced to 20%, and no glenoid loosening was observed with an average follow-up of 28 months.[1]

Other technical modifications have been recommended to prevent scapular notching. Nyffeler[19] proposed lowering the glenosphere by positioning the base plate in line with the lower edge of the glenoid. Kelly[15] positioned the central peg of the glenoid base plate 12 mm above the lower edge of the glenoid, which resulted in a 3.5-mm inferior overhang with use of a 29-mm-diameter base plate. Around the same time, eccentric and tilted glenospheres became available and were used in attempts to reduce inferior impingement by moving the joint COR downward. Limited data exist on these newer implants. Gutiérrez showed that the greatest abduction range of motion occurred when glenospheres with a lateralized COR were used.[10-12] Conversely, the most effective way of preventing notching seemed to be with use of an eccentric glenosphere.

The humeral component, specifically the retroversion of this implant, can also be altered to prevent scapular notching. Walch and colleagues have shown that the humeral component should be implanted with slight retroversion.[18] Stephenson et al[25] recently described that placement of the humeral component between 20° and 40° of retroversion restores a functional arc of motion without impingement, from 30° glenohumeral abduction in the scapular plane.

The purpose of this study was to evaluate the effect of various glenosphere and humeral retroversion combinations on abduction amplitude and the occurrence of scapular impingement.

Materials and methods

Shoulders and implants

This was a cadaver study involving 40 arms (20 right, 20 left). The average age at death was 79.1 years (range, 61-95 years). The male-to-female ratio was 21:19. Each anatomical specimen consisted of the shoulder girdle, humerus, forearm, and hand.

The Aequalis Reversed Shoulder Prosthesis for reverse shoulder arthroplasty was used (Tornier Inc., Edina, Minn, USA). The associated instrumentation was used according to the recommendations in the instructions provided by the manufacturer. A single type of humeral component was used during the study: 36-mm-diameter metaphysis, screwed to a 6.5-mm-diameter and 150-mm-long diaphysis, which was then screwed onto a 3.5-mm-diameter and 250-mm-long intramedullary rod. The rod crossed the distal humerus and olecranon; it was used to attach the humerus to the measurement jig. A removable humeral liner with a 36-mm diameter and 6-mm lateral offset was used. Its concavity (36 mm or 42 mm) was chosen to match the diameter of the sphere placed opposite to it.

A 29-mm glenoid base plate was implanted and combined with the following glenospheres and artificial spacers:

36-mm-diameter glenosphere, centered
36-mm-diameter glenosphere, eccentric (inferior offset of 2 mm)
36-mm-diameter glenosphere, tilted 10°
42-mm-diameter glenosphere, centered
36-mm-diameter glenosphere, centered, COR lateralization of 5 mm
36-mm-diameter glenosphere, centered, COR lateralization of 7 mm
42-mm-diameter glenosphere, centered, COR lateralization of 7 mm
42-mm-diameter glenosphere, centered, COR lateralization of 10 mm

Measurement jig

A modular metal column (Sawbones, Malmö, Sweden) was designed for this study. The column had a vise to fix the scapula and an articulated arm to attach the remainder of the upper limb via the intramedullary rod screwed to the humeral component. This experimental setup allowed various shoulder movements to be reproduced and the range of motion to be measured with protractors. The goal of the assembly unit was to dissociate the abduction and rotation measurements.

Experimental methods

The scapula of the anatomical specimen was fixed into the vise on the metal column. Dissection was performed to detach the deltoid muscle from its clavicle and acromion attachments and continued down to the deltoid tuberosity on the humerus to then expose the rotator cuff layer. The supraspinatus and infraspinatus muscles were resected. To provide good visualization of any anterior impingement, the subscapularis was detached from the lesser tuberosity of the humerus. The teres minor was preserved. A vertical glenohumeral arthrotomy was performed, followed by a capsulectomy. The long head of the biceps was resected at the same time. The ring around the glenoid cavity and the upper part of the scapular pillar were carefully exposed; the long head of the triceps was detached as needed. The entire anterior, inferior, and posterior borders of the glenoid needed to be clearly visible for any impingement to be detected during the measurements.

To implant the glenoid base plate, the glenoid labrum was excised, then a threaded guide pin was centered and inserted