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ORIGINAL ARTICLE

Geometrical analysis results of 42 resurfacing shoulder prostheses: A CT scan study

J.-Y. Deladerrière[a,*], **C. Szymanski**[a], **T. Vervoort**[a], **J.-F. Budzik**[b], **C. Maynou**[a]

[a] *Department of Orthopaedic Surgery A, Lille University Regional Hospital Center, R.-Salengro Hospital, rue Emile-Laine, 59037 Lille cedex, France*
[b] *Saint-Vincent-de-Paul Medical Imaging, boulevard de Belfort, BP 387, 59020 Lille cedex, France*

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KEYWORDS
Shoulder;
Prosthesis;
Computed tomography scanner

Summary
Background: Shoulder resurfacing arthroplasty was introduced in Scandinavia in the early 1980s then developed by SA Copeland.
Hypothesis: Resurfacing prostheses restore the normal anatomy of the proximal humerus. Here, our objective was to evaluate humeral resurfacing prosthesis position on radiographs and computed tomography (CT) images.
Materials and methods: We retrospectively reviewed 42 consecutive cases seen at a single centre between 2004 and 2009. Mean patient age was 65 years. CT was performed routinely before prosthesis implantation and at re-evaluation. The Copeland Mark III® (Biomet France SARL, 26903 Valence, France) implant was used in 32 cases and the Aequalis Resurfacing Head® (Tornier France, 38334 Saint-Ismier, France) in 10 cases. The post-implantation CT images were used to measure the angle of inclination, medial humeral offset, lateral glenohumeral offset, and version of the implant.
Results: Mean follow-up was 18 months. Compared to baseline, no significant changes were found at re-evaluation for the angle of inclination or lateral glenohumeral offset. In contrast, medial humeral offset increased by 3.47 mm, and excessive anteversion of 4.23° compared to the bicondylar line was noted.
Discussion: Humeral head resurfacing prostheses restore the overall anatomy of the proximal humeral head. Our CT scan evaluation protocol seems reproducible and enables an evaluation of implant geometry. In our experience, resurfacing arthroplasty restored the native humeral offset. Inadequate retroversion was noted and was probably related to insufficient exposure during surgery.
Level of evidence: Level IV, retrospective study.

* Corresponding author. Tel.: +33 32 04 46 800.
E-mail address: jean-yves.deladerriere@wanadoo.fr (J.-Y. Deladerrière).

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Introduction

Shoulder resurfacing arthroplasty (SRA) has the theoretical advantages of respecting humeral head anatomy and preserving humeral bone stock, which would be expected to promote favourable glenohumeral kinetics and optimal periarticular muscle function. The simplicity of the implant and ancillary instruments might seem to suggest an easy and reproducible technique. However, during implantation, challenges may arise when attempting to ensure optimal implant position (varus or valgus, implant version, or lateral offset). SRA was introduced in Scandinavia in the early 1980s [1] but was subsequently developed by S. Copeland [2—9] and evaluated in clinical studies of patients with a variety of shoulder disorders.

The Mark I® implant was made of titanium and had a central, smooth, perforated peg that was secured with a screw inserted through the lateral aspect of the proximal humerus to exert compression and prevent rotation, as no cement was used. This design was associated with loosening and migration and was therefore discarded in the early 1990s. Mark II® was a cobalt-chromium prosthesis that had a central, cone-shaped, grooved, press-fit post. The next improvement consisted in adding a hydroxyapatite coat to the concave surface of the implant to improve stability and promote bone integration (Mark III®). The various implant dimensions were selected based on radiographic studies of normal and osteoarthritic cadaver shoulders and followed anatomic rules as opposed to mathematical rules [6,10]. At present, many resurfacing prosthesis models are available. They were developed in part based on anatomic prosthesis design using the criteria developed by Pearl and Kurutz [11—14].

In the orthopaedics A department (Prof. Mestdagh and Prof. Maynou) of the Lille Teaching Hospital, Lille, France, SRA has been used since 2004. The objective of this study was to determine whether SRA restored the native proximal humeral anatomy, as assessed using computed tomography (CT) measurements.

Material and methods

Patients

We retrospectively reviewed the charts of 47 consecutive patients (including three with bilateral arthroplasty) who underwent SRA at a single centre between 2004 and 2009. Seven different surgeons performed the procedures. There were no exclusion criteria. All patients were to be re-evaluated by an independent assessor.

A clinical re-evaluation was performed in 39 patients; one patient was lost to follow-up and seven either were too ill or lived too far away to travel to our centre. Of these 39 patients, three underwent bilateral SRA: thus, the study included 42 shoulders. There were 25 women and 14 men with a mean age of 65 years (range, 45—83 years) at surgery. The dominant side was affected in 24 cases and the non-dominant side in 18 cases.

A history of surgery was noted for only two shoulders. Open repair of the rotator cuff tendon had been performed 3 years earlier in a woman whose CT scan performed before SRA showed an intact cuff. In a male patient, a comminuted extra-articular fracture of the proximal third of the humerus 30 years earlier had been treated with screw-plate fixation and autologous bone grafting.

Operative technique

Templates and radiographs of appropriate scale were routinely used to plan the procedure.

The patient was in the beach-chair position. The deltopectoral approach was used in all cases. The subscapularis tendon was divided 1 cm from its implantation on the lesser tuberosity. The long head of the biceps brachii muscle was divided in 38 (90.5%) cases; in the remaining four cases, tenodesis in the bicipital groove was performed. Peripheral osteophytes were removed routinely to allow accurate definition of the neck of the humerus. The anterior humeral circumflex vessels were exposed and preserved. The drill guide was positioned using the positioning phantom without fluoroscopy. The angle of inclination of the prosthesis was assessed relative to the anatomic neck and implantation site of the deep supraspinatus tendon fibres. Implant version was evaluated relative to the axis of the forearm.

No procedures were performed on the glenoid cavity. A single patient required a complementary procedure, which consisted in repair of an isolated distal tear of the supraspinatus tendon, without tendon retraction.

The underlying aetiologies were distributed as follows:

- primary glenohumeral osteoarthritis (GHOA) in 33 (78.6%) cases, including 16 stage 4, 13 stage 3, and four stage 2 in the modified Samilson and Prieto classification [15];
- avascular necrosis (AVN) in the absence of trauma in four (9.5%) cases, including three stage 3 and one stage 4 in the Arlet and Ficat classification as modified by Cruess [16];
- cuff tear arthropathy (CTA) complicating massive cuff tears in four (9.5%) cases, all of which were stage V in the Hamada classification scheme [17], with alterations in glenoid cavity bone stock that precluded implantation of a glenoid component;
- rheumatoid arthritis (RA) in 1 case.

A Mark III® implant was used in 32 cases and an Aequalis Resurfacing Head® implant in 10 cases. The Mark III® implant was made of a chromium-cobalt alloy with a coat of hydroxyapatite over the concave surface and was intended for implantation without cement. Five sizes were available. The radius of curvature of the implants used was 50 mm. As implant size was determined based on anatomic factors, as opposed to a mathematical rule, variable diameter differences occurred from one size to the next. The Aequalis Resurfacing Head® was also made of a chromium-cobalt alloy and intended for cementless implantation. Twelve sizes were available, with cap diameters ranging from 37 to 54 mm and two available heights for the three largest diameters. Peg length was 30, 35, or 40 mm depending on cap size. Cap dimensions were identical to those of Aequalis humeral heads for hemiarthroplasty. Mean difference in diameter from one size to the next was 2 mm. Primary fixation was ensured by a cone-shaped tri-fin peg and a diamond-shaped