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ORIGINAL ARTICLE

Association of lateral humeral offset with functional outcome and geometric restoration in stemless total shoulder arthroplasty

Bakir Kadum, MD, PhD, FEBOT, MRCS (Ireland)[a,*], Per Wahlström, MD[b], Shwan Khoschnau, MD, PhD[c], Göran Sjödén, MD, PhD[a], Arkan Sayed-Noor, MD, PhD, FRCS[a]

[a]*Department of Surgical and Perioperative Sciences (Orthopaedics-Sundsvall), Umeå University, Umeå, Sweden*
[b]*Department of Hand Surgery, Umeå University, Umeå, Sweden*
[c]*Department of Orthopaedics, Elisabethsjukhuset, Uppsala, Sweden*

Background: Restoration of shoulder geometry is desirable in total shoulder arthroplasty (TSA) and thought to influence the postoperative clinical outcome. We aimed to study the association of postoperative lateral humeral offset (LHO) changes and clinical outcome, as well as to investigate the ability of stemless anatomic TSA to restore shoulder geometry.

Methods: In patients with primary shoulder osteoarthritis who underwent stemless anatomic TSA, the preoperative and postoperative clinical outcome was measured. Shoulder geometry was measured on preoperative computed tomography for the osteoarthritic shoulder and contralateral healthy shoulder and on postoperative computed tomography for the operated shoulder.

Results: Forty-four patients with a minimum follow-up of 12 months (range, 12-50 months) were available for the study. Postoperatively, the clinical outcome measures improved. The postoperative difference in LHO between the operated shoulder and contralateral healthy shoulder was 1.3 ± 4.6 mm and was correlated with scores on the short version of the Disabilities of the Arm, Shoulder and Hand questionnaire at 3 months (Pearson correlation = 0.36, $P = .01$) and visual analog scale for pain at rest (Pearson correlation = 0.30, $P = .03$) and with exertion (Pearson correlation = 0.34, $P = .01$) at 3 months. Lengthening of LHO was associated with worsening shoulder function at 3 months but not at 12 months. The postoperative shoulder geometric parameters were restored postoperatively to acceptable ranges.

Conclusion: The stemless anatomic TSA could restore shoulder geometry in an acceptable manner. At 3 months but not at 12 months, increased LHO had a negative effect on shoulder function and resulted in more shoulder pain at rest and with exertion but did not affect quality of life, health status, or range of motion.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Stemless shoulder prosthesis; TESS shoulder prosthesis; shoulder anatomy restoration; shoulder offset; lateral humeral offset; total shoulder arthroplasty

The study was performed according to the Declaration of Helsinki, and the protocol was approved by the local ethics committee at Umeå University (diarie nomber [dnr] 2012-201-31 M).

*Reprint requests: Bakir Kadum, MD, PhD, FEBOT, MRCS (Ireland), Department of Orthopaedics, Sundsvall Hospital, Lasarettsvägen 21, S-85643 Västernorrland County, Sweden.

E-mail address: baqir_kareem@yahoo.com (B. Kadum).

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Restoration of shoulder joint biomechanics is an important goal in total shoulder arthroplasty (TSA). The length of the joint lever arm seems to relate to shoulder function, prosthetic stability, and polyethylene wear.[10,13] Distances between different anatomic landmarks in the glenohumeral joint have been studied to determine their clinical importance. The lateral humeral offset (LHO), which is the distance between the medial edge of the coracoid process and the greater tubercle, is considered an important parameter to restore. Other parameters include humeral head height (HH), center of rotation (COR), and neck-shaft angle (NSA).[13,31] Preoperative planning is a step that makes restoration of shoulder anatomy more feasible by assessing component position and proper size selection. Using plain radiographs in preoperative planning can be subject to projection and observer error,[26] whereas computed tomography (CT) has been shown to be superior to plain radiographs in assessing glenohumeral relationships, therefore supporting its use in clinical practice.[9] Kadum et al,[16] for instance, showed that CT had better interobserver and intraobserver reliability in measuring LHO than plain radiographs.

It is still a challenge to design shoulder prostheses that fit all anatomic variations.[3] A stemless prosthesis with total elimination of the humeral stem and total reliance on metaphyseal fixation was introduced in France in 2004 (Total Evolutive Shoulder System [TESS]; Zimmer Biomet, Warsaw, IN, USA). The main goals with this prosthetic modality were to avoid stem-related complications and to preserve bone stock.[11,15] The relative simplicity of placing stemless implants in a reproducible manner can also favor proper restoration of shoulder anatomy.[14] However, this has not been proved in the literature yet.

The aims of this study were to determine the association of postoperative LHO changes with shoulder function and quality of life and to investigate the ability of stemless anatomic TSA to restore LHO, HH, COR, and NSA. The hypothesis was that postoperative LHO changes would influence shoulder function and quality of life and the stemless anatomic TSA would restore the tested geometric parameters to acceptable limits.

Materials and methods

Patients

This prospective study was performed between May 2011 and August 2014 at Sundsvall Teaching Hospital, Sundsvall, Sweden. All patients with symptomatic unilateral primary osteoarthritis (OA) scheduled to undergo anatomic stemless TSA were considered for inclusion. Patients with previous shoulder surgery, cognitive impairment, or neurologic disorder were excluded. Informed consent was obtained from all patients.

Functional measurements

Within 6 weeks preoperatively, functional impairment was measured with the short version of the Disabilities of the Arm, Shoulder and Hand questionnaire (QuickDASH) score[2] (11-item score ranging from 0 [no disability] to 100 [most severe disability]) and quality of life was assessed with the EQ-5D (comprising 5 dimensions—mobility, self-care, usual activities, pain or discomfort, and anxiety or depression). In addition, a measure of health status was performed using the visual analog scale (VAS) component of the EQ-5D, pain was measured both at rest and with exertion using a VAS, and active range of motion (ROM) was recorded. Active ROM was measured by visual estimation in degrees of abduction, flexion, and external rotation, whereas internal rotation was measured as the ability to reach behind the back and the level reached.

Postoperatively, the patients were assessed with the same functional parameters at 3 months, 12 months, and then annually. One independent observer performed all functional measurements to ensure objectivity.

CT geometric parameter measurements

CT imaging was performed with the patient in the supine position and the arms by the side with the palms facing upward (anatomic position). Both shoulders were included in the axial CT sections. Preoperative CT was performed within 6 weeks before surgery and used to rule out the presence of any OA changes in the contralateral shoulder and therefore to confirm the diagnosis of unilateral OA. The postoperative CT scan was obtained at 3 months' follow-up. One independent investigator performed the radiologic measurements to ensure objectivity. All radiographs were obtained on a computerized radiography system (Siemens, Erlangen, Germany). The images were digitally acquired using a picture archiving and communication system (Impax; Agfa, Antwerp, Belgium).

LHO was measured on the axial section as the distance between the medial edge of the base of the coracoid process and the most lateral point of the greater tubercle (Fig. 1).[16] LHO was measured for the shoulder with OA (LHO OA) and for the contralateral healthy shoulder (LHO contra) on the preoperative CT scan, whereas LHO for the operated shoulder (LHO op) was measured on the postoperative CT scan. The difference between LHO op and LHO contra (LHO post) was calculated, and a positive value was obtained when LHO op was longer than LHO contra whereas a negative value indicated the opposite.

COR was measured by mapping a circle that traced the humeral head contour on the coronal CT section on which the entire humeral head was visible; the center of the circle was then identified. The long axis of the humeral diaphysis was defined by a proximal and distal point in the center of the intramedullary canal. COR was calculated, in millimeters, as the perpendicular distance from the center of the circle to the long axis of the humeral diaphysis[5] (Fig. 2). COR was measured for the shoulder with OA (COR OA) and for the contralateral healthy shoulder (COR contra) on the preoperative CT scan, whereas COR for the operated shoulder (COR op) was measured on postoperative CT scan. The difference between COR op and COR contra (COR post) was calculated, and a positive value was obtained when COR op was longer than COR contra whereas a negative value indicated the opposite.

HH was measured as the perpendicular linear distance from the anatomic neck to the apex of the circle. The anatomic neck was defined as the best-fit line created by placing 2 markers: superolateral (at the junction of the greater tuberosity and articular surface) and inferomedial (at the junction of the calcar and articular surface)[5] (Fig. 3). HH was measured for the shoulder with OA (HH OA) and for the contralateral healthy shoulder (HH contra)