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Original article

Total elbow arthroplasty: Influence of implant positioning on functional outcomes

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ABSTRACT

Background: Restoring the axis of rotation is often considered crucial to achieving good functional outcomes of total elbow arthroplasty. The objective of this work was to evaluate whether variations in implant positioning correlated with clinical outcomes.
Hypothesis: Clinical outcomes are dictated by the quality of implant positioning.
Material and methods: A retrospective review was conducted of data from 25 patients (26 elbows). Function was assessed using a pain score, the Disabilities of the Arm, Shoulder, and Hand (DASH) Score, and the Mayo Elbow Performance Score (MEPS). The patients also underwent a clinical evaluation for measurements of motion range and flexion/extension strength. Position of the humeral and ulnar implants was assessed by computed tomography with reconstruction using OsiriX software. Indices reflecting anterior offset, lateral offset, valgus, height, and rotation were computed by subtracting the ulnar value of each of these variables from the corresponding humeral value. These indices provided a quantitative assessment of whether position errors for the two components had additive effects or, on the contrary, counterbalanced each other. Elbows with prosthetic loosening or extensive epiphyseal destruction were excluded.
Results: Of the 26 elbows, 5 were excluded. In the remaining 21 elbows, the discrepancy between the humeral and ulnar lateral offsets was significantly associated with pain intensity ($P \leq 0.05$) and the MEPS ($P \leq 0.05$). Anterior position of the ulna relative to the humerus was associated with decreased extension strength ($P \leq 0.05$) and worse results for all functional parameters ($P \leq 0.05$).
Discussion: In the absence of loosening, positioning errors seem to adversely affect functional outcomes, probably by placing inappropriate stress on the soft tissues.
Level of evidence: III.

1. Introduction

The first total elbow prostheses, introduced in the 1970s, were rigid-hinge joints that were associated with high complication rates [1–4]. Complications are far less common with the newest-generation elbow prostheses [5–11], whose 10-year survival rates exceed 85% [7,12,13]. Nevertheless, the occurrence of complications, most notably loosening, remains a focus of constant concern [14,15]. A number of pathophysiological processes have been suggested to explain these complications [3,8,16–29]. Among contributors to prosthesis failure, the quality of implant positioning plays a preponderant role [8,17,30–38]. Thus, replicating the initial axis of rotation seems crucial to restore normal kinematics and appropriate stresses, thereby ensuring good elbow function.

The objective of this work was to investigate whether prosthesis position in the three planes influenced the clinical outcomes of total elbow arthroplasty.

2. Materials and methods

2.1. Study population

From October 2008 to January 2012, the Discovery™ Elbow System (Biomet, Warsaw, IN, USA) was used for total arthroplasty of 32 elbows in 31 patients. Among these patients, 5 were lost to

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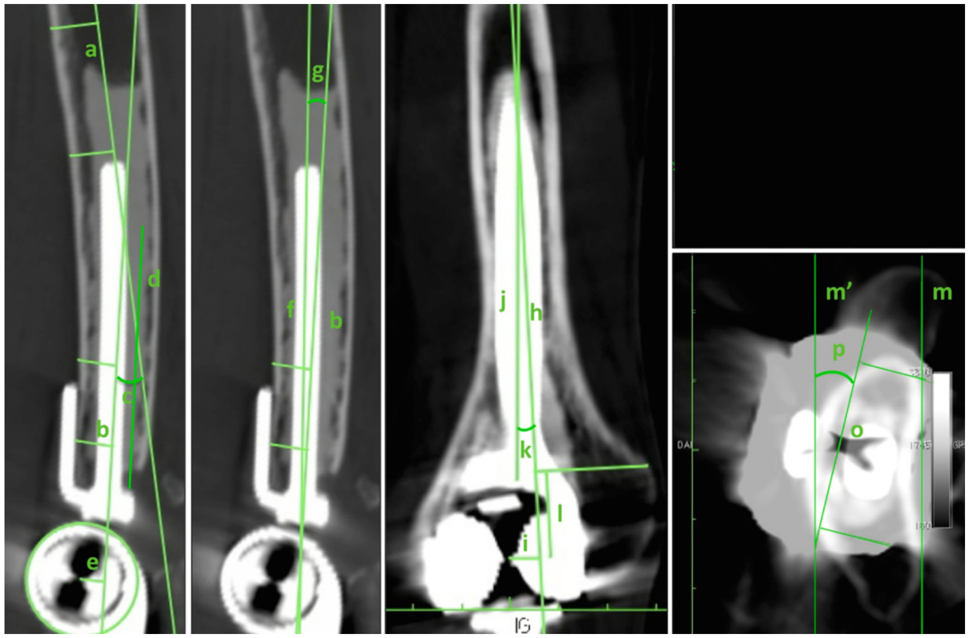

Fig. 1. Measures on computed tomography images of the humerus: a: axis of the proximal humeral shaft in the sagittal plane; b: axis of the distal humeral shaft in the sagittal plane; c: humeral anterior angulation; d: point of humeral anterior angulation; e: anterior offset; f: humeral stem axis in the sagittal plane; g: version of the humeral implant; h: humeral axis in the frontal plane; i: lateral offset; j: humeral stem axis in the frontal plane; k: valgus of the humeral axis; l: height of the humeral implant; m: axis of the distal humerus; m’: line parallel to the axis of the distal humerus; n: axis of the hinge; o: rotation of the humeral implant.

follow-up and 1 died, leaving 25 patients (26 elbows) for the study, 18 women and 7 men. Mean age was 64 years (range, 38–82) at last follow-up. Of the 25 patients, 13 (14 elbows) had rheumatoid arthritis and 6 a history of complex trauma. In addition, 2 patients experienced decompensation of rheumatoid arthritis lesions due to a fracture of the radial head or distal humerus, respectively. Of the remaining 4 patients, 1 each had primary elbow osteoarthritis, osteochondromatosis, severe haemophilia, and osteoma after a severe burn injury.

2.2. Operative technique and post-operative care

The posterior trans-tricipital approach with decortication of the olecranon was performed in all patients [8]. After radial head resection, ulnar nerve release was performed routinely. The Discovery™ Elbow System was used for all 26 elbows. Mobilisation was started within the first week after surgery. Elbow extension against resistance was postponed for 8 weeks.

2.3. Clinical evaluation

At last follow-up, each patient subjectively evaluated pain intensity on a scale from 0 (no pain) to 10 (worst possible pain) and overall elbow function on a scale from 0 (complete loss of function) to 100 (normal function). The Mayo Elbow Performance Score (MEPS) was determined routinely and the results categorised as follows: excellent, 90-100; good, 75–89; fair, 60–74; and poor, <60. The Disabilities of the Arm, Shoulder, and Hand (DASH) Score was also assessed in each patient. Patient satisfaction was rated as follows; very satisfied, satisfied, somewhat satisfied, and dissatisfied.

The physical examination included measurement of the ranges of flexion, extension, pronation, and supination using a goniometer. A dynamometer was used to measure flexion and extension strength with the elbow flexed at 90°. The ratio of extension over flexion strengths was computed.

2.4. Radiographs and computed tomography (CT)

Standard antero-posterior radiographs were obtained and CT imaging performed. The status of the bone-cement interface was graded as described by Morrey et al. [23]: type 0, lucent line less than 1 mm thick and involving less than 50% of the interface; type I, lucent line of 1 mm or more involving less than 50% of the interface; type II, more than 1-mm lucency involving more than 50% of the interface; type III, more than 2-mm lucency around the entire interface; and type IV, gross loosening.

To assess humeral and ulnar implant position, CT reconstructions produced using OsiriX® software (Fondation OsiriX, Geneva, Switzerland) were used (Figs. 1 and 2). The bones near the elbow are characterised by a humeral anterior angulation, ulnar anterior angulation, and ulnar varus angulation. The anatomical axes of the proximal and distal shafts of the humerus and ulna were determined based on previously published data [16,39–46], at a distance from the apices of the humeral anterior angulation and ulnar anterior angulation. Thus, the axis of the distal humeral shaft in the sagittal plane ran through the midpoints of the two line segments connecting the anterior and posterior cortices, with the distal and proximal line segments being located 1 cm and 3 cm from the most distal part of the humerus. The axis of the proximal humeral shaft ran through the middle of two line segments located 8 cm and 11 cm, respectively, from the most distal part of the humerus. In the frontal plane, the humerus has no angulation and the axes of the proximal and distal shafts are therefore the same. This frontal humeral axis ran through the midpoints of two line segments connecting the medial and lateral cortices at, and 8 cm proximal to, the most distal part of the diaphysis. The axis of the proximal ulnar shaft in the sagittal plane ran through the midpoints of two line segments connecting the anterior and posterior cortices, one at the coronoid process and the other 2 cm more distally. The axis of the distal ulnar shaft ran through the midpoints of two other line segments located 7 and 10 cm, respectively, from the tip of the olecranon. In the frontal plane, the axis of the proximal ulnar shaft ran through the midpoints of two line segments connecting the medial and lateral cortices and located 2 and 4 cm, respectively, from the tip of the