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Macroscopic investigation of failed Kudo type 5 total elbow arthroplasty

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Background: On the basis of the intra-articular findings during Kudo type 5 elbow prosthesis revision surgery, we infer the mechanisms leading to implant failure.
Materials and methods: We performed primary Kudo type 5 total elbow arthroplasty on 60 rheumatoid elbows in 45 patients between 1994 and 2003. Revision surgery was performed in 8 patients (9 elbows) because of implant failure. We radiographically assessed their status before this surgical procedure and then assessed the surgical intra-articular findings based on surgery records and photographs.
Results: In all cases, revision surgery was necessitated by failure of the ulnar component. There were 2 types of implant failure: fracture of the ulnar component neck (n = 3) and loosening of the ulnar component (n = 6). In the latter group, 2 elbows exhibited valgus deformity of the retrieved ulnar component. There were no cases of metallosis or wear of the articular surface.
Conclusion: This study describes the types of implant failure in unlinked Kudo type 5 total elbow arthroplasties with all-polyethylene ulnar components based on the intra-articular findings. Failure of the all-polyethylene ulnar component could have been caused by ulnar neck distortion that occurred prior to polyethylene wear on the joint surface. In addition, valgus stress on the elbow joint may have contributed to these implant failures.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Total elbow arthroplasty; rheumatoid arthritis; Kudo type 5 prosthesis; implant failure; revision surgery; all polyethylene

The unlinked Kudo type 5 elbow prosthesis was one of the most commonly used unlinked total elbow implants for treating end-stage rheumatoid arthritis (RA) of the elbow joint in the 1990s and 2000s.[6,7] The short-term outcomes of most total elbow arthroplasty (TEA) prosthesis designs are relatively good, but the incidence of aseptic loosening increases over time. According to a systematic review of TEA in 2017, aseptic loosening remains the most frequent problem necessitating primary TEA revision.[12] Therefore, reducing the rate of long-term aseptic loosening is essential for successful TEA. The Kudo type 5 prosthesis reportedly relieves pain, increases the range of movement, and has a low incidence of loosening in the long term[5,13,15,17]; however, detailed information regarding long-term outcomes of wear and loosening is lacking, with few reports in the literature and even fewer available from sources other than the designers.

This study was approved by the Institutional Ethics Committee of Hiroshima Prefectural Rehabilitation Center (study No. 201707).

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One long-term follow-up study on Kudo type 5 elbow prostheses found that the 10-year survival rate was 72%-100%,[7] another revealed a 5-year survival rate following Kudo TEA for RA of 79%,[17] and a third reported a 12-year survival rate of 74%.[13] In our previous study, the survival rate with a cementless humeral component and a cemented all-polyethylene ulnar component was 87.8% and 70.7% after 5 and 10 years, respectively.[5] The ulnar component of the Kudo type 5 prosthesis can be either all polyethylene or metal backed. A prospective randomized study showed that patients with the latter type experienced significantly better long-term survival than those with the former.[7] However, implant failure remains a potential problem.

The cause of articular surface wear and loosening in unlinked TEA may be soft-tissue laxity and initial incongruity of the ulnohumeral articulation.[5] Several risk factors for revision Kudo TEA have been reported. For example, joint destruction above Larsen grade IV[15] and intraoperative malpositioning of the ulnar component with varus-valgus alignment greater than 5°[1] can reduce survival. The significant risk factors for aseptic loosening or revision in our previous study were a short RA duration before TEA, which indicated rapid destruction of the joint, and a large preoperative range of elbow movement, suggesting laxity of periarticular tissues, including the ligaments and joint capsule.[5]

However, the biomechanical mechanisms leading to wear and loosening are still unclear, with few articles describing the intra-articular status at the time of revision surgery. The purposes of this study were to examine the pathologic specimens collected at the time of the revision of Kudo type 5 elbow prostheses with all-polyethylene ulnar components and to identify the type of all-polyethylene ulnar component failure.

Materials and methods

This is a retrospective case series of 9 cases involving failure of the Kudo type 5 TEA in which all-polyethylene ulnar components were used. Between 1994 and 2003, 45 patients (60 elbows) with RA underwent a Kudo type 5 TEA. Of these patients, 8 (11 elbows) died within 10 years of surgery and 6 (8 elbows) were lost during the follow-up period. The remaining 31 patients (41 elbows) were followed up for more than 10 years and were all included in our previous report, which described the surgical technique used.[5] Implant failure was defined as breakage of the components or loosening with a radiolucent line of greater than 1 mm in width around the entire component, as observed by radiography. Implant failure occurred in 12 of these elbows: 8 underwent revision, 1 had the ulnar component removed, 1 had a deep infection leading to the implant being removed 4 years after the initial operation, and 2 were not treated. In cases involving failure of the ulnar component only, the ulnar component was replaced with a metal-backed implant. In 1 case in which the stem of the ulnar component was tightly fixed and difficult to remove, the stem was left and only the articular part was removed without replacement of the implant. Two patients did not undergo revision surgery because of comorbidity.

In this study, we examined the data for the 9 elbows (8 patients) that underwent revision surgery (the infected elbow was excluded). The patients were all women, with a mean age of 63.6 years (range, 53-77 years) at the time of revision surgery. In every patient, the humeral component was implanted without cement while the all-polyethylene ulnar component incorporated cement fixation. The mean duration from primary TEA to revision surgery was 72.2 months (range, 36-101 months). The intra-articular findings at the time of revision were evaluated using surgical records and photographs.

We assessed radiographic status before revision surgery using the method proposed by Souter,[14] with a modified radiographic sheet. In our modification, the degree of loosening was classified into 4 grades (none, wide translucency of ≤2 mm, wide translucency of >2 mm, or major disruption); subluxation was classified into 4 grades (none, ≤3 mm, >3 mm, or frank dislocation); and the presence or absence of sinking, penetration, and implant fracture was evaluated. Furthermore, we defined the elbows as having severe valgus instability if there was greater than 15° of inclination of the stem of the ulnar component with respect to the stem of the humeral component. This definition was based on the assessment by Wagener et al,[16] which classified valgus instability into the following 4 grades according to the extent of joint space opening under valgus stress: grade 0, no instability; grade 1, mild instability (<3-mm opening of joint space at 60° of flexion under valgus load); grade 2, moderate instability (3- to 6-mm opening); and grade 3, severe instability (>6-mm opening). In this study, it was impossible to evaluate valgus instability based on the opening of the joint space because of the cases involving fracture or distortion of the ulnar component. Therefore, we defined valgus instability as more than 15° of valgus tilting, which was assumed to be equivalent to grade 3 (>6-mm opening) valgus instability, according to the aforementioned classification.

Results

In all cases, revision surgery was necessitated by failure of the ulnar component. Radiography revealed loosening around the ulnar component in 6 elbows. Of these, 3 had a wide translucency of 2 mm or less, 1 had a wide translucency of greater than 2 mm (Fig. 1, *A*), and 2 exhibited a major disruption: either perforation (Fig. 2, *A*) or ballooning (Fig. 3, *B*). There were no radiolucencies around the humeral component. We observed sinking of the ulnar component in 2 elbows (Fig. 4, *A*), and 1 elbow showed penetration of the ulnar component into the posterior wall of the ulna (Fig. 2, *A*).

Instability was evaluated based on the medial and lateral shift of the ulnar component with respect to the axis of the humeral component on the anteroposterior view. Subluxation was exhibited by 3 elbows: 3 mm or less in 2 and more than 3 mm in 1 (Fig. 3, *A*). Of the 9 elbows, 6 underwent more than 15° of valgus tilting after the initial operation (Fig. 3, *A*). An implant fracture was found in 3 cases, all of which were ulnar neck fractures. In addition, 2 of these 3 elbows had a cement fracture around the proximal portion of the ulnar component, which had occurred prior to the ulnar neck fracture (Fig. 5, *A*; Table I).

Surgical findings revealed no metallosis or wear of the articular surface in any of the cases, despite synovial proliferation (Fig. 2, *B*). There was no increase in inflammatory response during the blood examination before revision surgery. The surgical findings confirmed the radiographic findings of loosening of the ulnar component in 6 elbows. In these cases, we