Shoulder hemiarthroplasty for steroid-associated osteonecrosis

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Currently, there is little information on the outcome of humeral head replacement for steroid-associated osteonecrosis of the humeral head. The purpose of this study was to evaluate the outcome of patients who underwent humeral head replacement for steroid-associated osteonecrosis to determine the results, risk factors for an unsatisfactory outcome, and rates of revision surgery. Between 1980 and 2000, 32 shoulder hemiarthroplasties were performed for steroid-associated osteonecrosis. We included 31 hemiarthroplasties in 25 patients with a minimum 2-year follow-up (mean, 12.0 years) in the study. The mean age of the 23 female and 9 male patients was 49.4 years at the time of surgery (range, 25-86 years). Overall, mean pain scores decreased from 4.6 to 2.6 ($P < .0001$). However, moderate or severe pain was reported in 12 shoulders (38%) at the most recent follow-up, 2 of them requiring implant revision. The mean preoperative to postoperative active elevation increased from 92° to 139° ($P < .0001$), and external rotation increased from 36° to 65° ($P < .0001$). According to a modified Neer result rating system, there were 13 excellent results (42%), 4 satisfactory results (13%), and 14 unsatisfactory results (45%). Improvement in pain and function most often occurred after hemiarthroplasty as a treatment for steroid-associated osteonecrosis of the humeral head. However, there are a large number of unsatisfactory results related to glenoid cartilage wear over time. (J Shoulder Elbow Surg 2008;17:685-688.)

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The humeral head is the second most common site of osteonecrosis (ON) after the hip. Corticosteroid therapy is the most common reported cause of nontraumatic ON.[5,10,13] ON after steroid use was first reported by Pietrogrande and Mastromarino[18] in 1957. Heimann and Freiberger[8] and later Cruess et al[2] first described steroid-associated ON of the humeral head. Conservative treatment is often successful in patients with stage I and II disease or early stage III disease. However, as ON progresses to painful subchondral fracturing, irregular joint surfaces, and subsequent degenerative changes, prosthetic replacement is often indicated. Humeral head replacement (HHR) has been advocated for stage III and stage IV disease, when the glenoid cartilage is intact, and total shoulder arthroplasty (TSA) for stage V disease.[7,21]

There has been very little reported on HHR for steroid-associated ON. The few studies on ON of the humeral head have not separated steroid-induced ON from other diagnostic groups and have often grouped TSA together with HHR in their outcomes.[3,7,14,15,17,20,21] The purpose of this study is to evaluate the outcome of patients who underwent HHR for steroid-associated ON to determine the results, risk factors for an unsatisfactory result, and rates of revision surgery.

MATERIALS AND METHODS

Thirty-two HHRs were performed for the diagnosis of steroid-associated ON at our institution between April 4, 1980, and May 10, 2000. Over this time period, a total of 867 hemiarthroplasties were performed. Patients were identified with the use of a computerized database containing the files of all patients undergoing joint arthroplasty at our institution. The study proceeded under institutional review board approval. Patients entered in this database are asked to return for interviews, examinations, and radiographic evaluations at regular follow-up intervals. Those who are unable to return for a personal evaluation are sent a questionnaire and are also requested to have a local orthopaedic surgeon send us the results of their clinical examination and recent radiographs. All 32 HHRs were included in a survival analysis, with a revision procedure defined as the

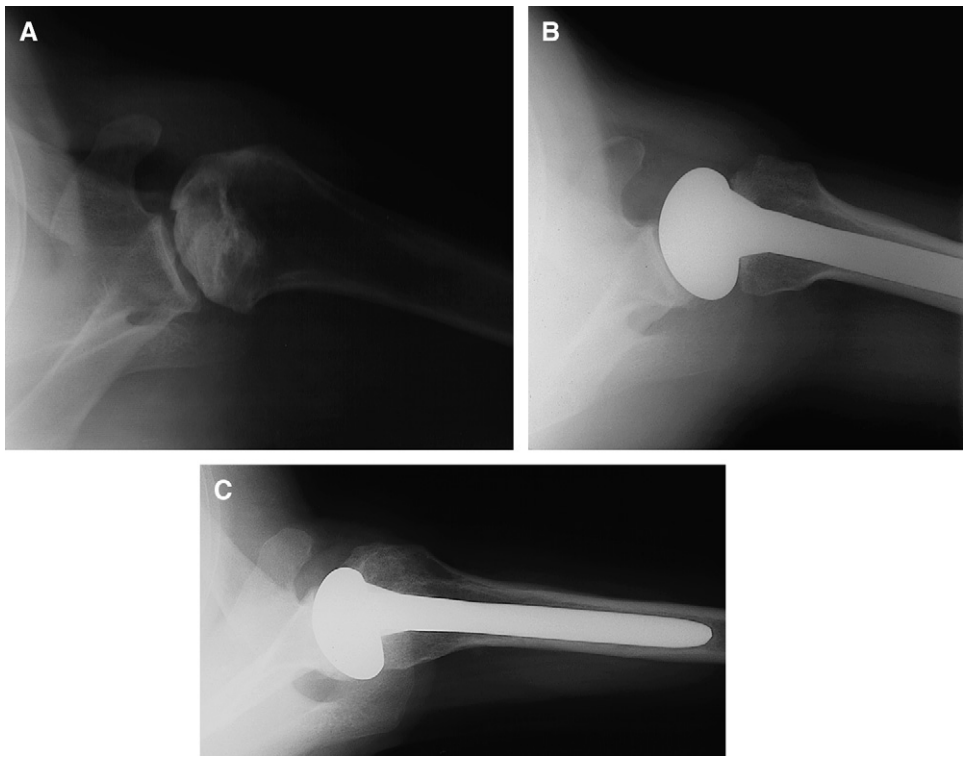

Figure 1 A, Preoperative radiograph of 39-year-old man with steroid-induced ON. He had 100° of active elevation, 20° of external rotation, and severe pain. **B**, Immediate postoperative radiograph. **C**, Thirteen years after hemiarthroplasty, he has moderate pain with 140° of active elevation and 50° of external rotation.

endpoint. One patient died with less than 2 years' follow-up. Therefore, 31 HHRs in 25 patients with a minimum 2-year follow-up (mean, 12.0 years), or until the time of revision surgery, were included in the clinical analysis. Radiographic follow-up was available for 23 of these shoulders, and a complete series of radiographs—preoperative, early postoperative, and at most recent follow-up, averaging 9.2 years—were available for 21 shoulders (Figure 1).

The mean age of patients undergoing HHR was 49 years (range, 25-86 years). There were 23 women and 9 men; 4 women and 3 men underwent bilateral HHR. Only 1 of the 31 shoulders had undergone a previous procedure—an open acromioplasty and distal clavicle resection. At the time of surgery, a rotator cuff tear was identified and repaired in 3 shoulders. The humeral head component was uncemented in 24 shoulders and cemented in 7.

At our institution, clinical assessment of all patients who have undergone shoulder surgery is recorded by use of a standard shoulder analysis sheet. Pain is graded according to scales previously published by Cofield[1] and Neer et al.[15] Shoulder pain was graded as follows: 1, no pain; 2, slight pain; 3, pain after unusual activity; 4, moderate pain; and 5, severe pain. Active abduction and passive external rotation were recorded in degrees. Internal rotation was recorded as the most posterior vertebral segment that could be reached by the thumb.

Preoperative radiographs were available for review for 27 patients, postoperative radiographs were available for 23 patients, and 21 patients had a complete set of radiographs with a mean follow-up period of 9.2 years. The projections used for radiographic analysis included 40° posterior oblique views with internal and external rotation of the humerus and an axillary view. Radiologic assessment included a classification of the extent of ON in the humeral head and the staging of humeral head ON. The extent of involvement, as described by Hattrup and Cofield,[6] was classified from the maximum involvement shown on any single view. Four groups were defined: those with less than one quarter of the humeral head involved, those with involvement between one quarter and one half of the diameter of the humeral head, those with involvement between one half and three quarters of the humeral head, and those with more than three quarters of the diameter of the humeral head involved. In our series, there were 2 shoulders with between one-quarter and one-half involvement, 14 with between one-half and three-quarters involvement, and 11 with greater than three-quarters involvement.

Staging was done according to the classification of Cruess,[3] modified from the system devised by Ficat[4] for the femoral head. Stage 1 disease is pre-radiographic and is diagnosed by magnetic resonance imaging, radioisotopic bone scanning, or biopsy. Mottled sclerosis on plain radiographs defines stage 2 disease. In stage 3 disease, subchondral fracturing is present, also known as a crescent sign, with occasional minimal flattening of the articular surface. In stage 4, there is collapse of the subchondral bone with loss of the spherical shape of the humeral head. Stage 5 is defined by glenoid degenerative changes. In our series, there were 6 shoulders with stage 3 disease, 16 with stage 4 disease, and 5 with stage 5 disease.

Erosion of the glenoid was graded as none, mild (erosion of the glenoid cortical bone), moderate (medialization of the glenoid subchondral bone with hemispheric conforming deformation of the glenoid), or severe (hemispheric deformation of the glenoid and central bone loss within 5 mm of the coracoid base).[22] Glenohumeral subluxation was evaluated for direction and degree and was graded as none; mild, when the center of the humeral head or prosthetic humeral head was translated less than 25% relative to the center of the glenoid; moderate, when the center of the humeral head or prosthetic head was translated 25% to 50% relative to the center of the glenoid; or severe, when the center of the humeral head or prosthetic humeral head component was translated greater than 50% relative to the center of the glenoid.[22]

Postoperatively, glenoid cartilage loss, glenoid bony erosion, and subluxation were evaluated in a similar fashion on the most recent radiographs available. Periprosthetic lucency and shifting of the humeral component were evaluated by 3 authors, and a consensus was reached. Periprosthetic lucency was graded as follows: 0, none; 1, 1 mm incomplete; 2, 1 mm complete; 3, 1.5 mm incomplete; 4, 1.5 mm complete; or 5, 2 mm complete.[22] A shift in component position was evaluated by comparing the early postoperative and most recent radiographs and was either present or not present.

The results were graded by use of a modification of the Neer result rating system.[1] For an excellent result, the patient had no or slight pain, was satisfied with the procedure, had active abduction of at least 140°, and had external rotation of at least 45°. For a satisfactory result, the patient had no pain, slight pain, or moderate pain only with vigorous activities; was satisfied with the procedure; had active abduction of at least 90°; and had external rotation of at least 20°. For an unsatisfactory result, these criteria were not met or the patient underwent an additional operative procedure.

Statistical analysis

The survival rate free of revision surgery was estimated as a function of time since the index procedure with the use of the Kaplan-Meier method and the Cox proportional hazards survival method with adjustment for correlated data (2 shoulders in those patients with bilateral HHR).[11,23] Univariate associations of risk factors with revision-free survival rate were assessed with log-rank tests. Associations between dichotomized risk factors and pain or movement were assessed with 2-sample *t* tests. The association between discrete risk factors and the Neer rating were assessed with an extension of the Fisher exact test for ordered contingency tables.[19] $P < .05$ was selected as the level of statistically significant differences among the various parameters.

RESULTS

Complications, revisions, and survivorship

No patient had perioperative complications. Of the 32 HHRs, 2 (8%) underwent a revision procedure. Both revisions, in the same patient, were performed for painful glenoid arthrosis with conversion to a TSA. The estimated survival rate for HHR was 100% at 5 years and 92% at 10 and 15 years.

Clinical evaluation

There was significant pain relief after surgery (31 shoulders) with mean pain scores decreasing from 4.6 to 2.7 ($P < .0001$). At the time of the most recent assessment, moderate pain was recognized in 8 shoulders and severe pain in 5. There were no significant associations detected for age, gender, rotator cuff tearing, glenoid cartilage wear, glenoid erosion, or subluxation with either the preoperative or postoperative measures of pain.

The mean postoperative active abduction increased from 92° to 139° ($P < .0001$). The mean postoperative external rotation increased from 36° to 65° ($P < .0001$). The mean postoperative internal rotation increased from L4 to L3 ($P < .444$). There were no significant associations between preoperative values of age or gender, the presence of rotator cuff tearing, preoperative glenoid erosion, preoperative glenoid cartilage loss, or immediate postoperative subluxation with the measures of abduction, external rotation, or internal rotation. A higher stage of ON was associated with worse preoperative external rotation ($P < .02$) and internal rotation ($P < .03$). An intraoperative finding of cartilage wear was associated with worse preoperative ($P < .04$) and postoperative ($P < .04$) active abduction.

On the preoperative radiographs, glenoid cartilage loss was graded as no wear in 19 shoulders, thinned (>50%) in 7, and complete loss in 1. Preoperatively, glenoid erosion was none in 25, mild in 0, moderate in 2, and severe in 0. On the preoperative radiographs, glenohumeral subluxation was present in 7 of 27 shoulders. There was more than mild subluxation in 4 shoulders.

At the time of the most recent radiographs, 11 of 23 HHRs that could be evaluated radiographically had some degree of glenohumeral subluxation present. There was more than mild subluxation in 6 shoulders. Glenoid cartilage loss progressed from 1 shoulder having full-thickness loss preoperatively to 14 at the most recent follow-up. Glenoid erosion was present in 14 of 23 shoulders: mild in 6 shoulders and moderate in 8. Humeral periprosthetic lucency was present in 1 shoulder and was 1 mm thick and incomplete.

Overall, there were 13 excellent, 4 satisfactory, and 14 unsatisfactory results. The contributing reasons for an unsatisfactory result were moderate or severe postoperative pain in 8, lack of postoperative abduction (<90°) in 1, and the presence of pain and lack of active abduction in 5.

DISCUSSION

Previous reports looking at HHR for steroid-induced ON have been limited. Cruess[3] reviewed 5 shoulders treated with HHR for steroid-induced ON. All had

good pain relief and near normal range of motion with 1 to 6 years of follow-up. Rutherford and Cofield[20] reported on 17 shoulders treated with arthroplasty for steroid-induced ON with 4.5 years' follow-up. All 10 of the shoulders treated with HHR had excellent or satisfactory results with mild or no pain and active abduction to 161°. Neer et al[15] reported excellent results with near normal motion in 24 patients who underwent shoulder arthroplasty for nontraumatic ON, 15 of which were HHRs. Other results that have been reported have not separated steroid-induced ON from other diagnostic groups, and these studies usually grouped HHR and TSA together in their outcomes.[7,14,17,21] Hattrup and Cofield,[7] looking at the results of replacement for humeral head ON at our institution, noted superior results in steroid-induced ON compared with post-traumatic ON. However, HHR for steroid-induced ON was not isolated in reporting the results. Other than Cruess' small series, there have been no reports looking specifically at HHR for steroid-induced ON.

Our study agrees with previous reports showing that HHR for ON is associated with significant improvements in pain and range of motion.[9,16] However, there were a large number of unsatisfactory results because of painful glenoid wear over time. This large number of unsatisfactory results in our study, compared with earlier reports, is likely a result of a greater number of cases and a much longer follow-up. In our series, there is a mean clinical follow-up of 12 years, with more than 10 years in 20 of 31 shoulders.

More recent reports on arthroplasty for nontraumatic avascular necrosis have also shown failure of HHR due to progressive glenoid arthrosis. Mansat et al[14] reported on 19 shoulder arthroplasties for the treatment of nontraumatic avascular necrosis of the humeral head with a mean 7-year follow-up. Painful glenoid wear developed in 2 of the 14 HHRs at 75 and 115 months of follow-up. Parsch et al[17] reported on 13 shoulders treated with arthroplasty for nontraumatic ON at a mean follow-up of 30 months. Painful glenoid wear developed in 2 of the 8 that received HHRs. Lau et al[12] reported on 7 hemiarthroplasties and 1 TSA in patients with avascular necrosis who had sickle cell disease. They reported that only 2 of 8 patients had improvement in visual analog pain scores.

This study has several limitations. Radiographic follow-up was not available for all patients. In addition, a limiting factor with regard to the outcome measurement is that, at the time that many of the patients underwent arthroplasty, specific functional outcome measurements, such as the Simple Shoulder Test and American Shoulder and Elbow Surgeons score, were not yet available. In addition, there may be improvement in outcome with newer implant designs.

Despite the high number of long-term unsatisfactory results, we believe HHR is still a good option for the younger active patients with stage III or stage IV disease who may not be willing to give up their more active and rigorous lifestyle. However, these patients should be counseled that glenoid wear and recurrent pain may occur over time.

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