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Core decompression and arthroplasty outcomes for atraumatic osteonecrosis of the humeral head

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Background: Humeral head osteonecrosis treatment varies depending on the stage and symptoms. Successful outcomes for humeral head core decompression for stage I/II disease in chronic steroid-induced (CSI) osteonecrosis have been reported, but fewer data exist for sickle cell disease (SCD) etiology. Resurfacing and hemiarthroplasty or total shoulder arthroplasty (TSA) are common for advanced collapse, with mixed results.

Methods: We evaluate radiographic and functional outcomes after procedures for humeral head atraumatic avascular necrosis (HAAVN), decompression efficacy in CSI and SCD populations, and report outcomes of advanced disease requiring arthroplasty. Twenty-five shoulders were treated surgically for HAAVN. Posttraumatic AVN patients were excluded. Stage I/II disease received core decompression and ultrasound bone stimulation. Stage III received surface replacement or hemiarthroplasty, and arthroplasty was performed for stage IV/V. Radiographs and clinical scores were recorded preoperatively and postoperatively.

Results: Included were 25 HAAVN shoulders (13 SCD and 12 CSI). Eleven shoulders (stage I/II disease) underwent core decompression. Seven of 8 shoulders (88%) progressed to stage III/IV after decompression. All SCD patients progressed to collapse. The procedure in 19 shoulders was surface replacement, hemiarthroplasty, or TSA. Constant, American Shoulder and Elbow Surgeons, Simple Shoulder Test-12, and University of California Los Angeles Shoulder scores were significantly higher at 1- and 2-year follow-up with arthroplasty; 13 of 16 arthroplasty patients (81%) had satisfactory to excellent results. One surface replacement was revised to reverse TSA.

Conclusions: Results suggest core decompression for AVN in SCD patients does not alter osteonecrosis progression and humeral head collapse. Resurfacing and hemiarthroplasty are viable treatment options for stage III, whereas shoulder replacement for stage IV/V disease appears to offer better functional results.

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

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Osteonecrosis of the humeral head develops when blood circulation to the area becomes disrupted and the area becomes ischemic. After a prolonged ischemic event, the cells in that region die, resulting in an increase in intraosseous pressure and bone death.[1,3,4] Patients with humeral head atraumatic avascular necrosis (HAAVN) experience increasing pain, decreasing function, and eventual collapse of the humeral head with significant arthrosis. Some osteonecrosis is considered idiopathic, but it is commonly associated with sickle cell disease (SCD), chemotherapy, systemic lupus erythematosus, human immunodeficiency virus, chronic steroid induced (CSI), and alcohol

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abuse. The patients in our cohort developed HAAVN from CSI or SCD. Treatment options consist of pharmacologic intervention, core decompression, arthroplasty, bone grafting, or resurfacing. Core decompression has been previously described as a joint-preserving procedure for symptomatic humeral head avascular necrosis (AVN).[13] This study evaluated the radiographic progression and clinical outcomes in patients with HAAVN subsequent to surgical intervention (core decompression vs arthroplasty) and analyzed the efficacy of these techniques in the context of certain staging criteria and specific AVN etiology (CSI vs SCD).

Studies conducted by Mont et al,[13] LaPorte et al,[8] and Harreld et al[5] on core decompression of stage I and II patients revealed improvements in pain and functional outcomes. Specifically, the Mont et al[13] study reported good to excellent results with core decompression of humeral head AVN in 73% of patients overall, with 100% efficacy in stage I and II disease treatment.[13]

Our study aimed to further investigate those results in our patient population. We implemented a treatment algorithm for SCD and CSI patients with HAAVN and monitored their clinical course. We attempted to stimulate angiogenesis and prevent humeral head collapse by combining standard core decompression with ultrasound bone stimulation in the treatment of stage I and II patients. The addition of ultrasound bone stimulation is theorized to improve revascularization of the treated area, as mentioned in fracture healing and AVN literature; moreover, to our knowledge, the current literature evaluating humeral head core decompression does not include the adjunctive use of bone stimulation to stimulate osteogenesis.[14] The use of resurfacing as a treatment option for stage III patients has minimal published literature, and further research is needed to prospectively evaluate the long-term outcomes of this treatment option. This study used resurfacing as a treatment for stage III patients and arthroplasty for stage IV/V patients in an attempt to analyze the outcome and determine efficacy with these treatment modalities.

The objective of the study was to analyze the effectiveness of the treatment strategy used at our institution. Our AVN study population represents etiology primarily due to CSI osteonecrosis or SCD. Patients with both osteonecrosis etiologies were monitored radiographically and clinically after treatment. We documented radiographic progression and functional outcomes after procedures for HAAVN and determine efficacy of core decompression and arthroplasty treatment algorithm in this select patient population.

Materials and methods

Between 2009 and 2014, 25 shoulders (20 patients) were treated surgically for HAAVN at a single institution by a single surgeon and principal investigator (L.A.C.). Patient recruitment and participation was in accordance with our Institutional Review Board-approved protocols. We included all patients with clinically and radiographically confirmed humeral head osteonecrosis. Inclusion criteria were primarily patients with a history of chronic steroid use due to various etiologies and those with SCD. Post-traumatic AVN patients and patients who had received previous surgical intervention for AVN were excluded.

Damage was classified according to the Cruess classification system using standard 3-view shoulder radiography with the addition of magnetic resonance imaging (MRI) in cases that were early stages or needed further definition for clear classification and treatment stratification.[3] The Cruess classification system stratifies patients into 1 of 5 stages of increasing severity and was used for staging in this study:

- Stage I was defined by radiographs showing no abnormalities and only marrow signal changes on MRI.
- Stage II disease was marked by wedged or mottled sclerosis on plain films but overall maintained sphericity of the humeral head.
- Stage III was identified by subchondral fracturing with frequently associated crescent sign signifying this compromised chondral integrity.
- Stage IV showed further subchondral bone collapse and flattening, with marked loss of humeral head sphericity on plain films.
- Stage V, the final stage of AVN, showed humeral head collapse along with significant deformation and extension of erosion into the glenoid.

Patient MRI and radiographs were reviewed retrospectively and prospectively by 2 independent nonblinded orthopedic surgical residents (J.C.K., J.P.S.) and the primary surgeon (L.A.C.). No patients in our cohort presented significant interobserver disagreement with regard to staged disease after MRI was used for further characterization. Patients received initial standard 3-view shoulder radiographs at the initial presentation and were monitored radiographically at subsequent visits as well as postoperatively.

Patients were treated surgically according to the stage of disease progression and intervention based on our chosen algorithm (Fig. 1) established by the principal investigator (L.A.C.) at our institution and previously detailed.[4] Stage I and II disease patients were treated with core decompression and postoperative ultrasound bone stimulator (EXOGEN 4000 + Ultrasound Bone Healing System; Bioventus, Durham, NC, USA).

Decompression was performed with a standard percutaneous technique as previously described by Harreld et al.[5] A standard 2.7-mm drill bit was used to decompress the humeral head using multiple small-diameter perforations under general anesthesia using fluoroscopic imaging guidance (Fig. 1, *A*). Stage III disease was treated with surface replacement, and stage IV/V shoulders were treated with arthroplasty options to include total shoulder arthroplasty (TSA) or reverse total shoulder arthroplasty (RTSA), based on age and rotator cuff integrity.

Patients received routine postoperative care and therapy regimens. Patients underwent postoperative radiographs and annual follow-up images to monitor the progression and efficacy of the operative intervention. Clinical data scores were obtained preoperatively and annually thereafter on all patients receiving resurfacing or arthroplasty with the following 4 functional and quality-of-life shoulder scoring systems: University of California Los Angles (UCLA) Shoulder Score, Simple Shoulder Test (SST)-12, American Shoulder and Elbow Surgeons (ASES) Shoulder Evaluation Form, and the Constant scores. Statistical analysis was performed to evaluate the mean,

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