Avascular Necrosis of the Proximal Humerus in Adolescents and Young Adults – Treatment and Long-Term Outcomes

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INTRODUCTION: Avascular necrosis (AVN) is a rare, degenerative condition caused by bony necrosis, most commonly of the epiphyseal region of the long bones, ultimately leading to subchondral collapse and degenerative joint disease. Proximal humerus AVN can be minimally painful and initially difficult to diagnose as the impact loading on the shoulder is limited compared to other common sites of AVN like the hip. However, symptoms can progress to pain and eventual reduction in shoulder motion. Currently, there is a dearth of literature regarding the indications for and long-term outcomes of treatments for proximal humerus AVN in the pediatric and young adult population. The purpose of this study is to report on a consecutive series of patients treated at a single institution with this condition, including diagnostic findings, implemented treatments, and long-term outcomes.

METHODS: A retrospective review and cross-sectional outcomes assessment was performed to identify patients with proximal humerus AVN treated at a single pediatric hospital between 2011 to 2021 using ICD-10 coding. Retrospectively studied variables included patient demographics, treatment strategies, and patient outcomes. A cross-sectional survey was then distributed that included patient-reported outcome measures and evaluated patients' definitive shoulder treatment. Descriptive statistics were used to summarize patient characteristics and outcome scores.

RESULTS: We identified 30 shoulders in 21 eligible patients. Patients were 16.9 years old at AVN diagnosis (Table 1) and predominantly male (57%). Diagnosis was prompted by pain in most cases (95%) and was often associated with cancer treatment (57%) and/or steroid use (48%). The vast majority of shoulders were examined with MRI (93%) and identified as Stage II at diagnosis (68%). Shoulders were usually nonsurgically treated at our institution initially. Eleven (52%) completed the cross-sectional outcomes assessment at an average of 7.13 years from diagnosis (Table 2). Notably, only 55.6% of shoulders underwent operative treatment within this time course. PROMIS and American Shoulder and Elbow Surgeons Evaluation (adult and pediatric metrics) score data showed scores within normative ranges for this population.

DISCUSSION AND CONCLUSION: The present study expands upon the limited literature base regarding AVN of the proximal humerus in young patients. This condition was most diagnosed in adolescents with a history of steroid use and/or cancer treatment. Patients were often treated nonsurgically through cross-sectional follow up. Importantly, patients reported functionality and overall outcome scores within normative ranges. These results suggest that nonsurgical treatment is an effective initial management strategy for AVN of the proximal humerus in pediatric patients. Further work is necessary to determine appropriate indications for surgical treatment.

Variable	N (%) or Mean ± SD
Demographics & Patient Characteristics (N = 21 patients)	
Sex	
Male	12 (57.1)
Female	9 (42.9)
Length of Retrospective Follow-Up (years)	2.23 ± 2.7
Race	
Black	7 (33.3)
White	10 (47.6)
Other	4 (19.0)
Hispanic/Latinx	2 (9.5)
Age at Diagnosis (years)	16.92 ± 3.64
Signs/Symptoms at Onset	
Pain	20 (95.2)
Mobility Difficulties	10 (47.6)
Abnormal Imaging	1 (4.8)
Presumed Etiology/Associated Diagnoses	
Cancer & Associated Treatment	12 (57.1)
Sickle Cell Disease	8 (38.0)
Steroid Use	10 (47.6)
Other Underlying Condition	3 (14.3)
Diagnostic Data (N = 30 shoulders)	
Radiographic Imaging at Diagnosis	14 (46.7)
Magnetic Resonance Imaging at Diagnosis	28 (93.3)
MRI-Based AVN Stage at Diagnosis (N = 28)	
I	0
IIa	7 (25.0)
IIb	12 (42.9)
III	9 (32.1)
IV	0
Highest Level of Institutional Treatment (N = 30 shoulders)	
No Treatment/Observation Only	12 (40.0)
Non-Operative Treatment	9 (30.0)
Physical Therapy	7 (77.8)
Steroid Injection	2 (22.2)
Operative Treatment	9 (30.0)
Arthroscopic Chondroplasty	1 (11.1)
Core Decompression/Bone Marrow Grafting	6 (66.7)
Arthroplasty	2 (22.2)
Time from Diagnosis to Surgery (months)	7.37 ± 5.9

Variable	N (%) or Mean ± SD
Demographics & Patient Characteristics (N = 11 patients)	
Age at Diagnosis (years)	16.92 ± 3.64
Age at Survey Response (years)	22.1 ± 4.5
AVN Stage at Diagnosis (by shoulder, N = 14/18 shoulders)	
I	0
IIa	1 (5.6)
IIb	9 (50.0)
III	4 (22.2)
IV	0
Race	
Black	1 (9.0)
White	7 (63.6)
Other	3 (27.3)
Hispanic or Latinx	2 (18.2)
Duration of Cross-Sectional Follow-up from Diagnosis (years)	7.13 ± 3.4
Development of contralateral AVN (N = 8 unilateral at initial diagnosis)	4 (50.0)
Highest Level of Treatment (N = 18 shoulders)	
None/Observation Only	5 (27.8)
Non-Operative Treatment	3 (16.7)
Physical Therapy	3 (100.0)
Steroid Injection	0
Operative Treatment	10 (55.6)
Arthroscopic Chondroplasty	1 (10.0)
Core Decompression/Bone Marrow Grafting	4 (40.0)
Arthroplasty	5 (50.0)
PROMIS Score (N = 11 patients)	
Physical Function	48.5 ± 6.4
Anxiety	49.0 ± 8.0
Depression	47.2 ± 6.7
Fatigue	47.9 ± 9.6
Sleep Disturbance	52.6 ± 7.7
Ability to Participate in Social Activities	53.2 ± 9.5
Pain Interference	53.2 ± 9.5
ASES Score (N = 11 patients)	
ASES Adult Total Score (N = 8)	76.9 ± 18.9
Pedi-ASES Score (N = 3)	51.0 ± 11.3