

Original Research

Radial Head Stress Fracture Nonunion in Adolescent Overhead Athletes: A Case Series

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Abstract

Background: While osteochondritis dissecans of the humeral capitellum is well-described in adolescent overhead athletes, lateral compartment overload may also present with isolated radial head involvement. The primary goals of this study are to present a case series of radial head stress fracture nonunions in adolescent athletes and to provide guidelines regarding surgical indications and treatment. We hypothesize that surgical reduction and fixation of symptomatic lesions is safe, effective, and preserves the stability and articular congruity of the radiocapitellar joint.

Methods: We retrospectively reviewed the clinical and radiographic records of nine patients presenting to a pediatric tertiary care center for radial head stress fracture nonunion from January 2008 to December 2016. Patient characteristics, presenting signs and symptoms, clinical and radiographic features, postoperative elbow motion, and radiographic healing were assessed.

Results: Nine patients (five female; mean age 12.0 years [range 9.3-14.8 years] at time of injury) were treated for symptomatic radial head stress fracture nonunion. All patients reported persistent elbow pain with activities of daily living (ADLs) and athletics. Seven patients had limited elbow range of motion. Radiographically, the nonunion fragments comprised 20-45% of the radial head articular surface, and five patients had concomitant radial head subluxation. Five patients underwent open reduction internal fixation, one patient underwent microfracture and debridement, and one patient underwent intraarticular corrective osteotomy. All operative patients had improved or complete resolution of pain with ADLs. Additionally, all operative patients had either some increase in or complete

regain of full elbow range of motion. Progressive or complete radiographic healing was seen at a median of 14 weeks postoperatively.

Conclusions: In this case series, skeletally immature athletes with radial head stress fracture nonunions experienced pain relief, maintained or improved motion, and radiographic bony union following surgical intervention. Radiocapitellar joint stability and congruity were preserved or restored.

Level of Evidence: Case series; Level IV

Key Concepts

- With increased participation in overhead and/or throwing sports, repetitive valgus stress on the elbow may lead to lateral compartment overload injuries.
- While osteochondritis dissecans (OCD) of the capitellum is well-characterized, isolated radial head stress injuries may also occur.
- Surgical treatment for symptomatic or displaced radial head stress injuries may provide pain relief, bony healing, improved range of motion, and return to sports.
- Patients, families, and providers should be aware of this clinical condition, and surgical treatment should be considered in cases of persistent pain, bony nonunion, displacement, joint instability and/or incongruity.

Introduction

While osteochondritis dissecans (OCD) of the capitellum is a well-described entity in adolescent throwing or overhead athletes, lateral compartment overload may also present with isolated radial head involvement.¹⁻⁵ Existing literature suggests that radial head lesions may present in the presence of a concomitant unstable OCD lesion. It has been suggested that osteochondral autograft transplantation surgery (OATS) may restore range of motion in patients with OCD of the capitellum.⁵ However, limited information is available regarding the clinical presentation, radiographic evaluation, and treatment results for overuse injuries isolated to the proximal radial epiphysis.

The purpose of this study is to present a case series of radial head stress fracture nonunions in adolescent athletes and to share our experience of operative and nonoperative management of this injury. We hypothesize that surgical reduction and fixation of symptomatic lesions can be a safe and effective option in patients who are refractory to conservative management and

preserves the stability and articular congruity of the radiocapitellar joint.

Materials and Methods

A retrospective review of nine patients presenting to a pediatric tertiary care center for radial head stress fracture nonunion between January 2008 and October 2016 was performed following institutional review board approval. A medical record database was queried to identify skeletally immature patients treated for intra-articular repetitive stress injuries of the proximal radial epiphysis. Clinical records were examined to collect patient demographics, preoperative clinical observations, radiographic findings, surgical procedures, postoperative clinical results, and postoperative complications. Subject to their availability, preoperative and postoperative plain radiographs, computed tomography (CT), and/or magnetic resonance imaging (MRI) were reviewed to evaluate lesion size, fragment displacement, joint congruity, secondary articular changes, and bony healing.

Repetitive stress nonunion was defined as a radiographically confirmed fracture line without bony or periosteal bridging on plain radiograph, CT, or MRI in the setting of symptoms lasting greater than 6 months. Surgical indications included fragment displacement causing joint incongruity or instability, or nondisplaced fragments with persistent pain and functional limitations despite prior rest and activity modification.

All statistics are descriptive in nature and were analyzed with Microsoft Excel (Microsoft, Redman, WA). Parametric data is presented as mean (range) and nonparametric data is presented as median [interquartile range (IQR)].

Results

Between January 2008 and December 2016, we treated nine patients with symptomatic radial head stress fracture nonunion. Five patients were female. The average age at time of injury was 12.0 years (range 9.3-14.8 years). Median time interval between injury and presentation to our institution was 7.0 months [IQR 1.1-13.0 months]. Median clinical follow-up from the date of initial presentation was 15.0 months [IQR 11.5-28.9 months]. Individual patient age, sex, primary sport, and handedness are presented in Table 1. All patients

Table 1. Patient Presentation Demographics

	Sex	Age	Sport	Dominant Hand	Affected Side
1	F	12.8	gymnastics	R	L
2	F	13.6	gymnastics	R	L
3	F	15.1	gymnastics	R	L
4	F	12.2	gymnastics	NA	L
5	M	12.5	baseball, golf	L	L
6	M	10.6	baseball	R	R
7	M	14.0	baseball, golf	R	R
8	M	14.8	baseball, tennis	R	R
9	F	9.3	cheerleading	R	L

NA = information not available.

were participating in competitive overhead sports (e.g., gymnastics, baseball) at the time of their injury.

Five patients (55%) recalled a specific inciting injury to the elbow during sport participation, whereas the others described gradual onset of pain. All patients endorsed persistent elbow pain with activities of daily living (ADLs), exacerbated by athletic participation. Six of the nine patients (67%) had limitations with elbow range of motion (Table 2). Seven patients (78%) had tenderness to palpation about the radial head; three (43%) of those patients also had crepitus with elbow flexion-extension and forearm rotation in the absence of other mechanical symptoms.

Radiographically, the intra-articular radial epiphyseal fracture lines were visible on plain radiographs, CT, or MRI (Figure 1). All patients had plain radiographs taken. Two patients (22%) had supplementary CT scans and eight patients (89%) had MRIs. The nonunion fragment comprised 20 to 45% of the total surface area of the articular portion of the radial head, as measured on axial cuts through the radial head on advanced imaging studies. Corresponding capitellar changes were noted in seven patients, including articular cartilage abnormalities and radiolucencies of the capitellar-ossification center (Table 2).

Seven patients (78%) underwent surgical treatment. Average patient age at time of surgery was 12.6 years (range 9.4-15.2 years). The median time interval between initial injury and surgery was 10.1 months [IQR 5.2-20.7 months]. The median duration between first presentation to our institution and the decision to operate was 29 days [IQR 13-50 days]. Five patients underwent open reduction and internal fixation (ORIF), one patient underwent arthroscopic microfracture and debridement, and one patient underwent intra-articular corrective osteotomy (Table 3).

In the patients treated with ORIF, a Kaplan approach was used to visualize the radiocapitellar joint. Full or near-full thickness chondral loss was noted in all patients. Any fibrinous tissue within the nonunion site

Table 2. Preoperative Physical Exam and Radiologic Characteristics

	Preoperative Arc of Elbow Motion (Degrees)	Preoperative Supination-Pronation (Degrees)	Pain	Radial Head Subluxation	% Radial Head Involvement	Fragment Location	Capitellar Changes	Growth Plate
1	0-150	80/80	+	+	40%	antero-lateral	+	closed
2	0-125	80/80	+		40%	postero-medial	+	closed
3	5-140	80/80	+		40%	anterior	+	open
4	0-150	80/80	+	+	45%	lateral	+	open
5	30-120	50/80	+	+	40%	anterior	+	open
6	0-115	0/60		+	40%	antero-medial	+	open
7	0-150	70/80	+	+	20%	anterior	+	open
8	10-110	80/80	+		45%	antero-medial		open
9	0-150	80/80	+		20%	anterior		open

(+) denotes presence of the given clinical/radiographic finding.

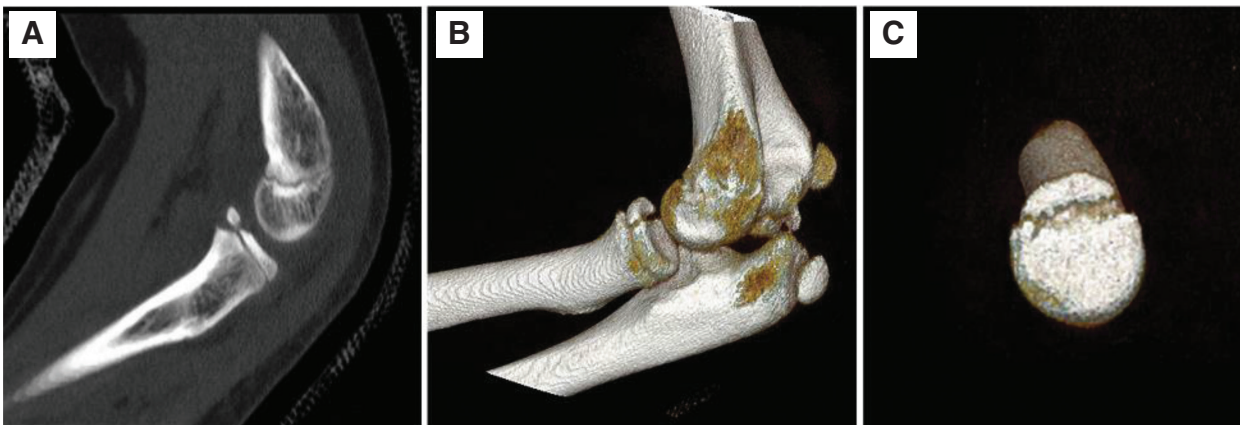


Figure 1. (A) Sagittal CT reconstruction depicting an intra-articular radial head stress fracture nonunion. (B) Three-dimensional CT scan highlighting the anterior location of the marginal radial head lesion. (C) Three-dimensional CT reconstruction with humeral subtraction depicting the small portion of the anterior surface area affected. (Images courtesy of Children’s Orthopaedic Surgery Foundation).

was resected, and the fragment was mobilized and fixed using one or two countersunk 1.3 mm, 1.5 mm, or 2.0 mm headed cortical screws (Synthes, Paoli, PA). Care was taken during the mobilization of the displaced nonunion fragment to preserve the periosteal soft tissue attachments on the periphery of the radial neck. This was done with the intention of preserving the vascularity of the small articular fragment. One ORIF patient required

autologous bone graft from the proximal ulna (see Illustrative Case Example).

Two operative patients presented with intra-articular fracture malunion with articular incongruity and underwent other procedures. The patient who underwent corrective osteotomy was an elite level gymnast presenting 10 months following her inciting injury. She was initially misdiagnosed as a Salter-Harris fracture and

Table 3. Summary of Surgical Treatment for Each Patient in the Series

Treatment	Indication	Implant	Time to Union (weeks)	Post-Operative Pain	Post-Operative Range of Motion	Return to Sport	Follow-up Time
1	ORIF with bone graft	two 1.5 mm screws	7	0/10	full	Yes	4.5 mos
3	Intraarticular corrective osteotomy	two 2.0 mm screws	9	0/10	full	Yes	16.5 mos
4	ORIF	one 1.5 mm screw	17	0/10	full	Yes	15.0 mos
5	ORIF	two 2.0 mm screws	53	0/10	20-130, 80-80	Yes	4.8 yrs
6	Micro-fracture and Debridement	N/A	N/A	3/10 ADLs	full	No	8.4 yrs
7	ORIF	two 2.0 mm screws	11	4/10 end-ROM 0/10 ADLs	0-125, 80-80	No	2.4 yrs
9	ORIF	two 1.3mm screws	26	0/10	full	Yes	14.0 mos

ORIF = open reduction and internal fixation, ADLs = activities of daily living, N/A = not applicable.

was never casted. She had full-thickness chondral and cystic changes affecting 30-40% of the cross-sectional area of the radial head, which was osteotomized. The other patient had radiocapitellar instability and an osteochondral lesion of the capitellum, in addition to an intra-articular fracture malunion. He underwent partial debridement and microfracture of the radial head and capitellum with arthroscopy and removal of the intra-articular loose body.

All surgical patients were immobilized in a bivalved long-arm cast for 3 to 4 weeks postoperatively, followed by physical therapy. Median postoperative clinical follow-up was 14.2 months [IQR 13.5-36.3 months]. No postoperative complications were identified, and all patients demonstrated complete bony healing on follow-up radiographs at a median of 14 weeks after surgery [IQR 10-24 weeks]. One patient had improvement in range of motion but remained limited (20-130 degrees flexion-extension arc; lacking terminal 15-20 degrees supination) despite prolonged physical therapy. Nevertheless, this patient was able to return to baseball and go on to compete at the collegiate level. Two patients were unable to return to sports and had persistent pain. One of these patients discontinued sport participation due to unrelated low back pain and went on to work as a manual laborer (masonry, loading/unloading suitcases from planes at the airport). His persistent pain was low-grade (1-3/10) and bilateral in nature. The last patient had 4/10 pain at terminal elbow extension but 0/10 pain with ADLs. He had persistent 20-25 degrees loss of terminal elbow flexion, and he gave up baseball due to his elbow pain. However, he was able to return to soccer as a goalie. Of note, this patient was initially misdiagnosed at an outside emergency department and did not undergo surgery until 2.3 years after his initial injury.

Two patients were treated nonoperatively; both had advanced imaging which demonstrated nondisplaced fragments without joint subluxation or incongruity. One nonoperative patient was treated with rest over the course of a year, followed by physical therapy for

motion and strengthening. At the time of his 1-year follow-up MRI, there was interval healing and articular congruity with slight irregularity at the articular cartilage surface. The patient reported improved pain and only occasional soreness during sport participation. The other nonoperative patient was recommended ORIF to preserve the integrity of the radiocapitellar joint and prevent further deformity. The patient elected not to undergo surgery and was subsequently lost to follow-up; to our knowledge, this patient did not undergo any surgical treatment at our institution.

Illustrative Case Example (Case No. 1)

A 12-year-old, right-hand-dominant female presented with persistent left elbow pain. She was a level-six gymnast who had been training competitively for 9 years. She reported having an unspecified elbow injury during a competition just over 3 years prior to presentation. Radiographs taken at this time revealed a stress fracture. She was able to resume full gymnastics activities with minimal but persistent pain. However, 1 year prior to presentation, her elbow pain increased

and radiographs at that time revealed a nonunion of the previously identified fracture in the radial head and neck region. She was treated with immobilization but had persistent fracture nonunion. She continued to have 3/10 pain during ADLs and 8/10 pain during gymnastics.

At initial presentation to our institution, a physical exam showed increased valgus-carrying angle on the left elbow without any gross deformity as compared to the right elbow. She was neurovascularly intact with full upper extremity strength. She had normal range of motion (0-150 degrees of flexion-extension and 80-80 degrees of pronation-supination) but experienced pain at terminal elbow flexion and extension. She had tenderness to palpation of the radial head but did not manifest any mechanical symptoms.

Radiographs taken at this presentation demonstrated a radial head stress fracture nonunion, with 40% involvement of the radial head and concomitant capitellar changes (Figure 2A). The distal humeral physes were closed. An MRI showed an anterolateral radial

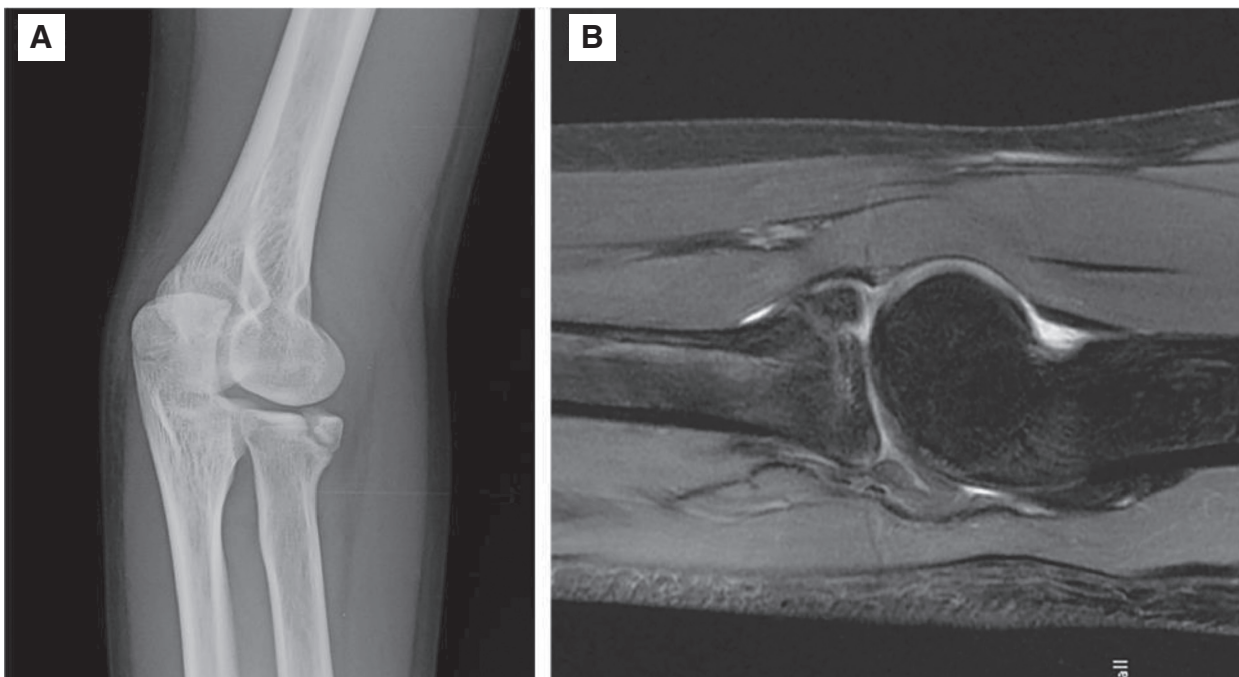


Figure 2. Illustrative case radiology. (A) Preoperative oblique radiograph depicting an intra-articular radial head stress fracture nonunion. (B) Sagittal MRI demonstrates a complete fragment with mild articular incongruity and a reduced radiocapitellar joint. (Images courtesy of Children’s Orthopaedic Surgery Foundation).

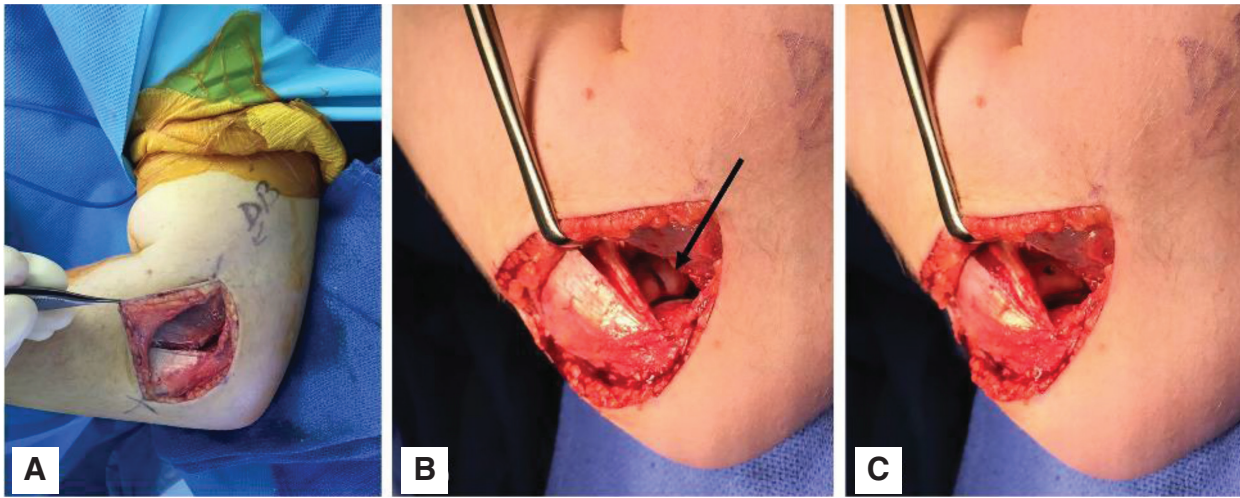


Figure 3. Illustrative case surgery. (A) Intra-operative photograph depicting a lateral incision and use of the Kaplan approach to the radiocapitellar joint. (B) After the joint is exposed, the displaced and unstable fracture fragment (arrow) is visualized. (C) The fragment is reduced and stabilized with countersunk-headed screws. Note the restoration of a congruent articular surface. (Images courtesy of Children's Orthopaedic Surgery Foundation).

head fragment with edema at the radiocapitellar joint (Figure 2B).

The patient underwent ORIF via a Kaplan approach (Figure 3A). There was obvious fibrinous connection and chondral wear of the anterior portion of the radial head and capitellum with full thickness cartilage loss of the radial head (Figure 3B). The nonunion site was debrided, and a 0.035-inch C-wire was used to perforate the cortex. An oval-shaped corticotomy was performed. The fragment was mobilized, reduced, and fixed with two 1.5 mm countersunk screws (Figure 3C), followed by the harvesting of cortical and cancellous bone from the proximal ulna to be used as bone graft. She was discharged with a bivalved, long-arm cast to wear for 4 weeks, as well as a prescription for physical therapy. This was completed at an outpatient facility.

There were no postoperative complications, and the patient had no further complaints of elbow pain. She regained full elbow range of motion and experienced no new mechanical symptoms or tenderness to palpation. Radiographs demonstrated a successful bony union after 7 weeks of postoperative healing (Figure 4). The patient was able to resume participation in competitive gymnastics.



Figure 4. Postoperative radiograph demonstrating bony healing. (Image courtesy of Children's Orthopaedic Surgery Foundation).

Discussion

Overuse injuries of the upper limb are becoming increasingly common in young adolescents. In the overhead throwing or upper extremity weight-bearing

athlete, repetitive lateral compression forces may lead to injuries across the radiocapitellar joint. While OCD of the capitellum is thought to be the most common condition, overuse injuries of the proximal radius may also occur. These typically affect the anterior portion of the radial head, given the loading that typically occurs in 30-45 degrees of elbow flexion.

A review of the published literature revealed only 17 reported cases of “OCD-like” conditions affecting the radial head.¹⁻⁴ In 2009, Dotzis et al. reported on the first case of an adolescent female patient who developed painless swelling after using elbow crutches.² Tatabe et al. described four cases of OCD of the radial head accompanied by radial head subluxation in adolescent male patients.⁴ All patients in that series had onset of symptoms while participating in overhead throwing sports activities, and their lesions were localized posteromedially. The authors posited that poor congruity of the radiocapitellar joint increased mechanical stress on the posteromedial radial head. Wu et al. found that radial head lesions were more commonly seen in the presence of more advanced OCD lesions, most notably Nelson Grade 4 (presence of loose body).⁵ They also noted that more severe OCD lesions were more likely to affect the anterior portion of the radial head. Furthermore, their study highlighted a greater postoperative improvement of mechanical symptoms following an OATS procedure of the capitellum as opposed to drilling or microfracture. This suggests that correction and preservation of the integrity and contour of the radiocapitellar joint may provide relief from mechanical symptoms.

Here we present a series of nine patients with marginal radial head stress fracture nonunions, likely due to lateral compression overload. We believe that radial head stress fracture nonunion and capitellar OCD are entities along the same spectrum of overuse injuries affecting the radiocapitellar joint in children and adolescents (Figure 5). There may be a continuum of injury that ranges from purely capitellar, to capitellar and radial, to purely radial involvement. Factors that influence the anatomic location of the lesion within this continuum

may include patient age, skeletal maturity, vascularity of the developing chondroepiphysis, generalized ligamentous laxity, and sport or technique-specific loading conditions.

Patients with radial head stress fractures typically present with vague lateral elbow pain, mechanical symptoms of locking or crepitus, and limited terminal forearm rotation and/or elbow flexion-extension. However, with increasing athletic demands and emphasis on specialized year-round sports participation, younger patients may dismiss seemingly benign lateral elbow pain, delaying presentation and possible earlier intervention. Careful examination will often elicit tenderness of the proximal radius, which is best appreciated anteriorly with the forearm supinated. Though subtle, plain radiographs will often reveal the small intra-articular stress fracture, and oblique views can be more effective in bringing the fracture fragment into profile (Figure 2A). While CT scans may provide additional diagnostic information, given the large cartilaginous component to these nonunion fragments, our preference is to use MRI to assess lesion size, displacement, healing, joint congruity, and bony edema pattern (Figure 5).

While the natural history of this uncommon condition has not been well characterized, it is believed that these injuries may have limited healing potential due to the repeated compression and shear forces from ADLs and continued sports participation. The intra-articular location and limited vascularity to the radial head are thought to further limit the healing potential of the radial head. Additionally, with persistent nonunion and fragment displacement, the concavity of the radial head and stability of the radiocapitellar joint may be compromised. This could lead to persistent symptoms, loss of joint containment, and ultimately posterior subluxation of the radial head (Figure 6). In rare cases, the nonunion fragment may unite in a displaced position, resulting in a bony malunion and persistent lack of proximal radial articular congruence.

Given these concerns, it is proposed that the treatment should be based on the degree of displacement and joint

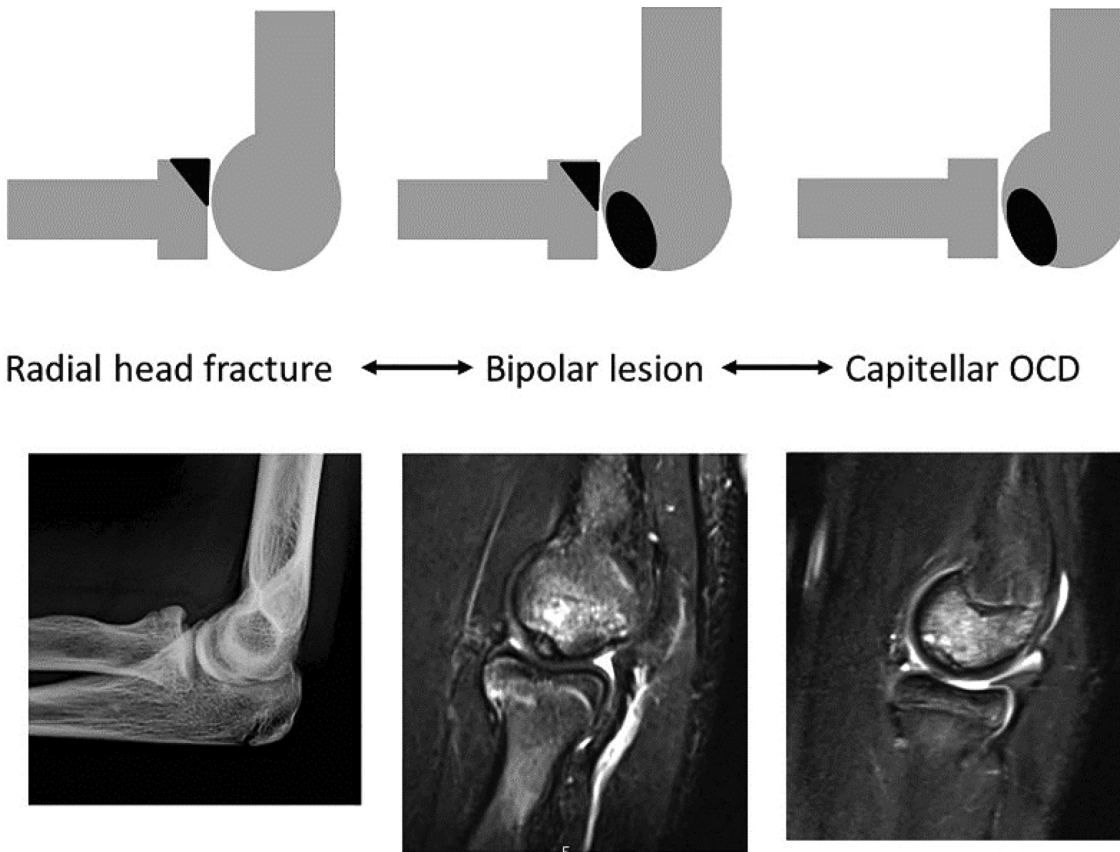


Figure 5. Schematic diagram and illustrative radiographic examples of the spectrum of radiocapitellar joint overuse injuries. (Images courtesy of Children’s Orthopaedic Surgery Foundation).

congruency. Non-displaced lesions (Types I and II) may be treated nonoperatively, but they should be monitored via serial radiographic imaging to ensure preserved joint alignment and bony healing (Figure 6). For displaced/misaligned lesions (Types III and IV), surgery is indicated as these are unlikely to achieve anatomic bony healing and joint congruity without intervention. Surgical treatment may also be considered for nondisplaced Type II lesions with unresolved pain and persistent radiographic nonunion despite prolonged rest and activity modification.

The goals of surgical treatment are to achieve bony union, reconstitute a smooth proximal radial articular surface, and maintain radiocapitellar joint stability. A Kaplan approach is advantageous in obtaining adequate access and exposure, given the anterior location of the majority of these lesions. Meticulous fragment

identification and mobilization are necessary to achieve a reduction that preserves the periosteal blood supply, minimizing the risk of iatrogenic osteonecrosis. Stable internal fixation will allow for early elbow range of motion and maximize bony healing potential. Typically, this is achieved using appropriately sized, countersunk-headed screws.

The patients in the currently described case series experienced pain relief, maintained or improved motion, and showed radiographic evidence of bony union following surgical reduction and stabilization. Perhaps more notably, joint stability and congruity were either preserved or restored in all cases, increasing the potential longevity of the radiocapitellar joint by maintaining its optimal function. The main limitation of our study is that our cohort is small and heterogenous with variable follow-up times. Extended follow-up

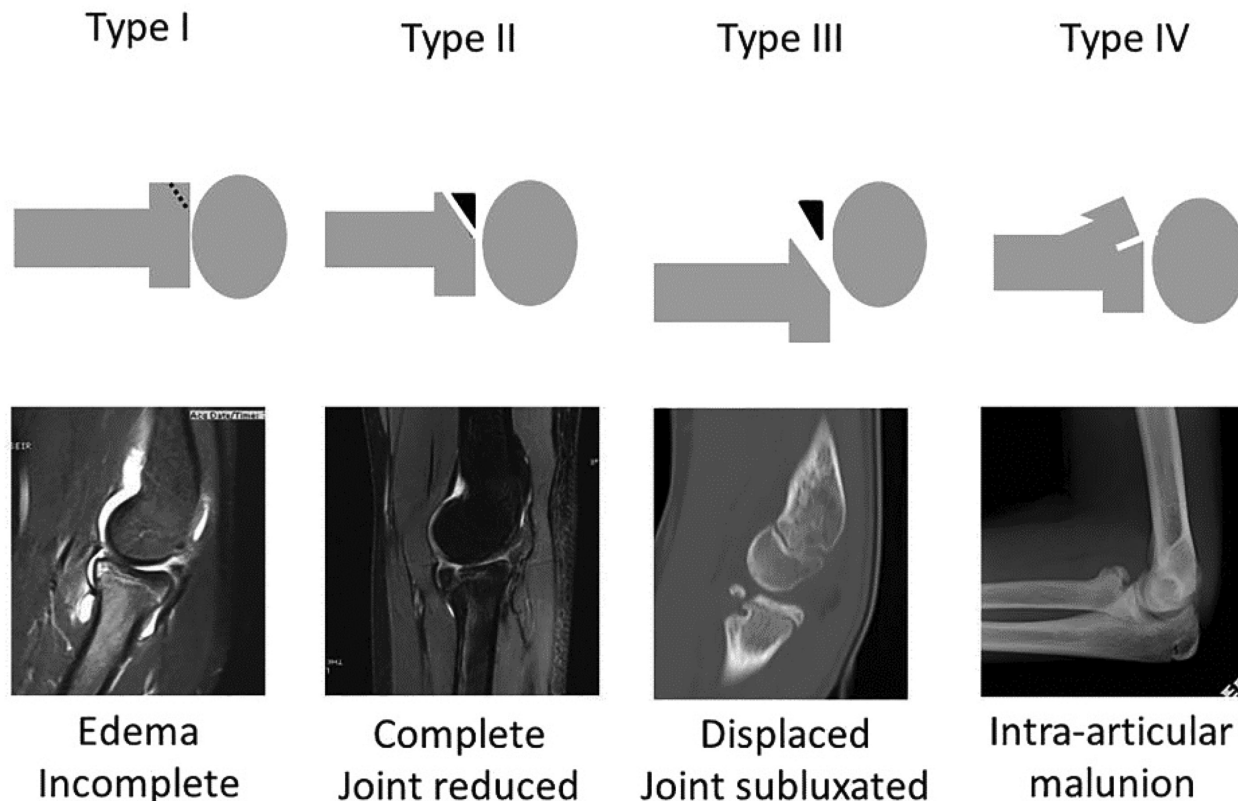


Figure 6. Proposed classification of intra-articular radial head stress fractures. Type I injuries may be radiographically occult, though MRI will demonstrate edema and cortical irregularities. Type II lesions are complete fractures with varying displacement, though the radiocapitellar joint remains congruently reduced. Type III injuries are established nonunions associated with radiocapitellar joint subluxation. Type IV variants denote intra-articular stress fractures which heal in a displaced position, resulting in bony malunion and articular incongruity. (Images courtesy of Children’s Orthopaedic Surgery Foundation).

on a greater number of patients is needed to better characterize the pathogenesis and natural history of these nonunions. Clarity on the natural history of this pathology will also help surgeons determine timing of operative management for these nonunions. Furthermore, additional research characterizing the comparative outcomes of operative vs. nonoperative management is needed to further illuminate the long-term benefits of undergoing surgical treatment.

Conclusion

This case series presents our experience with radial head stress fracture nonunions as a spectrum of injury of radiocapitellar OCD in adolescent athletes. All patients who underwent surgery had improved results in pain and function with high rate of return to sports postoperatively. Patients, families, and providers should be aware of

this clinical condition, and surgical treatment should be considered in cases of persistent pain, bony nonunion, displacement, joint instability and/or incongruity.

Additional Links

- *Orthopaedic Journal of Sports Medicine*: [Radial Head Changes in Osteochondritis Dissecans of the Humeral Capitellum](#), Mark Wu, BS; Katherine Eisenberg, BS; Kathryn Williams, MS; Donald S. Bae, MD
- POSNAcademy: [Autologous Osteochondral Grafting for Osteochondritis Dissecans of the Elbow](#), Evan Zheng, BA; Aimee Choi, MS; Donald S. Bae, MD; Boston Children’s Hospital

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Disclaimer

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