E-ISSN: 2707-8353
P-ISSN: 2707-8345
IJCRO 2022; 4(1): 79-83
Received: 12-11-2021
Accepted: 03-01-2022

Jonathan Boyce
Department of Orthopaedic Surgery and Sports Medicine, Temple University Hospital, Doctorate of Medicine, 3401 North Broad Street, Philadelphia, Pennsylvania, United States

Joshua Luginbuhl
Department of Orthopaedic Surgery and Sports Medicine, Temple University Hospital, Doctorate of Medicine, 3401 North Broad Street, Philadelphia, Pennsylvania, United States

Ryan Judy
Department of Orthopaedic Surgery and Sports Medicine, Temple University Hospital, Doctorate of Medicine, 3401 North Broad Street, Philadelphia, Pennsylvania, United States

Hesham Abdelfattah
Department of Orthopaedic Surgery and Sports Medicine, Temple University Hospital, Doctorate of Medicine, 3401 North Broad Street, Philadelphia, Pennsylvania, United States

Corresponding Author:
Ryan Judy
Department of Orthopaedic Surgery and Sports Medicine, Temple University Hospital, Doctorate of Medicine, 3401 North Broad Street, Philadelphia, Pennsylvania, United States

Humeral shaft fractures in overhead throwing athletes: A case series

Jonathan Boyce, Joshua Luginbuhl, Ryan Judy and Hesham Abdelfattah

DOI: https://doi.org/10.22271/27078345.2022.v4.i1b.97

Abstract
Humeral shaft fractures occurring in athletes exposed to repetitive overhead throwing are a rare but recognized phenomenon. Thrower's fractures are most frequently seen in baseball but are also documented in other activities such as javelin and grenade throwing. There are many biomechanical studies and retrospective cohort studies supporting explanations for mechanism of injury but little data exists to support surgical intervention and post-operative functionality after the injury occurs.
This case series examines the treatment and management of three baseball players who suffered thrower's fractures. Three Caucasian recreational male athletes in their mid-20s presented with thrower's fractures. None had prodromal symptoms. All were neurovascularly intact upon presentation and underwent open reduction internal fixation within 2 weeks of the injury. Follow-up time for each patient was variable but occurred as early as 3 weeks and as late as 3 months.
Humeral shaft fractures from atraumatic overhead throwing can be considered rare stress fractures often preceded by prodromal pain. Radial nerve palsy is a potential complication of humeral shaft fractures. While the traditional treatment for humeral shaft fractures has been functional bracing, over the last decade surgical management has increased. Young, active patients with humeral fractures due to throwing related activities respond positively to early surgical intervention with plate fixation. Because the demographic of those with thrower's fractures tends to be young, active males, we advocate for surgical fixation unless underlying medical conditions preclude the patient from surgery. This investigation supports recent literature promoting the operative fixation of not just humeral shaft fractures, but also thrower's fractures. It is one of the largest examinations of thrower's fractures to date.

Keywords: Humeral shaft fractures, phenomenon, injury occurs

Introduction
Humeral shaft fractures occurring in athletes exposed to repetitive overhead throwing motions is a rare but recognized phenomenon. The incidence of humerus fractures in the general population is approximately 13 per 100,00 people per year with most being secondary to trauma in young men (<17) [18, 24]. The incidence of humerus fractures from atraumatic throwing is much lower and most of the literature is in the form of case reports. Not surprisingly, Ogawa and Yoshida showed that the most common demographic for thrower's fractures were also younger males [29]. Thrower's fractures are frequently seen in the sport of baseball but are also documented in other sports and activities such as javelin and grenade throwing [25]. The goal of this case series is to review the biomechanics leading to fracture, discuss current management principles, address common complications, and examine the author's treatment of these rare cases.
There are several theories as to why this injury occurs in this demographic. The first theory attributes this type of fracture to the violent biomechanics that come with forcefully throwing an object. The throwing cycle is broken down into 6 phases: wind-up, stride, arm-cocking, arm acceleration and follow-through (Fig 1). During late-cocking and early acceleration, the humerus is subjected to a significant amount of torsional stress due to internal rotation pull of the subscapularis, latissimus dorsi, and pectoralis major. This force starts proximally and is transmitted down an already externally rotated arm which creates a transition point of opposing forces leading to fracture [19, 24, 33]. This theory, however, fails to explain certain fracture patterns and instances where fractures occur with minimal effort.
An alternative explanation, which accounts for this limitation, faults deconditioning of the humerus as the main cause for fracture.

This explanation is compelling as it has been shown that thrower's fractures are more likely to occur in amateur athletes with improper conditioning and a lesser degree of cortical adaptation, compared to those with an increase in bone mass when throwing is performed regularly [37, 39]. In these cases, the torsional force needed to produce a fracture is much less. Patients may present with disuse muscular atrophy or prodromal arm pain in these instances.

The primary complication associated with humeral shaft fractures is neurovascular injury. There is a predisposition for injury to the radial nerve with a ball thrower's fracture because of its anatomical location in the spiral groove. Perturbations in the winding course of the radial nerve as it wraps around the cylindrical shaped humerus makes the nerve susceptible to traction or laceration injuries when the humerus fractures. The prevalence of radial nerve palsy increases as the fracture site moves distally in the humerus, with a prevalence rate of 2% in the proximal third, 15% in the middle third and 24% in the distal third. Though radial nerve injury is a serious sequelae of humerus fractures, it is not a contraindication to functional bracing. Surgical exploration is indicated in open fractures and palsies that do not resolve in 3-6 months.

Humeral shaft fractures can be managed both surgically and nonsurgically. The traditional treatment for humeral shaft fracture is functional bracing [5, 21, 38]. Sarmiento et al demonstrated good functional outcomes with union rates approaching 96% with functional bracing alone. They also proved that there was no statistically significant difference in functional outcomes when compared with surgical treatment groups [10, 15]. Recent nonsurgical nonunion rates challenge this, ranging from 23%-33% as compared to 4%-10% for surgical intervention [43]. Nonsurgical treatment is also associated with a high conversion rate to surgery [38]. Surgical management with open reduction internal fixation has increased 13.1% over the last decade, especially in younger patients [26, 34]. Surgical management is preferred if important contraindications to functional bracing exist, including open fractures, vascular injury, unacceptable angulation, or more recently, thrower's fractures. Operative treatment of thrower's fracture has been shown to reduce time to return to sport, at 13.5 in the operative group versus 22.6 weeks in the non-operative group [1].

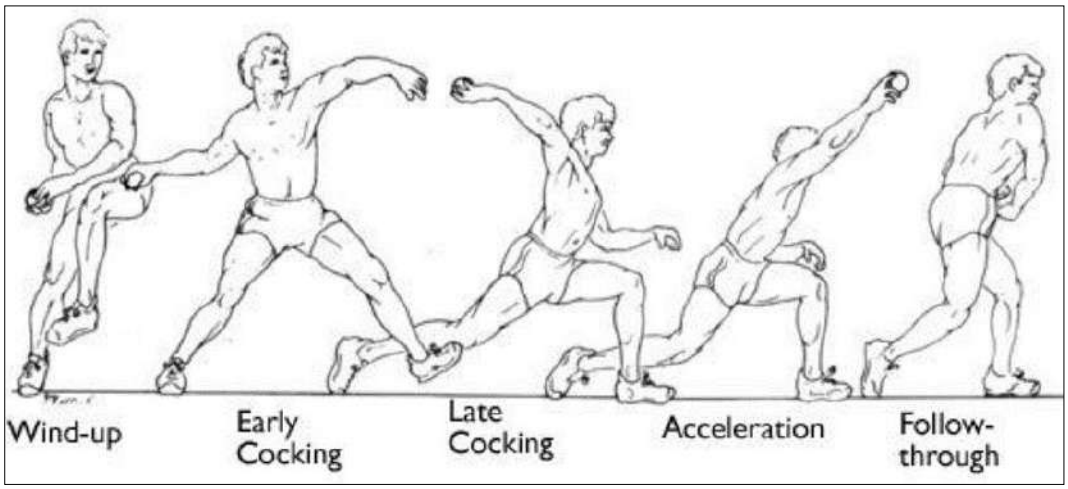

Fig 1: The throwing cycle

Materials and Methods

We performed a multicenter retrospective review to investigate three consecutive patients presenting with thrower' fractures. Study inclusion criteria included the presence of a thrower's fracture in an otherwise healthy patient stable for surgery. Definitive management of all fractures was obtained with open reduction internal fixation. All surgeries were performed by the senior author (H.A.). Three patients were treated, all male, with open reduction and internal fixation of the fragments using a posterior approach. All patients were treated within 2 weeks of injury. Postoperatively, each patient was evaluated clinically by their treating surgeon. All procedures were performed in compliance with institutional guidelines and all appropriate institutional committees approved them. Informed consent was obtained for all procedures.

Results

Case 1: 27 year-old right hand dominant male graphic designer presents with right arm pain after he felt a pop while throwing a baseball. He denied any prodromal pain. Post injury radiographs revealed distal third spiral humeral shaft fracture (Fig 2). He was neurovascularly intact on exam with no evidence of radial nerve palsy. Both nonoperative and operative management was discussed with the patient. The patient ultimately underwent open reduction and internal fixation using plate and screws through a posterior triceps sparing approach 8 days after injury. Post-operative course was uneventful at 6 weeks and he was not seen again until 18 months after surgery for medial arm pain after working out. He was thought to have triceps tendonitis which was treated with anti-inflammatory medication and activity modification.

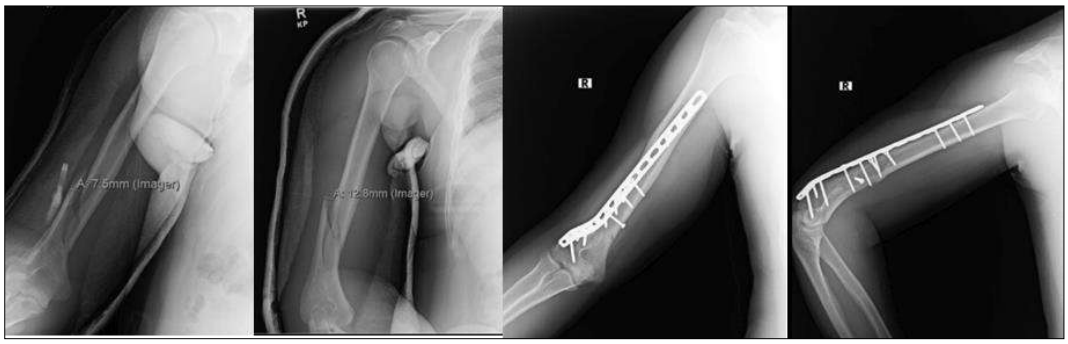

Fig 2: Post-injury and post-operative radiographs of case 1

Case 2: 26 year-old right hand dominant male who presented to clinic with right arm pain after throwing a baseball and hearing a loud pop. He denied any prodromal arm pain but did start playing baseball a couple of months ago after a long hiatus. Radiographs demonstrated a spiral humeral shaft fracture (Fig 3). Patient was neurovascularly intact on exam. Patient underwent open reduction and internal fixation 3 days after injury. He did well post operatively and had follow up of 3 months. At that time, the fracture was completely healed with no hardware complication on radiographs. The patient developed shoulder soreness with overhead activities which was treated with steroid injection into proximal biceps tendon.

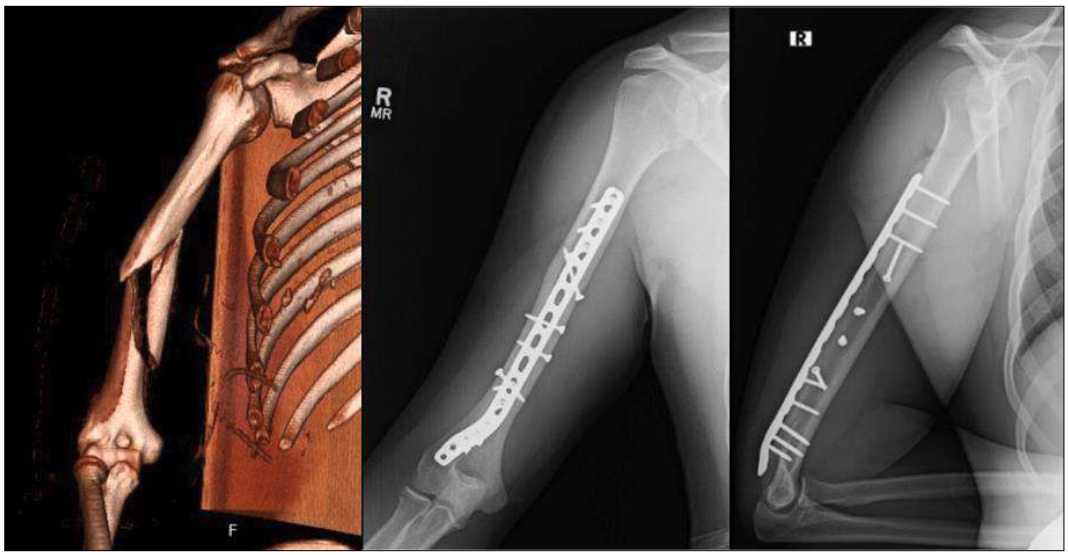

Fig 3: Post-injury and post-operative radiographs of case 2

Case 3: 26 year-old right hand dominant male barber presents to the emergency department with acute right arm pain after throwing a softball. He was found to have a right humeral shaft fracture with a butterfly fragment (Fig 4). He had no neurological deficits and was placed in a coaptation splint. Patient then underwent open reduction and internal fixation of humeral shaft fracture with plate and screws through a triceps split approach 10 days after injury. The patient was observed overnight in the hospital and was discharged postoperative day one in stable condition. He was seen in clinic 3 weeks postoperatively and was subsequently lost to follow up. At that visit, the incision was well approximated and he was neurovascularly intact.

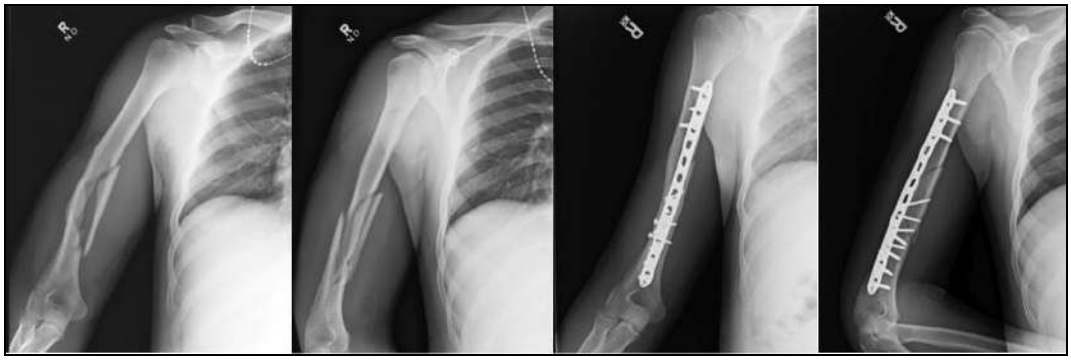

Fig 4: Post-injury and post-operative radiographs of case 3

Discussion

Overhead throwing is an uncommon mechanism for humerus fractures. In the cases presented above, all were recreational male athletes in their mid 20s who presented with thrower's fractures. None of the patients had prodromal symptoms. All were neurovascularly intact upon presentation and underwent open reduction and internal fixation within 2 weeks of injury.

As stated previously, a concerning complication associated with humeral shaft fractures is neurovascular injury. Though rare, there are case reports of radial nerve palsies secondary to humerus fractures caused by playing tennis, grenade throwing, javelin throwing, and dodgeball [2, 8, 14, 3, 6, 8, 9, 12-14, 17, 23, 25, 29, 37, 41, 42]. The radial nerve has a propensity to be injured after a thrower's fracture because it wraps around the humerus in the spiral groove directly adjacent to the cortex, making it susceptible to traction, laceration, compression, or contusion by fracture fragments [26, 43]. The prevalence of radial nerve palsy increases as the fracture site moves distally in the humerus, with a prevalence rate of 2% in the proximal third, 15% in the middle third, and 24% in the distal third [36]. Typically, treatment of the fracture itself is generally all that is necessary for proper healing of the nerve. However, in cases of open fracture or where the nerve does not show recovery in 3-6 months, surgical exploration is indicated. In the previously presented cases, no radial nerve palsies were observed before or after surgery.

The traditional treatment option for humeral shaft fracture is functional bracing [5, 21, 38]. Sarmiento et al demonstrated that bracing achieve good functional outcomes, similar to those treated surgically, with union rates approaching 96% [10, 15]. Recent data has questioned this claim, and over the last decade surgical management with open reduction and internal fixation has increased 13.1% [26, 34]. Surgical management is indicated in open fractures, vascular injury, or unacceptable alignment. The presence of radial nerve palsy is not an indication for open reduction and internal fixation. Many radial nerve injuries recover with time, however, several current studies have shown that surgical exploration has a higher likelihood of regaining radial nerve function as compared to nonsurgical treatment [22, 27, 31, 43].

Definitive fracture fixation can be accomplished using external fixation, plates and screws, or intramedullary implants. Utilization of direct compression plates for absolute stability is ideal especially if minimal cosmetic deformity is desired [38]. Other methods such as intramedullary nail fixation have been studied but results have shown suboptimal outcomes when compared to plating techniques [15, 28, 30, 40]. Importantly, shoulder pain is often reported following intramedullary fracture fixation due to rotator cuff violation during the procedure. This sequela is less than ideal in patients who participate in activities requiring overhead motion.

Despite recent trends towards surgical fixation for humerus fracture in young and active males, operative intervention does not come without risks like secondary radial nerve palsy [1, 16, 20, 32]. The incidence of iatrogenic nerve palsy has been reported between 6% and 32% [4, 7, 11]. Higher rates are seen during the use of external fixators and the lateral approach during fracture fixation [7, 35]. All of the cases presented underwent open reduction and internal fixation with no apparent complications. We advocate for surgical fixation of thrower's fractures unless there are underlying medical conditions precluding the patient from surgery.

Conclusion

In summary, humeral shaft fractures from atraumatic overhead throwing can be considered rare stress fractures often preceded by prodromal pain. Radial nerve palsy is a potential complication of humeral shaft fractures, although it is not an indication for surgical fixation in the general population. Because the demographic of those with thrower's fractures tends to be young, active males, we advocate for exploration and fracture fixation in the setting of radial nerve injury. In the absence of radial nerve palsy, conservative treatment with functional bracing can be considered, however, we prefer open reduction and internal fixation in these cases as well.

Acknowledgements

The authors declare there are no conflicts of interest. Funding for this project was provided by the Department of Orthopaedic Surgery and Sports Medicine Summer Research Program at Temple University Hospital

References

1. Belayneh R, Lott A, Haglin J, Konda S, Leucht P, Egol K. Final outcomes of radial nerve palsy associated with humeral shaft fracture and nonunion. J Orthop Traumatol. 2019;20:18
2. Bontempo E, Trager SL. Ball thrower's fracture of the humerus associated with radial nerve palsy. Orthopedics. 1996;19:537-540
3. Branch T, Partin C, Chamberland P, Emeterio E, Sabetelle M. Spontaneous fractures of the humerus during pitching. A series of 12 cases. Am J Sports Med. 1992;20:468-470
4. Bumbasirevic M, Lesic A, Bumbasirevic V, Cobeljic G, Milosevic I, Atkinson HD. The management of humeral shaft fractures with associated radial nerve palsy: a review of 117 cases. Arch Orthop Trauma Surg. 2010;130:519-522.
5. Chang G, Ilyas AM. Radial Nerve Palsy After Humeral Shaft Fractures: The Case for Early Exploration and a New Classification to Guide Treatment and Prognosis. Hand Clin. 2018;34:105-112.
6. Chao SL, Miller M, Teng SW. A mechanism of spiral fracture of the humerus: a report of 129 cases following the throwing of hand grenades. J Trauma. 1971;11:602-605
7. Claessen FM, Peters RM, Verbeek DO, Helfet DL, Ring D. Factors associated with radial nerve palsy after operative treatment of diaphyseal humeral shaft fractures. J Shoulder Elbow Surg. 2015;24:e307-311
8. Curtin P, Taylor C, Rice J. Thrower's fracture of the humerus with radial nerve palsy: an unfamiliar softball injury. Br J Sports Med. 2005;39:e40
9. DiCicco JD, Mehlman CT, Urse JS. Fracture of the shaft of the humerus secondary to muscular violence. J Orthop Trauma. 1993;7:90-93
10. Ekholm R, Adami J, Tidermark J, Hansson K, Tornkvist H, Ponzer S. Fractures of the shaft of the humerus. An epidemiological study of 401 fractures. J Bone Joint Surg Br. 2006;88:1469-1473
11. Hak DJ. Radial nerve palsy associated with humeral shaft fractures. Orthopedics. 2009;32:111

12. Helm RH, Stuart P. Fracture of humerus during use of an arm wrestling machine. Br Med J (Clin Res Ed). 1986;293:1644
13. Hennigan SP, Bush-Joseph CA, Kuo KN, Bach BR Jr. Throwing-induced humeral shaft fracture in skeletally immature adolescents. Orthopedics. 1999;22:621-622
14. Hufner A, Dodt C. Spiral Fracture of the Humerus after a Tennis Serve. Dtsch Arztebl Int. 2017;114:138
15. Jawa A, McCarty P, Doornberg J, Harris M, Ring D. Extra-articular distal-third diaphyseal fractures of the humerus. A comparison of functional bracing and plate fixation. J Bone Joint Surg Am. 2006;88:2343-2347
16. Kakazu R, Dailey SK, Schroeder AJ, Wyrick JD, Archdeacon MT. Iatrogenic Radial Nerve Palsy After Humeral Shaft Nonunion Repair: More Common Than You Think. J Orthop Trauma. 2016;30:256-261
17. Kaplan H, Kiral A, Kuskucu M, Arpacioglu MO, Sarioglu A, Rodop O. Report of eight cases of humeral fracture following the throwing of hand grenades. Arch Orthop Trauma Surg. 1998;117:50-52.
18. Karl JW, Olson PR, Rosenwasser MP. The Epidemiology of Upper Extremity Fractures in the United States, 2009. J Orthop Trauma. 2015;29:e242-244.
19. Kugelman DN, Frankel VH, Baker A, Egol K. A Recurrent Stress Fracture of the Humerus following Fixation: The Effect of Implant Stress Shielding. J Orthop Case Rep. 2019;9:3-6
20. Lang NW, Ostermann RC, Arthold C, Joestl J, Platzer P. Retrospective case series with one year follow-up after radial nerve palsy associated with humeral fractures. Int Orthop. 2017;41:191-196
21. Liu GY, Zhang CY, Wu HW. Comparison of initial nonoperative and operative management of radial nerve palsy associated with acute humeral shaft fractures. Orthopedics. 2012;35:702-708.
22. Mangan JJ, Graham J, Ilyas AM. Radial Nerve Palsy Recovery With Fractures of the Humerus: An Updated Systematic Review. J Am Acad Orthop Surg, 2019. 10.5435/jaaos-d-18-00142
23. Mayfield CK, Egol KA. Humeral Fractures Sustained During Arm Wrestling: A Retrospective Cohort Analysis and Review of the Literature. Orthopedics. 2018;41:e207-e210.
24. Miller A, Dodson CC, Ilyas AM. Thrower's fracture of the humerus. Orthop Clin North Am. 2014;45:565-569.
25. Morgenstern KD, Barinaga G, Cagle PJ Jr. Thrower's Fracture of the Humerus: An Investigation of Risk Factors Following an Unlikely Scenario: A Case Report. JBJS Case Connect. 2017;7:e35
26. Nachef N, Bariatinsky V, Sulimovic S, Fontaine C, Chantelot C. Predictors of radial nerve palsy recovery in humeral shaft fractures: A retrospective review of 17 patients. Orthop Traumatol Surg Res. 2017;103:177-182.
27. Noaman H, Khalifa AR, El-Deen MA, Shiha A. Early surgical exploration of radial nerve injury associated with fracture shaft humerus. Microsurgery. 2008;28:635-642
28. O'Toole RV, Andersen RC, Vesnovsky O, Alexander M, Topoleski LD, Nascone JW, *et al*. Are locking screws advantageous with plate fixation of humeral shaft fractures? A biomechanical analysis of synthetic and cadaveric bone. J Orthop Trauma. 2008;22:709-715
29. Ogawa K, Yoshida A. Throwing fracture of the humeral shaft. An analysis of 90 patients. Am J Sports Med. 1998;26:242-246
30. Ouyang H, Xiong J, Xiang P, Cui Z, Chen L, Yu B. Plate versus intramedullary nail fixation in the treatment of humeral shaft fractures: an updated meta-analysis. J Shoulder Elbow Surg. 2013;22:387-395.
31. Pailhe R, Mesquida V, Rubens-Duval B, Saragaglia D. Plate osteosynthesis of humeral diaphyseal fractures associated with radial palsy: twenty cases. Int Orthop. 2015;39:1653-1657
32. Rasulic L, Savic A, Vitosevic F, Samardzic M, Zivkovic B, Micovic M, *et al*. Iatrogenic Peripheral Nerve Injuries-Surgical Treatment and Outcome: 10 Years' Experience. World Neurosurg. 2017;103:841-851.e846.
33. Sabick MB, Torry MR, Kim YK, Hawkins RJ. Humeral torque in professional baseball pitchers. Am J Sports Med. 2004;32:892-898.
34. Schoch BS, Padegimas EM, Maltenfort M, Krieg J, Namdari S. Humeral shaft fractures: national trends in management. J Orthop Traumatol. 2017;18:259-263.
35. Schwab TR, Stillhard PF, Schibli S, Furrer M, Sommer C. Radial nerve palsy in humeral shaft fractures with internal fixation: analysis of management and outcome. Eur J Trauma Emerg Surg. 2018;44:235-243.
36. Shao YC, Harwood P, Grotz MR, Limb D, Giannoudis PV. Radial nerve palsy associated with fractures of the shaft of the humerus: a systematic review. J Bone Joint Surg Br. 2005;87:1647-1652.
37. Tullos HS, Erwin WD, Woods GW, Wukasch DC, Cooley DA, King JW. Unusual lesions of the pitching arm. Clin Orthop Relat Res. 1972;88:169-182.
38. Updegrove GF, Mourad W, Abboud JA. Humeral shaft fractures. Journal of Shoulder and Elbow Surgery. 2018;27:e87-e97
39. Warden SJ, Bogenschutz ED, Smith HD, Gutierrez AR. Throwing induces substantial torsional adaptation within the midshaft humerus of male baseball players. Bone. 2009;45:931-941
40. Wen H, Zhu S, Li C, Chen Z, Yang H, Xu Y. Antegrade intramedullary nail versus plate fixation in the treatment of humeral shaft fractures: An update meta-analysis. Medicine (Baltimore). 2019;98:e17952.
41. Weseley MS, Barenfeld PA. Ball throwers' fracture of the humerus. Six case reports. Clin Orthop Relat Res. 1969;64:153-156.
42. Wicks ED, White AE, Marshall S, Hadley CJ, Dodson CC. Missed Thrower's Fracture of the Humerus in a Pediatric Athlete: A Case Report. J Emerg Med. 2018;55:547-552.
43. Yorukoglu AC, Demirkan AF, Buker N, Akman A, Ok N. Humeral shaft fractures and radial nerve palsy: early exploration findings. Eklem Hastalik Cerrahisi. 2016;27:41-45.