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The arcuate fracture: A descriptive radiographic study

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ABSTRACT

Purpose: To assess plain radiographic morphology of arcuate fractures in order to identify patterns and help shape treatment algorithm for proximal fibula fracture.
Methods: A search of radiographic reports at a level 1 trauma center from 2014 to 2016 using MONTAGE search software for the phrases "arcuate fracture", "fibular head avulsion", or "fibular head fracture" was conducted. Descriptive measurements were obtained including dimensions of the fragment, the displacement of the fragment from its anatomic position, and the orientation of the primary fracture line relative to the axis of the fibular diaphysis in both the sagittal and coronal plane. After review of the measurements and radiographs, fracture patterns were assessed based off previous knowledge previous knowledge of posterior lateral corner (PLC) anatomy.
Results: Radiographic reports of 48 knees (48 patients) met inclusion criteria. The distance of fractures from the proximal aspect of the fibula averaged 9.25 ± 5.53 mm on AP radiographs, and 9.42 ± 4.89 mm on lateral radiographs. The medial-to-lateral width of the proximal fragment averaged 20.09 ± 7.94 mm on AP radiographs, while the anterior-to-posterior width measured on lateral radiographs averaged 17.53 ± 8.48 mm. Orientation of the primary fracture line was calculated at an average of $23.04 \pm 14.95^{\circ}$ from the perpendicular on the AP view, and $21.55 \pm 17.44^{\circ}$ from the perpendicular on the lateral. Maximal displacement at the primary fracture line on the AP view was 4.95 ± 8.49 mm). Maximal displacement on the lateral measured 3.98 ± 7.01 mm. Recurring fracture patterns were identified and described. Assessment revealed 11 (22.9%) pattern 1 fractures, six (12.5%) pattern 2 fractures, 31 (64.58%) pattern 3 fractures, possibly correlating with anatomical features and fracture mechanism.
Conclusions: These measurements and recurring patterns in our study shows the heterogeneity of the size and displacement of these fracture fragments and demonstrates the need for further studies in order to create an anatomic descriptive classification for arcuate fractures, which could be used for clinically for treatment.

Introduction

Proximal fibula avulsion fractures can occur during isolated knee injuries or as a component of complex knee trauma and multiligament injuries. Plain radiograph evaluation may demonstrate a fleck of bone superiorly displaced from the fibula, the so called "arcuate sign" [1]. The arcuate sign as seen on plain radiographs as a fracture of the proximal fibula represents an injury to the posterior lateral corner (PLC) of the knee, a primary stabilizer of varus stress, external tibial rotation, and posterior tibial translation [2]. The PLC is composed of fibular collateral ligament (FCL), biceps femoris tendon (BFT), popliteus tendon, and the arcuate complex which consists of the popliteofibular ligament, the arcuate ligament, and the variably present fabellofibular ligament [3–7].

Historically PLC injuries have been frequently overlooked, however it is now recognized that these injuries comprise up to 16% of all ligamentous knee injuries [8]. The radiographic finding referred to as the "arcuate sign" or "arcuate fracture" was coined by Shindell in 1984 who originally described it as an avulsed fibular styloid fragment related to the insertion site of the arcuate complex [1]. Failing to identify these injuries can lead to chronic

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posterolateral instability of the knee and increase the risk for failure of associated anterior cruciate ligament reconstructions.

Clinically, avulsions of the proximal fibula can be highly variable, and the literature is inconsistent when using the term "arcuate sign". In general, the term is often applied broadly to include small fractures of the fibular head signifying any injury to the structures of the PLC of the knee. Huang et al performed a radiographic study evaluating patients with traumatic knee injuries, identifying arcuate injuries in only 13 patients according to strict definitions. According to the authors, the fracture fragment typically involved the styloid process of the fibular head, and was described as horizontal in orientation, ranging from 8 to 10 mm in length and 2 to 5 mm in width [9]. Concomitant injuries were found to be common, with all 13 patients having an associated posterior cruciate ligament injury, 7 having lateral collateral ligament injuries, and 1 having a popliteal tendon injury. Ten of these patients underwent operative intervention.

The primary goal of this study is to accurately define radiographically fractures of the proximal fibula with regard to size, position, and displacement. Additionally, we hypothesize that there may be recurring identifiable fracture patterns correlating to anatomical features which may used to guide further research and surgical decision-making.

Methods

Appropriate institutional review board approval for a retrospective chart review was obtained., and a search for patients with proximal fibula fractures presenting to a level 1 urban tertiary care hospital from January 2014 to December 2016 was conducted. Inclusion criteria were defined as patients greater than 16 years of age with radiographs of the knee joint. A search of radiographic reports using MONTAGE search software (Nuance, Burlington, MA) including the phrases "arcuate fracture", "fibular head avulsion", or "fibular head fracture" was conducted. Exclusion criteria included isolated fractures of the fibular neck; evidence of prior surgical intervention to the knee, tibia, fibula, or femur; evidence of chronic injury; and severely comminuted fractures of the fibular head without apparent avulsion or proximal migration of the cephalad fragments. A minimum of two authors reviewed radiographs of the initial patient population to apply exclusion criteria and to identify reoccurring patterns in which there were no disagreements. Review of the radiographs for measurements was performed by a single radiologist reviewer for consistency in the measurements.

Plain radiographs of the knee in the anterior-posterior (AP) and the lateral view were evaluated using Centricity PACS 4.0 (GE Healthcare, Barrington, IL). Descriptive measurements were taken including the AP length of the fragment, the medial-lateral width of the fragment, the maximal displacement of the fragment from its anatomic position on AP and lateral radiograph, and the orientation of the primary fracture line relative to a line perpendicular to the axis of the fibular diaphysis in both the sagittal and coronal plane Fig. 1. If any image did not provide adequate quality to assess a measurement (due to image quality and/or overlap between tibia fibula) that subject was omitted from the given calculation. Standard descriptive statistical techniques were used to assess the mean and standard deviation of populations.

Initial inclusion criteria yielded 53 proximal fibula fractures in 52 patients, with one incidence of bilateral injury. Of these 53 injuries, 5 knees were excluded (1 periprosthetic fracture, 1 chronic injury, 3 comminuted fractures of fibular head without avulsion or proximal migration) leaving 48 fractures in 48 patients. Included patients were 24 males and 24 females. The average age was 42.94. Twenty-three knees were right, and 25 left. Twenty-one of 48 had isolated proximal fibula fractures on plain radiograph. Associated injuries were found in 27 of 48 patients, and included one vertical sheer pelvis fracture, three femur fractures, fourteen tibial plateau fractures, two tibial shaft fractures, and seven Segond fracture-avulsions Table 1.

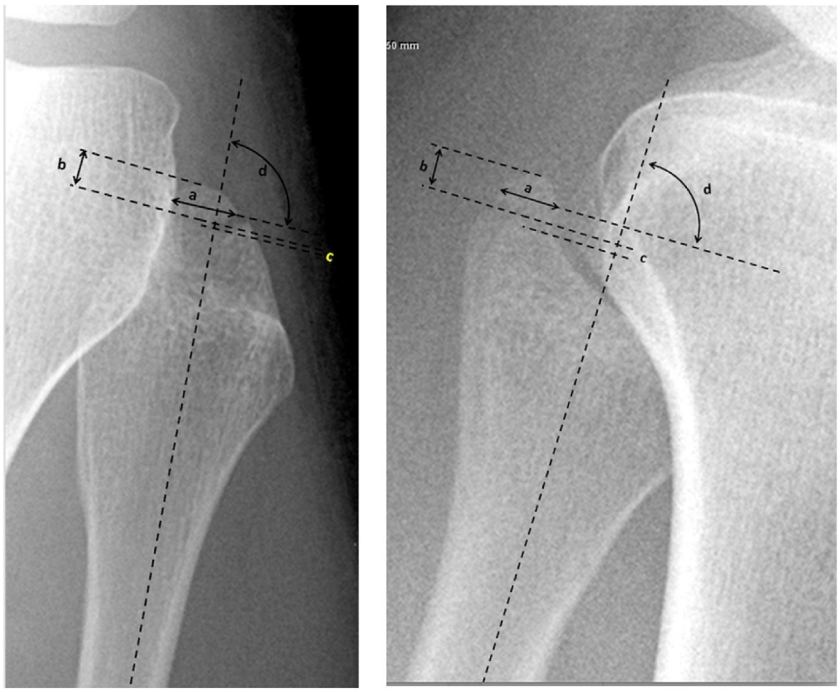

Fig. 1. Example of Measurements.
Arcuate fracture of the left fibula, AP (left) and lateral views (right). Labels demonstrate sample measurements of fragment width (a), height (b), displacement (c), and angle (d) relative to the long axis of the fibula.

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