Short Commentary

iMedPub Journals
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Journal of Clinical & Experimental Orthopaedics
ISSN 2471-8416

2016
Vol.2 No.3:26

DOI: 10.4172/2471-8416.100026

Historical Perspective of Distal Radius Fracture Classifications in the Twentieth Century

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Received date: Apr 20, 2016; **Accepted date:** Nov 15, 2016; **Published date:** Nov 21, 2016

Citation: Bregni M, Cahueque M, Cobar A (2016) Historical Parspective of Distal Radius Fracture Classifications in the Twentieth Century. J Clin Exp Orthop 2: 26. doi: 10.4172/2471-8416.100026

Abstract

For many years, distal radius fractures have been an important skeletal injury that has raised debate in the instance of its classification and management. The interest in the evaluation and treatment of distal radius fractures resides not only in the fact of its rising incidence, but also in the increasing development of diagnostic and treatment methods.

The mechanisms of injury resulting in distal radius fractures differ in energy, but result in important injuries that can complicate the outcome of each patient. Several classifications have been described throughout history, to recognize fracture patterns, determine associated injuries, and develop a treatment plan. The ideal classification should aid in treatment decision, and have inter and intra-observer reliability, as well as prognostic value. The following review describes the historical perspective of distal radius fracture classifications in the 20th century.

Keywords: Distal radius; Fracture; Classification

Introduction

Fractures of the distal radius are one of the most commonly seen injuries in the Emergency Room, and account for approximately 17% of fractures treated in this setting [1]. There are different fracture patterns, each corresponding to specific mechanisms of injury and age groups. A high-energy mechanism of injury corresponds to falling from a significant height, motor vehicle accidents, and industrial accidents that result in great comminution. On the other hand, fractures caused by low-energy mechanisms are due to intrinsic conditions that weaken the bone, making a patient prone to fractures [2].

For the initial assessment of distal radius fractures, plain X-ray film is commonly used. Standard AP and lateral views can limit the perception of the extent of the articular comminution involved, for it is difficult to see the details of overlapped fragments in one plane. In the presence of articular fracture patterns, Computed Tomography Imaging is indicated [3]. In trauma centers lacking CT Imaging, traction radiographs have shown to improve reliability in decision making, when compared to plain X-ray film [4].

When considering the decision in surgical treatment, patients must be evaluated according to the following criteria [5].

Patient factors

Fracture pattern

Fracture stability

Associated injuries

Patient factor variables include lifestyle, mental status, comorbidities, and the ability to comply with the treatment suggested by the treating physician. In assessing fracture patterns, many factors must be taken in account. Biomechanical studies have established reduction and anatomical goals in treatment, and the consequences of not achieving the accepted parameters in treating this fractures yields a wide variety of complications. For intra-articular fractures, congruity of the articular surface is an important treatment goal, for several studies have shown that a step off of 1 mm can result in radio carpal arthosis [6]. Radial inclination, length, tilt, and articular congruity are radiological variables that determine the measurements of an acceptable reduction [7].

When assessing fracture stability, several radiological signs have been described to alert the surgeon that the fracture is probably unstable [8]. Dorsal comminution greater than 50% of the width of the radius laterally, palmar metaphyseal comminution, initial dorsal tilt greater than 20°, initial displacement of more than 1 mm, and initial shortening of 5 mm are important radiological markers. An associated articular involvement, ulnar fracture, or severe osteoporosis is also factors to be noted in predicting instability. Fragility fractures must be carefully evaluated, to take in consideration important age-related factors to be treated to prevent future complications or further injuries.

In addition to patient factors, and fracture patterns and stability, the associated injuries present in distal radius fractures can also determine surgical treatment. Open injuries demand irrigation and antibiotic treatment, as well as operative treatment. Displaced distal radius injuries can be treated with percutaneous fixation or open reduction and internal fixation, as mentioned as emphasized recent studies [9]. Multi injury patterns, as well as bilateral distal radius fractures can also be considered surgical indications, and it is for these reasons that merely classifying a distal radius fracture does not determine its management or dictate its treatment.

Along the history of distal radius fracture diagnosis and treatment, several classification systems were developed that now are mainly of historical interest. Nissen-Lie first described distal radius fractures in 1939, in which 4 main groups were involved, without grading of the displacement: fracture of the distal radius with minimal displacement, an extra articular fracture with dorsal displacement, an articular fracture, and fractures of the radial styloid [10]. 10 years after Nissen-Lie's classification, Gartland and Werley described three different fracture types (Table 1). These corresponded to extra articular displaced fractures, and intra articular fractures with and without displacement [10]. The classification was later revised to add a fourth group extra articular fractures without displacement, and so all types of distal radius fractures were included. Both systems were a significant addition to the evaluation and management of these injuries, but lacked information in the description of all the fracture patterns that can be involved in complex injuries.

Table 1: Garland and Werley system of classifications.

Group	Description
1	Simple colles fracture with no involvement of the radial articular surface
2	Comminuted colles fracture with involvement of the radial articular surface
3	Comminuted colles fractures with involvement of the radial articular surface with displacement
4	Extra-articular, undisplaced

The extent of articular comminution began to be described in 1959, after the works of Lindstrom. In this classification, the evaluation criteria was expanded to 6 groups, with the direction of displacement being identified, along with a detailed description of the articular surface [11]. Older et al. described four different fracture types, and it is at this point that radial shortening begins to be measured (Table 2). The four different types range from more than 7 mm of shortening of the radius in relation to the ulna, to a "negative" radial length [12]. Along with articular comminution, radio carpal and ulnar involvement began to be described in 1967 after the works of Frykman. This classification continued to be one of the most popular, but failed to provide a description of the displacement, shortening or the extent of comminution involved. In Frykman's classification, eight different fracture patterns are described, where the presence or absence of an articular fracture, ulnar styloid process fracture, and radiocarpal or radioulnar joint involvement is documented and described [13].

Table 2: Older et al. system of classifications.

Type	Description
1	Nondisplaced Loss of some volar angulation and up to 5º of dorsal angulation NO significant shortening:>2 mm above the distal radius
2	Displaced with minimal comminution Loss of volar angulation or dorsal displacement of distal fragment. Shortening: usually not bellow the distal ulna but occasionally<3 mm bellow it Minimal comminution of the dorsal radius
3	Displaced with comminution of the distal radius Comminution of the distal radius Shortening: usually below the distal ulna Comminution of the distal radius fragment
4	Displaced with severe comminution of the radial head Comminution of the dorsal radius marked Comminution of the distal radial fragment: shattered Shortening: usually 2-8 mm below the distal ulna Poor volar cortex in some cases

As high velocity trauma resulting in more complex fractures began to evolve, the epidemiology of distal radius fractures began to shift from an elderly population, to a more active and young group of patients, where injuries seemed far more complex. This incidence can described as due to a greater participation in sporting activities, and higher presence of motor vehicle accidents. Along with an evolving population of patients, the search for the optimal classification system for distal radius fractures gained attention. The expansion of the knowledge of radio carpal joint kinematics and the patterns of ligament injuries has shown that these fractures correspond to an injury of the wrist, and not necessarily the bony radial injury alone.

The articular surface of the distal radius gained attention in 1984, when Melone described a classification for fractures that emphasized on the presence of the medial articular complex of the distal radius (Table 3). This classification involves four main fracture fragments (consisting of the radial shaft, radial styloid, dorsal medial fragment, and palmar medial fragment), and presents a guideline for the method of treatment [14]. In Melone's classification, five different fracture patterns are described, making emphasis on the "medial complex", which is comprised by the medial two components that attach to both the carpal bones distally, and the ulna medially [15]. Jenkins added direction and distribution of comminution to Melone's classification [16].

Table 3: Melone Classification of intra-articular fracture.

Type	Description

This article is available from: http://dx.doi.org/10.4172/2471-8416.100026

I	Stable fracture: nondisplaced or variable displacement of the medial complex as a unit, no comminution; stable after close reduction
II	Unstable "die-punch": moderate or severe displacement of the medial complex, as a unit, with comminution of both anterior and posterior cortices; separation of the medial complex from the styloid fragment; radial shortening>5-10 mm; considerable angulation usually exceeding 20°
III	"spike" fracture: unstable; displacement of the medial complex as a unit as well as displacement of and additional spike fragment from the comminuted radial shaft
IV	Split fracture; unstable, medial complex severely comminuted, with wide separation and/or rotation of the distal and palmar fragments.
V	Explosion injuries

The importance of articular involvement and its consequences was assessed in the classification devised by Murty and Jupiter [17]. As described by these authors, an intra-articular fracture is defined as any fracture extending into the radio carpal or radioulnar joint that is displaced more than 1 mm. Articular displacement is noted due to the fact that healing of fractures without anatomic articular reduction result in arthrosis [18].

In a Symposium for distal radius fractures, Rayshack proposed the Universal Classification System to classify the fracture's stability after it had been reduced [19]. This system gained acceptance for its simplicity and usefulness, due to the fact that it had the ability to guide the surgeon's treatment decision and plan. Cooney also described a Universal classification system, based on the findings of Gartland and Werley [20]. Intra-articular and extra-articular fracture patterns were noted, as well as those stable and unstable fractures.

The classification developed by Missakian, Cooney, Amadio, et al. for the Mayo Clinic in 1992 introduces a different feature. In this classification system, the variable of an articular involvement is described, distinguishing between a radioscaphoid and a radiolunate fragment as contact areas, and highlight fracture components (Table 4) [21]. Many authors argue that the Mayo classification system can result in a confounding problem, for the status of the ulnar styloid is ignored [22].

Table 4: Mayo Classification of Intra-articular fractures.

Type	Description
I	An intra-articular non-displaced fracture of the radio carpal joint
II	A displaced intra-articular fracture of the radioscaphoid joint involving a significant portion of distal radius
III	A displaced intra-articular fracture of the radiolunate joint that often presents a "die-punch" fracture, a displaced fracture component into the distal radioulnar joint is common
IV	A displaced intra-articular fracture involving both radioscaphoid joint surfaces. This fracture is usually comminuted.

Another classification system is the Comprehensive Classification of Fractures (AO/ASIF) (Table 5). This classification is based on the documentation of surgically treated fractures since 1959, for use by the Societe Internationale de Chirugie Orthopedique et de Traumatologie (SICOT). This system is composed of 27 different categories, and is the most detailed yet, describing anatomical fracture patterns, and aiding the orthopedic surgeon in decision making. Long bones are classified into 3 types based on the presence of articular involvement (extra-articular, partial, or complete articular), each subdivided into 3 groups, and each of these subdivided intro 3 different and new groups, in ascending order of severity of the bone and articular lesions. Due to the difficulty in achieving intra and inter-observer reliability, a binary system of questions was devised, to aid the surgeon in classification and decision-making [23]. According to Anderson et al. when reduced to only 3 fracture groups, the AO classification has questionable value over any other classification, but has a great value in documentation and research.

Table 5. Comprehensive Classification Systems (AO/ASIF).

Type	Description
A	Extra-articular fractures: fracture involves neither radiocarpal nor the radiolunar joint
B	Partial articular fractures: fracture involves only part of the articular surface.
C	Complete articular fractures: articular surface is disrupted, and completely separated from the diaphysis.

Mechanism of injury is an important factor in determining fracture patterns. Low energy falls in elderly patients commonly yield extra articular fractures, while high energy motor vehicle accidents can result in complex bony, articular, and soft tissue injuries. The classification designed by Fernandez is designed to form a practical approach to evaluating fracture morphology and determine mechanism of injury, as well as suggest stable *vs.* unstable patterns and identify pediatric fracture equivalents (Table 6).

Table 6: Fernandez Classification.

Type	Description
I	Bending fracture of the metaphysis
II	Shearing fracture of the joint surface
III	Compression fracture of the joint surface
IV	Avulsion fractures, radiocarpal fracture, dislocation
V	Combined fractures (I, II, III, IV), high-velocity injury

The categories include "flexion/extension" extra articular fractures (Type I), shearing joint surface injuries that result in articular involvement (type II), compression fractures (type III), avulsion fractures (type IV), and combined high energy injuries, where the aforesaid mechanisms are encompassed (type V).

Classifications in any type of fracture must be both functional and useful. Burnstein, in an editorial for the Journal of Bone and Joint Surgery, explained: "to be functional, the classification must have a high degree of inter-observer reliability or repeatability and intra-observer reliability. To be useful, the system needs to help the surgeon choose an appropriate method of treatment for each and every fracture [24]. Among the characteristics shared in distal radius classifications, important features to describe are: location, configuration, displacement, stability, radio-ulnar joint and ulnar styloid integrity, and associated injuries. An important factor that can be described additionally to the aforesaid features is mineral bone status and quality.

Based on standard radiological imaging, theoretical and practical difficulties arise for the development and use of an ideal classification system. For this reason, traction radiographs and CT imaging have been described as useful tools for the assessment of articular involvement. Magnetic resonance imaging has also widely gained acceptance as a helpful diagnostic imaging method for the evaluation of associated soft tissue injuries.

The increase of functional expectations in a risingly active population have led to the development of more and more accurate classifications to describe distal radius injuries, and lead to the optimal treatment decision, management and recovery for each patient. Along with the consideration of all the factors taken in account to classify distal radius fractures, the way in which these are treated is constantly changing, with percutaneous kirschner wire fixation, volar plating, and other treatments leading to adequate clinical outcomes [9].

Conclusion

There are several classification systems for distal radius fractures, ranging from the description of fracture patterns, to complex and detailed articular morphology and fracture mechanisms. Despite the great variety of systems, an adequate fracture classification must be simple, and provide adequate intra and interobserver reliability, as well as treatment guidelines and prognostic value. Many orthopedic surgeons believe greater time is invested in memorizing classification systems than in the inherent usefulness it may provide in understanding fracture mechanisms. For all the practical limitations that can be found in determining an ideal classification system, there are many that can be summarized to provide the information needed in each occasion. Gartland and Werley and Older classifications provide ideas on the extent of comminution of a fracture, whereas Lindstrom, Universal and AO/ASIF classifications provide information on the radiological appearance and degree of displacement of a fracture. For articular joint involvement, Frykman, Mc Murty and Jupiter, Melone and Mayo are classifications that differ in the patterns, but all describe the variables of articular fracture morphology. Finally, the Fernandez classification provides an idea on the fracture mechanism, and points to its pediatric fracture equivalents. Whatever fracture classification system may be used, its primary objective is the same: to provide the orthopedic surgeon with a reasonable and effective management strategy of distal radius fractures, that results in the optimal function and pain free wrist joint for the patient.

Conflict of Interest

The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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