Adult distal radius fractures classification systems: essential clinical knowledge or abstract memory testing?

A Shehovych¹, O Salar^{1,2}, CER Meyer^{1,2}, DJ Ford^{1,2}

¹Department of Trauma and Orthopaedic Surgery, Royal Shrewsbury Hospital, Shrewsbury, UK

²Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire, UK

ABSTRACT

Classification systems should be tools for concise communication, which ideally can predict prognosis and guide treatment. They should be relevant, reproducible, reliable, properly validated and most importantly simple to use and understand. There are 15 described distal radius classification systems present in the literature in the past 70 years, of which 8 are discussed in this paper. For each classification, we give an insight into its history, strengths and weaknesses, and provide evidence from the literature on reliability and reproducibility.

Sadly, on completion of this paper we have not found a distal radius fracture classification that proved to be useful. Failings range from poor reproducibility and reliability, and over-complexity mainly emanating from the inability to classify this spectrum of injury in all of its manifestations. Consequently, we would suggest that classification systems for acute adult distal radius fractures are not useful clinical knowledge but mainly historical and/or research tools. Moreover, we would discourage trainees from spending time learning these classifications, as they serve not as essential clinical knowledge but more as forms of abstract memory testing.

KEYWORDS

Distal radius – Fractures – Classification systems – Reliability – Reproducibility

Accepted 3 July 2016

CORRESPONDENCE TO

Andrew Shehovych, E: a.shev@gmail.com

Introduction

Distal radius fractures represent approximately 16% of all fractures managed by orthopaedic surgeons¹ They have a bimodal incidence, occurring in children with high energy trauma and in the elderly as a fragility fracture.²

The earliest classifications of distal radius fractures were with eponyms. In 1814, Colles described an extra-articular, dorsally displaced, metaphyseal fracture with radial shortening.³ Barton, in 1838, described intra-articular fractures with either volar or dorsal displacement of the distal radius.⁴ Smith, in 1847, classified volarly displaced fractures into three types, based on anatomical description.⁵ However, eponyms provide limited information regarding fracture stability, treatment and prognosis.

The value of classification systems varies considerably and an unhelpful classification system can serve as a conduit for miscommunication, offers little clinical application and soon transpires to be a tool for learning by humiliation. There have been 15 acknowledged classifications systems documented in primary literature for adult distal radius fractures in the past 70 years (Fig 1), as referenced by the International Distal

Radius Fracture Study Group. A Medline, Ovid and National Library for Health keyword search was performed to identify from within the 15 classification systems those that had been subjected to formal reliability and reproducibility studies using kappa statistics. From the 15 acknowledged classification systems, 7 were excluded on the basis of absence of reliability and reproducibility studies assessing them.

The remaining eight classification systems have been frequently used when attempting to classify adult distal radius fractures for clinical, historical or research purposes, as well as attempting to define a useful classification system. They are the Gartland and Werley, Older's, Frykman, Melone, AO/ASIF, Mayo, Fernandez and Universal classifications systems. The Gartland and Werley classification, although not having been subjected to formal reliability and reproducibility kappa statistics, is included in this review for a historical perspective, as it was the first classification system describing distal radius fractures that encompassed modern anatomical considerations.

We attempt to ascribe clinical value to each classification from the existing literature and to refute or confirm our

Figure 1 Timeline showing the 15 acknowledged distal radius classification systems

hypothesis that all adult distal radius classification systems are simply forms of abstract memory testing.

Defining a useful classification system

The purpose of any classification system should be to name and describe characteristics in an easy to follow universal language, to allow ordering into hierarchy, to guide action or intervention and to predict the potential outcomes of an intervention.^{1,6} In addition, we suggest that they should be simple, easy to remember and have acceptable interobserver agreement (reliability), intra-observer agreement (reproducibility) and validity.⁷

Reliability and reproducibility are demonstrated by the ability of a classification to return the same result for a particular patient's data when shown to multiple observers (reliability) or to the same observer viewing the same patient's data at different time points (reproducibility). Validity is the accuracy with which the classification determines the true fracture type. This requires a gold standard for identifying the true fracture type, such as intra-operative findings and corroboration, which is not always appropriate or possible, so this aspect can be difficult to test.¹ Once validated as a functional classification system, it should undergo prospective clinical studies to determine whether it has significant prognostic value.

Reliability and reproducibility are commonly tested in studies by subjecting a series of radiographs to review by a panel of observers. Instead of using percentage agreement on radiographs, a more precise measure – the kappa statistic – is used, which adjusts for any chance agreement.^{8,9} A value of +1 represents perfect agreement, 0 chance agreement

and –1 perfect disagreement. A suggested interpretation of the kappa statistic is presented in Table 1.

Some examples of well-known classifications in orthopaedics include the Garden classification¹⁰ for proximal femoral fractures and the Neer classification¹¹ for proximal humeral fractures. These are examples of ordinal classification systems, ordered I to IV to indicate increasing severity, greater instability and higher risk of complications. They are simple and easy to remember and they guide treatment. However, they have been shown to have poor reliability and reproducibility.

Main classification systems used for distal radius fractures

Gartland and Werley (1951)

In 1951, Gartland and Werley created a three-part classification based on the presence of an extra- or intra-articular component, angular deformity and metaphyseal comminution.^{1,12} In 1985, Solgaard added a fourth group for completeness (Fig 2).¹⁵ The original study showed that 88% of fractures were intra-articular (grade II and III) with one-third having unsatisfactory outcomes, whereas extra-articular fractures (grade I) were associated with only 14% of

Figure 2 Gartland and Werley's 1951 classification with Solgaard's added group (I = extra-articular displaced; II = intra-articular, no displacement; III = intra-articular, displaced; IV = extra-articular, non-displaced)

Table 1 Interpretation of kappa statistic	
Kappa (κ)	Reliability/reproducibility
0–0.2	Slight
0.21–0.4	Fair
0.41–0.6	Moderate
0.61–0.8	Substantial
0.81–1	Excellent

unsatisfactory outcomes. This method of classification was useful because the outcome was linked to the type of fracture sustained. The classification does not, however, grade the amount of comminution or quantify the extent of fracture displacement. With the advent of newer and more detailed classifications, it has now been superseded and has not been subjected to published kappa statistical analysis.

Older's (1965)

In 1965, Older and colleagues published a four-part classification system applicable to the extra-articular Colles-type fracture.¹⁴ It was later modified by Solgaard in 1985 (Fig 3).¹⁵ The classification grades fractures according to the degree of dorsal angulation, the extent of metaphyseal comminution

and the direction and extent of the displacement. It was also the first to incorporate shortening of the distal radial fragment in relation to the distal ulna, which was found to be important in predicting functional outcome.¹⁵ Its use is limited, however, as it does not include intra-articular distal radius fractures.

The evidence for the reliability and reproducibility of the Older classification has not been consistent in the literature. When first tested, it demonstrated substantial agreement between observers with kappa statistics of 0.69 for reliability and 0.75 for reproducibility.¹⁵ A more recent study showed poor agreement for reliability (not using kappa statistic) and only fair agreement for reproducibility with a kappa statistic of 0.27.¹⁶

Frykman (1967)

Frykman was one of the first to recognise the importance of ulna styloid fractures. His classification system identifies the involvement of the radiocarpal and radioulnar joint, as well as the presence or absence of an ulna styloid fracture (Fig 4).^{17,31} It is a simple system with eight main divisions and four main types of injuries (odd numbers), with the addition of an ulna styloid fracture to each injury (even numbers). It does not, however, take into consideration the extent of fracture displacement, degree of comminution or shortening of the radius, so its ability to guide treatment and predict prognosis is limited.^{2,18} Critics cite great difficulty in agreeing on the involvement of the radioulnar joint as one of its main downfalls.¹⁹ Studies evaluating the reliability and reproducibility of the classification showed that there was fair to moderate agreement between observers, with kappa statistics ranging from 0.22 to 0.38 for reliability and from 0.26 to 0.6 for reproducibility.^{7,16,19–21}

Melone (1984)

The Melone classification, initially reported in 1984 and later revised, outlined a classification on intra-articular fracture patterns of the distal radius (Fig 5).^{1,22,25} The five-part classification is based on the observation that there are four components to radiocarpal articular injuries: the radial shaft, radial

Figure 3 Older et al.'s 1965 classification modified by Solgaard (I: dorsal angulation ≤ 5 degrees, length of radial styloid ≥ 7 mm; II: dorsal angulation > 5 degrees, length of radial styloid < 7 and ≥ 1 mm; III: dorsal angulation > 5 degrees, length of radial styloid ≤ 4 mm slight dorsal comminution; IV: dorsal angulation > 5 degrees, length of radial styloid usually negative, comminution, often intra-articular involvement)

Figure 4 Frykman's 1967 classification (I: extra-articular; II: as I with fracture of the distal ulna; III: radiocarpal joint involved; IV: as III with fracture of the distal ulna; V: distal radioulnar joint involved; VI: as V with fracture of the distal ulna; VII: radiocarpal and distal radioulnar joints both involved; VIII: as VII with fracture of the distal ulna)

Figure 5 The Melone classification (I: undisplaced, no or minimal comminution; II: 'die punch' fracture with moderate to severe displacement (IIa: reducible; IIb: irreducible); III spike fragment present; IV: wide separation of intra-articular fragments; V explosion fracture with severe comminution, transverse split and rotational displacement)

Figure 6 Swiss Association for the Study of Internal Fixation (AO/ASIF) classification of 23 distal radius fracture patterns (23-A extra-articular; 23-B partial articular; 23-C complete articular)

styloid, dorsal medial fragment and palmar medial fragment of the lunate facet of the radius. These components are a result of the lunate impaction on the radius during injury. The Melone classification attempts to highlight the importance of the lunate facet of the radius and its significance in functional outcome. It has also been useful in defining indications and methods of surgical fixation²⁴ but its use is limited to intra-articular fractures. It was shown to have slight to moderate reliability and reproducibility with kappa values of 0.337, 0.4–0.6, respectively, in one study¹⁹ and 0.056, 0.262 in another study.⁷ Observers had the greatest challenge in identifying the four fragments on x-ray.¹⁹

AO/ASIF (1990)

In 1986, the Swiss Association for the Study of Internal Fixation (ASIF) proposed a classification for fractures, which was later reviewed by Muller in 1990 and Fernandez in 2001 (Fig 6).^{25,31} Initial problems with reproducibility culminated in 1995 when Muller *et al* revised the classification into a binary system.²⁶ Twenty-three distal radius fractures are labelled and then there are three types: type A is extra-articular, type B is partial articular and type C is complete articular (Fig 6). There are further subdivisions into groups and subgroups, making a total of 27 fracture patterns of the distal radius.

This classification system is comprehensive; it can serve as a basis for treatment and retrospective evaluation of results and is heavily used in research. Unfortunately, as a result of the extensive subdivisions, it can be perceived as being complicated and cumbersome when applied in an everyday clinical setting.

Studies have confirmed the reproducibility of defining distal radius fractures into types A, B and C^{19,27} and suggest substantial agreement ($\kappa > 0.6$ for both reliability and

Figure 7 Mayo Clinic classification (I: intra-articular, undisplaced; II: intra-articular, displaced, involving significant portion of articular surface; III: intra-articular, displaced, often presents as 'die punch' fracture of lunate fossa; IV: intra-articular, displaced, involving both radioscaphoid joint surfaces and usually sigmoid fossa of distal radioulnar joint, usually comminuted)

Figure 8 Fernández classification (I: bending of the metaphysis; II: shearing fractures of the joint surface; III: compression of the joint surface; IV: avulsion or radiocarpal fracture dislocations; V: combined fractures with high velocity injuries)

reproducibility).¹⁹ Reliability and reproducibility worsens to fair to moderate when divisions within each type are considered.^{7,16,19}

Mayo (1992)

In 1992, the Mayo Clinic proposed its own classification. It is a four-part classification similar to the Frykman classification in that it focuses on fracture extension into the radiocarpal or radioulnar (Fig 7).^{28,29} In addition, it distinguishes between radioscapoid and radiolunate joint surface involvement but does not place any emphasis on associated ulna fractures. Although in essence it is a simple classification system, reliability and reproducibility are variable, with reliability of $\kappa = 0.428$ and reproducibility between $\kappa = 0.296$ – 0.626 ,¹⁹ suggesting that it does not work much better than other classification systems.

Table 2 Distal radioulnar joint injuries included in the Fernández classification	
Type	Injury
I	Stable (following reduction of the radius the DRUJ is congruous and stable)
II	Unstable (subluxation or dislocation of the ulnar head present)
III	Potentially unstable (subluxation possible)

Fernandez (1993)

A more recent classification proposed by Fernandez in 1993 classifies fractures of the distal radius according to mechanism of injury.^{1,30} Using a mechanism-based classification was thought to provide a better understanding of the potential soft-tissue damage and thus a better overall assessment. The classification includes five types of injury, which increase in complexity of the bony lesion and severity of associated soft-tissue injury from type I through to type V fractures (Fig 8). It also has a separate group for distal radioulnar joint injuries (Table 2), which is important since one of the most common causes of disability after healed fractures is post-traumatic derangement of radioulnar articulation.⁵¹ The advantages of this classification are that it is practical, determines stability, includes associate soft-tissue injuries and provides treatment and recommendations for both adults and paediatric patients. It is, however, a more complicated system, more time consuming and it also, when tested in contemporary literature, offers little difference from other classification systems in terms of reliability and reproducibility, with kappa scores ranging from 0.15 to 0.46 and -0.003 to 0.6 , respectively.^{16,20,21,32}

Figure 9 Universal classification of distal radial fractures

Table 3 Summary of kappa values for reliability						
Classification	Anderson <i>et al.</i> (1991)	Anderson <i>et al.</i> (1996)	Belotti <i>et al.</i> (2008)	Naqvi <i>et al.</i> (2009)	Kural <i>et al.</i> (2010)	Kucuk <i>et al.</i> (2013)
Older's	0.69					
Frykman		0.364	0.26		0.219	0.38
Melone		0.337			0.056	
AO/ASIF		0.252	0.31		0.096	0.30
Mayo		0.428				
Fernández			0.44	0.15–0.39	0.235	0.46
Universal			0.41		0.226	0.24

Table 4 Summary of kappa values for reproducibility							
Classification	Anderson <i>et al.</i> (1991)	Anderson <i>et al.</i> (1996)	Ploegmakers <i>et al.</i> (2007)	Belotti <i>et al.</i> (2008)	Naqvi <i>et al.</i> (2009)	Kural <i>et al.</i> (2010)	Kucuk <i>et al.</i> (2013)
Older's	0.75		0.27				
Frykman		0.404–0.605	0.26	0.55		0.305	0.60
Melone		0.412–0.633				0.262	
AO/ASIF		0.229–0.379	0.52	0.49		0.309	0.50
Mayo		0.296–0.626					
Fernández			0.24	0.59	–0.003 to 0.29	0.474	0.60
Universal				0.61		0.621	0.49

Universal (1993)

The Universal classification was proposed by Rayhack⁵³ and was later refined by Cooney in 1993 (Fig 9).^{54,55} It attempted to improve on the Frykman classification to make a distinction between displaced and nondisplaced intra-articular fractures.⁵¹ The classification thus simply differentiates extra- and intra-articular fractures and displaced and non-displaced fractures (Fig 8). The simplicity of this system is attractive and it also provides treatment recommendations. It has shown fair to moderate reliability ($\kappa = 0.226\text{--}0.41$) but fair to substantial reproducibility ($\kappa = 0.49\text{--}0.621$).^{7,20,21}

Conclusion

Classification systems in their most useful form can be tools for succinct rapid communication in clinical contexts between healthcare professionals. Further, when they elude to treatment, recovery or prognosis, they become an invaluable tool for a clinician and can often guide or polarise treatment strategy. Unfortunately, this review highlights that no single adult distal radius classification system has been robust enough to survive any form of statistical scrutiny, often failing at the first few hurdles, being unreliable, irreproducible or simply too complicated or abstract (Table 3 and Table 4).

One must temper the above with recognition that the spectrum of injuries that can affect the distal radius is broad,

not fully understood and often multi-faceted. While the authors acknowledge the significant efforts that have been invested in the creation of these classification systems, we nonetheless find no scrutinised classification system to be satisfactory for use in a clinical settings, owing to unsatisfactory reliability and/or reproducibility.

More effort by trainee orthopaedic surgeons is spent on trying to memorise classifications rather than in understanding fracture mechanics or factors that have a bearing on treatment and prognosis.¹⁹ Fracture classifications have a legitimate place in education, research, communicating severity of fractures and providing treatment alternatives. However, with no adequate evidence proving their clinical usefulness, they can cease to become useful clinical knowledge and serve more as tools for abstract memory testing.

Acknowledgements

Illustrations kindly provided by Mr Andrew Biggs, Medical Illustrator, Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire.

References

1. Bucholz RW, Heckman JD, Court-Brown CM *et al.* *Rockwood And Green's Fractures In Adults*. 7th edn. Philadelphia, PA: Lippincott Williams & Wilkins; 2010.

2. Ilyas AM, Jupiter JB. Distal radius fractures: classification of treatment and indications for surgery. *Hand Clin* 2010; **26**(1): 37–42.
3. Colles A. On the fracture of the carpal extremity of the radius. *N Engl J Med* 1814; **3**(4):368–372.
4. Barton J. Views and treatment of an important injury of the wrist. *Med Exam* 1838; **1**: 365.
5. Smith R. *A Treatise on Fractures in the Vicinity of the Joints and on Certain Forms of Accidental and Congenital Dislocations*. Dublin: Hodges and Smith; 1847.
6. Burstein AH. Fracture classification systems – do they work and are they useful. *J Bone Joint Surg Am* 1993; **75A**(12): 1,743–1,744.
7. Kural C, Sungur I, Kaya I *et al*. Evaluation of the reliability of classification systems used for distal radius fractures. *Orthopedics* 2010; **33**(11): 801.
8. Cohen J. A coefficient of agreement for nominal scales. *Educ Psychol Meas* 1960; **20**: 37–46.
9. Landis J, Koch G. The measurement of observer agreement for categorical data. *Biometrics* 1997; **33**:159–174.
10. Thomsen NO, Jensen CM, Skovgaard N *et al*. Observer variation in the radiographic classification of fractures of the neck of the femur using Garden's system. *Int Orthop* 1996; **20**(5): 326–329.
11. Sidor ML, Zuckerman JD, Lyon T *et al*. The Neer classification system for proximal humeral fractures. An assessment of interobserver reliability and intraobserver reproducibility. *J Bone Joint Surg Am* 1993; **75A**(12): 1,745–1,750.
12. Gartland JJ, Werley CW. Evaluation of healed Colles fractures. *J Bone Joint Surg Am* 1951; **33A**(4): 895–907.
13. Solgaard S. Classification of distal radius fractures. *Acta Orthop Scand* 1985; **56**(3):249–252.
14. Older TM, Stabler EV, Cassebaum WH. Colles fracture: evaluation and selection of therapy. *J Trauma* 1965; **5**: 469–476.
15. Andersen GR, Rasmussen JB, Dahl B *et al*. Older classification of Colles fractures – good intraobserver and interobserver reproducibility in 185 cases. *Acta Orthop Scand* 1991; **62**(5): 463–464.
16. Ploegmakers JJW, Mader K, Pennig D *et al*. Four distal radial fracture classification systems tested amongst a large panel of Dutch trauma surgeons. *Injury* 2007; **38**(11): 1,268–1,272.
17. Frykman G. Fracture of the distal radius including sequelae: shoulder–hand–finger syndrome, disturbance in the distal radio-ulnar joint and impairment of nerve function. *Acta Orthop Scand Suppl* 1967; **108**: 1–153.
18. Flinckila T, Raatikainen T, Hamalainen M. AO and Frykman's classifications of Colles' fracture. No prognostic value in 652 patients evaluated after 5 years. *Acta Orthop Scand* 1998; **69**(1): 77–81.
19. Andersen DJ, Blair WF, Steyers CM Jr *et al*. Classification of distal radius fractures: An analysis of interobserver reliability and intraobserver reproducibility. *J Hand Surg Am* 1996; **21A**(4): 574–582.
20. Belloti JC, Tamaoki MJ, Franciozi CE *et al*. (2008) Are distal radius fracture classifications reproducible? Intra and interobserver agreement. *Sao Paulo Med J* **126**(3): 180–185.
21. Kucuk L, Kumbaraci M, Gunay H *et al*. Reliability and reproducibility of classifications for distal radius fractures. *Acta Orthop Traumatol Turc* 2013; **47**(3):153–157.
22. Melone CP Jr. Articular fractures of the distal radius. *Orthop Clin North Am* 1984; **15**(2): 217–236.
23. Melone CP Jr. Distal radius fractures – patterns of articular fragmentation. *Orthop Clin North Am* 1993; **24**(2): 239–253.
24. Jupiter JB, Fernandez DL. Comparative classification for fractures of the distal end of the radius. *J Hand Surg* 1997; **22**(4): 563–571.
25. Mueller M, Nazarian S, Koch P *et al*. *The Comprehensive Classification of Long Bones*. New York: Springer-Verlag; 1990.
26. Muller M. *Comprehensive Classification of Fractures*. Pamphlet 1. Berne, Switzerland: ME Muller Foundation; 1995.
27. Kreder HJ, Hanel DP, McKee M *et al*. Consistency of AO fracture classification for the distal radius. *J Bone Joint Surg* 1996; **78**(5): 726–731.
28. Missakian ML, Cooney WP, Amadio PC *et al*. Open reduction and internal fixation for distal radius fractures. *J Hand Surg* 1992; **17**(4):745–755.
29. Berger RA, Weiss APC. *Hand Surgery*. Philadelphia, PA: Lippincott Williams and Wilkins; 2004.
30. Fernández DL. Fractures of the distal radius: operative treatment. *Instr Course Lect* 1993; **42**: 73–88.
31. Fernández DL. Distal radius fracture: the rationale of a classification. *Chir Main* 2001; **20**(6): 411–425.
32. Naqvi SG, Reynolds T, Kitsis C. Interobserver reliability and intraobserver reproducibility of the Fernandez classification for distal radius fractures. *J Hand Surg Eur Vol* 2009; **34**(4): 483–485.
33. Rayhack J. Symposium on distal radius fractures. *Contemp Orthop* 1990; **21**(21): 71–104.
34. Cooney WP. Fractures of the distal radius: a modern treatment-based classification. *Orthop Clin North Am* 1993; **24**(2) :211–216.
35. Cooney W, Linscheid R, Dobyns J. *The Wrist: Diagnosis and Operative Treatment*. St Louis, MO: Mosby Publishing; 1998.