



A Radiographic Classification System for Intracapsular Hip Fractures that Reflects Fracture Displacement and Predicts Complications after Internal Fixation: A Clinical Study of 2262 Patients



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Abstract

Introduction: Intra-capsular hip fractures may present on a spectrum from clinical suspicion of an un-displaced fracture on the radiograph, to off-ended with no overlap between fracture fragments. Existing classification systems such as AO, Garden, and Pauwels classifications attempt to describe this, but they rely purely on the Antero-Posterior (AP) radiograph. These classifications have all been found to be unreliable. In this study we propose a new classification system that details the progressive displacement of an intra-capsular fracture into six grades based on the fracture characteristics on the AP and lateral radiographs. The aim is to determine if this classification system is predictive of the occurrence of fracture non-union or Avascular Necrosis (AVN) and compare against traditional classification methods.

Method: Data was collected from 2,262 intra-capsular hip fractures undergoing internal fixation between May 1989 and April 2019 at Peterborough City Hospital.

Results: Fracture non-union was observed for 338 (12.9%) patients and avascular necrosis in 141 (5.4%) patients. The risk of fracture non-union increased for greater degrees of fracture displacement (5.2% to 36.8%, $p < 0.0001$). For AVN the risk increased from 0.0% to 7.1% ($p < 0.0001$) with increasing displacement. The overall risk of developing a fracture healing complication increased with progressive displacement (5.2% to 43.9%, $p < 0.0001$). When classified using Garden classification; both non-union and avascular increased with increasing grade (non-union 5.9% to 22.9% $p = 0.001$), AVN (4.0% to 8.1% $p = 0.0001$), and overall fracture healing complications (9.8% to 31.0%, $p = 0.0001$).

Conclusion: The new classification system was found to be highly predictive of fracture healing complications following internal fixation of an intra-capsular fracture. We have also demonstrated significant improvement in predicting fracture healing complications compared to the abilities of the established classification system. Thus, this new classification system can be used to guide operative decision making.

Keywords: Hip Fracture; Intra-capsular; Fixation; Non-Union; Fracture Healing Complications

Introduction

The prevalence of hip fractures continues to rise as life expectancy increases. Surgical management of hip fractures is determined by the fracture pattern, degree of displacement and patients' physical expectations of their hip. Intra-capsular neck of femur fractures has traditionally been classified using the Garden classification based on the Antero-Posterior (AP) radiograph alone [1], alternative classification systems include Pauwels [2] and the AO classification system [3]. The reliance on the AP radiograph alone to determine surgical management has been shown to change in almost a quarter of cases when the corresponding lateral radiograph is available to the Surgeon [4]. The value of the Garden and Pauwels classification has been questioned in its ability to predict non-union [5-7]. The AO and Garden classification have also been shown to demonstrate poor inter and intra-observer variability with poor reproducibility, suggesting their clinical use should be avoided [7, 8]. A simplified version of the Garden classification in which fractures have been categorized as either displaced or un-displaced, has been shown to improve inter and intra-observer

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reproducibility compared to the traditional classification [9-11].

Intra-capsular neck of femur fractures may present on a spectrum from clinical suspicion on a radiograph, to completely off-ended on both the AP and lateral radiographs. Traditionally minimally displaced fractures have been managed with internal fixation. While those that are displaced are more likely to be treated with arthroplasty due to the high risk of fracture healing complications after internal fixation. This study aims to propose the use of a new classification system designed to assess both the AP and lateral radiographs to determine the degree of fracture displacement, and its potential to predict occurrence of fracture non-union or Avascular Necrosis (AVN).

Patients and Methods

The classification system is formed of six grades. To classify the fracture, the four 'corners' of the fracture are defined on both the AP and lateral radiographs. Displacement of 2mm or more at each corner of the fracture on either the AP or lateral radiograph is allocated 1 point per corner (Figure 1). For those fractures which were displaced on all 4 corners, they were further subdivided into those in which there was less (4a) or more than (4b) 50% displacement between fragments. If the lateral radiograph was of poor quality, then a best estimation was made. Examples of fractures for each of the grades is given in figures classification system is demonstrated in Figures 2-6.

Data from all patients with a hip fractures admitted to a single centre were prospectively recorded at the time of admission onto a local hip fracture database. This included the type of fracture, radiographic classifications including the new classification method, treatment, and subsequent follow up details. Patients were subsequently seen in a hip fracture clinic, and follow up radiographs performed as indicated. At one-year patients are either reviewed in the clinic or via a telephone consultation. For those describing any significant symptoms during a telephone consultation, a clinical review was arranged.

Fracture union was defined by complete obliteration of the fracture margins on both the AP and lateral follow-up radiographs. Non-union was identified from AP and lateral radiographs if there was displacement of the fracture with failure of the fracture to heal, or if there were still clearly visible fracture margins at one year from occurrence of the fracture. Avascular necrosis was defined as any patient with grade 2 or above necrosis as defined by the classification of Steinberg [12]. This included any patient with diffuse sclerosis of the femoral head, cyst formation, subchondral fracture, crescent sign, femoral head collapse or acetabular involvement.

Statistical evaluation between groups was using the chi-squared test. Reproducibility of the classification system was evaluated by assessing inter and intra-observer variability. The Intra-class Correlation Coefficient (ICC) and Cronbach alpha were calculated utilising the statistic software SPSS for inter and intra-observer reliability. A *p*-value of less than 0.05 was considered statistically significant.

Results

Between May 1989 and April 2019, 6148 patients with an acute intra-capsular fracture were admitted. Of these patients 2400 were treated by internal fixation and retention of the femoral head. Excluded from these patients were 29 patients with pathological fractures, 3 patients with later proven deep infection treated by

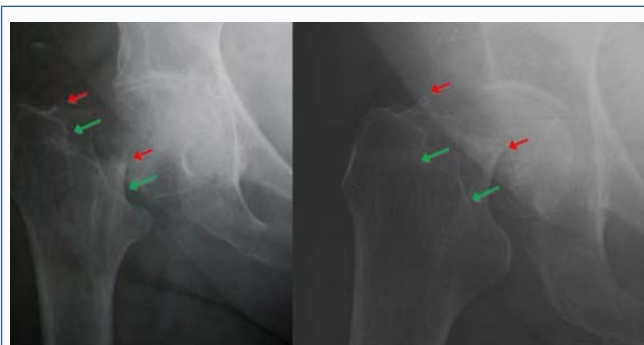


Figure 6: Grade 4. For grade 4a the four 'corners' of the fracture has more than 2mm of displacement but there is less than 50% displacement between the two bone ends for grade 4b there is more than 50% displacement between the two bone ends.

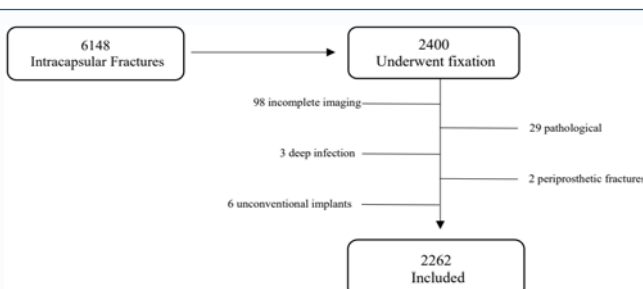


Figure 7: Flow diagram detailing patients excluded from the study.

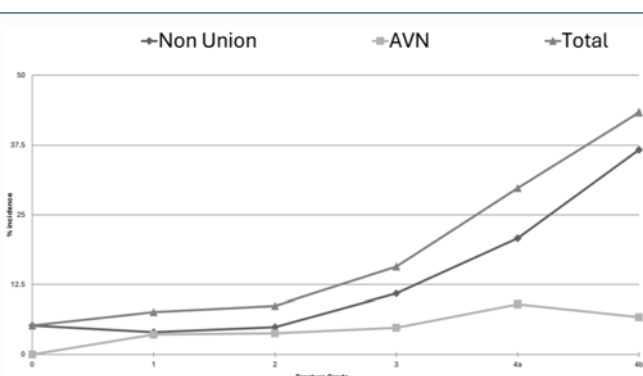


Figure 8: Incidence of non-union and Avascular Necrosis (AVN) for the new classification method.

excision arthroplasty, and 98 patients with incomplete classification of their radiographs. Lack of classification was generally due to a lateral radiograph not being available. Also excluded were six patients treated by unconventional implants and two patients who had a peri-prosthetic fracture treated by arthroplasty. This was two patients treated by a condylar plate fixation and four patients treated by intramedullary nail fixation. After these exclusions, 2262 patients remained in the study (Figure 7).

The mean age of the patients was 75.8 years (range 16 to 103), and 707 (31.3%) were male. The methods of fixation utilized were; multiple cancellous screws 1194 (52.8%), Targon hip screws 994 (43.9%) and sliding hip screw 74 (3.3%). 92 (4.1%) patients died within 30 days of injury, and by one year of injury 439 (19.4%) had died. 10 (0.4%) patients were lost to follow up at one year (range of follow up 18-290 days). Mean length of radiographic follow up was

Table 1: Incidence of fracture healing complications by grade of new classification system compared to the traditional Garden classification.

Grade	New Classification				Garden Classification (grades 1-4)			
	Total cases	Non-union (%)	AVN (%)	All complications	Total cases	Non-union (%)	AVN (%)	All complications
0	57	3 (5.2%)	0 (0)	3(5.2%)				
1	309	12 (3.9%)	11 (3.6%)	23 (7.4%)	985	58 (5.9%)	39 (4.0%)	97 (9.8%)
2	481	23 (4.8%)	18 (3.7%)	41 (8.5%)	96	8 (8.3%)	2 (2.1%)	10 (10.4%)
3	323	34(10.5%)	15 (4.7%)	49 (15.2%)	701	162(23.1%)	61 (8.7%)	223(31.8%)
4a	856	178(20.8%)	80 (9.3%)	258 (30.1%)	480	110(22.9%)	39 (8.1%)	149(31.1%)
4b	239	88(36.8%)	17 (7.1%)	105 (43.9%)				

281 days. 222 (9.8%) of patients had no radiographic follow-up and were assessed via telephone consultation.

As detailed in table 1, fracture healing complications were found in 494 of 2262 (21.8%) of patients. The total number of fracture healing complications increased with fracture displacement, with 43.9% of grade 4b affected, compared to 5.2% in grade 0 (p value= <0.0001) (Figure 8). With progressive fracture displacement, non-union increased from 5.2% to 36.8% (p value= <0.0001), and AVN from 0.0% to 7.1% (p value= <0.0001) (Figure 4). When compared to Gardens classification (grades 1-4); total healing complications progressed from 9.8%-31.0% (p value=0.14), non-union from 5.9% to 22.9% (p value=0.0001) and AVN from 4.0% to 8.1% (p value=0.0001).

To confirm the functional use of the classification system as a clinical tool, the inter and intra-observer variability was assessed of 10 Orthopaedic Surgeons grading 10 sets of antero-posterior and lateral radiographs of intra-capsular neck of femur fractures. The same radiographs were re-evaluated 1 month later by the same Surgeons. These showed excellent inter-observer reliability at >0.9 (95% CI 0.994-0.999) with a Cronbach alpha 0.9, demonstrating good intra-observer reproducibility.

Discussion

We found the proposed classification system can be utilized to describe the progressive displacement of an intra-capsular fracture, and predict the increasing risk of fracture healing complication occurring with increasing displacement of the fracture. To confirm the functional use of the classification system as a clinical tool, the inter and intra-observer variability has been performed which showed excellent inter-observer reliability. A number of additional factors will also aid in determine if an intra-capsular fracture is treated by internal fixation or arthroplasty. These include the patient's preference, age and co-morbidities. This classification therefore allows for better decision making regarding the treatment of this fracture.

Using both the AP and lateral radiographs gave a more precise estimation of fracture displacement and it demonstrated a progressive risk of fracture healing complications from approximately 5% in the completely un-displaced fracture to 44% in the completely displaced grade 4b fractures. Garden 1 fractures are often described as impacted, but on the lateral view there may be progressive angulation at the fracture site into retroversion, which is not considered by the classification system. As the fracture progressively displaces it becomes more unstable, with increasing fracture healing complications [13, 14].

Previous classification systems for intra-capsular fracture have all been found to have limited value in predicting fracture healing

complications. All previous systems use only the appearance of the fracture in the AP radiograph. The reliance on the AP radiograph alone to determine surgical management has been shown to change in almost a quarter of cases when the corresponding lateral radiograph is available to the Surgeon [4]. Regarding the Garden classification, the division into four grades has been shown to be of little use and suggested to divide grades into those fractures that are essentially un-displaced (grade 1 and 2) and those that are displaced (grade 3 and 4) [9, 10]. This finding is confirmed in this study with Figure 10 demonstrating that there was only a difference for grade 1 and 2 fractures versus grades 3 and 4.

The Pauwels classification is based on the angle of the fracture line. Un-displaced fractures are more likely to have a more horizontal fracture line, with a lower risk of fracture healing complications. Even if only displaced fractures are considered it remains questionable if there is any increased risk of fracture healing complications for the more vertical fractures [6]. The more recent AO classification has nine grades and has been found to be only of value for predicting fracture healing complications for those fractures within the displaced groups, versus those in the un-displaced group [7, 8, 10].

Advantages of this study were the large patient numbers and the prospective collection of data. Fractures were classified using the new system on admission, and therefore without knowledge of the subsequent development of fracture healing complications. We included all patients to enable a fair representation of the risk of complications occurring at the point of operative decision making at admission. The hospital treating these patients was the only one in the city treating hip fractures and their complications, thus any subsequent complications following the fracture were generally referred back to the same unit.

A proportion of patients would have died before the potential development of fracture healing complications, and as such, a difficulty with this patient population is that of loss to follow up. There were also some patients who were unable to attend for a full radiographic follow up. To reduce the risk of missing fracture healing complications, all surviving patients were contacted at one year and any patient with significant symptoms related to the operative hip were asked to re-attend. These difficulties are inevitable with this frail population and the associated mortality of such an injury. This classification gives insight into predicting clinical outcomes following internal fixation at the time of admission. While there is a loss to follow up in this study, these losses would not be dissimilar to other institutions general practice.

In recent years there has been increased questioning of the choice of treatment for un-displaced intra-capsular fractures. A systematic

review of un-displaced neck of femur fractures has shown increased fracture healing complications with internal fixation with 9-18% rate of conversion to arthroplasty [15]. Replacement arthroplasty has been suggested with signs of displacement of the fracture being used to influence the choice of treatment. This study provides a mechanism for documenting the degree of displacement of the fracture, including that occurring on the lateral radiograph, and thereby may be used to determine the optimum choice of treatment. With the ability of the new classification system to reliably predict fracture healing complications, greater consideration should be given to manage grade 4a and particularly 4b type fractures with arthroplasty.

In summary this study reports on a new classification method for intra-capsular fractures that represents the progressive displacement of the fracture. Increased fracture healing complications were found for greater degrees of displacement. This classification system may therefore be used to assist in determining the most appropriate choice of operative management at the time of presentation.

References

1. Garden RS. Stability and union in subcapital fractures of the femur. *J Bone Joint Surg.* 1964; 46B: 630-647.
2. Bartonicek J. Pauwels' Classification of femoral neck fractures: Correct interpretation of the original. *J Orthop Trauma.* 2001; 15: 358-360.
3. Orthopaedic Trauma Association, Committee for Coding and Classification: Fracture and dislocation compendium. *J Orthop Trauma.* 1996; 10(1 Suppl): S1-S154.
4. Aggarwal A, Singh M, Aggarwal AN, Bhatt S. Assessment of interobserver variation in Garden classification and management of fresh intracapsular fractures. *Chin J Traumatol.* 2014; 17(2): 99-102.
5. Parker MJ. Garden grading of intracapsular fractures: Meaningful or misleading? *Injury.* 1993; 24(4): 241-242.
6. Parker MJ, Dynam E. Is Pauwels classification still valid? *Injury.* 1998; 29: 521-523.
7. Masionis P, Uvarovas V, Mazarevicius G, Popov K, Venckus S, Baužys K, et al. The reliability of a Garden, AO and simple II stage classification for intracapsular fractures. *Orthop Traumatol Surg Res.* 2019; 105(1): 29-33.
8. Blundell CM, Parker MJ, Pryor GA, Hopkinson-Woolley J, Bhonsle SS. An Assessment of the AO classification of intracapsular fractures of the proximal femur. *J Bone Joint Surg.* 1998; 80(4): 679-683.
9. Van Embden D, Rhemrev SJ, Genelin F, Meylaerts SAG, Roukema GR. The reliability of a simplified Garden classification for intracapsular neck of femur fractures. *Orthop Traumatol Surg Res.* 2012; 98(4): 405-408.
10. Masionis P, Uvarovas V, Mazarevicius G, Popov K, Venckus S, Baužys K, et al. The reliability of a Garden, AO and simple II stage classification for intracapsular fractures. *Orthop Traumatol Surg Res.* 2019; 105(1): 29-33.
11. Crijns TJ, Janssen SJ, Davis JT, Ring D, Sanchez HB. Reliability of the classification of proximal femur fracture: Does clinical experience matter? *Injury.* 2018; 49: 819-823.
12. Choi HR, Steinberg ME, Cheng E. Osteonecrosis of the femoral head: diagnosis and classification systems. *Curr Rev Musculoskeletal Med.* 2015; 8(3): 210-220.
13. Lawrence CR, Parker MJ. Complication rates related to the degree of displacement of femoral neck fractures: a clinical study of 878 internally fixed intracapsular fractures. *J Orthop Trauma.* 2011; 1: 1-6.
14. Palm H, Gosvig K, Krashennikov M, Jacobsen S, Gebuhr P. A new measurement of posterior tilt predicts reoperation in undisplaced femoral neck fractures: 113 consecutive patients treated by internal fixation and followed up for 1 year. *Acta Orthop.* 2009; 80: 303-307.
15. Onativia IJ, Slullitel PA, Dileria FD, Viezcas JMG, Vietto V, Ramkumar PN, et al. Outcomes of nondisplaced intracapsular femoral neck fractures with internal screw fixation in elderly patients: a systematic review. *Hip Int.* 2018; 28(1): 18-28.