

Dorsally displaced distal radius fractures: introduction of Pacetti's line as radiological measurement to predict dorsal fracture displacement

Valerio Pace^{1,2}, Riccardo Maria Lanzetti¹, Teresa Venditto³, Chang Park⁴, Woo Jae Kim⁵, Giuseppe Rinonapoli¹, Auro Caraffa¹

¹Department of Trauma&Orthopaedic, University of Perugia, Perugia, Italy; ²The Royal National Orthopaedic Hospital, Stanmore, London, United Kingdom; ³Neuromotor Rehabilitation - Hospital Service Policlinico Italia SRL, Rome, Italy; ⁴Department of Trauma&Orthopaedic, North West Thames London, London, United Kingdom; ⁵Department of Trauma&Orthopaedic, St. Mary's Hospital, London, United Kingdom

ABSTRACT. *Background and aim of the work:* In the best of our knowledge there is not yet in the literature a measurement able to assess post reduction stability of distal radius fractures. *Aim:* to study the relationship between our newly introduced Pacetti's line, anatomical reduction of DRFs and post-reduction stability of fractures. *Methods:* Retrospective observational study. Patients/Participants: 230 patients (122men, 108women) who sustained a dorsally displaced distal radius fracture. Close reduction procedures attempted; below elbow cast applied. Follow-up: Pacetti's line used on true AP and lateral view xrays after reduction and casting (T0) and at 7-14 days (T1-T2). *Main Outcome Measurements:* Assessment and prediction of early displacement of DRFs. *Results:* The Pacetti's line intersected the lunate bone in 162 cases (70.4%) after anatomical reduction, of which 20.4% (N=33) lost anatomical reduction. Cramer's V test: significant relationship between transition of Pacetti's line through the semilunar bone and stability of anatomical reduction at T0 follow-up ($p < 0.001$, Cramer's value=0.83). The Pacetti's line intersected the lunate bone in 119 cases (51.7%) at 7-14 days follow-up. None of patients lost anatomical reduction. Cramer's V test: significant relationship between transition of Pacetti's line through the semilunar bone and stability anatomical reduction at T1 and T2 follow-up ($p < 0.001$, Cramer's value=0.73). *Conclusions:* We strongly recommend the use of the Pacetti's line as it seems to provide reliable prediction of further fracture displacement and consequently of definitive management. The Pacetti's line seems to represent a very useful tool providing simple, feasible, efficient and reliable information on DRFs characteristics and natural course.

Key words: Distal radius fractures, conservative management, radial tilt, radial inclination, Pacetti's line, displaced distal radius fractures

Introduction

Distal radius fractures (DRFs) are very common injuries encountered in district hospitals and trauma centers all round the world, particularly amongst the elderly. Due to the sheer number of cases and injury cohort, the treatment is resource intensive (1-2) and can be a big burden on Orthopaedic departments.

There is already much literature available with regards to the management of distal radius fractures using several radiological measurements including radial height, radial inclination, volar tilt and ulnar variance (1-2-3) to ascertain whether to manage conservatively or surgically. However, there is yet to be an established radiological marker which is able to assess the stability of conservatively managed distal radius

fractures. This marker would be tremendously valuable to the Orthopaedic department as it would allow the surgeons to predict whether there would be displacement of these fractures in the first 2 weeks, thus requiring operative management.

There has been an abundance of improvements recently in the diagnosis and treatment of distal radius injuries. This has caused higher expectations for the surgeons to appropriately assess patients with distal radius fractures and interpret the relevant radiological imaging studies. Conventional radiographic examinations, as well as more sophisticated and invasive studies, have important roles in the evaluation of wrist fractures and dislocations.

The aim of this paper is to establish a relationship between the Pancetti's line and the anatomical reduction of dorsally displaced distal radius fractures. Pancetti's line is a novel radiological marker introduced in this study which could predict possible further dorsal displacement of distal radius fractures, thus facilitating management for clinicians. Pancetti's line could represent a very useful and simple tool for the clinician treating distal radius fractures by providing information on the natural course of the fracture in the first 1-2 weeks following the injury and therefore help make the most appropriate management decision at the earliest possible stage.

Materials and methods

Study design and Participants

A retrospective observational study was carried out on patients who had sustained a dorsally displaced distal radius fracture in the set time frame of 2 years. The study sample consisted of 230 patients of which there were 122 men and 108 women with a mean age \pm standard deviation (SD) of 42 ± 20.4 years.

The patients were treated and followed up by the local orthopaedic team in a secondary referral center for orthopaedic trauma and all surgical procedures were performed by the same team. After a clinical and radiological assessment of a PA and true lateral wrist views at initial presentation, a closed reduction procedure was attempted for all patients with a below

elbow cast. A CT scan of the injured wrist was also performed when indicated to further study the fracture. A post-reduction radiograph of both AP and true lateral wrist views were performed for all cases with follow up plain radiographs at 7 and 14 days following initial presentation. A full clinical examination of the ipsilateral upper limb was also performed at the end of the conservative treatment.

Inclusion-Exclusion criteria

We included in the study all patients presenting or referred to the local trauma team after sustaining a dorsally displaced distal radius fracture including both extra and intra-articular fractures. Patients must have had radiographs post reduction, 1 week post reduction and 2 weeks post reduction including PA and true lateral views. At least the distal third of the radius should be shown on the plain films. Only those whose risk factors were strictly related to fractures' characteristics and patterns were included.

We excluded patients who sustained volarly displaced distal radius fractures, as well as patients with open growth plates or inappropriate radiographic imaging. Additionally, patients with congenital or post traumatic upper limb deformities, polytrauma patients and those with severe medical comorbidities which affects management were excluded.

Every patient included in the study followed strict instructions given at the time of discharge by the surgeon after manipulation and casting.

True PA and lateral view radiographs of the injured wrist according to the most recent internationally recognised standards were required. A true lateral wrist radiograph is defined by the pisoscaphocapitate relationship, where the palmar cortex of the pisiform should lie centrally between the anterior surface of the of the distal pole of the scaphoid and the capitate, ideally in the central third of this interval. There is a superimposition of the carpal bones, including the distal portion of the scaphoid and the pisiform. The radius and ulna are superimposed and the ulna styloid can be seen posteriorly (1).

Postero-anterior (PA) and true lateral view plain radiographs were taken for all enrolled patients at all

follow up stages: the first one following close fracture reduction and casting (T0), and then again during the follow up clinic appointments at 7 days (T1) and 14 days (T2) post-casting.

We adopted the Pacetti's line using true lateral x-ray views of patients' wrists after sustaining a distal radius fracture. On this view we drew a straight line tangent and parallel to the volar diaphyseal radial cortex (the Pacetti's line). The proximal starting point of this line is the most proximal part of the volar diaphyseal radial cortex shown on the available plain films with the distal third of the radius available on the lateral radiograph. In order to make the line parallel to the diaphyseal radial cortex, we extended this line up, keeping the line always tangent to the diaphyseal radial cortex, from the starting point till the junction between the radial diaphysis and metaphysis at the level of the volar radial cortex. We further extended the line till the point it crosses the lunate bone with this upwards extension. This line was drawn on plain films performed straight after close fracture reduction and again at 7 and 14 days post manipulation and casting.¹ (Fig. 1,2,3,4)

We assessed: a) the presence of good anatomical reduction following closed reduction and casting; b) intra/extra-articular fracture extension; c) the loss of reduction at 7 to 14 days post reduction. For the purposes of the study, we considered the transition of the Pacetti's line through the semilunar bone and the loss of anatomical reduction as binary variables, either a yes or a no. There was one single observer performing the measurements and no other observers were involved in the measurements in order to avoid bias errors and increase level of reliability.

Radial inclination, volar tilt and percentage translation of the fracture fragments were recorded. Radial inclination represents the angle between the line linking the ulnar aspect of the distal radius and the radial styloid tip with a line perpendicular to the longitudinal radial axis and the normal range is from 21 to 25 degrees. Volar tilt represents the angle between a line along the distal articular surface and the line perpendicular to the longitudinal radial axis at the level of the joint margin with a normal range of 10 to 15 degrees. Fracture translation represents the movement

of the fractured bones away from each other and can be described using the width of the bone as context. (1)

All participants signed an informed consent form in accordance with the Declaration of Helsinki. Formal approval from our Institutional Review Board (IRB) was officially obtained from our Institution.

Sample Size

A priori power calculation was performed according to the primary outcome measure, assuming a two tailed α value of 0.05 (sensitivity 95 %), a β value 0.10 (study power: 90%) and a correlation ρ H1 0.25. We determined that at least 230 subjects were required via the G Power3 power analysis program.

Statistical analysis

Data was analyzed by a single researcher and Statistical Package for Social Sciences (SPSS version 18; IBM, Armonk, NY, USA) was used for calculations. Differences with P values <0.05 were considered to be statistically significant, and all results were expressed with a 95% confidence interval.

The Cramer's V statistic test was used to assess the correlation between the transition of the Pacetti's line through the semilunar bone after reduction and the loss of reduction at 7 and 14 days follow-up.

Results

Baseline characteristics of the sample are reported in Table 1. A total of 230 patients with a dorsally displaced distal radius fracture were enrolled in the study.

We observed that the Pacetti's line intersected the lunate bone in 162 cases (70.4%) of the total 230 on the lateral view plain radiograph after anatomical reduction and casting, of which the 20.4% (N=33) of the sample lost the anatomical reduction at further follow ups. The Cramer's V test showed a significant relationship between the transition of Pacetti's line through the semilunar bone and the stability of anatomical reduction at T0. ($p < 0.001$, Cramer's value=0.83). (Figure. 1,2)

Table 1. baseline characteristics of the studied population

N	230 (122 M, 108 F)
Age	42±20.4 (years)
Radial Inclination	17.95±4.52
Dorsal angulation	16.84±14.39
Percentage of translation (%)	12.98±16.64
N=number, M=male, F=female,	

**Figure. 1-2:** AP and lateral view of DRF after reduction with Pacetti's line crossing the lunate bone

The Pacetti's line intersected the lunate bone in 119 cases (51.7%) of the total sample on the lateral view plain radiograph at 7 and 14 days follow-ups. None of these patients lost their anatomical reduction at further follow ups. The Cramer's V test showed a significant relationship between the transition of Pacetti's line through the semilunar bone and the stability anatomical reduction at T1 and T2 follow up ($p < 0.001$, Cramer's value=0.73). (Figure. 3,4)

Discussion

Fractures of distal radius account for up to 20% of all fractures treated in the emergency department

**Figure. 3-4:** Loss of reduction of DRF at 7 days follow up with Pacetti's line not crossing the lunate bone (AP and lateral view)

(2-3). Initial assessment includes a full history including mechanism of injury and other associated injuries with further appropriate radiological evaluation. Treatment options include conservative management, internal fixation with pins, bridging and non-bridging external fixation and dorsal or volar plating with/without arthroscopy assistance. However, many questions regarding these fractures remain unanswered and good prospective randomized trials are needed. (2)

On the basis of physical examination results and the mechanism of injury, the onus is on the examining surgeon to pinpoint potential sites of bone or ligament disruption. Following this evaluation, further appropriate imaging studies will help direct treatment and improve outcome with clarity and good level of certainty. (4)

Closed treatment of distal radius fractures remains the predominant treatment method among all age groups, but DRFs are increasingly being treated with open reduction and internal fixation (ORIF). (5) Several publications (including Cochrane reviews) have outlined the need for more evidence to determine the most appropriate method of cast immobilization. (6) Furthermore, it has been shown that surgical and non-operative methods produce similar results in the treatment of DRFs in the elderly people, and minor objective functional differences did not result an impact on subjective function outcome and quality of life. (7)

No significant difference is found in the literature with regards to outcomes in patients treated with ORIF or external fixation. (8) In the past several years, an increase in open reduction and internal fixation (ORIF) for intra-articular distal radius fractures have been observed. This technique leads to a faster recovery of function compared to non-operative treatment. However, some patients continue to have painful and stiff wrist postoperatively, thus arthroscopic assisted removal of intra-articular fracture haematoma and debris may improve the functional outcomes following operative treatment of intra-articular distal radius fracture. (9)

Given the uncertainty in terms of available evidence for the treatment of DRFs, valid radiological and/or clinical predictor factors may play a very significant role in helping the surgeons take the most appropriate management decision at an early stage with the aim to achieve the best possible clinical outcome. (10-11)

Traditionally the management of distal radius fractures is guided by the interpretation of radiological findings. As a guide for treatment selection, palmar tilt, ulnar variance and radial angle and height measurements are useful. Radiological assessment of these parameters seems to be a reliable method of determining the degree of displacement of a DRF. (11-12)

Size of dorsal cortex comminution, age and sex of the patients could be a predictor factor for late dorsal tilt angulation of distal articular surface of radius at the end of immobilization. (13) The statistically derived clinical prediction formula Edinburgh wrist calculator (EWC) has uncertain relevance in predicting loss of alignment of DRFs with contradictory results and (14-15) measurement of intra-articular gap and step appear unreliable. (11)

Despite the wide utilization of the above mentioned radiological measurements and their significance in helping determining the management of DRFs, there has been a lack of literature of significant and reliable predictor factors which are able to predict further displacement and loss of anatomical reduction of dorsally displaced DRFs following reduction. The ability to predict the definitive treatment of DRFs imminently following closed reduction and casting may allow surgeons to promptly plan the treatment

accordingly and provide the best clinical outcome for the patients. This is also very important especially when planning surgical management, as surgery could be planned and performed at an earlier stage following the injury, reducing the time of non-useful immobilization and long-term joint stiffness. Not only does this bode better for patient outcomes, it could reduce the overall cost of care for the patient as it reduces the length of the follow ups by earlier definitive treatment. (16-17-18-19-20-21-22)

The newly introduced Pacetti's line has been shown to successfully achieve all the above goals. It is a simple measurement with a very high level of prognostic value, seeming to be a reliable instrument with a good potential to be implemented to the already existing specific radiographic findings for DRFs.

A confounding factor could be the incorrect execution of lateral view wrist radiographs, which was unexpectedly noted in a significant number of cases that were excluded in the study. Encouragement to the radiology departments to perform true lateral views radiograph in keeping with the most recent and accepted guidelines should be sought. This could allow a wider use of the Pacetti's line which consequently could provide a bigger impact and the described advantages of the introduction of the line in the management of DRFs.

We strongly recommend the use of the Pacetti's line to the trauma teams dealing with distal radius fractures as early results showed that this novel radiological measurement provides a reliable prediction of further fracture displacement and consequently the definitive management of the fractures. A widespread use of the Pacetti's line could allow the formation of a bigger database and definitive validation of his importance within the already existing radiological measurement for DRFs.

The very good sustainability of such a simple, easily calculated and cheap radiological measurement associated with a positive and relevant impact in the management of DRFs seems to be the first step of widespread use of the Pacetti' line.

In our experience the studied and newly introduced Pacetti's line seems to represent a very useful tool for all trauma teams dealing with plenty of distal radius fractures, providing simple, feasible, efficient

and reliable information with regards to the fractures' characteristics and natural course and consequently to their most appropriate management options.

However, there are some limitations to our study which have been identified. Interobserver variability of Pacetti's line drawing might partially bias the results. As seen in our study, there were a significant amount of substandard lateral views performed routinely for the management and follow up of our patients. Therefore a big effort and encouragement directed to the Radiology Departments to perform optimum lateral views should be sought. The use of Pacetti's line is limited to dorsally displaced DRFs and it cannot be used for volarly displaced DRFs or in paediatric patients. Bigger cohorts or studies with higher level of evidence are recommended in order to definitively validate our hypothesis and results.

This is a unique study utilising the Pacetti's line to radiologically assess and predict early displacement and loss of anatomical reduction in dorsally displaced distal radius fractures with great prognostic value. We believe our measurement could help the orthopaedic surgeons in taking the most appropriate management decision at an early stage of fracture management. As a consequence, this is also very relevant in terms of time and costs saving and clinical outcomes improvement. In fact its use could allow the performance of the most appropriate treatment plan from a very early stage (with the aid and confirmation of the other well known radiological parameters if necessary) and the avoidance of unnecessary radiological and clinical reviews and all the costs and the psychological-social impact on patients in relation to them. (22)

The Pacetti's line seems to be an ideal implementation to the already existing traditional radiological measurements for distal radius fractures, excelling for his simplicity and high level of prediction for loosening of anatomical reduction. We invite all the orthopaedic surgeons dealing with distal radius fractures to try its utilization in their practice, with the certainty of the achievement of excellent results, as already testified by the numbers and statistics shown in our study. We believe the simplicity of the drawing of the Pacetti's line and the immediacy of the findings are absolute and objective advantages compared to the use of any other radiological parameter.

Bigger case-control studies are needed in order to further validate Pacetti's line. The execution of appropriate and true lateral view radiographs of fractured wrists is a key to allow the correct drawing of the Pacetti's line and his proper use.

Conflicts of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Contributorship statement: VP, RL and AC planned the study and proposed the Pacetti's line as radiological measurement. VP, RL, TV, CP, WJK and AC made the literature search, selected and fully reviewed the articles. VP and RL collected the data. TV performed the statistical analysis. VP, RL, TV, CP, WJK and AC reviewed and discussed the results and findings and made discussion and conclusions. VP and RL wrote the paper, which was reviewed by TV, CP, WJK and AC. VP submitted the article.

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- Correspondence:**
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Dr. Valerio PACE University of Perugia (Perugia, Italy),
T&O Department 2 The Royal National Orthopaedic
Hospital (Stanmore, London, UK),
T&O Department, Via Settembrini 15, 06073,
Corciano (PG), Italy;
ORCID: 0000-0002-4499-9157,
Phone: 00447551881723,
Fax: 0755783531,
E-mail: valeriopace@doctors.org.uk