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ORIGINAL STUDY

The use of the three-point index in the management of extra-articular distal radius fractures

Bobby SIDDIQUI, Shanaka SENEVIRATHNA, Alistair HAYES, Aysha RAJEEV, Rahul KAKKAR, John HARRISON

From Queen Elizabeth Hospital, Gateshead, United Kingdom

Conservative management has been the mainstay of treatment for simple extra-articular distal radius fractures. Several factors, such as quality of definitive casting, have been implicated in the risk of fracture re-displacement during follow-up.

Objective assessments of the quality of casting using various indices have been documented in literature, although overall evidence remains scant, and only one study in the literature discusses the use of the three-point index (3-PI) in adults.

Currently, no independent study assessing the 3-PI in adults has been documented. This retrospective study aimed to assess the 3-PI in terms of (1) predicting fracture re-displacement and (2) evaluating its practicality in everyday clinical use.

We had 54 patients (47 female, 7 female), out of which 35 patients had a 3-PI greater than the suggested cut-off value of 0.8 ; of these, 22 went on to re-displace. The remaining 19 patients had a 3-PI below the cut-off and 14 went on to re-displace.

No statistical significance was found for the 3-PI as a predictor for fracture re-displacement, although inter-observer reliability was high ; its impact on clinic times (in calculating the 3-PI) remained low.

Keywords : three-point-index ; distal radius fracture ; plaster cast.

INTRODUCTION

Fractures of the distal radius account for an increasing percentage of the emergency department and orthopaedic case admissions, accounting for 20% of all fractures in the adult (*11*).

Management of these fractures depend on many patient, fracture and surgeon-related factors, each carrying a differing significance in prediction of fracture re-displacement and functional outcome (*5,6,10*). Plaster cast immobilisation of simple extra-articular distal radius fractures has often been the mainstay of treatment. Due to increasing unfamiliarity with proper casting techniques and reliance on operative intervention, this mode of management is often inadequate and may leave the patient with fracture re-displacement and potentially a protracted recovery.

■ Bobby Siddiqui, MBBS, MRCS(Ed), BSc, Clinical Research Fellow.
■ Shanaka Senevirathna, MBBS, MRCS, Senior Clinical Fellow.
■ Alistair Hayes, MBChB, MRCS(Ed), BSc(Hons), MSc, Surgical Registrar.
■ Aysha Rajeev, FRCS, Associate Specialist.
■ John Harrison, MSc, FRCSEd(Tr&Orth), MFSEM(UK), Consultant Orthopaedic Surgeon.
Queen Elizabeth Hospital, Gateshead, U.K.
■ Rahul Kakkar, FRCS (Tr+Orth), MBBS, Speciality Registrar.
University Hospital North Tees, Stockton-on-Tees, U.K.
Correspondence : Mr Rahul Kakkar, Department of Orthopaedics, University Hospital North Tees, Stockton-on-Tees, U.K. E-mail : rahulkaks@gmail.com

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Fracture patterns with initial complete displacement and degrees of obliquity, have been shown to be the most important risk factors for redisplacement (*2,6,10*). Studies conducted in the past have attempted to objectively assess the quality of plaster casting and reduction, and specifically to identify those casts that carry a high risk of re-displacement. Indices such as the Cast Index, Gap Index, Pad Index, Canterbury index and more recently, the 3-Point Cast index, have all been critically evaluated and compared (*1,2,5,8,10*). The literature favours the higher sensitivity, specificity and positive and negative predictive values of the 3-point index (3-PI).

The 3-PI, devised by Alemdaroglu *et al* (*2*) has been shown to be the most statistically significant predictor of re-displacement amongst surgeon factors in conservatively managed fractures of the distal radius (*9,10,12*). It objectifies the basic principles of fracture management : good anatomical reduction and three-point fixation. Based on data from Alemdaroglu *et al*, a 3-PI equal or greater than 0.8 led to a relative risk of 46 for fracture re-displacement.

However, overall evidence remains scant regarding this index, so far only 5 articles exist in the literature that compare and contrast the different indices. Four of the articles relate to management of paediatric fractures – one of which, being the seminal paper from Alemdaroglu *et al* (*2*) – whilst only one relates to adult injuries (*1*).

The objectives of this study were to evaluate (1) the efficacy and accuracy of the 3-PI in predicting re-displacement of conservatively-managed extra-articular distal radius fractures in the adult, and (2) the practicality of implementing the 3-PI, in everyday clinical use.

PATIENTS AND METHODS

All patients admitted to our institution with a distal radius fracture between January 2009 and August 2011 were identified from our hospital trauma database records. The same exclusion criteria used by Alemdaroglu *et al* (*1*) were implemented : (1) Age < 18 ; (2) intra-articular fracture ; (3) undisplaced, or minimally-displaced extra-articular fracture ; (4) pathological fracture ; (5) history of previous wrist fracture. All relevant radiographs were retrospectively analysed using the electronic PACS-based system electronic callipers (IMPAX ©Agfa v 6.2.1.258). Those cases found to have non-anatomical reduction as defined by Alemdaroglu *et al* (*1*), were also excluded from the study. This included radial inclination of less-than or equal-to seventeen degrees ; volar tilt of less-than or equal-to five degrees ; translation of greater-than or equal to two millimetres.

The local procedure for distal radial fractures was as follows : patients underwent initial reduction under haematoma block in the emergency department and were placed in a temporary short-arm 'backslab'. Distal neurovascular observations of the affected limb were made pre- and post-manipulation. Post manipulation radiographs (antero-posterior and lateral) were taken and presented to the department trauma meeting the following morning. Decisions regarding conservative or operative interventions were taken at that point. All surgically managed patients were excluded from the study. All conservatively managed patients were referred for definitive casting (usually within 72 hours to allow for reduction in soft-tissue swelling) by senior orthopaedic plaster technicians, followed by check radiographs, which were reviewed by senior orthopaedic medical staff.

Casting was conducted with a standardised technique, using one 3" length of '*Scotchcast Plus', 'Stockinette'* cut to length, and one roll of 4" orthoban wool. A three-point index was retrospectively calculated (Fig. 1) from this post-casting radiograph. Signs of re-displacement, as defined by Alemdaroglu *et al* (*1*), were checked on follow-up radiographs (at 1, 2 and 3-6 week intervals). Re-displacement was considered to have occurred when there was : (1) increase of 10° of dorsal or volar angulation, or (2) loss of ± 5° radial deviation or (3) more than 2 mm increase in ulnar variance or (4) a combination of 5° of dorsal and 3° of radial angulation and 1 mm of shortening.

Where fracture re-displacement was identified, subsequent radiographs were checked to establish whether this was managed conservatively or operatively (either by MUA, MUA and Kirschner-wire fixation or ORIF).

Calculation of a 3-PI and assessment of re-displacement was performed by the chief analyser (BS) in all cases. Inter-observer reliability was assessed through selection of ten patients by a computerized random number generator before calculation of a 3-PI score and assessment of re-displacement, independently performed by a senior orthopaedic practitioner (AR), who was blinded to the presence of re-displacement and in accordance with the guidance set out by Alemdaroglu *et al* (*1*). Mean length of time taken to perform 3-PI calculation was

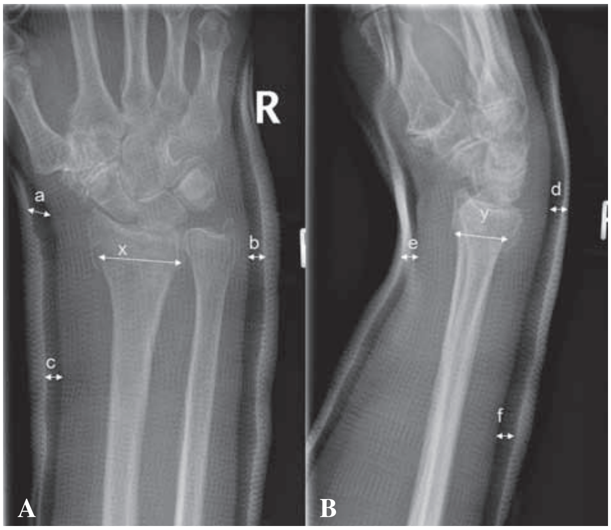

Fig. 1A & B. — Three point index was calculated using : *[(a + b + c)/x] + [(d + e + f)/y]*.
"a" = narrowest distal side gap at the level of radiocarpal or proximal carpal joint,
"b" = narrowest ulnar-side gap at the level of the fracture (within 1 cm of fracture line),
"c" = narrowest proximal radial side gap within the area between 3 and 7 cm proximal to the fracture site.
"x" = projection of contact length between the proximal and distal fragments in the horizontal plane on the anteroposterior radiograph.
"d" = narrowest distal dorsal-side gap at the level of the radiocarpal joint or proximal carpal bones,
"e"= narrowest volar-side gap within 1 cm of the level of the fracture line,
"f" = narrowest proximal dorsal-side gap within the area between 3 and 7 cm of fracture,
"y"= projection of the contact length between the proximal and distal fragments in the sagittal plane on the lateral radiograph.

recorded to assess the feasibility of utilising the 3-PI system in the clinic.

For continuous variables, Mann Whitney-U was used for analysis. Fisher's exact test was used to evaluate differences in categorical data. Inter-observer analysis was calculated using Spearman rank correlation. GraphPad Prism (version 5.0 for Mac OS X GraphPad Software, San Diego, USA) was used to perform statistical analysis and produce the graphs included. A *p*-value < 0.05 was considered significant.

RESULTS

We identified 371 consecutive fractures of the distal radius from the 32-month period at our institution. Using the exclusion criteria set out by Alemdaroglu *et al*, 54 patients were included in this study (47 female and 7 male). Their mean age was 68 years (range : 18 to 99).

Overall, the mean 3-PI was 1.01 (range : 0.444 to 1.996). Re-displacement occurred in 36 of the 54 patients. The mean time for re-displacement was approximately 2 weeks in both groups. Age was not significantly associated with re-displacement ($p = 0.083$).

Inter-observer testing found acceptable agreement in calculation of 3-PI values ; Spearman rank = 0.661 ($p = 0.044$). Kappa score analysis found reasonable agreement in end of follow-up redisplacement outcomes (K = 0.412, SE 0.301) between the chief analyser (BS) and independent analyser (AR).

Patients were analysed initially by dividing them into two categories, as shown in Table I : those with a 3-PI ≥ 0.8 (group 1) and those with a 3-PI of < 0.8 (group 2). Thirty-five patients were in group 1 (mean age : 66.1 years), 22 of which went on to re-displace. In group 2, there were 19 cases (mean age : 71.6 years). Among these, there were 14 re-displacements. A greater proportion of group 1 cases were managed conservatively.

Patients were then re-classified according to whether they had re-displaced or had remained un-displaced by the end of the follow-up. The mean 3-PI in the re-displacement group (0.93 +/- 0.05 SEM) was lower than that in the undisplaced group (1.10 +/- 0.09 SEM) ; the difference was however not significant ($p = 0.103$).

As the majority of patients were female in our study, we undertook further analysis of this main subgroup. Analysis found that female sex significantly increased the risk of re-displacement (Odds Ratio 6.54, $p = 0.034$). Age, however, did not correlate with re-displacement ($p = 0.425$). The mean 3-PI for re-displacement amongst females was also found to be lower (0.945 +/- 0.051 SEM) than the non-displaced 3-PI (1.18 +/- 0.112 SEM). This difference was close to, but not reaching statistical significance ($p = 0.056$).

Table I. — Comparisons between patients with 3-PI greater and less than cut-off value (0.8)

	3-PI ≥ 0.8 (Group 1)	3-PI < 0.8 (Group 2)
No. of patients	35	19
Average 3-PI	1.16	0.62
Average age of patients (years)	66.1	71.6
No. of re-displacements	22	14
Average time to re-displacement (weeks)	2.23	2.14
Management following re-displacement:		
MUA	1	2
UA+K-Wire	0	2
ORIF	2	1
Conservative	19	9

Table II. — Influence of gender and age on the likelihood of re-displacement

	Odds Ratio	95% Confidence Interval for Odds Ratio	*P*-value*
Gender (Female)	6.54	1.12 to 38.0	0.034 †
Age (all)			
18-65	0.385	0.118 to 1.25	0.137 †
65+	2.60	0.801 to 8.44	0.137 †
80+	2.80	0.770 to 10.2	0.142 †

† Fisher's exact test. P < 0.05 statistical significance, *significant values are denoted in bold.

Time taken to calculate the three point index reduced with increased familiarity. At the first attempt, it took 201.6 seconds to calculate the index, but by the 10th attempt this reduced to 87 seconds.

DISCUSSION

Our study disagreed with the findings of Alemdaroglu *et al* (*1*), in several ways : we could not find a statistically significant difference in the mean 3-PI values between patients that did not re-displace and those that did. In fact, on average, a higher 3-PI correlated with *lower* rates of re-displacement. Also, using a cut off value of ≥ 0.8 did not correlate with an increased risk of fracture re-displacement in our population.

Demographically, patient cohorts in our trial and those of Alemdaroglu *et al* (*1*) seemed comparable : 54 and 75 patients, respectively. Females accounted for the majority in both cohorts (87% in our study and 79% for Alemdaroglu *et al* (*1*) and this gender was identified as a significant risk factor for fracture re-displacement. Mean age was significantly different, however : 68 years for our study, and 53 years for the Turkish study, hinting towards the greater proportion of elderly patients in our western population. Nonetheless, we could not find any significant associations between fracture re-displacement and gender (the latter of which was also found by Alemdaroglu *et al* (*1*).

The vast majority of patients with a retrospectively-calculated 3-PI ≥ 0.8 were managed conservatively ; we speculate that re-displacement is often judged subjectively, and that lack of awareness of objective measures of re-displacement – as cited by Alemdaroglu *et al* (*1*) – may mean that patients were not treated appropriately. However, we admit to one of the limitations of the study : retrospective analysis of radiographs only. Patient factors, such as age, functional demand, choice ; have not been reviewed

Table III. — FEMALE PATIENTS - Influence of age on the likelihood of re-displacement

	Odds Ratio	95% Confidence Interval for Odds Ratio	*P*-value*
Age (females)			
18-65	0.492	0.125 to 1.94	0.467 †
65+	2.03	0.516 to 7.99	0.467 †
80+	2.00	0.515 to 7.7	0.348 †

† Fisher's exact test. P < 0.05 statistical significance, *significant values are denoted in bold.

and they will have had an impact on management decision.

Empirical calculation of the 3-PI showed resistance to interobserver variability, as was the case for detecting fracture re-displacement ; highlighting the integrity of the calculation and the accuracy of measurements using electronic callipers.

It was encouraging to note, that there were no excessively low (i.e. < 0.25) 3-PI values, which Alemdaroglu *et al* (*1*), state can lead to an increase in cast-splitting due to swelling and median nerve compression symptoms.

Our study agreed with the findings of Alemdaroglu *et al* (*1*), that although initial calculations of the 3-PI may be cumbersome, this is overcome within a few trials. This was clearly evidenced by the time taken per case during our interobserver trials : from approximately 4 minutes (240 seconds) at first trial, down to just over 60 seconds at the tenth attempt.

Therefore, impact on clinic times would be minimal.

There are several limitations in this study.

The retrospective basis of this study may be considered as a potential weakness, but also a potential strength, as the decisions of those involved were not influenced by an ongoing prospective study.

The final sample size (54 patients) was small, however, we feel this was a consequence of the stringent exclusion and inclusion criteria, set out by Alemdaroglu *et al* (*1*). However, *w*ith the number of patients studied, we cannot exclude the possibility of a type II error for some of the comparisons.

Improvements in the future could take the form of a prospective trial with larger patient cohort. The authors would advocate educating all involved clinicians in the criteria for fracture re-displacement as laid out by Alemdaroglu *et al* (*1,2*), prior to any trial ; thereby reducing subjectivity to a bare minimum.

Functional assessment using DASH scores could be implemented (something that was overlooked by Alemdaroglu *et al* (*1*), although work by Downing and Karantana (*3*) mentioned that although non-anatomical reduction did lead to radiological articular degeneration, there was little long-term correlation in an increase in perceived and objective disability.

To answer our initial questions : use of the 3-PI as radiological prognostic factor for fracture re-displacement in adults, did not tally with our findings. We could find no statistical correlation between a 3-PI score and fracture re-displacement.

However, there was good reproducibility of 3-PI scores calculated between individuals, and the potential impact on clinic times has been shown to be minimal.

Further prospective studies, with larger sample sizes, are indicated here and the cost implications of repeating a doubtful cast versus theatre time and material cost (distal radius locking plates, for example) should be investigated.

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