A RADIOLOGICAL ASSESSMENT OF THE QUALITY OF REDUCTION OF DISTAL RADIUS FRACTURES AT CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

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A Research Report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Orthopaedic Surgery

Johannesburg, 2016

DECLARATION

I, Akin A. Minnis declare that this research report is my own work. It is being submitted for Master of Medicine (in the branch of Orthopaedic Surgery) in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

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Akin A. Minnis

................day of …………………. 20……

DEDICATION

This research report is dedicated to my loving wife, Talietha for her unwavering love, patience, and support.

And to my parents, Ms. Vernel Davis and Mr. Randolph J. Minnis, for believing in me.

PUBLICATIONS AND PRESENTATIONS

There are currently no publications or presentations arising from this research report.

ABSTRACT

Distal radius fractures are one of the commonest injury types encountered by an orthopaedic surgeon. At Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), patients are exposed to a surgical staff with different levels of experience. Adequate assessment and management are of paramount importance in improving the chances of a good functional outcome.

The primary purpose of this study was to assess the quality of reduction of acute distal radius fractures at our institution CMJAH using the universally accepted parameters of distal radius morphology, to determine if surgeon's experience level influences the quality of reductions of distal radius fractures and secondarily, to ascertain if our surgeon based management reflects the suggested management of the IDEAL classification system.

An observational prospective review was performed. Twenty-six (26) patients with DRF's were treated at CMJAH over a six-month period and their pre- and post-reduction radiographs were assessed for the adequacy of reduction using manual measurements with standardised goniometer and ruler. Comparisons were made between the various surgeons' experience levels and the surgeons' management strategy was compared to the IDEAL classification. Descriptive statistics, paired sample tests, tests of normality, analysis of variance, and paired proportions were used to analyse the data.

All radiological parameters assessed demonstrated a statistically significant degree of reduction ($p<0.05$). There was good interobserver agreement in all of the radiographic parameters assessed except radial height and lateral articular gap ($p>0.05$). The surgeon's choice of reduction method closely resembles that suggested by the IDEAL Classification System.

We concluded that distal radius fractures presenting to CMJAH casualty over a six-month period were adequately reduced. The surgeon's level of experience may impact the quality of reduction of the radial height. The IDEAL classification may prove

useful as an alternative in classifying and guiding management at our institution. Outcome studies of this cohort are required to determine if our statistically significant reductions are functionally significant.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to the following people that assisted me with this research report:

Professor M Lukhele, consultant orthopaedic surgeon, Charlotte Maxeke Johannesburg Academic Hospital, for co-supervising this research project and for all of his valuable contributions, including the proofreading and editing of this report.

Dr. T Pikor, consultant orthopaedic surgeon, Charlotte Maxeke Johannesburg Academic Hospital, for the research topic, for supervising this research project and for all of his valuable contributions, including the proofreading and editing of this report.

Professor F Bischof, M Poopedi, Dr. M Jingo and Dr. B Milner for their input and suggestions for this report.

M Lusembo, statistician for statistical advice for this report.

All surgical registrars at Charlotte Maxeke Johannesburg Academic Hospital, Division of Orthopaedic Surgery, University of Witwatersrand that assisted with the follow-up and data collection.

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NOMENCLATURE/ABBREVIATIONS

AO: Arbeitsgemeinschaft für Osteosynthesefragen

ANOVA: Analysis of variance

ASIF: Association of the Study of Internal Fixation

CHBAH: Chris Hani Baragwanath Academic Hospital

CMJAH: Charlotte Maxeke Johannesburg Academic Hospital

CR: Closed reduction

CT- Scan: Computerised Tomography scan

DRF: Distal radius fracture

DRUJ: Distal radio-ulna joint

Ex-fix: External Fixator

FS: Fragment Specific

HREC - Human Research Ethics Committee

IDEAL: **I**ncongruity, **D**isplacement, **E**nergy, **A**ge, **L**esions

K-Wire: Kirschner wire

Lat: Lateral

MVA: Motorised vehicle accident

ORIF: Open reduction internal fixation

PA: Posteroanterior

PACS: Patient Archiving Communication System

PVA: Pedestrian-vehicle accident

SPSS: Statistical Packages for Social Science

USD: United States dollar

DEFINITIONS

Anterior: Nearer the front, especially in the front of the body, or nearer to the head or forepart.

Displacement: defined in terms of the abnormal position of the distal fracture fragment in relation to the proximal bone.

Distal: Situated away from the centre of the body or from the point of attachment.

Inclination: the fact or degree of sloping.

Insufficiency fracture: a fracture caused by normal or physiologic stress upon weakened bone

Intra-articular: situated within, occurring within, or administered by entry into a joint.

Lateral: Situated on one side or other of the body or of an organ, especially in the region furthest from the median plane.

Ligamentotaxis: a technique of using continuous longitudinal force (distraction) in order to bring fracture fragments more closely together.

Locking Plate: A metal plate with threaded screw holes that allow mechanical coupling to a locking head screw. The device is typically used in orthopaedic surgery to stabilise a bony fracture to allow healing.

Palmar: referring to the palm of the hand; volar.

Posterior: Further back in position; of or nearer the rear or hind end.

Radio-carpal Joint: A joint between the distal end of the radius and the proximal row of carpal bones.

Radio-ulnar Joint (Distal): A pivot joint formed between the head of ulna and the ulnar notch on the distal extremity of radius.

Radius: The thicker and shorter of the two bones in the human forearm.

Radial: located on the same side of the forearm as the radius.

Reduction: a surgical procedure to restore a fracture or dislocation to the correct alignment.

Ulna: The thinner and longer of the two bones in the human forearm, on the side opposite to the thumb.

Ulnar: located on the same side of the forearm as the ulna.

CHAPTER 1 - INTRODUCTION

1.1 INTRODUCTION

Studies that assess the quality of reduction of distal radius fractures (DRF) in orthopaedic training programmes are few. In our setting, many patients with distal radius fractures present to CMJAH and are exposed to varying levels of surgeon experience. It is therefore important to classify the fracture pattern, institute appropriate management, evaluate the adequacy of the reductions, and identify any shortcomings or deficiencies that may negatively impact the ultimate goal of a better functional outcome and level of satisfaction in our patient population.

The primary aim of this study is to evaluate the quality of the reduction of distal radius fractures that were reduced at CMJAH during a six-month period and to assess the impact of surgeon experience on the quality of the reductions performed on these patients. A secondary aim of this study is to determine if the surgeon based management decision corresponds with a newer distal radius fracture classifying system.

1.2 BACKGROUND

1.2.1 Anatomy

There are two bones in the forearm; the medial bone is known as the ulna and the lateral bone is called the radius (Figure 1.1). It consists of a proximal and distal end, and a shaft. The distal end encompasses the metaphysis, scaphoid facet, the lunate facet, and sigmoid (ulna) notch (Figure 1.2), which supports and articulates with the carpus and the distal ulna(1). Injuries to the distal radius are the most common injury in the upper extremity and are estimated to have an incidence of 17.5% (2, 46). According to Ikram et al. (2013), it also accounts for one sixth of the emergency room admissions (47).

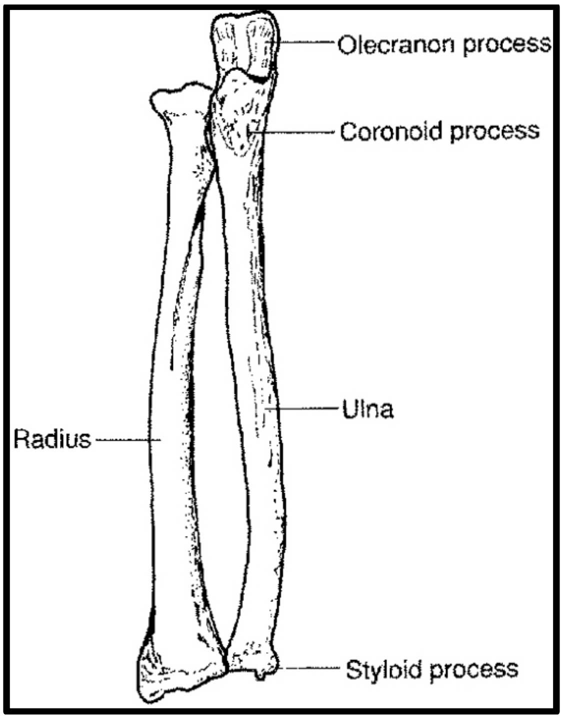


Figure 1.1 Bones of the forearm (50)

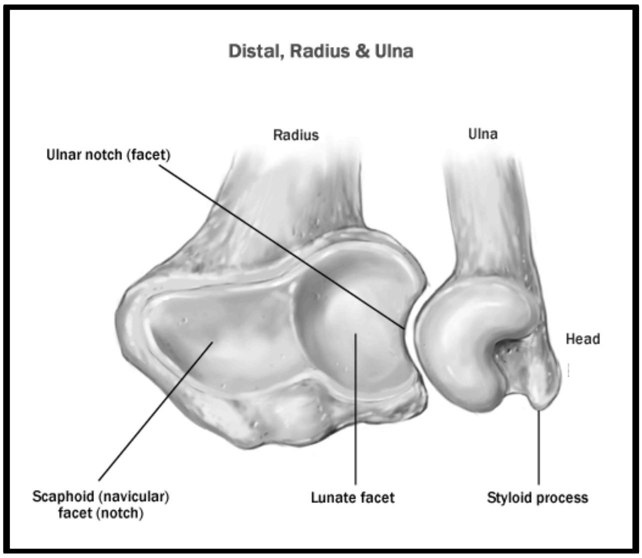


Figure 1.2. Distal radius and ulna anatomy (51)

1.2.2 Epidemiology

Evidence demonstrates that the distal radius fracture carries a bimodal distribution that is both gender and age specific, with peaks in incidence in the young male under the age of fifty years and in the older female over the age of forty years, Figure 1.3 (4, 5). This difference can be attributed to the high-energy trauma sustained in the younger group and, in the older population, to the combination of high-energy and insufficiency fractures – fractures occurring as a result of normal energy on abnormal bone (3).

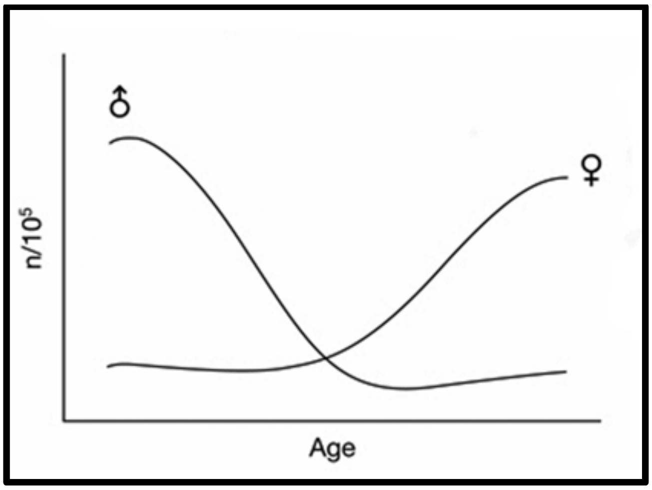


Figure 1.3. Bimodal distribution of distal radius fractures (46)

Distal radius fractures account for one of the most common fracture types that a trauma orthopaedic surgeon encounters, and therefore have a significant financial impact on both the patient and healthcare facility (6). Total health-care and productivity cost data have demonstrated that these injuries account for the most expensive injury group when compared to hip and lower limb injuries costing approximately USD$740 million per annum, Table 1.1, Figure 1.4 (7). It is therefore important to identify and treat these injuries appropriately, thereby reducing the hospitalisation cost, the risk of degenerative changes and disability, and the emotional and physical impact that a poorly treated distal radius fracture will have (8). Currently, no data is available that outlines the hospitalisation costs at Charlotte Maxeke Johannesburg Academic Hospital.

Table 1.1. Health-care and productivity costs of the most expensive injury type in 2007 (7)

	No. of Injuries* (thousands)	Cases (per 100,000)	Health-Care Costs† (millions)	Health-Care Costs per Case†	Productivity Costs† (millions)	Productivity Costs Per Case†	Total Costs† (millions)
Hand and wrist injuries	260	1575	329	1265	411	1580	740
Knee and lower leg fractures	66	400	233	3530	329	4985	562
Hip fractures	15	90	480	32,000	52	3465	532
Superficial injuries*	270	1600	301	1115	107	400	408
Skull brain injury	32	200	136	4250	219	6845	355
Other	277	1700	988	3570	801	2890	1789
All injuries	920	5600	2467	2680	1919	2086	4386

*Superficial injuries to hand or wrist were excluded. †The values are given in U.S. dollars.

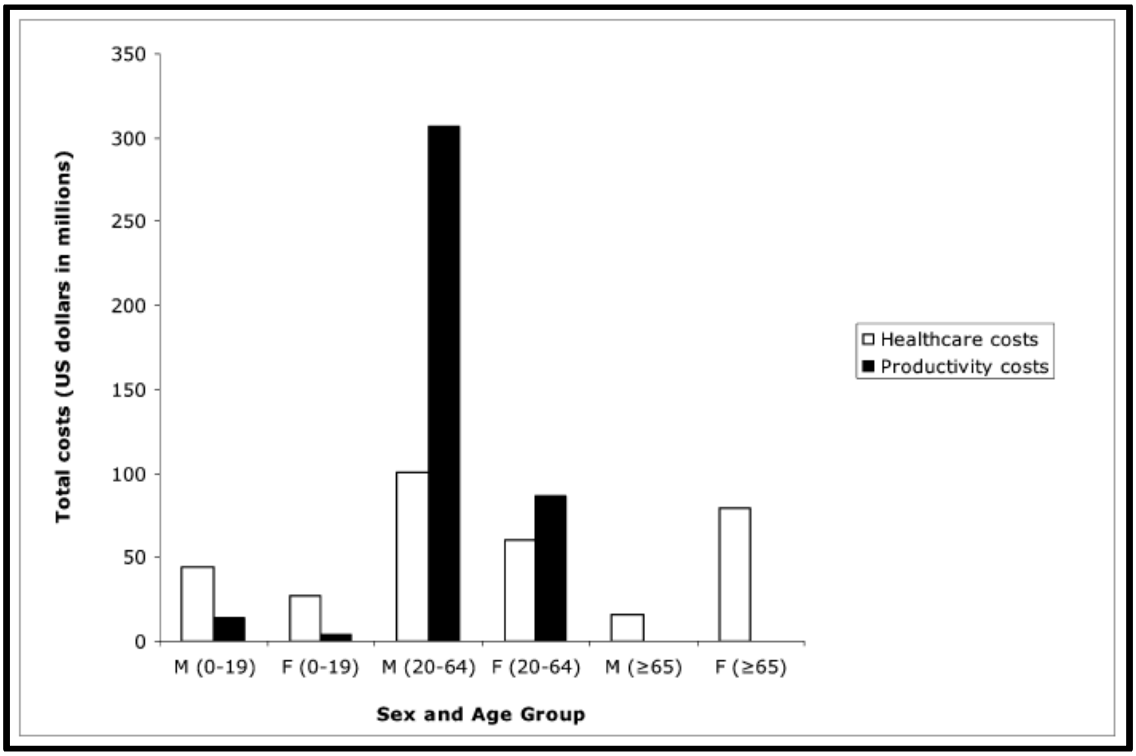
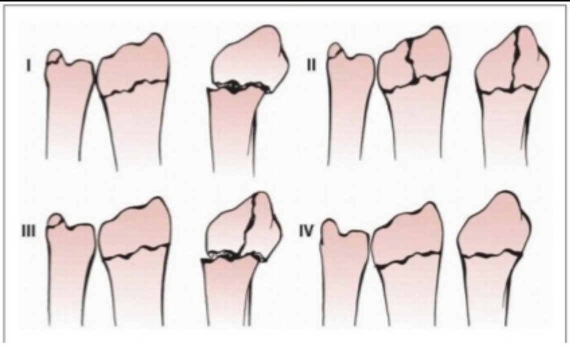


Figure 1.4. Total health-care and productivity costs (U.S. dollars in millions) due to hand and wrist injuries in the Netherlands in 2007, according to sex and age group (7)

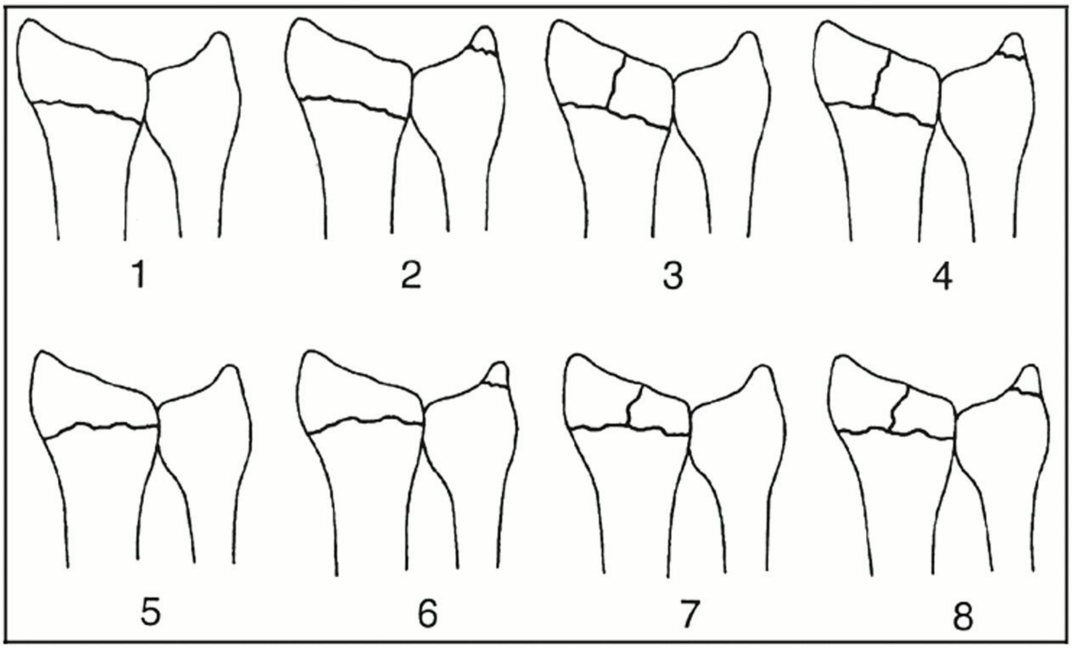
1.2.3 Classification Systems of Distal Radius Fractures

Many classifications systems for distal radius fracture have been designed with the intention to guide treatment and predict outcome. The more commonly used classification systems cited in the literature include Lidström, Garland and Werley (Figure 1.5), Older, Frykman (Figure 1.6), Thomas, Melone, Jenkins, Jupiter, Universal, Mayo, AO/ASIF (Figure 1.7), Fernandez (4). However, not one seems to be adequately reproducible and reliable because of the variable number of fracture patterns that exist. Thus, the classification system used most commonly offers an acceptable inter- and intraobserver reliability at best, thereby limiting its clinical use (3, 4).



1. Simple Colles fracture without intrarticular involvement
2. Comminuted Colles' fractures with intra-articular extension without displacement
3. Comminuted Colles' fractures with intra-articular extension with displacement
4. Extra-articular, undisplaced

Figure 1.5. Garland and Werley classification for fractures of the distal radius (10)



Articular involvement	Without distal ulna fracture	With distal ulna fracture
Extra-articular	I	II
Intra-articular (radiocarpal joint)	III	IV
Intra-articular (distal radio-ulna joint DRUJ)	V	VI
Intra-articular (radiocarpal & DRUJ)	VII	VIII

Figure 1.6. Frykman Classification (48)

The most widely used and accepted classification system in use to date is the AO/ASIF Muller classification system (Figure 1.7) (11, 12). The most recent classification system developed is the IDEAL classification system, Tables 1.2, 1.3 (9). It encompasses the most significant features of distal radius fractures that will guide management and predict patient outcome. Also, it considers both epidemiological and radiographic parameters in a scoring system that is easy to use in clinical practice, and offers better interobserver and intraobserver reliability and reproducibility (9).

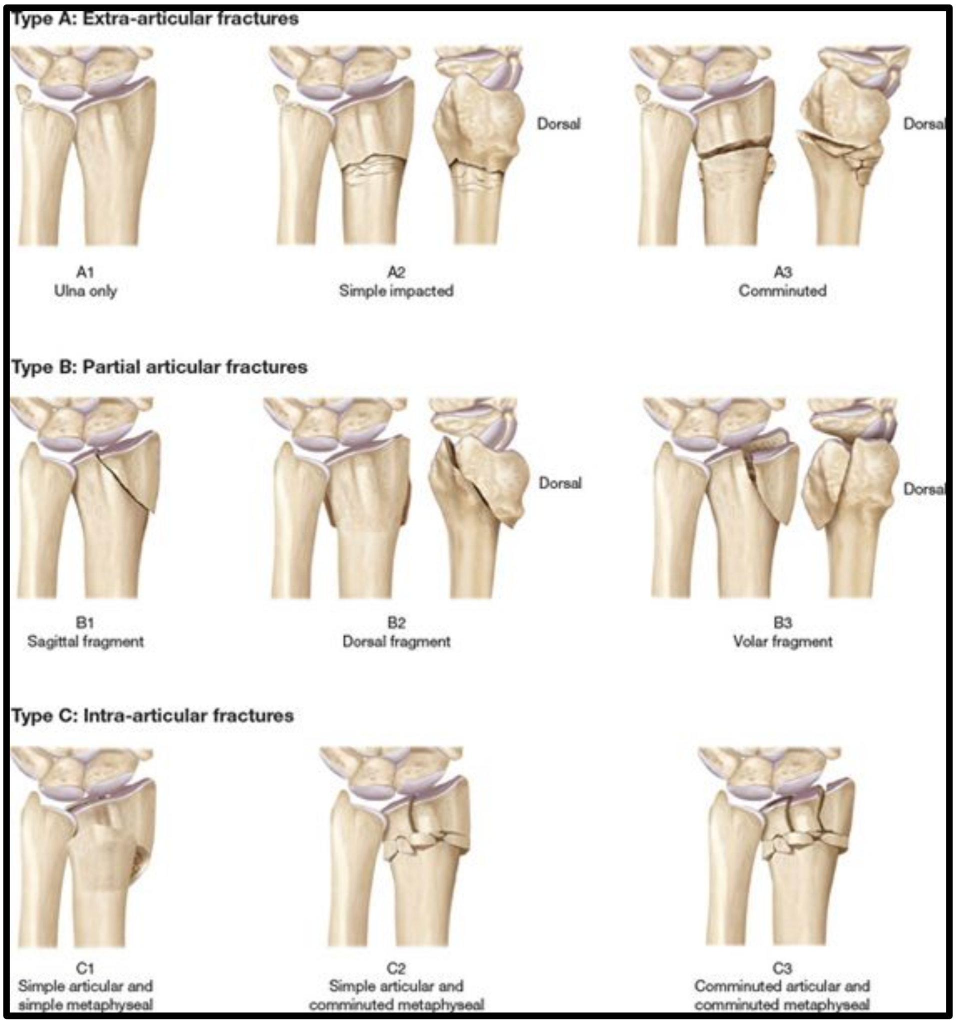


Figure 1.7. AO/ASIF Classification of distal radius fractures (11)

Table 1.2. IDEAL classification system: rationale and scoring (9)

	Parameter	0 points	1 point
I	Joint incongruity	No	Step or gap > 2 mm
D	Displacemen	No	Requires reduction
E	Energy[1]	Low	High
A	Age	< 60 years old	≥ 60 years old
L	Associated lesions[2]	Absent	Present

[1]Low = fall from standing height, or High = other; [2]Open fracture/carpal fractures and/or instability/distal ulnar fractures.

Table 1.3. IDEAL classification system: Treatment and prognosis guide (9)

Type	Score	Description	Treatment	Prognosis
I	0-1 points	Stable	Conservative	Good
II	2-3 points	Potentially unstable	Pins/external fixation/plating	Intermediate
III	4-5 points	Complex	Associated methods/bone graft	Poor

1.2.4 Goals of Management

The goal of treatment of a distal radius fracture is to restore normal anatomy, provide stable fixation and early pain free and full functional movement about the wrist. When treating a distal radius fracture, consideration must be given to patient factors, fracture pattern, fracture stability, timing and modalities available, and the quantitative parameters that define the acceptable reduction (3-5). This consideration is essential to achieving good functional and radiographic outcomes. It was found by Robert Medoff (2005) that accurate assessment of the radiographic abnormalities of the distal radius improves the surgeon’s ability to make a more informed decision on fracture management (13).

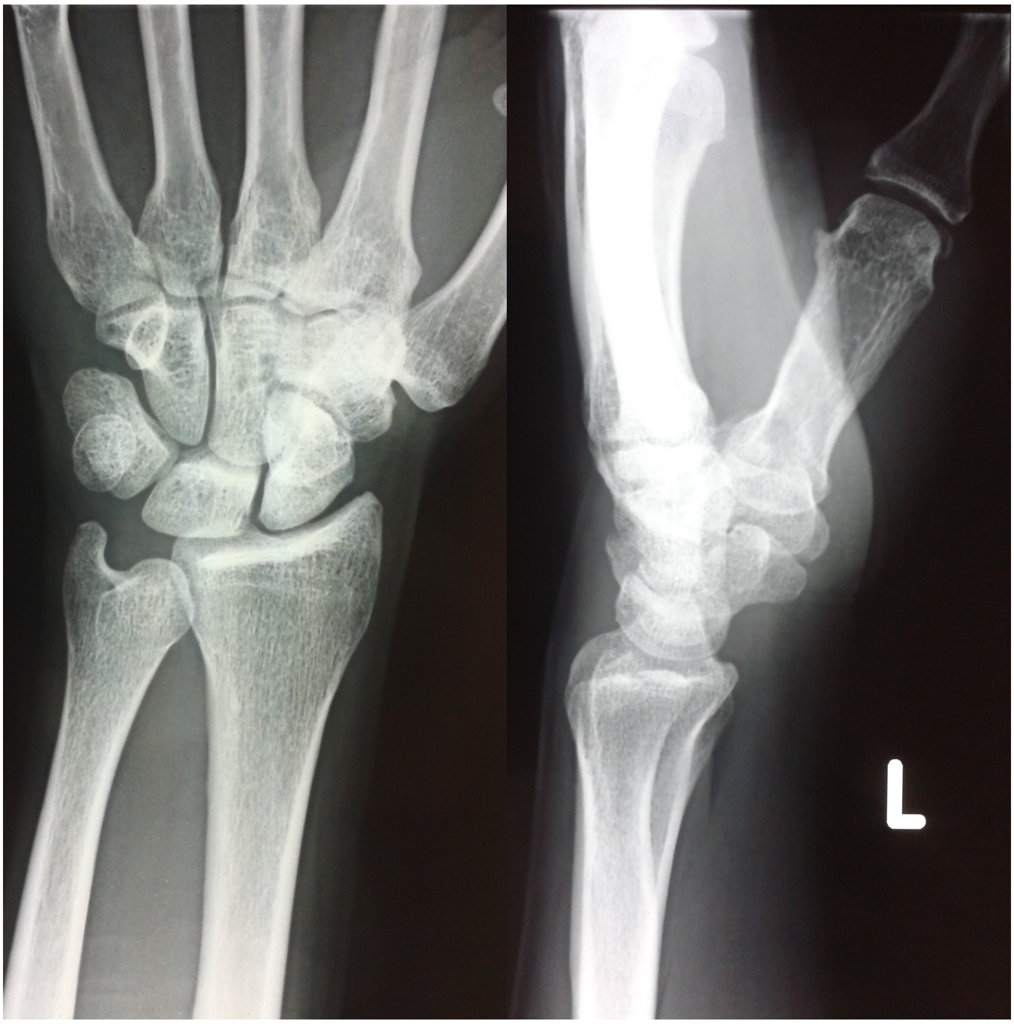
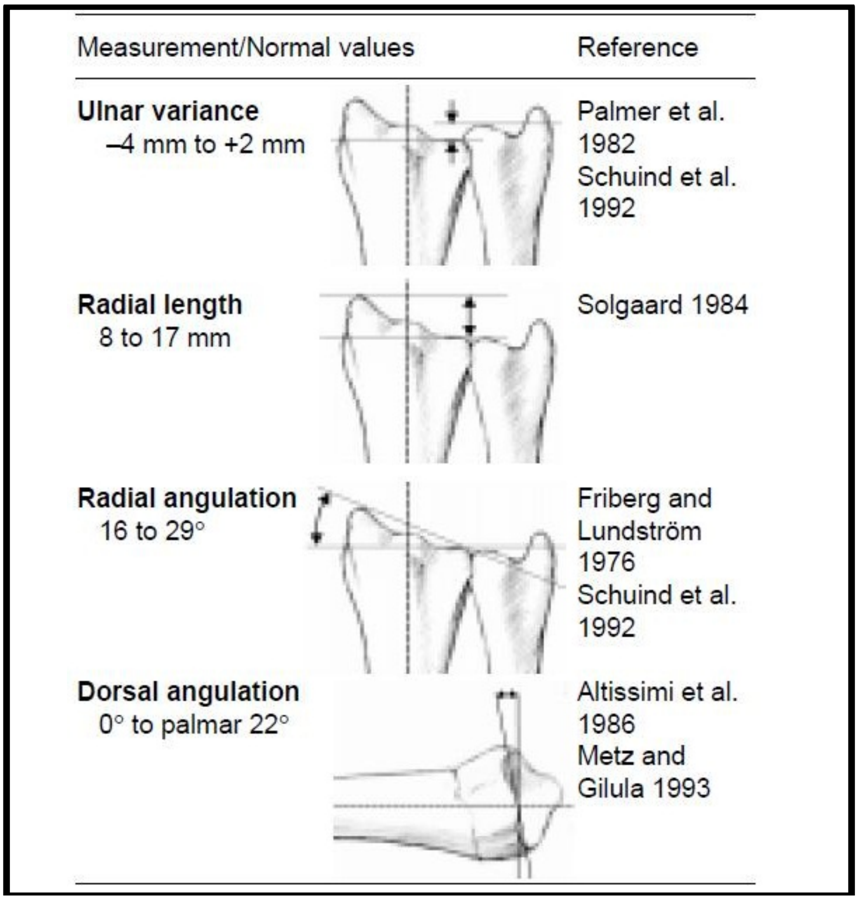


Figure 1.8. Posteroanterior and lateral radiographs of the distal radius (52)

1.2.5 Normal Anatomic Parameters

To achieve the goal of restoration of normal anatomy the treating surgeon must note and consider the following key radiographic parameters which are the gold standard measurements that define radiographic reduction quality on posteroanterior and lateral films (Figure 1.8): dorsal tilt, dorsal displacement, radial inclination, radial height, ulna variance, intra-articular gap and intra-articular step (Figures 1.9, 1.10, 1.11) (14, 15). The universally accepted values for palmar tilt (dorsal angulation) is 0 – 22° degrees, radial height (length) is 8 -17mm, radial inclination (angulation) is 16 - 29°, ulnar variance is -4 - +2mm (16-21). Studies have demonstrated that an adequate reduction leads to high levels of patient satisfaction (15).



Measurement/Normal values	Reference
Ulnar variance –4 mm to +2 mm	Palmer et al. 1982 Schuind et al. 1992
Radial length 8 to 17 mm	Solgaard 1984
Radial angulation 16 to 29°	Friberg and Lundström 1976 Schuind et al. 1992
Dorsal angulation 0° to palmar 22°	Altissimi et al. 1986 Metz and Gilula 1993

Figure 1.9. Normal values of the distal radius morphology (22)

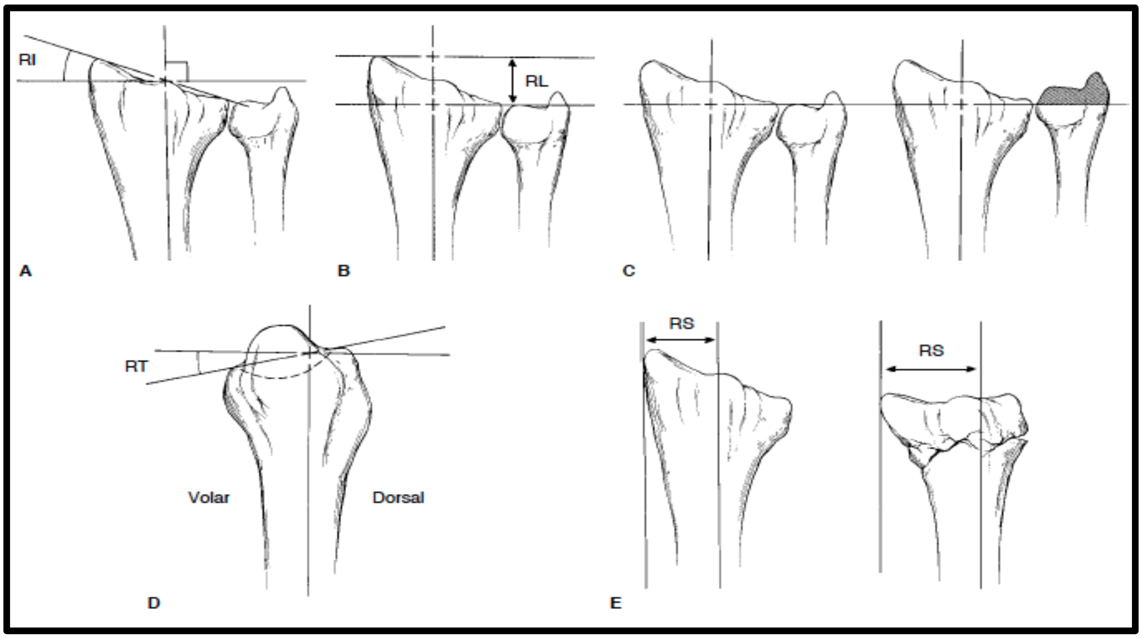


Figure 1.10. Calculation of radiographic measurements of the distal radius. A, On a PA radiograph, the radial inclination (RI) is the angles subtended by a line perpendicular to the long axis of the radius and a line reflecting the articular surface of the radius. B, On a PA film, the radial length (RL) is the distance between tangents drawn at the radial styloid and the ulnar pole, perpendicular to their shaft axes. C, The ulnar variance, or radio-ulnar length, also measured on a PA film, reflects the axial relationship between the ulnar pole and the ulnarmost aspect of the distal radius. In the drawing on the left, the radio-ulnar length is neutral. The drawing on the right demonstrates a prominent ulna at the DRUJ. D, on a lateral radiograph, the radial tilt (RT) is the angle between the articular surface and a line perpendicular to the radial shaft. E, On a PA film, the radial shift (RS), or radial width, is a comparison measurement made between the malunited radius and the non-injured radius. It is the distance between parallel lines drawn tangent to the radial styloid and the long axis of the radius (1).

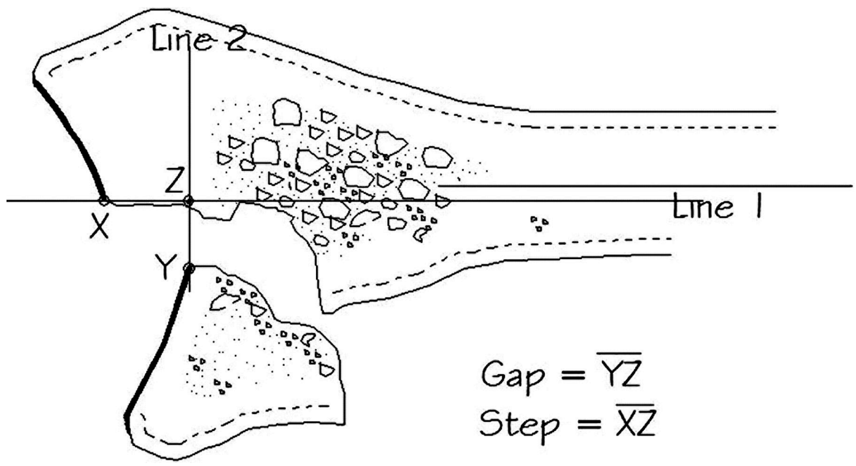


Figure 1.11. Illustrations of the distal radius intra-articular step and intra -articular gap measurement (23)

Many methods exist to achieve the aforementioned goals of treatment of distal radius fractures. These methods include closed reduction and casting (Figure 1.12), percutaneous pinning (Figure 1.13), external fixation (Figure 1.14) and open reduction and internal fixation (Figure 1.15). Closed reduction is a method ideally suited for non-comminuted minimally displaced fracture patterns, whereas percutaneous pinning is better suited for fractures that have two or less intra-articular fragment and are reduced with traction. In cases where there is significant intra-articular fragmentation and soft tissue damage, ligamentotaxis can aid the reduction then an external fixator is warranted, however if the palmar tilt or the intra-articular displacement cannot be restored then open reduction internal fixation is the preferred technique (24).

Figure 1.12. A short arm cast (Courtesy of CMJAH, Gauteng Health Department)

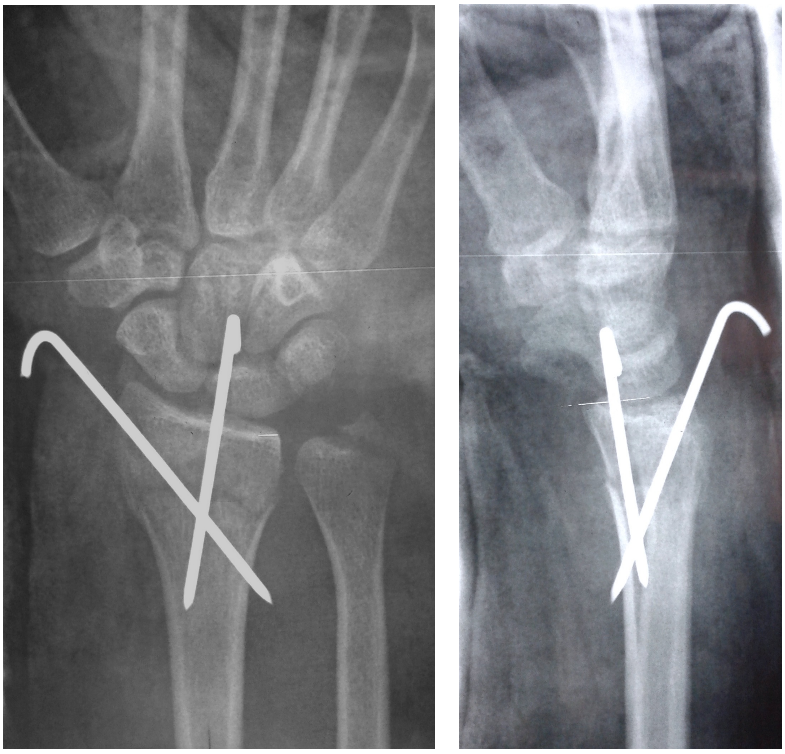


Figure 1.13. X-ray demonstrating reduction of the fracture maintained with two percutaneous pins (Courtesy of CMJAH, Gauteng Health Department)

Figure 1.14. An external fixator (49)

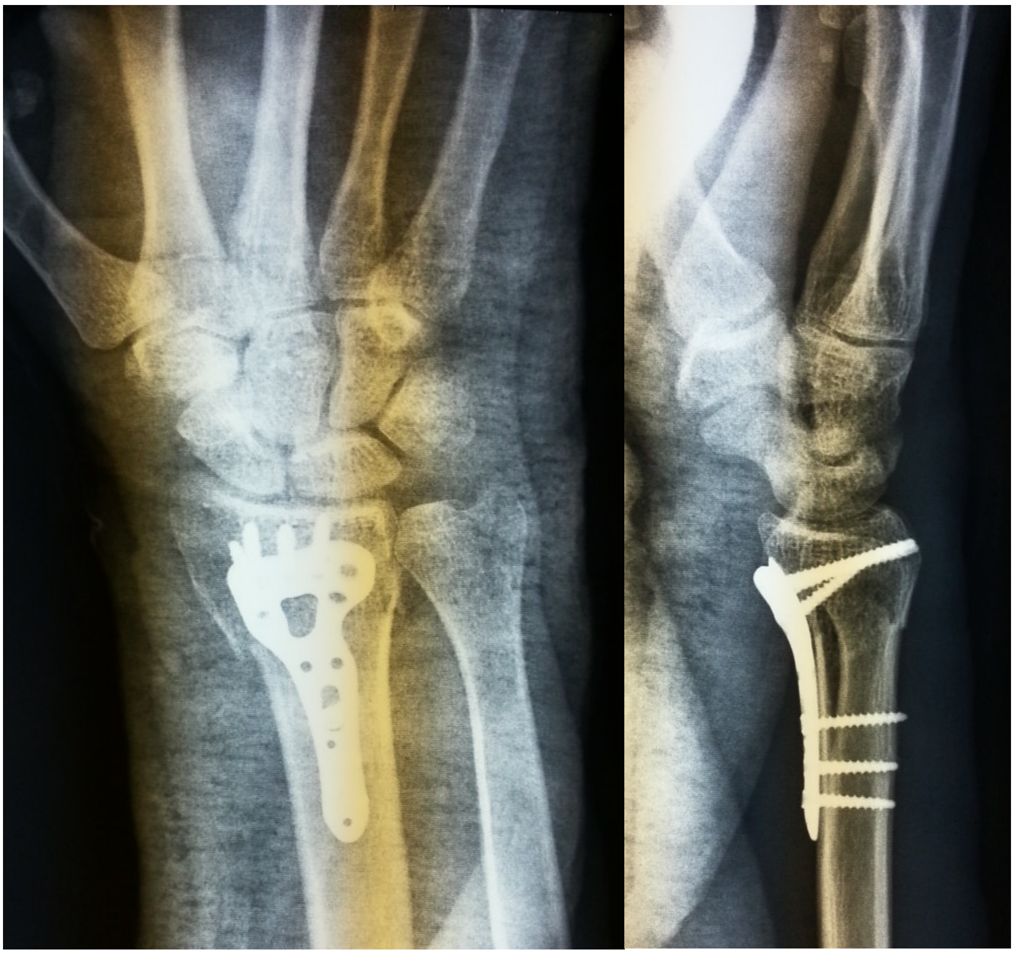


Figure 1.15. X-ray of an open reduction internal fixation of a distal radius fracture with a volar plate (Courtesy of CMJAH, Gauteng Health Department)

To achieve and maintain an adequate reduction the orthopaedic surgeon will utilise, in varying ways, one, or a combination of these methods. Currently no data exists that assesses the quality of the reduction at CMJAH, so that the more successful reduction methods can be identified and the less successful methods identified and improved upon, thereby providing the patient with the most appropriate and best form of treatment that will ultimately improve their functional outcome and level of satisfaction.

This study will examine and provide objective evidence that the quality of reductions performed by the surgical staff at Charlotte Maxeke Johannesburg Academic Hospital are within the universally accepted ranges and are therefore adequate.

1.3 Research Questions

1. Is there a difference between the pre-reduction and the post-reduction radiographic parameters of distal radius fractures reduced at CMJAH?

2. Does the experience level of the surgeon influence the quality of the reduction of distal radius fractures performed at CMJAH?

3. Does the surgeon's choice of reduction reflect the reduction method suggested by the IDEAL classification system?

1.4 Study Objectives

1. To compare the pre-reduction radiographic parameters with the post-reduction parameters of distal radius fractures presenting to Charlotte Maxeke Johannesburg Academic Hospital over a six-month period and to assess whether the quality of reduction is adequate according to universally accepted parameters.

2. To ascertain if the experience level of the operating surgeon has an impact on any of the radiographic parameters.

3. To compare the surgeon based management to the new IDEAL Classification system and highlight any similarities.

CHAPTER 2 – METHODS AND MATERIALS

2.1 METHODS

2.1.1 Ethics

The Human Research Ethics Committee (HREC) of the University of the Witwatersrand approved this study. The clearance number is M150491.

Throughout this study, from commencement to termination, patient confidentiality was maintained and strict adherence to the terms and conditions set out by the HREC Approval Committee was strictly adhered to.

2.1.2 Study Design

An observational prospective review of distal radius fracture radiograph measurements was performed over a six-month period on a consecutive sample group of twenty-six (26) patients that had non-operative [closed reduction], operative [percutaneous pinning/open reduction internal fixation or external fixation] management. Surgeons utilized various classification systems to guide management, with the exception of the newer IDEAL system.

2.1.3 Population

The population included all patients sustaining a distal radius fracture and subsequently undergoing non-operative [closed reduction] or operative [percutaneous pinning/open reduction internal fixation or external fixation] management. Twenty-six (26) patients [twenty-seven (27) wrists] were recruited to this study.

2.1.4 Setting

Charlotte Maxeke Johannesburg Academic Hospital – Orthopaedic Department: Trauma Unit. This is a tertiary level facility situated in Johannesburg, South Africa and represents referral area for many peripheral hospital and clinics and can therefore provide the number of patients required to meet the needs of this study.

2.1.5 Inclusion Criteria

1. Age 18 years or older and able to give informed consent.
2. All distal radius fractures (intra-articular and extra-articular fractures).
3. All acute distal radius fractures less than 2 weeks post injury.
4. All patients with pre-operative injury films will be included in the study.

2.1.6 Exclusion Criteria

1. Patients undergoing distal radius revision surgery.
2. Patients with previous wrist injury on the side evaluated.
3. Any case not satisfying the aforementioned inclusion criteria.

2.1.7 Recruitment

The Charlotte Maxeke Johannesburg Academic Hospital Orthopaedic, Diagnostic Radiology, and Casualty Department were briefed on the aim and the inclusion/exclusion criteria of the study.

Patients were educated about this study and informed consent (Appendix B, Appendix C) was obtained from the patient before their inclusion. A distal radius fracture data form (Appendix D) was then completed.

2.2 Materials

Standard orthogonal radiographic projections of the wrist were taken at 100 percent magnification for analysis. Images included pre-operative injury postoperative films [posteroanterior (PA) and Lateral (Lat.) projections]. A goniometer, a ruler with 1-millimetre (mm) scale and SPSS (Statistical Packages for Social Sciences) Software Version 13 were used for analysis.

2.3 Measured Variables

The radiographic parameters undergoing assessment were as follows:

Posteroanterior (PA) (16-21)

- radial inclination [degrees]
- radial length [mm]
- articular step-off [mm]
- articular gap [mm]
- ulnar variance [mm]

Lateral (Lat) (16-21)

- palmar/volar tilt [degrees]
- articular step-off [mm]
- articular gap [mm]

2.4 Follow-up

The initial pre-reduction injury and post-reduction wrist radiographs were collected and assessed by two independent observers.

2.5 Assessors

There were two assessors for this study – the principal investigator and the project supervisor. Both assessors were blinded to each other's assessments of each patient's radiographs. All measurement were independently taken and assessed by the principal investigator and project supervisor.

2.6 Data Analysis

Statistical analyses of the data are presented in the following section. First, demographic profiles of patients are described in pie charts and information related to injury variables is presented in table format. The tests of significance, related samples tests and analysis of variance (ANOVA) were then carried out, respectively, to determine whether there is a significant difference between pre-reduction injury radiographic and post-operative radiographic parameters, for two different assessors, and whether the post-operative reduction differs significantly among the experience levels of the treating surgeons.

To carry out the two above-mentioned tests of significance, it was decided on whether a parametric version or a non-parametric version would be used. If variables are normally distributed, the parametric test (Paired Sample T-test and ANOVA) is used; otherwise, a non-parametric test (Wilcoxon and Kruskal Wallis) is used.

The Kolmogorov Smirnov test of normality is carried out to determine whether each of the pre-reduction and post-operative radiographic parameters is normally distributed. In this test, the null hypothesis is that the variable is normally distributed and the alternative hypothesis is that it is not. If the p-value is less than 0.05, the hypothesis of normality is rejected.

All the analyses were carried out using the SPSS (Statistical Packages for Social Sciences) software, version 13.

CHAPTER 3 – RESULTS

3.1 DESCRIPTIVE STATISTICS

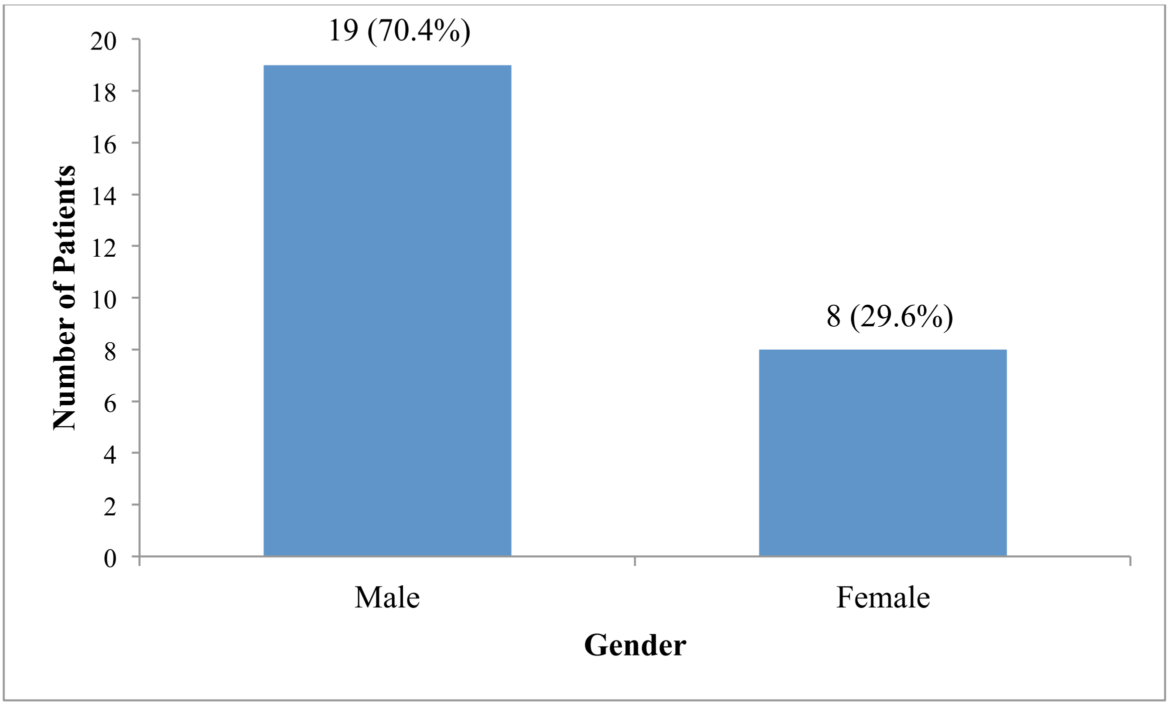


Figure 3.1. Gender distribution of patients in the study (n = 27)

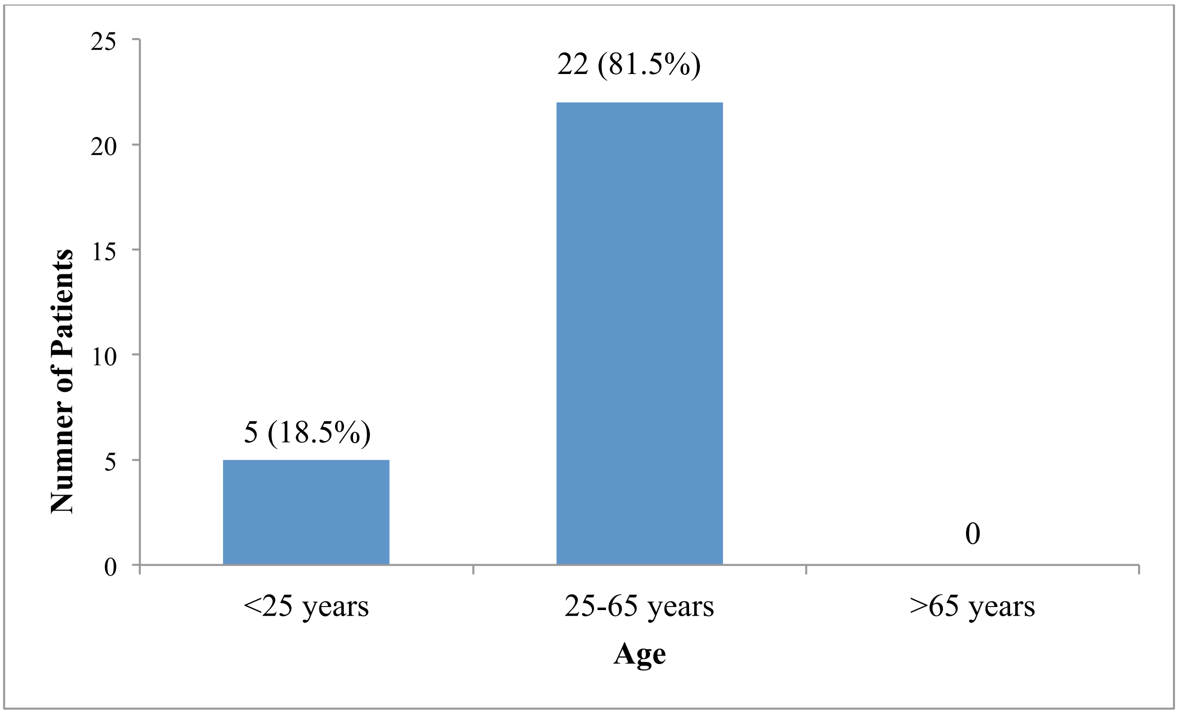


Figure 3.2. Age group distribution of patients in the study (n = 27)

Figures 3.1 and 3.2 above indicate the gender and age group distributions of the patients. The majority of patients (70.4%) are males, Figure 3.1, and 81.5% of them are in the middle-aged category (25-65 years), Figure 3.2.

Table 3.1. Frequency distribution of injury variables

Variable	Categories	Frequency	Percentage(%)
Injury side	Left	13	48.1
	Right	14	51.9
	Total	27	
Mechanism of injury	PVA	4	14.8
	Fall	18	66.7
	MVA	3	11.1
	Assault	2	7.4
	Total	27	
Soft tissue injury	Closed	24	88.9
	GA2	2	7.4
	GA3a	1	3.7
	Total	27	
Articular involvement	Extra-articular	5	18.5
	Intra-articular	22	81.5
	Total	27	

Table 3.1 shows the injury side, mechanism of injury, soft tissue injury and articular involvement of patients. The number of patients with left and right injury side is almost balanced (13 left and 14 rights). Concerning the circumstance in which injuries occurred, the majority (66.7%) fell. Of the three types of soft-tissue injuries, closed injury is predominant (88.9%) in patients. The majority of patients (81.5%) are involved had an intra-articular fracture.

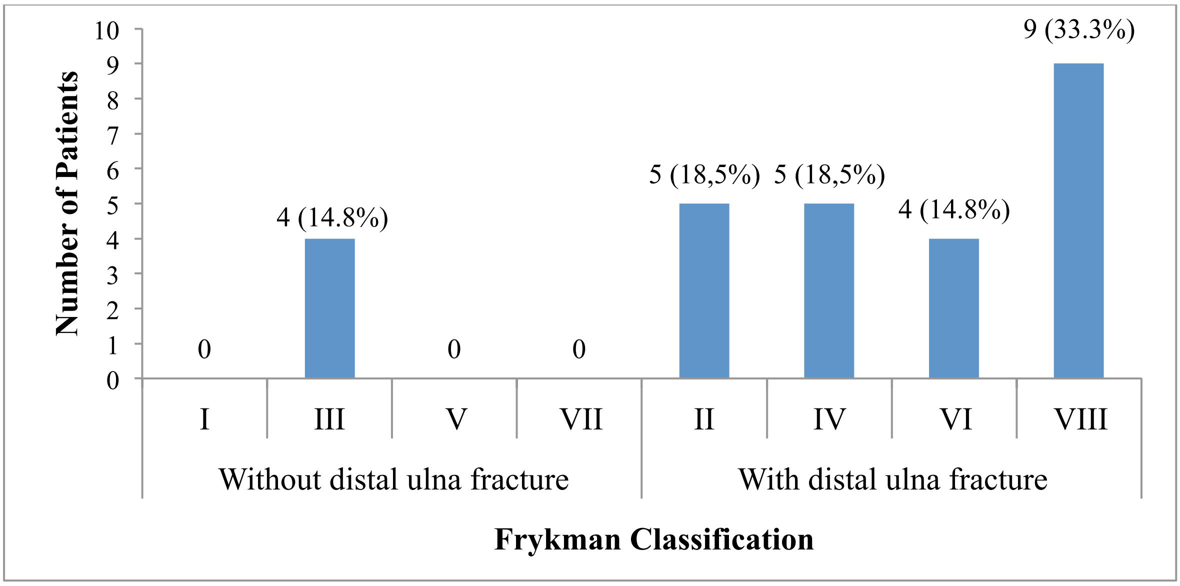


Figure 3.3. Frequency distribution of the Frykman classification

The Frykman classification of distal fractures in Figure 3.3 above, shows that, among the 23 patients with distal ulna fracture, 33.0% are intra articular (radio-carpal & DRUJ), group VIII; 18.5% are extra-articular, group II; 18.5% are intra-articular (radio-carpal joint), group IV. The remaining 15.0% are intra-articular (distal radio-ulna joint DRUJ), group VI. All four patients without distal ulna fracture are intra-articular (radio-carpal joint), group III.

According to the IDEAL classification, 88.9% of patients are classified as types II and III, scoring more than 1 point, Figure 3.4. Also, 81.5% are described as unstable with an intermediate prognosis, Figure 3.5.

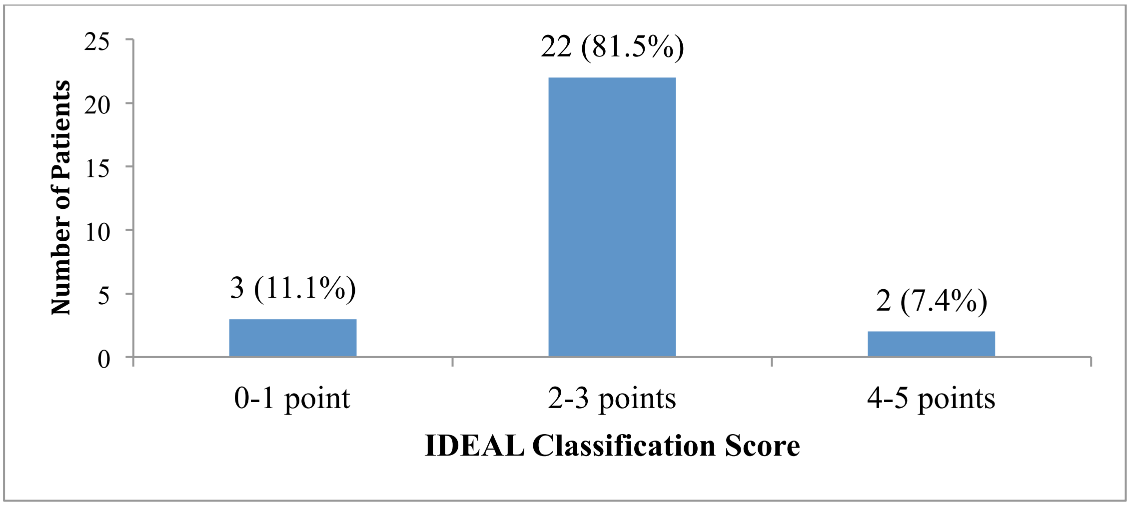


Figure 3.4. Frequency distribution of IDEAL classification score

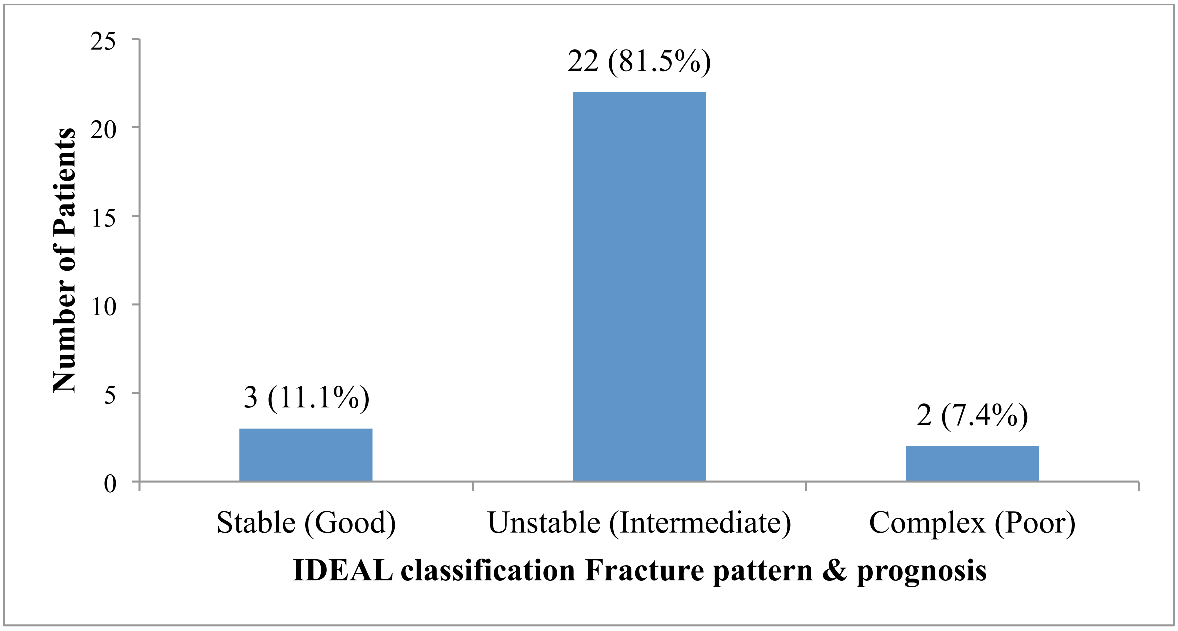


Figure 3.5. Frequency distribution of IDEAL classification fracture pattern & prognosis

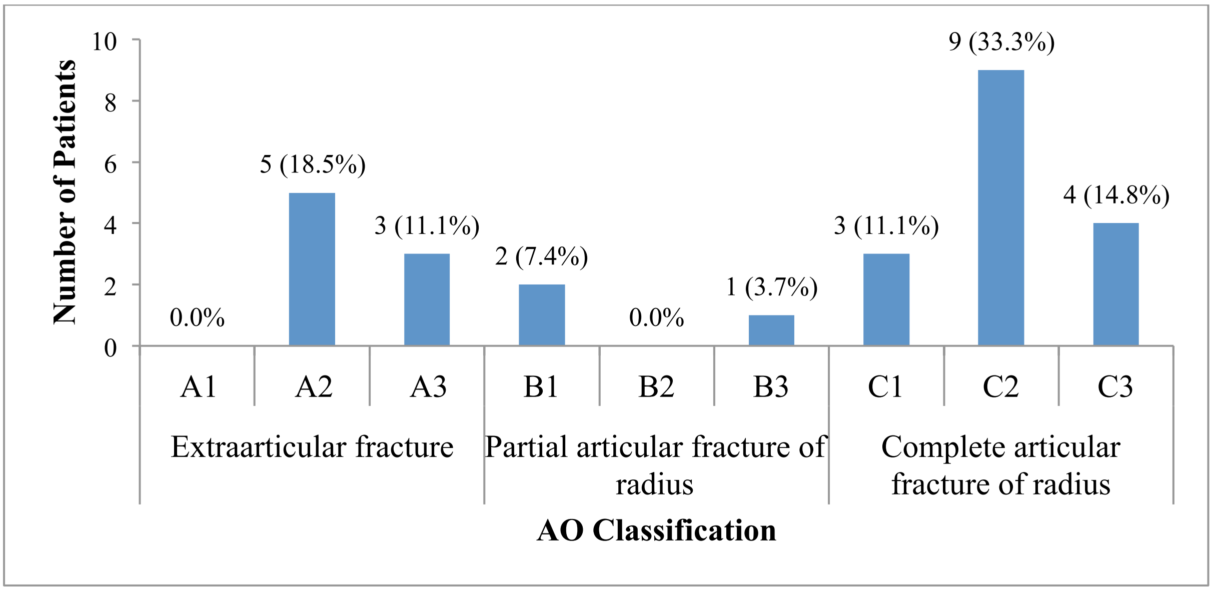


Figure 3.6. Frequency distribution of AO classification of distal radius fractures

Figure 3.6 shows that 33.3% are classified as C2, in AO classification of distal radius fractures, followed by A2 with 18.5%.

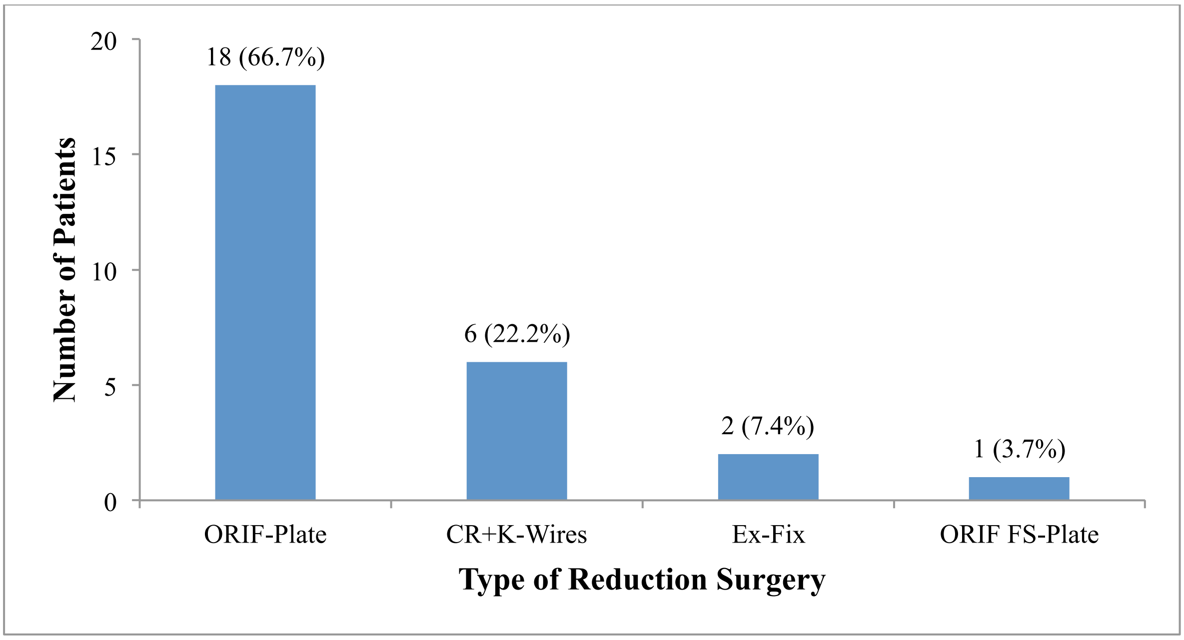


Figure 3.7. Frequency distribution of reduction surgery

The most surgical procedure used to restore fractures to the correct alignment is ORIF-Plate, 66.7%, followed by the CR+K-wires, 22.2%, Figure 3.7. Both procedures represent 88.9%.

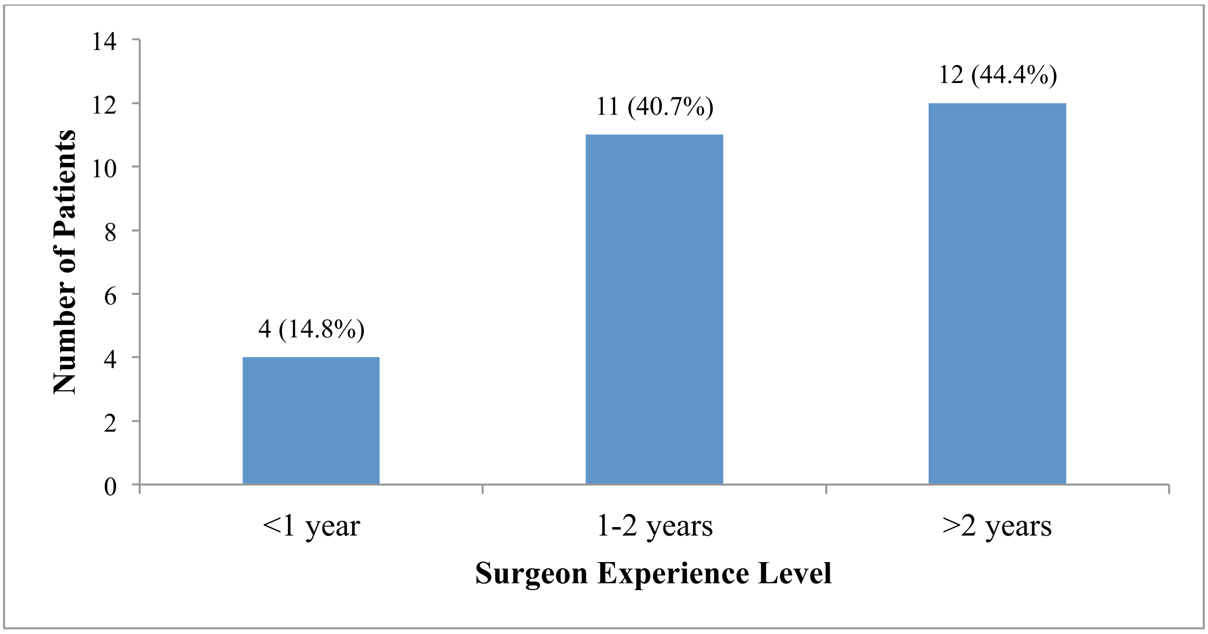


Figure 3.8. Frequency distribution of surgeon experience level

Table 3.2. Cross-tabulation of Ideal type and class, reduction surgery and prognosis

Ideal type	Ideal class	Reduction surgery	Prognosis	Count
0-1 point	**Stable**	CR+K-wires	Good	1
	Unstable	CR+K-wires	Good	1
2-3 points	**Unstable**	ORIF-plate	Good	1
		ORIF-plate	Intermediate	12
		CR+K-wires	Intermediate	3
		EX-Fix	Intermediate	1
4-5 points	**Unstable**	ORIF-plate	Intermediate	5
		ORIF-FS plate	Intermediate	1
	Complex	CR+K-wires	Poor	1
		EX-Fix	Poor	1

Among the 17 patients in type II (2-3 points), 12 of them are classified as unstable with ORIF-plate treatment and intermediate prognosis, Table 3.2.

3.2 SIGNIFICANCE TESTS OF RADIOGRAPHIC PARAMETERS

3.2.1 Paired sample tests

Paired samples tests are used when one want to compare two measurements on individuals in the sample before and again after a treatment. In this study, it is used to compare the pre-reduction injury radiographic and post-operative clinic. Before that, graphical comparisons of pre-reduction and post-operative of all radiographic parameters are presented in Figures 3.9 to 3.16 below.

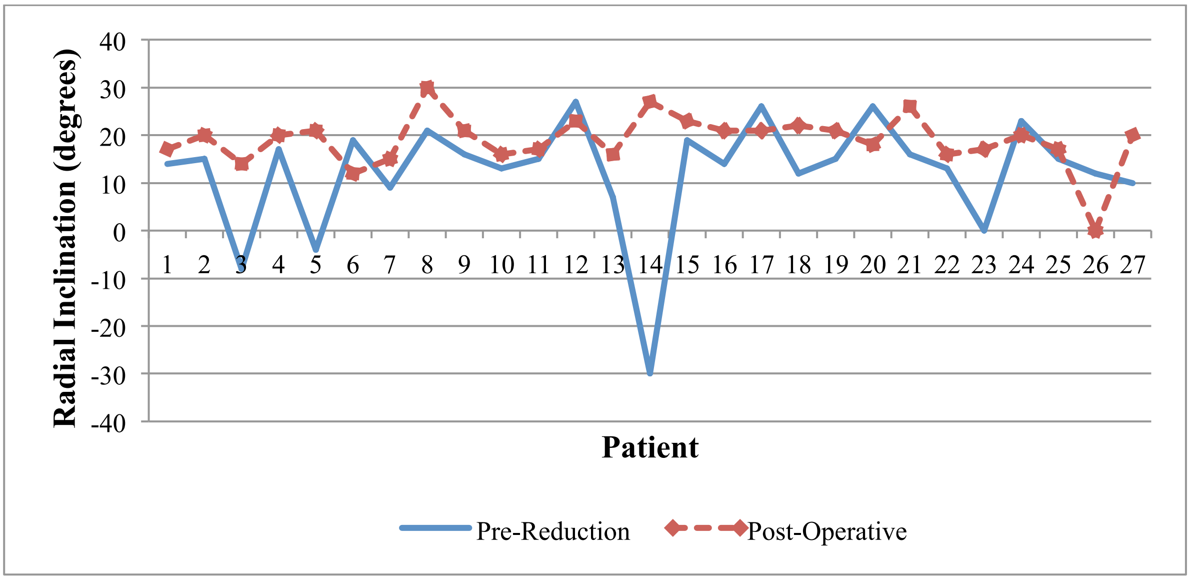


Figure 3.9. Graphical comparison of pre-and post-operative radial inclination

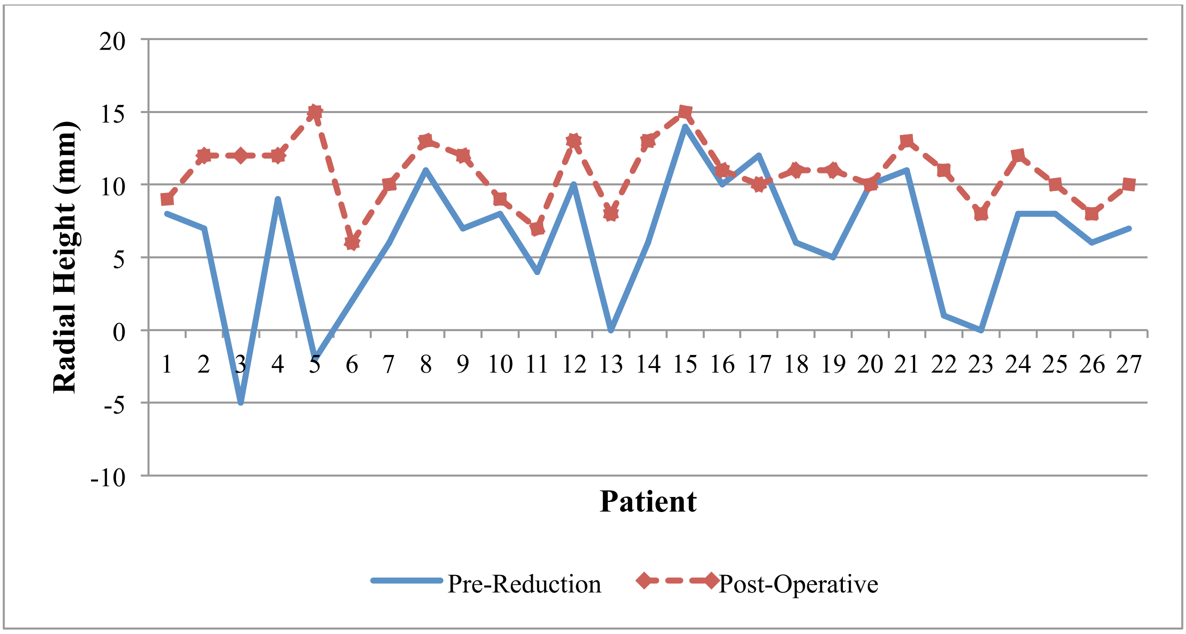


Figure 3.10. Graphical comparisons of pre-and post-operative radial height

In Figures 3.9 and 3.10 above, it can be seen that post-operative radial inclination and height are higher, in most of the patients, than the pre-reduction. Similar trend is also noticed in Figure 3.12 below, for volar tilt. While, in Figures 3.11, 3.12, 3.13, 3.14, 3.15 and 3.16 below, an opposite trend is observed. That is, the post-operative measurements of ulnar variance, PA articular step-off, PA articular gap, lateral articular step-off and lateral articular gap are lower in post-operative than in pre-reduction.

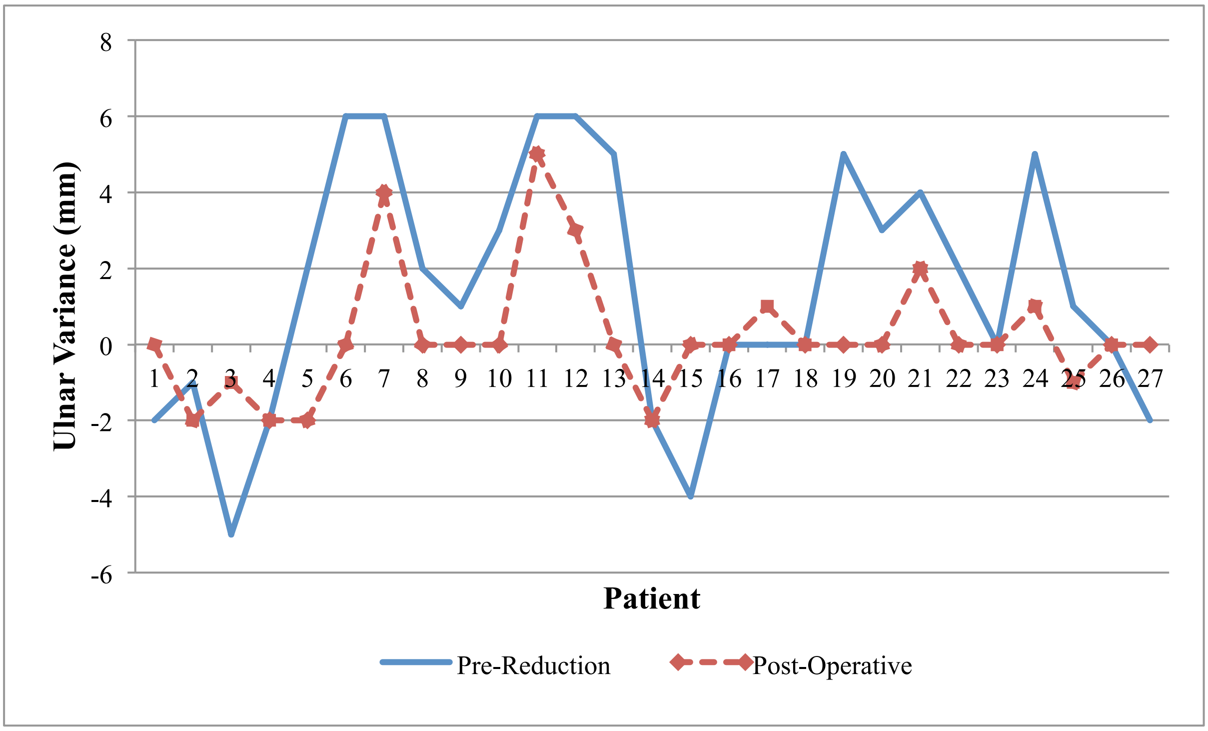


Figure 3.11. Graphical comparison of pre-and post-operative ulnar variance

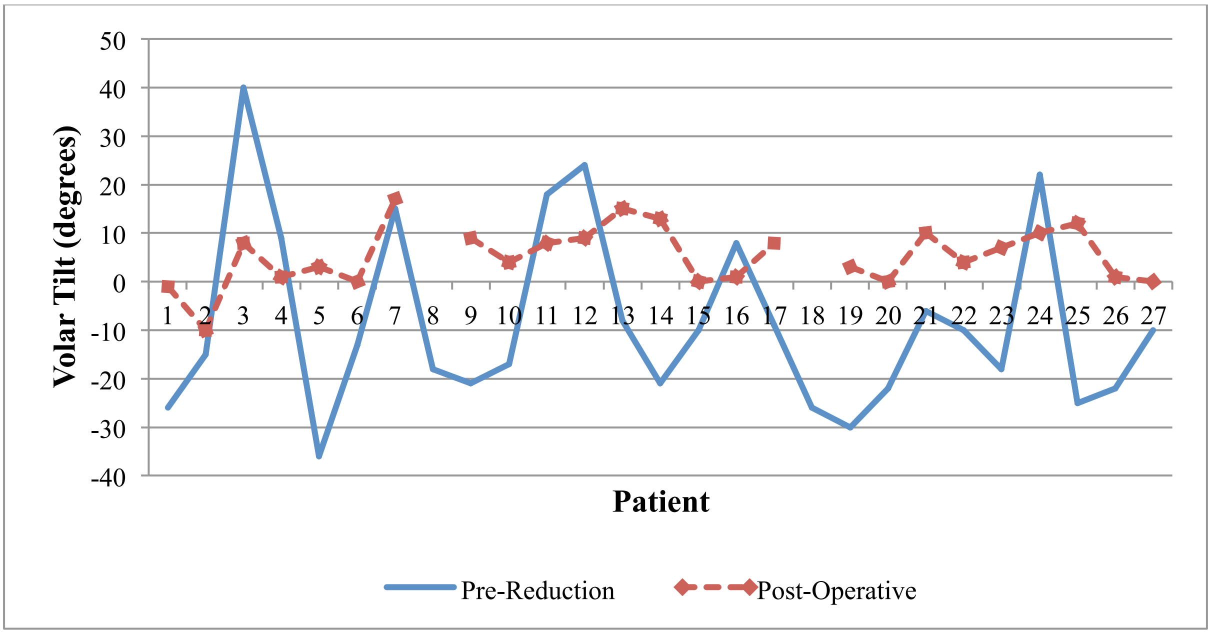


Figure 3.12. Graphical comparison of pre-and post-operative volar tilt

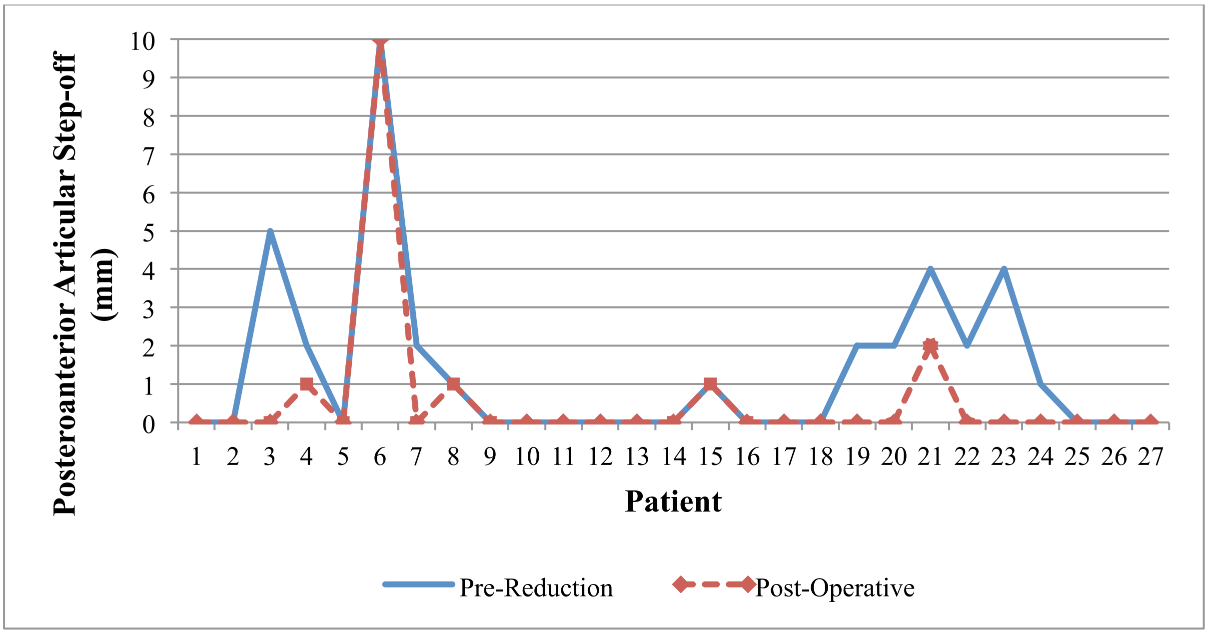


Figure 3.13. Graphical comparison of pre-and post-operative posteroanterior articular step-off

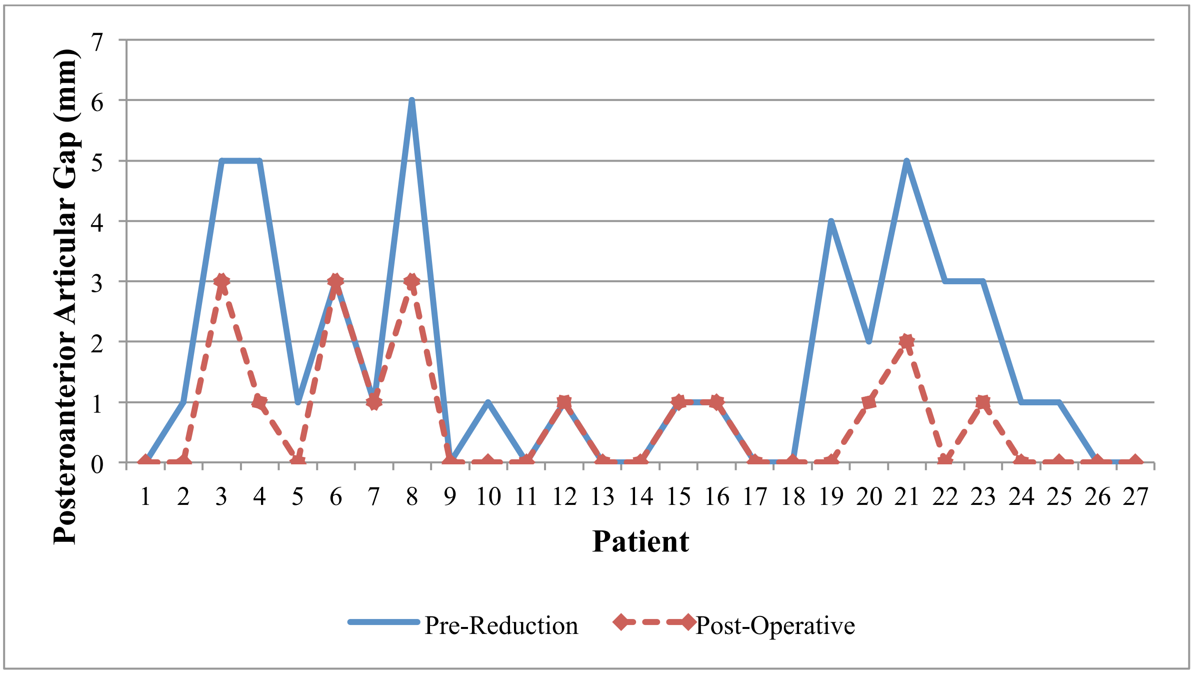


Figure 3.14. Graphical comparison of pre-and post-operative posteroanterior articular gap

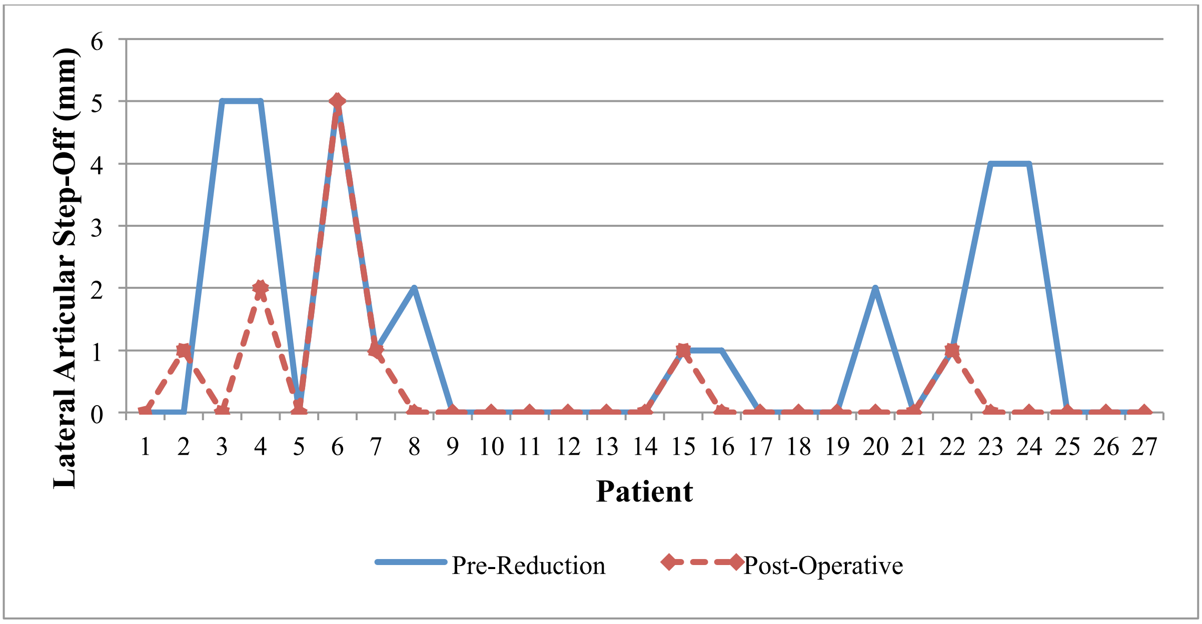


Figure 3.15. Graphical comparison of pre-and post-operative lateral articular step-off

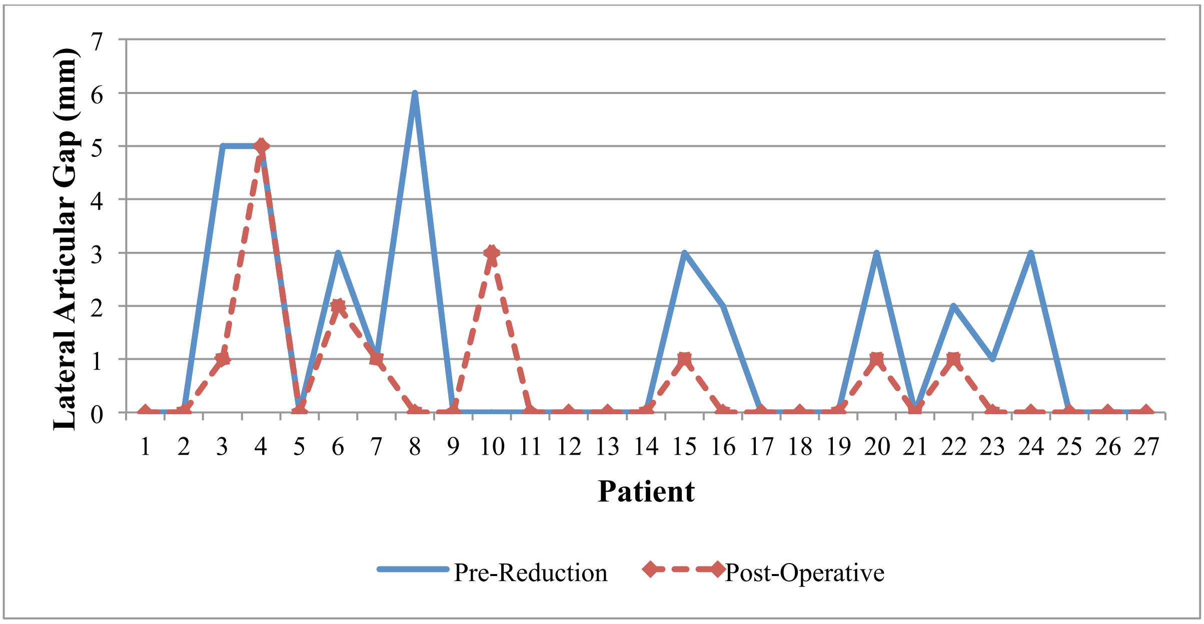


Figure 3.16. Graphical comparison of pre-and post-operative lateral articular gap

Tables 3.3, 3.4 and 3.5 indicate the results of the Kolmogorov-Smirnov test for normality of radiographic parameters for Assessor 1, Assessor 2 and their differences, respectively. The null hypothesis (H0) is that the data is normally distributed and the alternative hypothesis (H1) is that the data is not normally distributed. H0 is rejected, at 5.0% significance level, when the p-value is less than 0.05. Otherwise, H1 is rejected. Where H0 is rejected, non-parametric test is used and where it is not, parametric test is used.

Table 3.3. Kolmogorov-Smirnov test of normality of radiographic parameters - Assessor 1

Variable	Kolmogorov-Smirnov Z	P-value
Pre-Radial inclination (degrees)	1.199	0.113
Post-Radial inclination (degrees)	0.780	0.577
Pre-Radial height (mm)	0.939	0.341
Post-Radial height (mm)	0.588	0.880
Pre-Ulnar variance (mm)	0.649	0.793
Post-Ulnar variance (mm)	1.718	0.005
Pre-Volar Tilt (degrees)	1.014	0.256
Post-Volar Tilt (degrees)	0.596	0.869
Pre-PA Articular Step-off (mm)	1.447	0.030
Post-PA Articular Step-off (mm)	2.219	0.000
Pre-PA Articular Gap (mm)	1.586	0.013
Post-PA Articular Gap (mm)	1.767	0.004
Pre-Lateral Articular Step-off (mm)	1.724	0.005
Post-Lateral Articular Step-off (mm)	2.160	0.000
Pre-Lateral Articular Gap (mm)	1.789	0.003
Post-Lateral Articular Gap (mm)	1.943	0.001

When both pre-reduction and post-reduction radiographic parameters are normally distributed, paired sample T-test is used to compare the difference between them. When at least one is not normally distributed, non-parametric version of paired sample T-test, the Wilcoxon test, is used instead. In these tests, the null hypothesis is that the mean of the differences between the pairs of data is equal to zero and the alternative hypothesis is that this mean is different from zero. The results of the paired sample tests are presented in Tables 3.6, 3.7 and 3.8 below.

Table 3.4. Kolmogorov-Smirnov test of normality of radiographic parameters - Assessor 2

Variable	Kolmogorov-Smirnov Z	P-value
Pre-Radial inclination (degrees)	0.816	0.518
Post-Radial inclination (degrees)	0.802	0.541
Pre-Radial height (mm)	0.989	0.282
Post-Radial height (mm)	0.874	0.430
Pre-Ulnar variance (mm)	0.968	0.306
Post-Ulnar variance (mm)	1.076	0.430
Pre-Volar Tilt (degrees)	0.703	0.706
Post-Volar Tilt (degrees)	0.911	0.378
Pre-PA Articular Step-off (mm)	1.863	0.002
Post-PA Articular Step-off (mm)	2.657	0.000
Pre-PA Articular Gap (mm)	1.594	0.012
Post-PA Articular Gap (mm)	2.558	0.000
Pre-Lateral Articular Step-off (mm)	2.106	0.000
Post-Lateral Articular Step-off (mm)	-	-
Pre-Lateral Articular Gap (mm)	1.982	0.001
Post-Lateral Articular Gap (mm)	2.751	0.000

Table 3.5. Kolmogorov-Smirnov test of normality of differences in radiographic parameters between pre and post reduction radiographs

Variable	Kolmogorov-Smirnov Z	P-value
Assessor 1		
Radial inclination (degrees)	1.301	0.068
Radial height (mm)	1.029	0.240
Ulnar variance (mm)	0.678	0.748
Volar Tilt (degrees)	0.677	0.749
PA Articular Step-off (mm)	2.005	0.001
PA Articular Gap (mm)	1.520	0.020
Lateral Articular Step-off (mm)	2.214	0.000
Lateral Articular Gap (mm)	1.719	0.005
Assessor 2		
Radial inclination (degrees)	0.485	0.973
Radial height (mm)	0.498	0.965
Ulnar variance (mm)	0.936	0.345
Volar Tilt (degrees)	0.486	0.972
PA Articular Step-off (mm)	2.051	0.000
PA Articular Gap (mm)	2.053	0.000
Lateral Articular Step-off (mm)	2.106	0.000
Lateral Articular Gap (mm)	1.959	0.001

Table 3.6. Paired sample test results - Assessor 1

	Mean	Median	STD	Difference	
				Mean ± STD	P-value
Pre-Radial inclination (degrees)	12.30	15.00	11.799	6.63 ± 13.098	0.014
Post-Radial inclination (degrees)	18.93	20.00	5.526		
Pre-Radial height (mm)	6.26	7.00	4.503	4.52 ± 4.448	0.000
Post-Radial height (mm)	10.78	11.00	2.259		
Pre-Ulnar variance (mm)	1.44	1.00	3.215	-1.22 ± 2.547	0.019
Post-Ulnar variance (mm)	0.22	0.00	1.672		
Pre-Volar Tilt (degrees)	-7.32	-13.00	19.202	12.60 ± 18.308	0.002
Post-Volar Tilt (degrees)	5.28	4.00	6.079		
Pre-PA Articular Step-off (mm)	1.33	0.00	2.253	-0.78 ± 1.340	0.007
Post-PA Articular Step-off (mm)	0.56	0.00	1.948		
Pre-PA Articular Gap (mm)	1.67	0.00	1.881	-1.00 ± 1.330	0.001
Post-PA Articular Gap (mm)	0.67	0.00	1.000		
Pre-Lateral Articular Step-off (mm)	1.12	0.00	1.818	-0.69 ± 1.543	0.034
Post-Lateral Articular Step-off (mm)	0.42	0.00	1.065		
Pre-Lateral Articular Gap (mm)	1.08	0.00	1.623	-0.50 ± 1.304	0.073
Post-Lateral Articular Gap (mm)	0.58	0.00	1.172		

In Table 3.6, the measurements of all the radiologic parameters, except lateral articular gap, are significantly different between pre-reduction and post-operative, as the null hypothesis is rejected in all of them, except, lateral articular gap.

Table 3.7. Paired sample test results - Assessor 2

	Mean	Median	STD	Difference	
				Mean ± STD	P-value
Pre-Radial inclination (degrees)	14.81	15	6.956	4.67 ± 7.306	0.003
Post-Radial inclination (degrees)	19.48	20	3.877		
Pre-Radial height (mm)	7.56	8	3.468	3.15 ± 3.110	0.000
Post-Radial height (mm)	10.70	11	2.216		
Pre-Ulnar variance (mm)	2.56	2	2.342	-2.54 ± 2.429	0.000
Post-Ulnar variance (mm)	0.02	0	2.186		
Pre-Volar Tilt (degrees)	-5.70	-8	20.889	10.00 ± 21.015	0.020
Post-Volar Tilt (degrees)	4.30	6	8.166		
Pre-PA Articular Step-off (mm)	0.78	0	1.553	-0.44 ± 0.892	0.018
Post- PA Articular Step-off (mm)	0.33	0	1.544		
Pre- PA Articular Gap (mm)	0.89	0	1.311	-0.59 ± 1.185	0.011
Post- PA Articular Gap (mm)	0.30	0	0.823		
Pre-Lateral Articular Step-off (mm)	0.56	0	1.050	-0.56 ± 1.050	0.011
Post-Lateral Articular Step-off (mm)	0.00	0	0.000		
Pre-Lateral Articular Gap (mm)	0.63	0	0.926	-0.52 ± 0.935	0.011
Post-Lateral Articular Gap (mm)	0.11	0	0.424		

Table 3.8. Paired samples test results of the differences of pre and post radiological parameters between Assessor 1 and Assessor 2

Variable	Mean ± STD	P-value
Radial inclination (degrees)	-1.96 ± 14.654	0.493
Radial height (mm)	-1.37 ± 4.068	0.092
Ulnar variance (mm)	-1.32 ± 3.104	0.700
Volar Tilt (degrees)	-3.30 ± 21.52	0.433
PA Articular Step-off (mm)	0.33 ± 1.271	0.208
PA Articular Gap (mm)	0.41 ± 1.047	0.060
Lateral Articular Step-off (mm)	0.19 ± 0.921	0.248
Lateral Articular Gap (mm)	0.19 ± 1.302	0.672

Table 3.8 indicates that there is no significant different between Assessor 1 and Assessor 2 as the null hypothesis of no difference is not rejected in all the eight radiological parameters (p-values not less than 0.05).

3.2.2 Analysis of Variance (ANOVA)

To determine whether post-operative measurements of radiographic parameters for different surgeon's experience levels differ significantly an Analysis of Variance (ANOVA) is carried out. ANOVA provides a statistical test of whether or not the means of several groups are equal, and therefore generalises the *t*-test to more than two groups. ANOVAs are useful for comparing (testing) three or more means (groups or variables) for statistical significance.

In this study, the null hypothesis (H0) and alternative hypothesis (H1) are formulated as follow:

H0: On average, post-operative measurements of radiographic parameters do not differ across the three registrar levels; against the alternative hypothesis

Ha: The measurements differ across the three levels.

All the statistical tests are carried out with 5.0% significance level. So, we reject H0 if p-value (the probability of getting the observed result by chance alone) is less than 0.05 in favour of the alternative hypothesis, otherwise we fail to reject it.

Following the results of normality tests in Tables 3.3, 3.4, and 3.5 for normally distributed variables, ANOVA is carried out, otherwise, the Kruskal Wallis test, the non-parametric version of ANOVA is used instead.

Table 3.9. Analysis of variance results – Assessor 1

Post-operative	Registrar level	Mean ± STD	Median	P-value
Radial inclination (degrees)	<1 year	21.50 ± 4.123	21	0.055
	1-2 years	15.91 ± 5.991	17	
	>2 years	20.83 ± 4.407	21	
Radial height (mm)	<1 year	11.00 ± 0.816	11	0.025
	1-2 years	10.36 ± 3.075	9	
	>2 years	10.92 ± 1.621	12	
Ulnar variance (mm)	<1 year	-0.25 ± 1.258	0	0.513
	1-2 years	0.64 ± 1.859	0	
	>2 years	0.00 ± 1.651	0	
Volar Tilt (degrees)	<1 year	7.25 ± 5.909	9	0.7289
	1-2 years	4.36 ± 6.652	4	
	>2 years	5.50 ± 5.911	3	
PA articular step-off (mm)	<1 year	0.00 ± 0.000	0	0.257
	1-2 years	0.91 ± 3.015	0	
	>2 years	0.42 ± 0.669	0	
PA articular gap (mm)	<1 year	0.00 ± 0.000	0	0.122
	1-2 years	0.545 ± 0.934	0	
	>2 years	1.00 ± 1.128	1	
Lateral Articular step-off (mm)	<1 year	0.00 ± 0.000	0	0.511
	1-2 years	0.64 ± 1.502	0	
	>2 years	0.36 ± 0.674	0	
Lateral Articular gap (mm)	<1 year	0.00 ± 0.000	0	0.376
	1-2 years	0.64 ± 1.027	0	
	>2 years	0.73 ± 1.489	0	

Table 3.9 shows the results of the ANOVA tests. The null hypothesis is not rejected in all the parameters, except for radial height. That is, there is no significant difference in the treatments of surgeons with different experience levels, except for radial height.

Table 3.10. Analysis of variance results – Assessor 2

Post-operative	Registrar level	Mean ± STD	Median	P-value
Radial inclination (degrees)	**<1 year**	19.75 ± 1.708	20	0.916
	1-2 years	19.09 ± 4.505	20	
	>2 years	19.75 ± 4.003	21	
Radial height (mm)	**<1 year**	11.00 ± 1.826	11	0.814
	1-2 years	9.46 ± 2.296	10	
	>2 years	11.92 ± 1.782	12	
Ulnar variance (mm)	**<1 year**	-1.13 ± 4.008	0	0.482
	1-2 years	0.45 ± 1.864	0	
	>2 years	0.00 ± 1.758	-1	
Volar Tilt (degrees)	**<1 year**	6.00 ± 8.485	3	0.715
	1-2 years	2.73 ± 7.875	2	
	>2 years	5.17 ± 8.789	8	
PA articular step-off (mm)	**<1 year**	0.00 ± 0.000	0	0.563
	1-2 years	0.73 ± 2.412	0	
	>2 years	0.08 ± 0.289	0	
PA articular gap (mm)	**<1 year**	0.00 ± 0.000	0	0.693
	1-2 years	0.27 ± 0.905	0	
	>2 years	0.42 ± 0.900	0	
Lateral Articular step-off (mm)	**<1 year**	0.00 ± 0.000	0	-
	1-2 years	0.00 ± 0.000	0	
	>2 years	0.00 ± 0.000	0	
Lateral Articular gap (mm)	**<1 year**	0.00 ± 0.000	0	0.744
	1-2 years	0.18 ± 0.603	0	
	>2 years	0.08 ± 0.289	0	

3.3 FREQUENCY OF NORMAL PARAMETERS

Table 3.11. Frequency of normal assessments by Assessor

Post-operative	Normal	Frequency (%)	
		Assessor 1	Assessor 2
Radial inclination (degrees)	19-29	15 (55.6%)	19 (70.4%)
Radial height (mm)	8-17	25 (92.6%)	25 (92.6%)
Ulnar variance (mm)	2-6	4 (14.8%)	5 (18.5%)
Volar Tilt (degrees)	0-22	25 (92.5%)	23 (85.2%)
PA articular step-off (mm)	0	22 (81.5%)	25 (92.6%)
PA articular gap (mm)	0	16 (59.3%)	25 (92.6%)
Lateral Articular step-off (mm)	0	21 (77.8%)	27 (100.0%)
Lateral Articular gap (mm)	0	19 (70.4%)	25 (92.6%)

3.4 MATCHED PAIRED PROPORTIONS

3.4.1 McNemar's Test

Table 3.12 presents the results of McNemar's test of matched pair proportions. This test assesses the significance of the difference between two correlated proportions, such as might be found in the case where the two proportions are based on the same sample of subjects or on matched-pair samples.

Two proportions are paired (as opposed to independent) if they share a common feature that affects the outcome. As the same sample of patients is put into both assessors, this is the "pairing". Pairs of results from multiple samples can then be compared as a pair of proportions:

The question in the McNemar test is: do these two proportions, proportion 1 and proportion 2, significantly differ? The results in Table 3.12, show that there is no significant different in all the parameters, except PA articular gap.

Table 3.12. Comparison of matched pair proportions between the two Assessors

Post-operative Radiological Parameters		Assessor 1			P-value
Assessor 2		**Normal**	**Abnormal**	**Total**	
Radial inclination (degrees)	**Normal**	13	6	19	0.289
	Abnormal	2	6	8	
	Total	15	12	27	
Radial height (mm)	**Normal**	24	1	25	1.000
	Abnormal	1	1	2	
	Total	25	2	27	
Ulnar variance (mm)	**Normal**	3	2	5	1.000
	Abnormal	1	21	22	
	Total	4	23	27	
Volar Tilt (degrees)	**Normal**	22	1	23	0.625
	Abnormal	3	1	4	
	Total	25	2	27	
PA articular step-off (mm)	**Normal**	22	3	25	0.250
	Abnormal	0	2	2	
	Total	22	5	27	
PA articular gap (mm)	**Normal**	15	10	25	0.012
	Abnormal	1	1	2	
	Total	16	11	27	
Lateral Articular step-off (mm)	**Normal**	21	6	27	-
	Abnormal	0	0	0	
	Total	21	6	27	
Lateral Articular gap (mm)	**Normal**	18	7	25	0.070
	Abnormal	1	1	2	
	Total	19	8	27	

CHAPTER 4 – DISCUSSION

4.1 DEMOGRAPHICS

4.1.1 Age and Gender

A review of the epidemiological data on age by Court-Brown et al. (2006)*,* shows that there are three main peaks in distal radius fracture distribution (2). The first, occurring in children between the ages of 5 -14 years, the second peak occurring in males less than 50 years old, and the third peak occurring in perimenopausal females greater than 40 years (46). More recent evidence published by Court-Brown et al. (2010), also suggests that the incidence of DRF's in the 25 – 65 year group should be lower than the younger and older sample groups thereby demonstrating a bimodal distribution (46). When examining the age group 25-65 years, Solgaard et al. (1985)., and Lindau et al. (1999), highlighted out of their findings that the nature of the injury may account for the differences in the peak incidences between the 25-65 years old and the greater than 65 years sample group, and hence this group should be regarded differently from the perimenopausal and the elderly (26, 32).

In our study all participants with distal radius fractures admitted and treated at CMJAH over a six-month period were eighteen (18) years or older. The middle-aged adult (25-65 years) represents the most common age category treated. Our study excluded participants less than 18 years of age therefore comparisons and or conclusions cannot be made about this group. In contrast to the literature published by Cuenca et al. (2003), the peak incidence of distal radius fractures in the middle age category fractures does not resemble the incidence distributions of other geographical areas namely Northern Europe, and the Mediterranean (30).

Our data confirms a majority of the injuries sustained were intra-articular fractures and potentially unstable, therefore we postulate that the increased incidence in the 25–65 years old group is secondary to younger patients sustaining higher energy mechanisms of injury requiring hospital admission and operative intervention.

Many studies performed on Western populations show that there is an increased incidence of distal radius fractures in women than in men particularly after the age of 40 years, a trend largely due to the onset of osteoporosis or oestrogen withdrawal (25-27, 30, 32).

A Swedish study by Brogren et al. (2007) shows that female distal radius fracture incidence is doubled particularly when the age category includes women greater than 50 years and less than 65 years (25). With this subgroup of women excluded from the 25 – 65 years category the incidences for men to women are similar (33).

With regards to the gender differences, our study sample shows an overall predominance of males to females is 2.3:1, (Figure 3.1), This represents a reversal of the gender relationship that is not supported in the published literature (25-27). When specifically looking at our data in the age category of 25-65 years for gender distribution, the male predominance persists and therefore our finding is not supported by recent literature.

This difference in gender distribution is due to increased incidence in falls in the younger working-class male in Johannesburg, South Africa who may be exposed to higher risk employment than their age-matched counterpart. South Africa's life expectancy for 2014 as reported by the World Bank is 57.2 years versus that for the United Kingdom, United States of America, Sweden, and Canada are 81, 79, 82, 82 years respectively (53). This helps to explain the overall reduced numbers in the greater that 65 years category. As for the gender incidence reversal and low incidence of women presenting to the CMJAH over the six-month study period in the over than 65 years age group, females in this age category who have sustained low energy fragility fractures may have been managed conservatively by the peripheral health care facility, obviating the need to be referred to CMJAH casualty for more expert management and surgical intervention.

4.2 Mechanism of Injury

The majority of studies show that overall, falls has the highest incidence statistic when compared to other injury mechanisms like motorised vehicle accidents (MVA) and pedestrian-vehicle accidents (PVA) (26, 35-38). When considering the mechanism of injury in relation to age, the majority of the fractures within the age category (25 – 65 years) should be secondary to high-energy trauma, e.g., motor vehicle accidents and sports (28, 29, 34, 46).

Our study shows overall incidence rates that are consistent with the majority of published data as it relates to falls and all ages. What is surprising is that, in contrast to the few published articles that address the mechanism of injury in relation to a specific age, namely that of 25- 65 years, our data does not reflect the findings of published data that show the majority of the distal radius fractures within this group to be secondary to high-energy trauma e.g., MVA's and PVA's.

We believe that this difference is due to the nature of the fall sustained by the participant, i.e., a fall from height versus a fall from standing position. This distinction would be a key factor in elucidating the magnitude of energy (high vs. low) causing the distal radius fracture. Our study did not distinguish between falls from height versus falls from standing position; therefore, this creates a limitation to our study in explaining the aforementioned discrepancy between age and mechanism of injury.

4.3 Classification

The Frykman, IDEAL, and the AO classification systems were used in our study to classify all of the fractures presenting to CMJAH. A study by Ceunca et al. (2003) that used the Frykman classification in their analysis demonstrated that 69.3% of fractures were intra-articular (30). Kim et al. (2010), and May et al. (2002), showed that ulna styloid fractures occur in up to 60.0% of distal radius fractures (39, 40).

Our study reveals that according to the Frykman classifications system 81.5% of the fractures that were treated at CMJAH were intra-articular, i.e., Types III – VIII. Our data also demonstrated that 18.5% of all fractures were extra-articular Type II, which was in agreement with the 17.9% published in a study done by Cuenca et al. in 2003 (30). We also found that 85.0% of the fractures treated were associated with an ulna styloid fracture was approximately 20.0% higher that in that published by Kim et al. (2010), and May et al. (2002).

Few studies have been published examining the distal radius fracture types according to AO classification system. According to the AO group, types A, B, C, have a reported incidence of 52.1%, 14.6%, and 33.3% respectively, with type B demonstrating the lowest incidence (29, 31, 46). The latest epidemiological review of distal radius fractures in 2013 in an Asian population performed by Koo et al. (2013), reported a similar trend in classification (29). They reported that 53.0% were type A, 13.0% were type B, and 32.0% were type C fractures. Epidemiological data from a more recent multicentre randomised control trial in 2014 performed by Bentohami et al. (2014), shows that 25.0% of all fractures that presented to the emergency departments were AO type C fractures (41, 42).

As it relates the AO grouping, our study shows that AO group A, B, and C has a incidence of 29.6%, 11.1%, and 59.2% respectively, demonstrating little correlation between the percentages of published data and our study. The trend however, is similar in that AO Type B fractures have the lowest incidence in both studies. This may be due to the specific types of forces required to create the Barton, Reverse

Barton, Smith and Chauffer's type of injury making them relatively uncommon (29, 31, 46).

Epidemiological data from two recent multicentre randomised control trials shows that 25.0% of all fractures that presented to the emergency departments were AO type C fractures (41, 42). This is in contrast to what we see in our study where our numbers are more than double that reported i.e., 59.2%. There is also a reversal of the AO groups A and C values, a finding that was not surprising. This can be explained by the observation that with younger males, there is an association with higher energy injuries and therefore a more complex fracture pattern than that seen in the ageing peri-menopausal female population – a subgroup that when considered, contributes significantly incidence statistics and may leads to misinterpretations of the data if not regarded differently (46).

Currently, no large multicentre epidemiological studies that use the IDEAL classification system to classify distal radius fractures have been published. The IDEAL classification system by Belloti et al. (2013) is the latest classification system with greater reliability and reproducibility than the Frykman and AO systems (9). Advantages of this system rests in its ability to combine epidemiological and radiographic data in an easy to use scoring system that guides management and predict patient outcomes.

In our study, the Frykman and AO classification systems were used to classify fractures in the sample group. When the IDEAL classification system is retrospectively applied to each fracture in our sample group, it becomes evident that the surgeon's assessment and definitive management corresponds well with the fracture classification and recommended treatment modality i.e., the appropriate reduction method corresponded with the IDEAL Class and Type (Table 3.2). We however, cannot comment on the validity of prognostic value of the IDEAL Classification system until a review of the functional outcomes is performed on our sample group.

4.4 Reduction Surgery

The literature review in a most recently published protocol of a randomised control trial currently being undertaken in the Netherlands performed by Mulders et al. (2016), reports that no evidence exists that addresses the optimal reduction method for patients with distal radius fractures ages 18 to 65 years (43).

At Charlotte Maxeke Johannesburg Academic Hospital, the treatment decision was surgeon based and considered the fracture configuration, energy involved, extent soft tissue injury, age and occupation. The most common procedure performed was an open reduction internal fixation (ORIF).

In our study, 66.7% and 22.2% of distal radius fractures had plate fixation and percutaneous wire fixation respectively. This corresponds well with what is expected when we consider that according to the AO classification system 59.2% of the fractures that presented to us were complete intra-articular and of the Type C category and according to the IDEAL Classification of the potentially unstable type, which warrants some form of operative fixation. Closed reduction and percutaneous pinning was performed on 22.2% of the wrists treated. This operative method is chosen when an adequate reduction can be obtained and maintained.

Radiographic measurements of pre-reduction versus post-reduction values for the radial inclination, radial height, and volar tilt demonstrated overall increases in the means and differences of means (Table 3.6). The p-values all indicating that the change was statistically significant and confirms that operative intervention results in significant postoperative improvements in radiographic position.

As it relates the remaining parameters, there was an overall decrease in the mean and difference of mean: ulna variance (1.44, 0.22; -1.22, p=0.019), P/A articular step-off (1.33, 0.56; 0.78, p=0.007), P/A articular gap (1.67, 0.67; 1.00, p=0.001), and lateral articular step-off (1.12, 0.42; 0.69, p=0.034). Again, this decrease confirms that operative intervention resulted in statistically significant improvements in radiological outcomes for these parameters. Although there was an overall reduction in the lateral articular gap (1.08, 0.58; 0.50, p=0.073), this finding was not statistically significant for this parameter. This can be attributed to errors in measurement or variances in measuring this parameter by both observers. In analysing the matched pair proportions (Table 3.12), there is agreement between both assessors on 18 of the 27 patients (66.7%) as being normal with assessor two categorising 25 patients (92.6%) as normal and assessor 1 categorising 19 as normal. This 22.2% difference in matched pair proportions together with the increased value for the standard deviations of the means for assessor 1 (-0.50±1.304, p=0.073) versus assessor 2 (-0.52±0.935 p=0.011) may account for the erroneous acceptance of the null hypothesis representing a false negative result. We can correct for this by performing further studies, repeat analysis and increasing statistical power by increasing the sample size.

4.5 Anomalous Results

We can therefore state that operative intervention resulted in improvements the large majority of our patients. However, there are examples where our analysis yielded unexpected results.

Patient number twenty-six (26) had a radial inclination that was worse postoperatively. On review of this postoperative radiograph for patient number 26, we found there to be considerable rotation of the PA radiograph – a finding that contributed to the inaccuracies of measurement.

Patient number four (4) had open reduction internal fixation of the distal radius with a fragment specific plate and a K-wire fixation of the radial styloid for a complex distal radius fracture. This combined fixation method is usually performed when standard techniques of reduction and stabilisation will not provide adequate anatomical reduction. This excessively comminuted fracture may have required the use of an external fixator to aid reduction and stabilisation, which in this case was not required. Also, of note patient number four (4) had an ipsilateral proximal radius and ulna fracture that increased the IDEAL class to complex. Posteroanterior radiographs of the injury available for our assessment were rotated and therefore posed a challenge in assessment of the radial inclination. Repeat radiographs with a better PA orientation were not available. We attribute the inaccuracies in the volar tilt assessment to the presence of significant comminution involving the most distal and dorsal cortex of the distal radius.

4.6 Surgeon Experience Level

Prior to publication of this research report, a online database search was performed using National Centre for Biotechnology Information Online Database (NCBI) PUBMED search engine and the online search engine Google Scholar. Search results yielded no published studies in the English speaking literature that examined the effect of surgeon's experience level on the quality of reductions of distal radius fracture parameters. This study may represent one of the few published studies, if not the only study that examined the effect of surgeon level experience on post-operative DRF reduction.

Our study analysed the impact of the surgeons' level of experience on each reduction parameter. It was shown from the principal investigator's (assessor 1) data that among the three categories of surgeon experience, there is a statistically significant difference (p-value = 0.025) for radial height.

From the results of the second assessor, no significant difference was found for radial height. In examining the frequency of normal value by assessor 1 and 2 (Table 3.11), we see that the number of normal results for radial height is the same for both assessors (25 out of 27 patients totaling 92.6%). When analysing Table 16 for the matched pair proportions of both assessors, there was agreement on twenty-four out of the twenty-five patients considered normal. Closer examination of the ANOVA results for radial heights of assessor 1 and assessor 2 (Table 3.9, 3.10) shows that assessor 1 has a greater degree of variability amongst the standard deviations for the means as compared to assessor 2. To highlight this fact, standard deviation values for the means of assessor 1 for radial height vary from 0.816 to a high of 3.075, whereas for assessor 2, the variability differences were from as low as 1.782 to a high of 2.296. This greater degree of variability in standard deviations can explain why there was a significant statistical difference for assessor 1 and not assessor 2. It is for this reason that further studies, repeat analysis and review of the standard measuring protocols, and a larger sample size are required to reduce the statistical error that has occurred.

On the basis of our findings, we cannot effectively conclude that the surgeon's level of experience influences the quality of the reduction of the radial height. Therefore, further studies should be performed for this parameter.

4.7 Study Limitations

Posteroanterior and lateral films of the contralateral wrist in adults are not done routinely. It is warranted only in cases where there is an unclear diagnosis. No contralateral wrist radiographs were taken in our study, thereby limiting the treating surgeon's ability to preoperatively assess and intra-operatively restore each radiographic parameter to its original anatomical position. This creates a limitation in our study in that the normal radiologic parameters for each individual cannot be attained and the contralateral or normal wrist cannot be used as a control.

Standardisation of radiographs with specifically trained personnel would improve consistency, reproducibility, and diagnostic accuracy by minimising variations in extremity positioning and image quality. It also improves the ability of the observer to identify, interpret, and measure the appropriate radiographic landmarks. The possibility for errors in measurement exists and is increased because of the lack of standardisation of radiographs. In our institution, radiographers with different experience levels ranging from trainee to the qualified and experienced were found undertaking the task of radiographic evaluations. This variation in staff experience performing radiographs was a product of the limited human resources at CMJAH during the study period.

Another cause for inaccuracies of measurement may have occurred with the smaller units of measurements (millimetres) of the articular gap and the step-off in combination with the instruments used. Although the measuring instrument was standardised, it was only accurate to one millimetre; therefore, measurements that were a part thereof could be erroneously interpreted, as being greater or lesser than it should be. Utilising a Patient Archiving Communications System (PACS) could reduce this error. A study by Robertson et al. (2010) assessing visual estimation versus computer software measurements of angulation showed that visual estimation were less accurate and less reliable than calculations using computer software (44). A drawback of this method is that the accuracy and reliability is directly correlated to surgeon experience level.

Another drawback of this study was that the small number of patients would have a negative impact on the treatment effect size, and power of the study. Increasing our sampling size would improve the statistical power of our study. The resource constraint of the investigator was an important and significant limiting factor in recruiting patients from different geographically located hospitals. Therefore, a longer study period with larger numbers is needed.

With regards to the data collection and record keeping, challenges with missing data that were expected did not impact our study as all records and data was appropriately collected and stored.

4.8 Interobserver Reliability

An independent second assessor performed a blinded assessment of all radiographic parameters and these were compared to the principal assessor's results. It was demonstrated that overall there was no statistically significant difference between all eight radiographic parameters (Table 3.8) when the paired sample test was applied. This proves that there is good agreement between the assessors in their analysis. This improves the strength of the analysis for our study and helps to minimise any assessor bias.

As it relates the match-paired proportions between assessors, analysis demonstrates that the variability of the normal to abnormal results were statistically not significant (Table 3.12), except for the PA articular gap. This difference can be attributed to differences in the technique for measuring the articular gap on the radiographs. Another contributing factor to the aforementioned observation is that the magnitude of measurement for this parameter is small and unintended inaccuracies in assessors' measurements may result in a misclassification of the data as normal or abnormal thereby affecting matched pair results i.e., a measurement lying between millimetre gradations may have been rounded up or down depending on the observers interpretation.

All attempts had been made to reduce the errors in measurement by standardising the method of measurements by having both assessors follow a standard measurement protocol. Instrumentation accuracy was an issue whereby the rulers although standardised were not calibrated to measure part of one millimetre. One solution to this problem may be that a cone beamed computed tomography scan (CT-Scan) of the wrist be done to visualise and measure these intra-articular fractures more accurately, but because of the increased radiation exposure and resource constraints scanning all DRF's may lead to increased and unwarranted surgical management (45). Repeating the measurements for each assessor and increasing the number of independent assessors would also improve accuracy.

CHAPTER 5 – CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSION

5.1.1 Primary Research Question

Patients with distal radius fractures treated at Charlotte Maxeke Johannesburg Academic Hospital were adequately reduced. The experience level of the surgeon does not appear to influence the quality of reductions performed at our institution. However, because of the differences in statistical outcomes between assessors 1 and 2 on restoring the radial height, and lateral articular gap, further assessment of these parameters is required.

5.1.2 Secondary Research Question

The classification system used by the treating surgeon to guide management of the fracture was unknown to the investigators. By comparing the surgeon's treatment method used to the IDEAL's recommended treatment method for the same injury, the surgeon's method of reduction closely resembles that which is suggested by the IDEAL classification system. Utilising the IDEAL classification system may prove valuable in guiding our management of distal radius fractures and in aiding our predictions of prognosis and functional outcomes. Its use may also simplify and standardize the process of treating distal radius fractures at our institution. However, further studies are needed to confirm and validate the prognostic value and use of the IDEAL classification system.

5.2 RECOMMENDATIONS

As it relates the level of experience of the registrar performing the reduction, greater emphasis and training can be placed on restoring radial height and the lateral articular gap.

PACS analysis of the radiographic parameters should be utilised to improve the precision and accuracy of measurement.

Increasing the number of patients would increase the statistical power of this study and minimise a type II error, especially for radial height and lateral articular gap.

Better characterisation of falls into high energy versus low energy mechanisms and reducing the minimum age category of elderly patients to 50 years would reduce confounding variables and bias.

Increasing the number of independent observers with the inclusion of a radiologist as an observer will strengthen the reliability of future studies.

REFERENCES

REFERENCES

1. Graham TJ. Surgical Correction of Malunited Fractures of the Distal Radius. The Journal of the American Academy of Orthopaedic Surgeons. 1997;5(5):270-81. Epub 2000/05/05.

2. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury. 2006;37(8):691-7. Epub 2006/07/04.

3. Ipaktchi K, Livermore M, Lyons C, Banegas R. Current concepts in the treatment of distal radial fractures. Orthopedics. 2013;36(10):778-84. Epub 2013/10/08.

4. Ilyas AM, Jupiter JB. Distal radius fractures--classification of treatment and indications for surgery. Hand clinics. 2010;26(1):37-42. Epub 2009/12/17.

5. Chen NC, Jupiter JB. Management of distal radial fractures. The Journal of bone and joint surgery American volume. 2007;89(9):2051-62. Epub 2007/09/05.

6. Kakarlapudi TK, Santini A, Shahane SA, Douglas D. The cost of treatment of distal radial fractures. Injury. 2000;31(4):229-32. Epub 2000/03/17.

7. de Putter CE, Selles RW, Polinder S, Panneman MJ, Hovius SE, van Beeck EF. Economic impact of hand and wrist injuries: health-care costs and productivity costs in a population-based study. The Journal of bone and joint surgery American volume. 2012;94(9):e56. Epub 2012/05/04.

8. Lichtman DM, Bindra RR, Boyer MI, Putnam MD, Ring D, Slutsky DJ, et al. American Academy of Orthopaedic Surgeons clinical practice guideline on: the treatment of distal radius fractures. The Journal of bone and joint surgery American volume. 2011;93(8):775-8. Epub 2011/04/22.

9. Belloti JC, dos Santos JB, de Moraes VY, Wink FV, Tamaoki MJ, Faloppa F. The IDEAL classification system: a new method for classifying fractures of the distal extremity of the radius - description and reproducibility. Sao Paulo medical journal = Revista paulista de medicina. 2013;131(4):252-6. Epub 2013/10/22.

10. Lidstrom A. Fractures of the distal end of the radius. A clinical and statistical study of end results. Acta orthopaedica Scandinavica Supplementum. 1959;41:1-118. Epub 1959/01/01.

11. Sebastin S, Chung K. Management of Wrist Fractures. Internet: publisher unknown; 2016 [updated 2016 September 26]; The AO classification of distal radius fractures]. Available from: http://plasticsurgerykey.com/management-of-wrist-fractures/.

12. Müller ME, Nazarian S, Koch P, Schatzker J. The comprehensive classification of fractures of long bones: Springer Science & Business Media; 2012.

13. Medoff RJ. Essential radiographic evaluation for distal radius fractures. Hand clinics. 2005;21(3):279-88.

14. Kreder HJ, Hanel DP, McKee M, Jupiter J, McGillivary G, Swiontkowski MF. X-ray film measurements for healed distal radius fractures. The Journal of hand surgery. 1996;21(1):31-9.

15. Jaremko J, Lambert R, Rowe B, Johnson J, Majumdar S. Do radiographic indices of distal radius fracture reduction predict outcomes in older adults receiving conservative treatment? Clinical radiology. 2007;62(1):65-72.

16. Maurizio A, Renato A, Claudio F, Giovanni M. Long-term Results of Conservative Treatment of Fractures of the Distal Radius. Clinical orthopaedics and related research. 1986;206:202-10.

17. Friberg S, Lundström B. Radiographic measurements on the radio-carpal joint in distal radial fractures. Acta radiologica: diagnosis. 1976;17(6):869-76.

18. Solgaard S. Angle of inclination of the articular surface of the distal radius. Der Radiologe. 1984;24(7):346-8.

19. Schuind F, Linscheid R, An K-N, Chao E. A normal data base of posteroanterior roentgenographic measurements of the wrist. The Journal of bone and joint surgery American volume. 1992;74(9):1418-29.

20. Solgaard S. Distal radius fractures: Classification, function and recommendations to treatment: Lægeforeningens forlag; 1992.

21. Palmer AK, Glisson RR, Werner FW. Ulnar variance determination. The Journal of hand surgery. 1982;7(4):376-9.

22. Beumer A, Adlercreutz C, Lindau TR. Early prognostic factors in distal radius fractures in a younger than osteoporotic age group: a multivariate analysis of trauma radiographs. BMC musculoskeletal disorders. 2013;14(1):1.

23. Arora S, Grover SB, Batra S, Sharma VK. Comparative evaluation of postreduction intra-articular distal radial fractures by radiographs and multidetector computed tomography. The Journal of bone and joint surgery American volume. 2010;92(15):2523-32.

24. Chapman MW, Szabo RM, Marder RA. Chapman's orthopaedic surgery: Lippincott Williams & Wilkins Philadelphia; 2001.

25. Brogren E, Petranek M, Atroshi I. Incidence and characteristics of distal radius fractures in a southern Swedish region. BMC musculoskeletal disorders. 2007;8(1):1.

26. Solgaard S, Petersen VS. Epidemiology of distal radius fractures. Acta orthopaedica Scandinavica. 1985;56(5):391-3.

27. Thompson PW, Taylor J, Dawson A. The annual incidence and seasonal variation of fractures of the distal radius in men and women over 25 years in Dorset, UK. Injury. 2004;35(5):462-6.

28. Nellans KW, Kowalski E, Chung KC. The epidemiology of distal radius fractures. Hand clinics. 2012;28(2):113-25.

29. Koo KO, Tan DM, Chong AK. Distal radius fractures: an epidemiological review. Orthopaedic surgery. 2013;5(3):209-13.

30. Cuenca J, Martinez A, Herrera A, Domingo J. The incidence of distal forearm fractures in Zaragoza (Spain). Chirurgie de la main. 2003;22(4):211-5.

31. Broadbent M, Quaba O, Hadjucka C, McQueen M. The epidemiology of multifocal upper limb fractures. Scandinavian journal of surgery. 2003;92(3):220-3.

32. Lindau TR, Aspenberg P, Arner M, Redlundh-Johnell I, Hagberg L. Fractures of the distal forearm in young adults: an epidemiologic description of 341 patients. Acta orthopaedica Scandinavica. 1999;70(2):124-8.

33. Cummings SR, Black DM, Rubin SM. Lifetime risks of hip, Colles', or vertebral fracture and coronary heart disease among white postmenopausal women. Archives of Internal Medicine. 1989;149(11):2445-8.

34. Porrino Jr JA, Maloney E, Scherer K, Mulcahy H, Ha AS, Allan C. Fracture of the distal radius: epidemiology and premanagement radiographic characterization. American Journal of Roentgenology. 2014;203(3):551-9.

35. Alffram P-A, Bauer GC. Epidemiology of fractures of the forearm. The Journal of bone and joint surgery American volume. 1962;44(1):105-14.

36. Róbertsson GO, Jónsson GT, Sigurjónsson K. Epidemiology of distal radius fractures in Iceland in 1985. Acta orthopaedica Scandinavica. 1990;61(5):457-9.

37. Hove LM, Fjeldsgaard K, Reitan R, Skjeie R, Sörensen FK. Fractures of the distal radius in a Norwegian city. Scandinavian journal of plastic and reconstructive surgery and hand surgery. 1995;29(3):263-7.

38. Kelsey JL, Browner WS, Seeley DG, Nevitt MC, Cummings SR. Risk factors for fractures of the distal forearm and proximal humerus. American Journal of Epidemiology. 1992;135(5):477-89.

39. Kim JK, Koh Y-D, Do N-H. Should an ulnar styloid fracture be fixed following volar plate fixation of a distal radial fracture? The Journal of Bone & Joint Surgery. 2010;92(1):1-6.

40. May MM, Lawton JN, Blazar PE. Ulnar styloid fractures associated with distal radius fractures: incidence and implications for distal radioulnar joint instability. The Journal of hand surgery. 2002;27(6):965-71.

41. Bentohami A, Bosma J, Akkersdijk G, van Dijkman B, Goslings J, Schep N. Incidence and characteristics of distal radial fractures in an urban population in The Netherlands. European Journal of Trauma and Emergency Surgery. 2014;40(3):357-61.

42. Brogren E, Hofer M, Petranek M, Wagner P, Dahlin LB, Atroshi I. Relationship between distal radius fracture malunion and arm-related disability: a prospective population-based cohort study with 1-year follow-up. BMC musculoskeletal disorders. 2011;12(1):1.

43. Mulders MA, Walenkamp MM, Goslings JC, Schep NW. Internal plate fixation versus plaster in displaced complete articular distal radius fractures, a randomised controlled trial. BMC musculoskeletal disorders. 2016;17(1):1.

44. Robertson G, Robertson B, Thomas B, McEachan J, Davidson D. Assessing angulation on digital images of radiographs of fractures of the distal radius: visual estimation versus computer software measurement. Journal of Hand Surgery (European Volume). 2011;36(3):230-5.

45. Hunt JJ, Lumsdaine W, Attia J, Balogh ZJ. AO type‐C distal radius fractures: the influence of computed tomography on surgeon's decision‐making. ANZ journal of surgery. 2013;83(9):676-8.

46. Green DP, Rockwood CA, Bucholz RW, Heckman JD, Tornetta P. Rockwood and Green's fractures in adults: Lippincott Williams & Wilkins; 2010.

47. Pienaar G, Anley C, Ikram A. Restoration of teardrop angle (TDA) in distal radius fractures treated with volar locking plates. SA Orthopaedic Journal. 2013;12(3):32-4.

48. Trumble TE, Culp R, Hanel DP, Geissler WB, Berger RA. Instructional Course Lectures, The American Academy of Orthopaedic Surgeons-Intra-Articular Fractures of the Distal Aspect of the Radius*†. The Journal of bone and joint surgery American volume. 1998;80(4):582-600.

49. Surgeons AAOO. OrthoInfo. Distal Radius Fractures(Broken Wrist). 2013.

50. Ulna. [Internet]: Medicalpicturesinfo.com; 2015 [cited 24 January 2015]; Ulna]. Available from: http://medicalpicturesinfo.com/ulna/.

51. Skeletal System - Appendicular Skeletal System. [Internet]: Kreativestudios.com; 2015 [24 January 2015]; Available from: http://kreativestudios.com/Tooltip/06Skeletal/03AppendicularSkeleton/02PectoralUE.html.

52. http://www.firstlightwebdesign.com/ H. The Wrist. [Internet]: Imageinterpretation.co.uk; 2015 [24 January 2015]; Available from: http://www.imageinterpretation.co.uk/wrist.html.

53. World Development Indicators - World DataBank. [Internet]: Databank.worldbank.org; 2016 [3 October 2016]; Available from: http://databank.worldbank.org/data

APPENDICES

APPENDIX A

HUMAN RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

R14/49 Dr Akin A Minnis

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M150491

NAME: (Principal Investigator)	Dr Akin A Minnis
DEPARTMENT:	Orthpaedics Charlotte Maxeke Johannesburg Academic Hospital
PROJECT TITLE:	A Radiological Assessment of the Quality of Reduction Distal Radius Fractures at Charlotte Maxeke Johannesburg Academic Hospital
DATE CONSIDERED:	24/04/2015
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	03/06/2015

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned

contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**.

Principal Investigator Signature ____________ Date ____________

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX B

DISTAL RADIUS FRACTURE INFORMATION SHEET

My name is Dr. Akin Minnis. I am a postgraduate student in the Department of Orthopaedic Surgery at The University of the Witwatersrand – Charlotte Maxeke Johannesburg Academic Hospital, Johannesburg, South Africa and currently I am pursuing a Master's of Medicine Degree in the field of Orthopaedic Surgery. My coursework/research is titled '*A Radiological Assessment of the Quality of Reduction of Distal Radius Fractures at Charlotte Maxeke Johannesburg Academic Hospital.'*

I would like, with your permission, for you to participate in this study that has been approved by both the Postgraduate Committee at CMJAH and the CMJAH Hospital Ethics Committee.

The purpose of this research is to determine the quality of the reductions of distal radius fractures by the Orthopaedic Surgical Training Staff here at CMJAH by measuring the degrees of correction on the radiographs before and after non-operative and operative intervention.

If you agree to participate in this study and thereby give consent, you will be asked relevant personal information (demographics pertaining only to this study), and radiographs (X-rays) of both the uninjured and injured limb [before and after treatment] will be used to assess the quality of reductions.

There is no anticipated risk or harm to you for participating in this study. Your information will be kept confidential and your participation will occur at no additional cost to you. Appropriate treatment will be given at all times and participation in this study is voluntary. You will not be denied treatment if you decline participation in this study. You may decide to decline participation in this study at any time without explanation and without fear of consequence.

APPENDIX C

CONSENT FORM

I ………………………………………… do hereby give consent to participate in this study as explained to me by..……………………………………………. I have been informed of the nature of this study and I do understand that there are no risks or harm involved and that my participation is voluntary, that participation should not compromise the standard of care treatment in any way whatsoever. I may also choose to terminate participation without explanation and consequence at anytime whatsoever. I have been assured that my personal details will remain confidential. I do hereby confirm that all my concerns have been adequately and sufficiently addressed to my satisfaction by the investigator/interrogator

Participant' s Name (Print)…………………………………………

Participant's Signature or Thumbprint…………………………….

Date:……………………………………….

I hereby confirm that I have clearly explained the nature of this study and the contents of this consent in detail to the satisfaction of this participant and that he/she voluntary agrees to participate in this study.

Investigator's Name (print) ……………………………………...

Investigator's signature ………………………………………….

Witness' Name (print) …………………………………………...

Witness' Signature ………………………………………………

Date:……………………………………….....…………….

For enquiries, please contact:

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APPENDIX D

DISTAL RADIUS FRACTURE DATA FORM

Participant/Patient Study Number:

Age (years):

Sex: Male Female

Dominant Hand: Right Left

Fracture Data

Injury Side:

Right Left Both

Mechanism of Injury

Fall MVA PVA Assault Other

Soft Tissue

Closed Open (GA Type): 1 2 3a 3b 3c

Surgeon Experience Level

Level of Orthopaedic Training Staff at Surgical Intervention

Intern

Medical Officer (years experience) 1st 2nd 3rd 4th 5th

Registrar (training year) 1st 2nd 3rd 4th 5th

Consultant/Specialist

Reduction Method - Casualty

None Closed Reduction

Reduction Method - Theatre

Closed Reduction K-wires External Fixation Internal Fixation

Radiographic Assessment Data Form

Patient number:

Fracture Classification

Intra-articular □ Extra-articular □

Frykman Classification

1 2 3 4 5 6 7 8

AO/Muller Classification

A1 A2 A3 B1 B2 B3 C1 C2 C3

Lidstrom Classification

Excellent □ Good □ Fair □ Poor □

Ideal Classification
Stable (0-1) □ Potentially Unstable (2-3) □ Complex (4-5) □

Radiographic Parameters

Radiographic Parameters			
	Posteroanterior X-Ray	**Pre- Reduction**	**Post-Reduction**
	Radial Inclination		
	Radial Length		
	Step-Off		
	Gap		
	Lateral X-ray		
	Palmar/Volar Tilt		
	Step-Off		
	Gap		

APPENDIX E

DATA COLLECTION TABLE
26 Patients (27 wrists)

Patient No.	Age	Gender	Injury Side	Mechanism of Injury	Soft Tissue Injury	Joint Involvement	Frykman Class	IDEAL Type	IDEAL Class	IDEAL Prognosis	AO Class	Reduction Surgery	Surgeon Experience
1	40	M	R	PVA	Closed	Extra-articular	2	2	Unstable	Intermediate	A2	ORIF - Plate	<1yr
2	23	M	R	Fall	Closed	Intra- articular	4	2	Unstable	Intermediate	C1	ORIF -Plate	1-2yrs
3	57	F	L	Fall	Closed	Intra- articular	8	2	Unstable	Intermediate	C2	ORIF - Plate	>2yrs
4	58	M	L	PVA	Closed	Intra- articular	8	3	Complex	Poor	C3	ORIF - Plate/K-Wires	>2yrs
5	65	M	R	Fall	Closed	Intra- articular	8	2	Unstable	Intermediate	C2	ORIF - Plate	>2yrs
6	60	F	R	MVA	GA2	Intra- articular	8	3	Complex	Poor	C3	Ex-Fix	1-2yrs
7	37	F	L	MVA	Closed	Intra- articular	6	2	Unstable	Intermediate	C2	ORIF - Plate	>2yrs
8	33	M	R	Fall	Closed	Intra- articular	8	2	Unstable	Intermediate	C3	ORIF - Plate	>2yrs
9	29	M	R	Fall	Closed	Extra-articular	2	2	Unstable	Intermediate	A2	CR + K-Wires	<1yr
10	27	M	R	Assault	Closed	Intra- articular	3	2	Unstable	Intermediate	C1	ORIF - Plate	1-2yrs
11	22	M	R	PVA	GA2	Intra- articular	6	2	Unstable	Intermediate	A3	K-Wires	1-2yrs
12	22	M	L	PVA	Closed	Intra- articular	8	2	Unstable	Intermediate	C2	ORIF - Plate	1-2yrs
13	32	F	L	Fall	Closed	Intra- articular	6	2	Unstable	Intermediate	A2	ORIF - Plate	1-2yrs
14	50	M	L	Assault	GA3a	Extra-articular	2	2	Unstable	Intermediate	A3	Ex-Fix	<1yr
15	42	M	R	Fall	Closed	Intra- articular	3	2	Unstable	Intermediate	C2	ORIF - Plate	>2yrs
16	28	M	R	Fall	Closed	Intra- articular	3	2	Unstable	Intermediate	C2	ORIF - Plate	>2yrs
17	55	F	L	Fall	Closed	Extra-articular	2	1	Stable	Good	A2	K-Wires	<1yr
18	24	M	L	Fall	Closed	Intra- articular	4	1	Unstable	Good	C1	K-Wires	>2yrs
19	35	M	L	Fall	Closed	Intra- articular	8	3	Unstable	Intermediate	C2	ORIF - Plate	>2yrs
20	53	F	R	Fall	Closed	Intra- articular	8	2	Unstable	Intermediate	C2	ORIF - Plate	1-2yrs
21	21	M	R	Fall	Closed	Intra- articular	4	3	Unstable	Intermediate	B1	ORIF - Plate	>2yrs
22	38	M	L	Fall	Closed	Intra- articular	4	3	Unstable	Intermediate	C3	ORIF - Plate	1-2yrs
23	28	M	R	Fall	Closed	Intra- articular	4	3	Unstable	Intermediate	B1	ORIF - FS Plate	1-2yrs
24	29	M	L	Fall	Closed	Intra- articular	3	3	Unstable	Intermediate	B3	ORIF - Plate	1-2yrs
25	34	M	L	Fall	Closed	Intra- articular	8	3	Unstable	Intermediate	C2	ORIF - Plate	>2yrs
26	32	F	L	Fall	Closed	Extra-articular	2	2	Unstable	Good	A2	ORIF - Plate	1-2yrs
27	26	F	R	MVA	Closed	Intra- articular	6	2	Unstable	Intermediate	A3	K-Wires	>2yrs