Post-operative radiological outcome of ankle fractures after treatment by orthopaedic registrars

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A research report submitted to the Faculty of Health Sciences, University of the

Witwatersrand, in partial fulfilment of the requirements for the degree of Master of

Medicine

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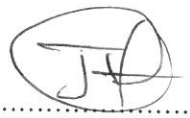
DECLARATION

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

Signature of candidate: 

17th of November 2021 in Johannesburg, South Africa

DEDICATION

- This study is dedicated to my grand-mother Mrs B.P Mchunu, my late mother Mrs S.V. Gcaba as well as my late aunt Miss R.F. Mchunu. I will be forever grateful for the sacrifices they made for me to get educated.

- To my dearest wife Dr L.P. Metsing-Mchunu and my lovely children Njabulo and Rethabile for always being supportive in whatever I do.

- Lastly, to my late uncle Mr S.F Mchunu, for teaching me good human values and respect.

ABSTRACT

Background: Ankle fractures are the commonest fractures encountered by orthopaedic surgeons. They account for 10% of all orthopaedic fractures treated in the emergency departments. Orthopaedic registrars are expected to accurately diagnose and surgically manage these fractures during their training and progression towards competent and independent practice. This study aimed to evaluate the post-operative radiological outcome of ankle fractures treated by orthopaedic registrars at Chris Hani Baragwanath Academic Hospital (CHBAH).

Methodology: This was a retrospective cross-sectional study of ankle fractures treated with open reduction and internal fixation by registrars at CHBAH from 01 January 2018 to 30 June 2018. Only Weber A, B1 and B2 fractures were included while B3 and C fractures were excluded. Post-operative x-rays were used to measure TCA (Talocrural angle and MCS (medial clear space). These measurements were used to determine the accuracy of fracture reduction in order to assess the competence of registrars. Secondarily, checked if these were influenced by registrars' seniority or timing of surgery. Study permission received in December 2018 and ethics approval in April 2019 after which data collection commenced. Measurements were confirmed by a blinded independent observer (IO), Dr Kgabo (qualified orthopaedic surgeon).

Results: A total number of 98 patients were surgically treated for Weber B ankle fractures during the study period. Only 64 patients met the inclusion criteria while 34 were excluded. The mean age of studied participants was 41.3 years. Female patients accounted for 64 % of studies cases while males accounted for 36%. The right ankle was

the most fractured side (59.4%). Majority (79.7%) of the operated ankles had good radiological outcome. Surgeries performed between 00:00 and 06:59 hrs were 5.8 times more likely to have a poor radiological outcome compared to those performed between 07:00 and 23:59 hrs. Seniority of the registrars did not show any influence in radiological outcome.

Conclusion: Majority (79.7%) of ankle fractures surgically treated by the registrars at CHBAH had good radiological outcome, with only 20.3% showing the poor results. Timing of surgery had an influence in radiological outcome as oppose to registrars' seniority.

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- Prof S.K. Magobotha – Supervisor: Thank you for the guidance, mentorship and teaching.
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LIST OF ABBREVATIONS/NOMENCLATURE

AO: Arbeitsgemeinschaft für Osteosynthesefragen

BMI: Body Mass Index

CEO: Chief Executive Officer

CHBAH: Chris Hani Baragwanath Academic Hospital

HREC: Human Research Ethics Committee

IO: Independent observer

MCS: Medial Clear Space

mm: Millimetres

MS: Microsoft

ORIF: Open Reduction and Internal Fixation

OTA: Orthopaedic Trauma Association

PI: Principal Investigator

PTOA: Post-traumatic Osteoarthritis

TCA: Talocrural Angle

TFCS: Tibiofibular Clear Space

USA: United States of America

CHAPTER ONE

1. INTRODUCTION

1.1 Anatomy

The ankle joint is a complex three bone joint, which is made up of tibiotalar, tibiofibular and talofibular joints. The ankle stability is achieved by bony elements, namely: talus dome (wedge shaped with a wider anterior part and a narrow posterior part), three malleoli (lateral, medial and posterior) and the ligamentous elements (lateral collateral ligaments, syndesmotic ligament complex and medial deltoid ligament complex). Some of these anatomical structures are shown in Figures 1.1 and 1.2, respectively[1].

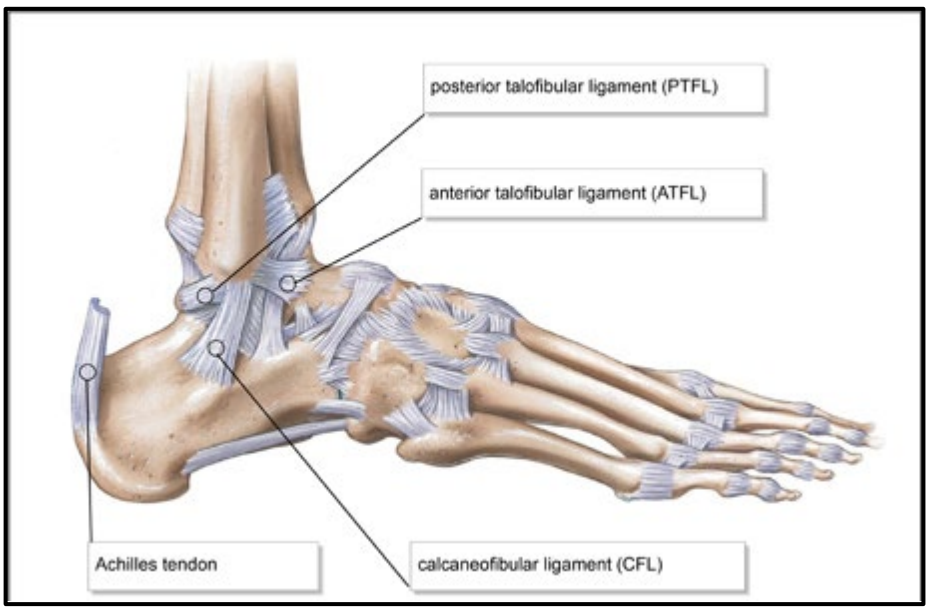

Figure 1.1: Lateral collateral ligament of the ankle[2].

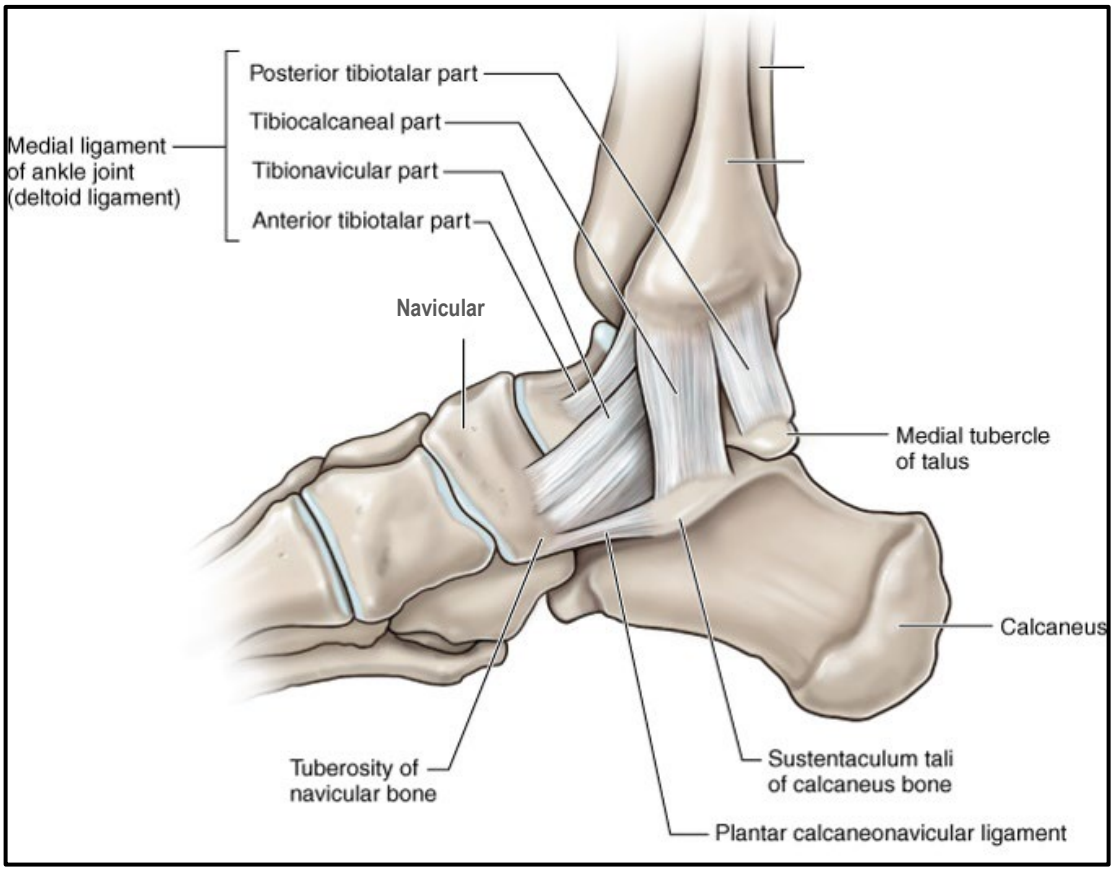

Figure 1.2: Deltoid ligament complex of the ankle[2].

1.1.1 Ligaments of the ankle

Ligaments of the ankle are divided as follows:

(i) Lateral collateral ligaments:

- Anterior talofibular ligament,
- Posterior talofibular ligament and
- Calcaneofibular ligament.

(ii) Medial collateral ligaments of the ankle (deltoid ligament complex):

- Superficial parts:
    - Tibionavicular ligament,
    - Tibiocalcaneal ligament and
    - Posterior tibiotalar ligament.

- Deep part:
    - Anterior tibiotalar ligament

(iii) Syndesmotic ligaments:

- Anterior-inferior tibiofibular ligament,
- Posterior-inferior tibiofibular ligament,
- Transverse tibiofibular ligament and interosseous ligament.

1.1.2 Bones of the ankle

- Medial malleolus
- Lateral malleolus
- Posterior malleoulus
- Talus dome
- Tibial plafond

Biomechanically, the ankle joint is more stable in the dorsiflexion position as the larger anterior articular surface of the talus matches the tibiofibular articular surface. It is subjected to more weight bearing force with the tibio-talar interface as the load bearing aspect and is susceptible to injuries more than any other joint in the body[3-5]. The ankle's uniqueness in anatomy, mechanical load and cartilage composition makes it highly susceptible to trauma, thereby, leading to post-traumatic osteoarthritis[4].

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

Ankle fractures are the commonest fractures treated in Orthopaedic Surgery[6]. They account for 10% of all orthopaedic fractures treated in the emergency departments[7-11]. Shibuya *et al.,* reported that of all the foot and ankle injuries treated in all trauma hospitals in the United States of America between 2007 and 2011, 56% were ankle fractures[12]. Most ankle fractures are due to a low energy rotational mechanism; however, some may result from pedestrian/motor vehicle accidents as well as falling from a height. Thur *et al.,* in the Swedish National Patient Register data review found that 64% of patients had sustained ankle fractures after falling from the same ground level, followed by falling from a height (10%), however, they did not report on the incidence of those who might have been involved in pedestrian/motor accidents[6].

They further reported that 20% of all open fractures were due to transport accidents compared to 9% of closed fractures[6]. Shu-Ma Han *et al*., in their ankle fracture epidemiology study reported Danis-Weber B injury as the commonest type, accounting for 42% of all ankle fractures compared to Danis-Weber type A and C, which only accounted for 31% and 19%, respectively[13].

2.2 Classification of ankle fracture

Several classifications for ankle fractures exist but none of them has been proven reliable. Danis-Weber classification has stood test of time. It describes the fracture level of the lateral malleolus in relation to the syndesmotic injury[14]. However currently; the most used classification is the Arbeitsgemeinschaft für Osteosynthesefragen classification (AO). The AO foundation and Orthopaedic Trauma Association (OTA) expanded from the Danis-Weber classification scheme to include the involvement of the medial and posterior malleoli[8]. This type of classification looks at the fracture line in relation to the syndesmosis and allocates a number depending on the number of malleoli except for Weber C fractures where the number is allocated according to fibular facture pattern (see Table 2.1 and Figure 2.1).

Table 2.1: The Danis-Weber classification[14].

Weber A	Infra-syndesmotic fracture
Weber B	Trans-syndesmotic fracture
Weber C	Supra-syndesmotic fracture

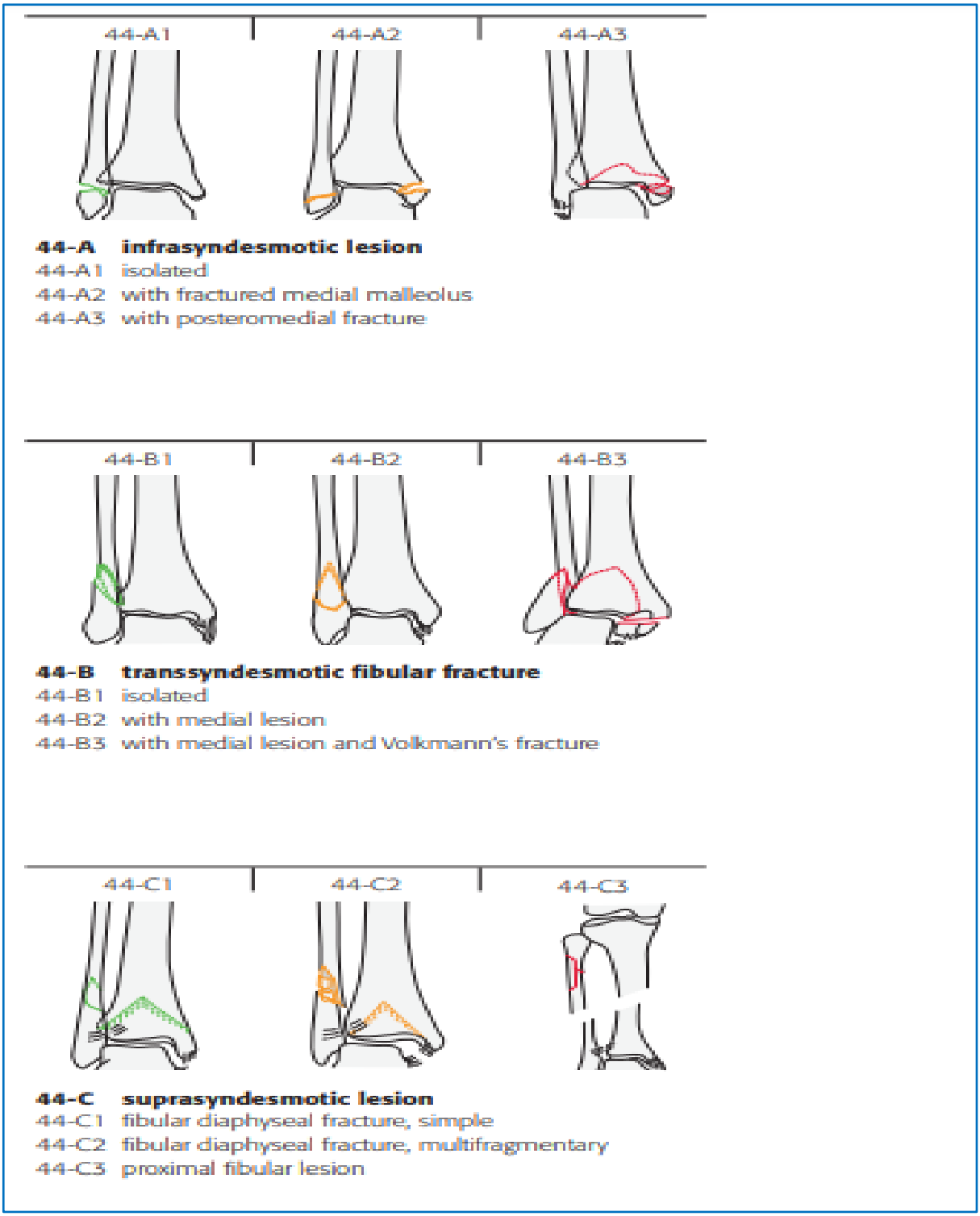

Figure 2.1: AO foundation and OTA classification[15].

About 15-38% of Weber B ankle fractures have associated syndesmotic injury while this is seen in 100% of Weber C[5,6,16]. A failure of two or more ligaments results in syndesmosis instability[17], which is associated with worse clinical outcome if not treated appropriately.

2.3 Diagnostic tools for ankle fractures

X-ray imaging remains the most recommended tool in the diagnosis of ankle injuries, fracture evaluation and joint reduction after any form of treatment. Several radiographic parameters must be restored after conservative and surgical treatment of these fractures to avoid poor clinical and radiological outcomes. Amongst these parameters are the fibular length, lateral talar shift and syndesmotic diastasis, which if not restored and corrected may result in the alteration of the ankle biomechanics and predisposes the joint to post-traumatic osteoarthritis (PTOA). Sinha *et al.*, in their study of seven patients who were treated for malunited Weber C fractures with persistent ankle pain, fibular shortening and lateral talar subluxation were the causes of malunion[18]. They reported that the fibular lengthening osteotomy resulted in restoration of ankle biomechanics and a pain free function of the joint in all treated patients, however, their study sample size was small[18].

Ovaska *et al.*, in a retrospective chart review of patients with post-operative ankle fracture malreductions treated between 2002 and 2011 who had revision surgery done; found that poor fibular length restoration and errors in surgical syndesmotic reduction were the common reasons for the malreductions[19].

In retrospective review by Walsh *et al.*, the authors reported that eight of the thirteen (66%) patients who required revision surgery within eight weeks after the primary surgery was done, had sustained Weber B fractures and five (34%) had sustained Weber C fractures. They further reported that seven (54%) patients had a neglected or undertreated syndesmotic injury as a common reason for revision surgery[7].

The most useful radiographic sign for assessing a fibular length is the measurement of a Talocrural angle (TCA) which is done on the ankle mortise view. TCA is measured on an anteroposterior or mortise radiographic image. It is the angle between the longitudinal axis line of the tibia (which should run perpendicular to the line along the tibial plafond) and a line connecting the tips of the lateral and medial malleoli[18]. The normal TCA value is 83 ± 4 degrees, and the reproducible measurement is by the comparison of the measurements with the uninjured contralateral side. The TCA of a properly reduced ankle should be within ≤ 2 degrees of the uninjured side[5,20]. The lateral talus shift is assessed by measuring the Medial clear space (MCS). The MCS is measured on the mortise view as a distance between the lateral border of the medial malleolus and the medial border of the talus at the dome level[10], and the normal MCS should measure 2 – 4 millimetres (mm). The Tibiofibular clear space (TFCS) provides information about the syndesmosis integrity and is a useful sign for the diagnosis of the syndesmotic injury. The TFCS is a measured horizontal distance between the incisura fibularis of the tibia and the medial border of the fibula, 1 cm above the tibial plafond[5,21,22], and the normal TFCS should measure < 6 mm on both anterior- posterior and mortise views of the ankle, as shown in Figure 2.2.

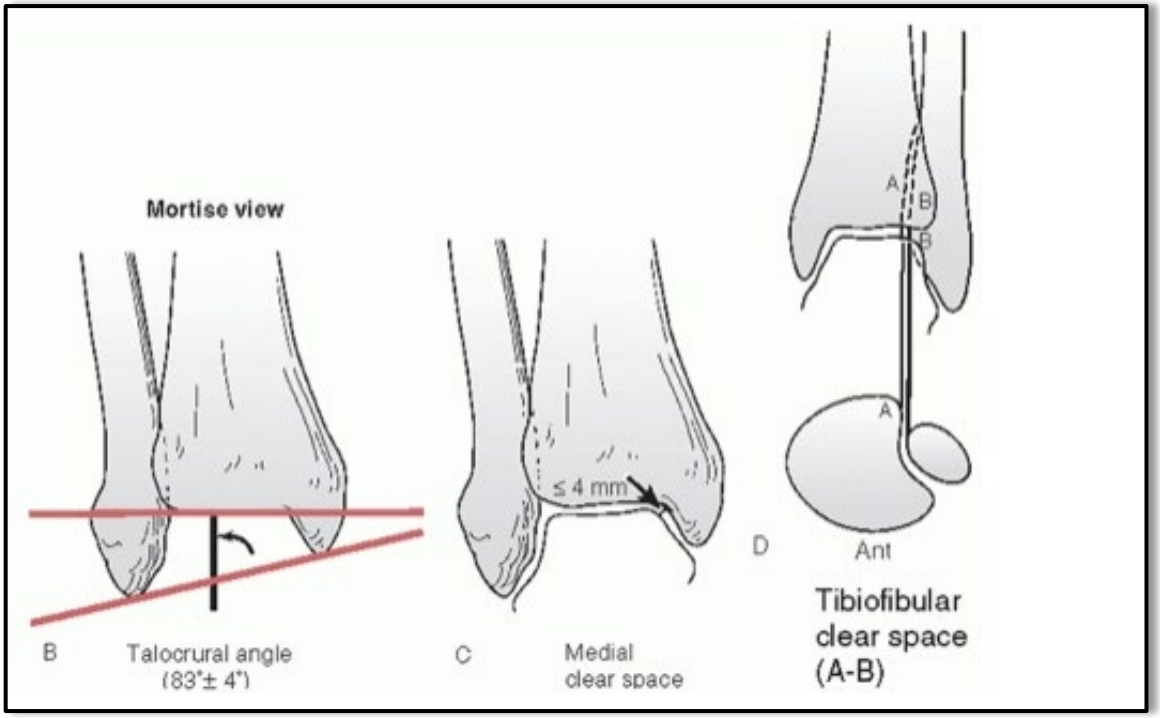

Figure 2.2: Measurements of TCA, MCS and TFCS[5].

Similarly to any other intra-articular fractures, the main goal of treatment of these fractures whether operatively or non-operatively, is to preserve function by restoring anatomical congruency and achieving a painless full range of motion of the joint[1,22].

2.4 Predictors of outcome of ankle fractures after treatment

The type of fracture and intervention/s applied influences the functional, clinical, or radiological outcome and complications that may develop following these injuries.

Evidence from literature suggests that stable ankle fractures can be treated conservatively with good clinical and radiological outcome.

The converse is the case with unstable and displaced fractures, which do better with operative treatment[9]. A retrospective study done in Turkey demonstrated that closed ankle fracture had a better outcome as opposed to open ankle fractures[23]. Furthermore, the presence of chondral lesion due to the initial trauma (a condition more prevalent among older patients) was found to be associated with poor clinical and functional outcomes[22]. Lower clinical and radiological outcome scores were also reported in other studies, which investigated patients with open ankle fractures[24-26].

A prospective study reported that for adult patients surgically treated with closed bi-malleolar fractures, the functional and radiological outcome was better in patients who underwent stable internal fixation of the medial malleolus with at least one cancellous or malleolar screw or tension band wiring of the medial malleolus compared to those who had less rigid fixation of the medial malleolus using Kirschner wires[27]. Verhage *et al*., from their retrospective cohort study reported that surgically treated bi-malleolar and tri-malleolar fractures had worse functional outcomes compared to isolated fibular fractures. However, the fracture with the involvement of both the medial and posterior malleoli result in a poor functional outcome[10]. Furthermore, Sipahioglu *et al*. defined the accurate reduction of syndesmosis as the most important predictor of good clinical outcome in surgically treated ankle fractures.

There is no consensus on the role of age, gender, and obesity in clinical and functional outcomes in patients with ankle fractures. Younger age and low Body Mass Index (BMI)

were reported to be associated with good functional outcome among the conservatively treated ankle fractures[9]. Furthermore, younger age and male sex were reported as being predictive of functional recovery at one year following ankle fracture surgery[29]. The Swedish study by showed that elderly females had lower functional scores one year following surgically treated ankle fractures[30].

2.5 Registrars' factors and surgical outcome

Orthopaedic surgeons in training are often faced with challenges of accurately diagnosing and treating these fractures as early as in their first year of training and mostly during their night duties where fatigue may influence their decision-making capacity. Vidyarthi *et al.,* conducted a survey on internal medicine residents to determine self-reported errors during their long duty shifts; fatigue and excessive workload were among the factors reported[30]. Kelz *et al*., in their retrospective cohort study reported that general and vascular non-emergent surgical cases done after 16:00 hrs in the United States of America (USA) were significantly associated with increased morbidity and mortality[31]. Although the study design could not prove a causal relationship between timing of surgery and morbidity or mortality, the study suggests that poor outcome is associated with timing of surgical procedures.

In contrast to the study by Yaghoubian *et al.,* found no difference in clinical outcome in surgery performed by sleep deprived trauma residents compared with those performed by their counterparts during daytime[32].

2.6 Problem statement

Due to the common nature of ankle fracture injuries and the high level of expectations from orthopaedics trainees, the researcher aims to explore the competency of these trainees in treating ankle fracture injuries and identify independent factors associated with the poor postoperative radiological outcome in order to introduce interventions that may enhance their training, subsequently the improvement patient's outcome.

2.7 Relevance of study

Our study serves as a guide to assess the standard of care given to patients and the level of training given to registrars to:

- Ensure that patients receive a deservedly good quality care.
- Evaluate the surgical skill competence of the registrars.
- Determine the kind of procedures that registrars should be allowed to perform during specific times of the day.
- To improve registrars' training and supervision where need

CHAPTER THREE

3. METHODOLOGY

3.1 Hypothesis

Orthopaedic surgery registrars at the University of the Witwatersrand can achieve adequate reduction and good post-operative radiological outcome of surgically treated ankle Weber A and B fractures.

3.2 Research question

What is the post-operative radiological outcome of the ankle fractures treated by orthopaedic registrars at the University of Witwatersrand?

3.3 STUDY AIM AND OBJECTIVES

3.3.1 Aim:

To evaluate the post-operative radiological outcome of Weber A and B ankle fractures treated by orthopaedic registrars at Chris Hani Baragwanath Academic Hospital (CHBAH).

3.3.2 Study Primary Objective:

- To assess post-operative reduction adequacy of the ankle fractures.

3.3.3 Study Secondary Objectives:

- To assess the influence of time of the day at which the surgery is performed has an effect on the radiological outcome.
- To assess registrars' seniority effect in the post-operative radiological outcome.

3.4 Study design and sample size

This was a retrospective cross-sectional study of all ankle fractures treated with open reduction and internal fixation by registrars at CHBAH over a six-month period (01 January 2018 to 30 June 2018). Ninety-eight patients with Weber B ankle fractures were treated with open reduction and internal fixation during the study period, with 64 patients meeting the study inclusion criteria. Thirty-four patients were excluded (7 due to lack of information, 6 poor x-rays quality and the rest to other factors).

3.5 Patient Selection Criteria

3.5.1 Inclusion criteria:

- Patients with age: ≥ 18 years
- Patients with A and B ankle fractures without syndesmotic injury.
- Patients with surgical procedure performed within two weeks after injury.
- Patients with fractures due to low energy mechanisms (slipping and fall, twisting injuries
- Patients with fractures treated only by registrars.

3.5.2 Exclusion criteria:

- Patients with all B2 associated with syndesmotic injury and C.
- Patients with A and B with the posterior malleolar involvement
- Patients with fracture dislocations at presentation.
- Patients with posterior malleolus involvement.
- Patients with open fractures.
- Patients with pilon and pathological fractures.
- Patients with surgically revised fractures.
- Lack of information and poor quality x-rays.
- Patients with fracture due to high-energy mechanism (fall from height, pedestrian and motor vehicle collisions).

3.6 Data collection

Study permission received in December 2018 and ethics approval in April 2019 after which data collection commenced. The principal investigator (PI) retrieved the data of all the patients with ankle fractures treated surgically at CHBAH during the study period from the Orthopaedic department Registry. The patients' x-rays were retrieved from the Radiology Department's Online X-Ray database, which is accessible to clinicians, employed at CHBAH and were printed onto hard copies at the investigators financial costs. Pre-operative x-ray images were used to classify the fracture. However, in cases where syndesmotic injury was diagnosed intraoperatively and fixed, the post-operative x-ray images analysis further assisted to exclude such patients. The TCA and MCS parameters were measured on mortise view. The PI did these measurements on physical x-ray films using a goniometer. The x-ray films were then re-evaluated and re-measured by the independent observer (IO), Dr Kgabo (a qualified orthopaedic surgeon) with more than two years of experience. The IO was blinded on PI measurement findings.

A good radiological outcome was defined as both TCA and MCS being within the normal limits (83°+/- 4° and 2 – 4 mm, respectively) as shown below in Figure 3.1. In comparison, a poor outcome was defined as one or both of these measurements not being within normal limits". The relevant data from the Orthopaedic department registry and x-rays were extracted and transferred to the data collection sheet (see Appendix A). The PI kept the completed data collection sheets safe and subsequently the data collection sheets were transferred into an MS-Excel spreadsheet of the primary researcher's computer, which was password-coded.

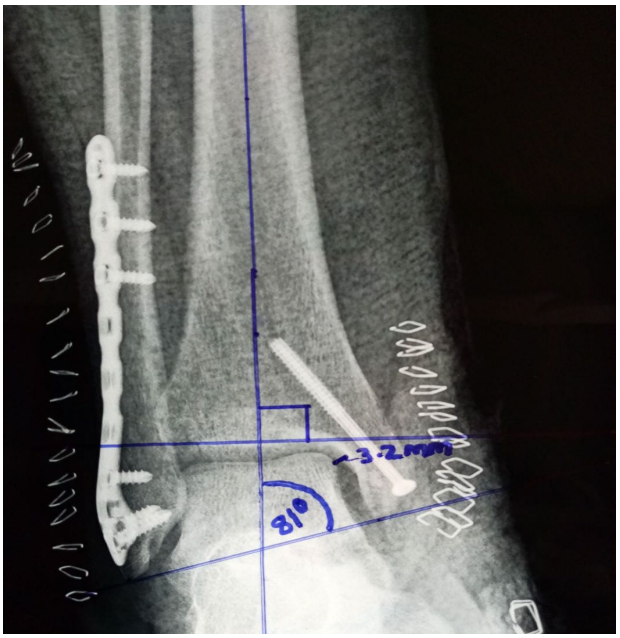

Figure 3.1: Post-operative x-rays, mortise view of Weber B2 fracture showing normal measured TCA and MCS (81º and 3.2 mm, respectively).

CHAPTER FOUR

4. RESULTS

Ninety-eight patients with Weber B ankle fractures were treated with ORIF by registrars at CHBAH during the selected study period (01 January 2018 to 30 June 2018), of which 34 patients were excluded with lack of data and poor quality x-rays accounting for 38.2% of those. Data were entered into the windows 10 MS-Excel spreadsheet and imported to the statistical software for coding and analysis. STATA version 14.0 (Stata Corp, College Station, TX) was employed for data cleaning and analysis. Descriptive statistics was used to describe patient's socio-demographics (age and gender), clinical/radiological characteristics of the patients (fracture classification, radiological outcome of operation) and registrars' characteristics (number of years in training, time of surgery). Frequency, percentage, means and standard deviation, were reported as appropriate. Chi-squared test was used to assess association between numbers of years in training of the registrars, the time of the day at which the surgery is performed and radiological outcome. Logistic regression analysis was utilised out where significant association was detected. Significance level was taken as p-value < 0.05.

4.1 Descriptive statistics – Patient characteristics

4.1.1 Age

Figure 4.1 shows the age distribution of the patients where the majority (39.1%) of the patients were aged 30 to 39 years, followed by patients aged 40 to 49 years (23.4%). Together, patients in these two age bands accounted for more than 62.5% of all study participants. Patients aged 50 years and older accounted for a quarter of participants while patients younger than 20 years were 12.5% of the total cases. The mean age of our participants was 41.3 years (standard deviation (SD) = 11.3).

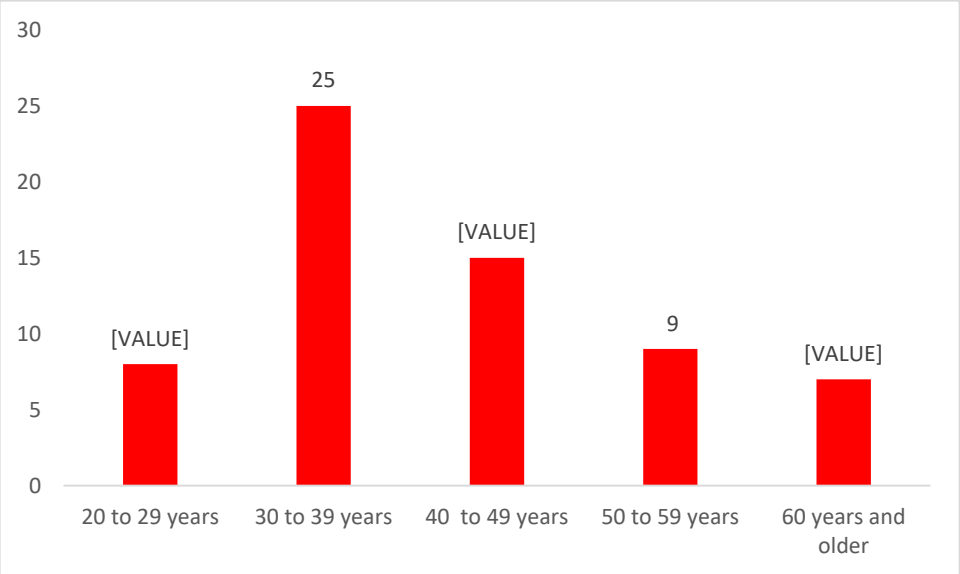

Figure 4.1: Age distribution of participants.

4.1.2 Gender

Figure 4.2 below depicts the gender distribution of the patients, females accounted for 64% and males 36% of all the patients in our study.

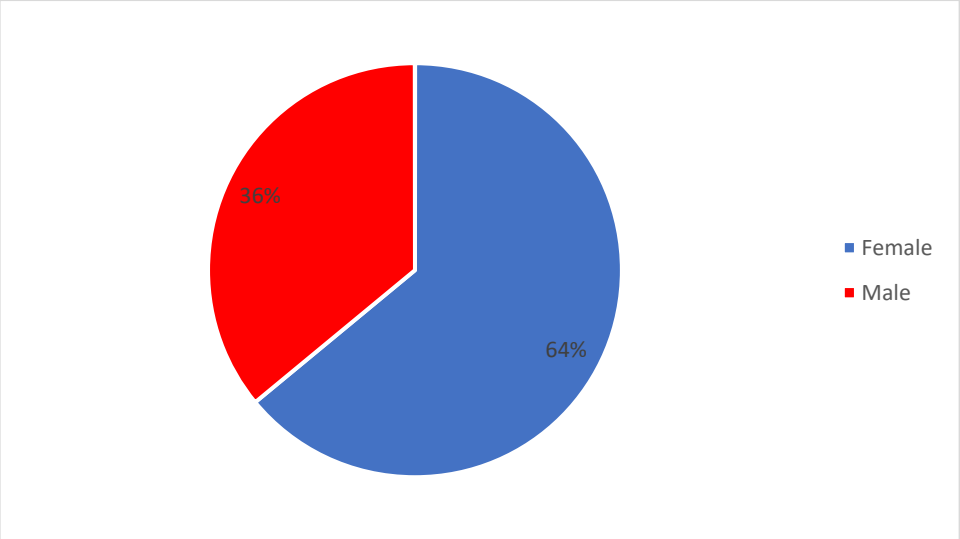

Figure 4.2: Gender distribution of participants.

4.1.3 Laterality of ankle fracture

Figure 4.3 shows the distribution of the affected ankle. In our study, 59.4% of fractures were observed to have occurred on the right ankle and the left ankle made up for the remaining fractures (40.6%).

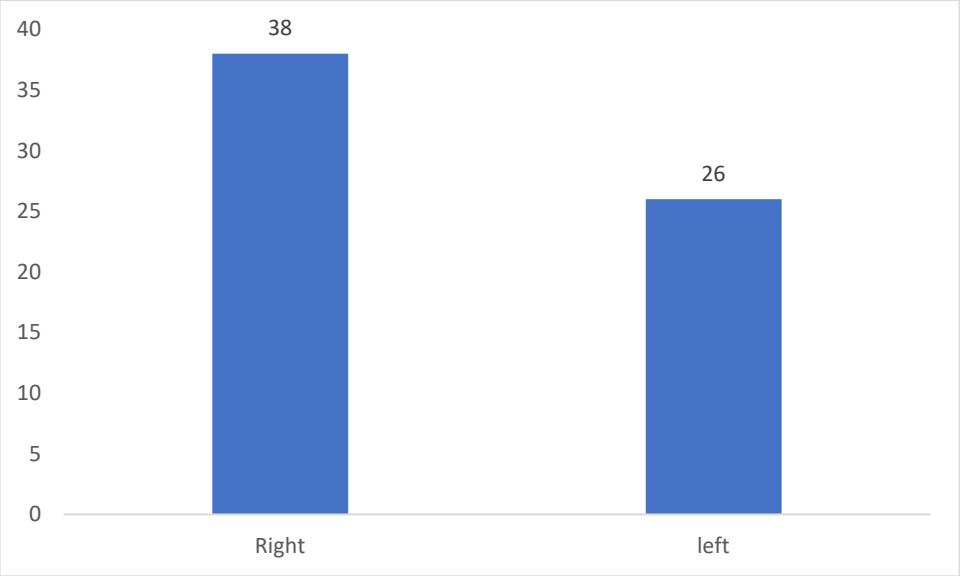

Figure 4.3: Laterality of injury.

4.1.4 Type of ankle fracture

All the ankle fractures observed among patients in our study were Weber B2 fractures. There were no Weber A and B1 fractures that were treated operatively during the study period.

4.1.5 Time of operation

As shown in Figure 4.4 below, majority (35.9%) of the operations were done between 00.00 and 06.59 hrs, followed by operations done between 16:00 and 23.59 hrs (32.8%). Operations done during work hours accounted for 31.3% of all the cases.

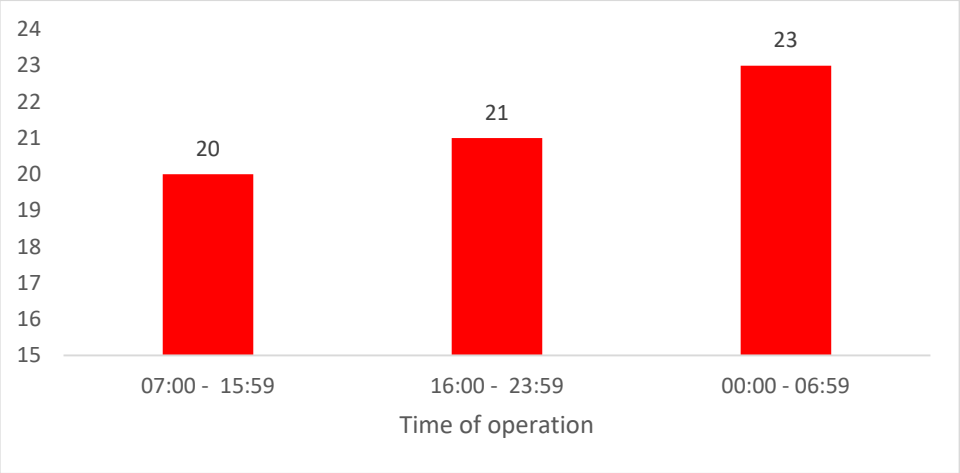

Figure 4.4: Time of operation.

4.1.6 Seniority of registrar

The seniority of the registrars was defined as doctors with two or more years of training as a postgraduate in the orthopaedic surgery department while junior was defined as doctors with less than two years of postgraduate training. More than half (52%) of the open reduction and internal fixation operations for the ankle fractures in our study were done by senior registrars. Junior registrars carried out the remaining operations (48%).

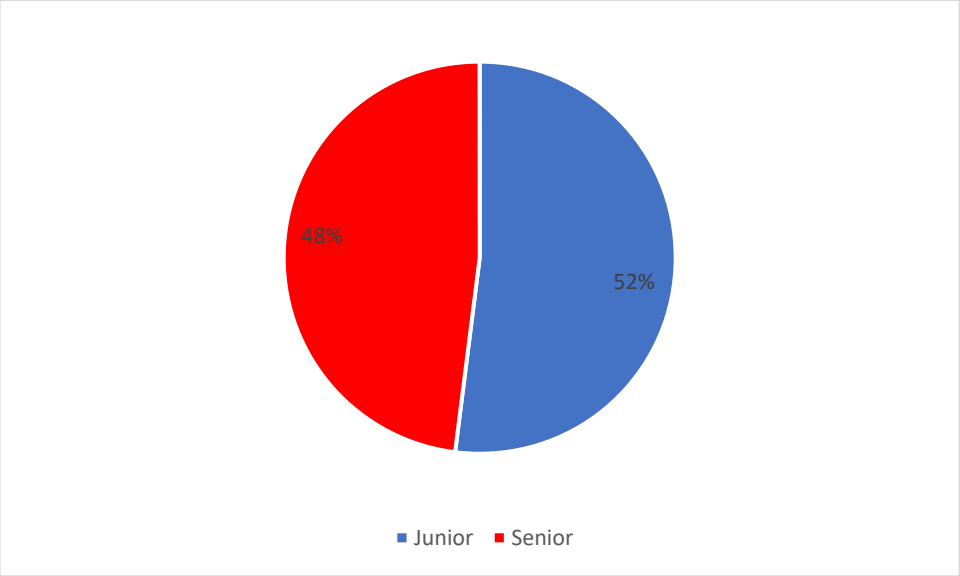

Figure 4.5: Distribution of seniority of registrars.

4.1.7 Radiological outcome of surgery

There was 100% inter-observer variability in the measurements done by PI and OI. As depicted in Figure 4.6 below, 79.7% of the operations carried out by registrars in our study had a good radiological outcome. A poor radiological outcome was observed in 20.3% of the operations.

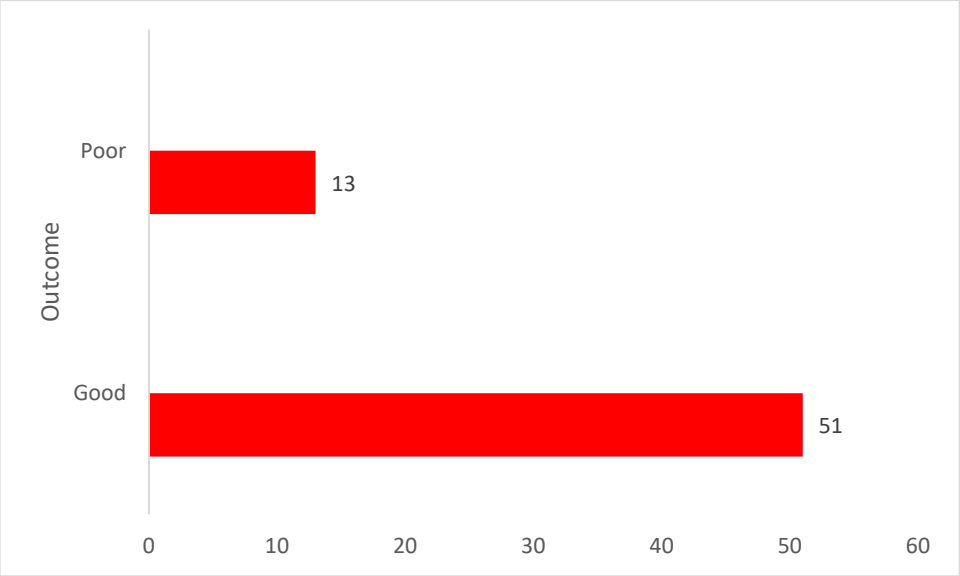

Figure 4.6: Radiological outcome of operation.

4.2 Inferential statistics

4.2.1 Association between radiological outcome of surgery and seniority of registrar/time of operation

As shown in Table 4.1 below, there was a statistically significant association between timing of surgery and radiological outcome. In contrast, the seniority of registrar did not show any significant association with radiological outcome of surgery

Table 4.1: Radiological outcome of surgery *versus* seniority of registrar/time of surgery.

	Outcome of surgery		*p*-value
	Good *n* (%)	Poor *n* (%)	
Seniority of registrar			
Junior	30 (58.82)	5 (38.46)	0.224
Senior	21 (41.18)	8 (61.54)	
Time of surgery (hrs)			
07:00 – 15:59	18 (35.29)	2 (15.38)	0.024
16:00 – 23:59	19 (37.25)	2 (15.38)	
00:00 – 06:59	14 (27.45)	9 (69.23)	

4.2.2 Association between radiological outcome of surgery and time of operation

As shown in Table 4.2 below, further analysis using logistic analysis demonstrated that surgeries done between 00:00 hrs – 06:59 hrs were 5.8 times more likely to have a poor outcome compared to surgeries done between 07:00 hrs – 15:59 hrs (OR 5.8, 95% CI

1.07 – 31.2, p = 0.041). Surgeries done between 16:00 am and 23:59 pm did not show any significant association with radiological outcome.

Table 4.2: Logistic regression analysis.

	Odds Ratio	***P*-value**	**95% Confidence Interval**
Time of surgery (hrs)			
07:00 – 15:59	1	-	-
16:00 – 23:59	0.9	0.959	0.12 – 7.5
00:00 – 06:59	5.8	0.041	1.07 – 31.2

CHAPTER FIVE

5. DISCUSSION

5.1 Socio-demographic characteristics

The sociodemographic characteristics are discussed below under the following sub-headings: age and gender.

5.1.1 Age

The age range of the participants was 20 to 70 years with a mean age of 41.3 years and the commonest age group being 30 – 39 years. Disaggregated by gender, the mean age among male and females were 41.0 and 41.7 years, respectively. The mean age of participants in this study similar to the Australian study (39 years)[33] and Indian study (37.8 years)[29] but lower to the findings of two studies conducted in Netherlands[9,10]. All these studies investigated surgically treated ankle fractures. In addition, the most common age group in this study was older than that reported in the Indian study[29]. The disparity in the mean age observed in this study when compared to other studies may be because of the small sample size and the relatively narrow age range 20 – 67 years. However, as the population is aging, the number of elderly patients sustaining ankle injuries requiring surgery is expected to rise.

5.1.2 Gender

Literature shows that gender differences in ankle fracture were attributed to the mechanism of injury. Where male predominance was reported, it was due to injuries resulting from motor vehicle accidents, working in factories and outfield[13,27]. In this study, there was a preponderance of female similar to findings by Ovaska et *al.*[11]. The commonest injury mechanism in this study was a fall due to slipping and twisting.

5.2 Predictors of outcome

5.2.1 Registrars' seniority

Our study demonstrates that seniority of registrar is not related to the post-operative radiological outcome of ankle fractures. This finding is consistent with both studies by Gross *et al.* and Pugely *et al.*, which investigated association between resident involvement in ankle surgery and postoperative morbidity and mortality[34,35]. The researchers demonstrated that the level of seniority of residents did not affect the outcome of the surgery. Furthermore, involvement of residents in ankle operations was not associated with greater morbidity or mortality[34,35].

This is in contrast to the USA study by Halvachizadeh *et al.,* which reviewed 66 817 cases done over a seven-year period across six orthopaedic procedural domains with or without registrars' involvement. There was an increased morbidity rate; higher re-operation rate and longer hospital stay in surgical procedures, which involved registrars[36].

This study differs from our study in that it does not specifically investigates ankle operations and the details of the 8221 lower extremity trauma cases were not provided by the researchers. Therefore, caution should be exercised in generalising and applying these findings in the South African context.

Moreover, there was no evidence that level of seniority of the registrars played any consistent role in the outcome of procedures carried out by registrars. Striking a balance between clinical exposure or training and workload is important. The survey conducted among faculty and residents in a tertiary academic hospital in California (USA), reported that the residency programmes were not negatively affected by the limits residents hours of work to 80 hours per week[37].

5.2.2 Timing of surgery

This study observed poor radiological outcome in ankle surgery performed between midnight and 07:00 hrs compared to surgery performed during normal working hours (07:00 – 15:59 hrs). Possible contributing factors include surgeon fatigue and sleep deprivation, which is an area for further investigation. Our findings correlate with other studies. Halvachizadeh *et al*., reported from their prospective study a higher complication and mortality rates for orthopaedic trauma surgery cases performed after hours compared to surgery performed in the morning[38].

Similarly, a retrospective study, which investigated the association between surgical start time and mortality for non-urgent surgical procedures, observed a higher risk of morbidity in surgeries starting between 16:00 and 18:00 hrs compared to those starting

between 07:00 and 16:00 hrs[30]. In contrast to the study by Mittal *et al,* which compared the outcomes of trauma surgery performed by surgery residents during daytime *versus* evening hours (those performed beyond 16:00 hrs), found no difference between the two groups. The researchers concluded that the timing of surgery is not a predictor of morbidity[33].

5.2.3 Other predictors of outcome

Literature confirms that insulin-dependent diabetes, Body mass index (BMI), advanced age, fibular displacement, higher American Society of Anaesthesiologists Score, and longer operative times are predictors of clinical outcome of ankle surgery[9,24,34]. However, these factors did not fall within the objectives of the index study. Therefore, they were not investigated.

5.3 LIMITATIONS

- There were no patients with Weber A and B1 fracture in this surgically treated cohort, even though this was part of inclusion criteria. This was due resources constrains in our hospital such as a lack of theatre time, hence many of these cases are often offered the non-operative treatment since they are more stable than Weber B2 fractures.
- The sample size of this study is small, which limits the sub-analysis and the power of the study. Therefore, the results should be interpreted with caution.
- Lack of clinical data in 7 and poor quality x-rays in 6 patients led to the exclusion of potential study participants.

CHAPTER SIX

6. CONCLUSION

This study found that the ankle fractures treated by registrars at CHBAH had good postoperative radiological outcome (79.7%) with only 20.3% noted to have poor outcome. However, the seniority of the operating registrars did not show any effect in the outcome. Contrary, the time of the day at which surgeries were performed, was found to be an important factor in the outcome; surgical procedures that were done between 00:00 and 06:59 hrs were 5.8 times more likely to have a poor radiological outcome when compared to those who were done between 07:00 and 23:59 hrs.

6.1 RECOMMENDATIONS

- Adjustment of the current 24-hour shift system, in order to avoid the poor patient outcomes which could be possibly due to tiredness, fatigue and poor level of concentration.
- Limit the work hours of orthopaedic residents to a maximum of 80 hours per week including night duty calls, as the evidence from literature suggests this is optimal for training, education, and exposure[37].
- Careful selection of surgical procedures to be performed in the early hours of the morning to minimise the poor outcome as observed in our study.
- Allow registrars enough rest during the night shift duties to avoid mental and physical exhaustion

- Further research is needed for ankle fractures due to assault. We are not aware of any study on this at present. We have observed a high incidence of ankle fractures due to this mechanism in clinical practice. This may be due to increasing violent behaviour in the community.

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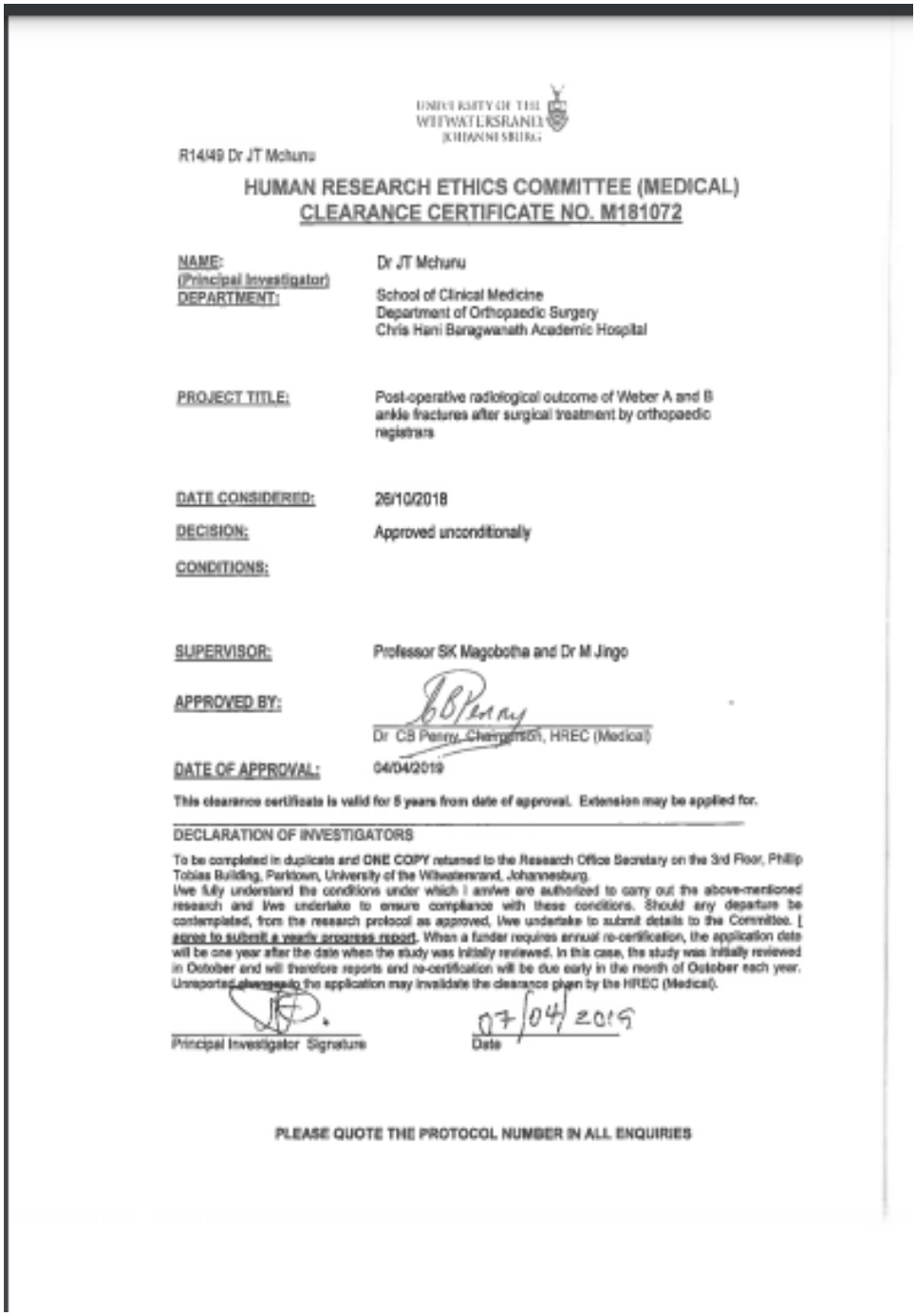
APPENDICES

Appendix A: Data collection sheet

PATIENT STUDY CODE		CHBAH ANK01
DEMOGRAPHICS	Age	
	Gender	
FRACTURE CLASSIFICATION	Weber A1	
	Weber A2	
	Weber B1	
	Weber B2	
	Weber C1	
	Weber C2	
	Weber C3	
X-RAY MEASUREMENTS IN MORTISE VIEW	TCA	
	MCS	
SURGERY TIME	07h00 -15h59	
	16h00 - 23h59	
	00h00 - 6h59	
NUMBER OF YEARS IN TRAINING OF THE REGISTRAR WHO PERFORMED THE SURGERY		

Appendix B: HUMAN RESEARCH ETHICS CLEARANCE



UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Dr JT Mchunu

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M181072

NAME: (Principal Investigator)	Dr JT Mchunu
DEPARTMENT:	School of Clinical Medicine Department of Orthopaedic Surgery Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	Post-operative radiological outcome of Weber A and B ankle fractures after surgical treatment by orthopaedic registrars
DATE CONSIDERED:	26/10/2018
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Professor SK Magobotha and Dr M Jingo
APPROVED BY:	Dr CB Perry, Chairperson, HREC (Medical)
DATE OF APPROVAL:	04/04/2019

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 Research Office Secretary on the 3rd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

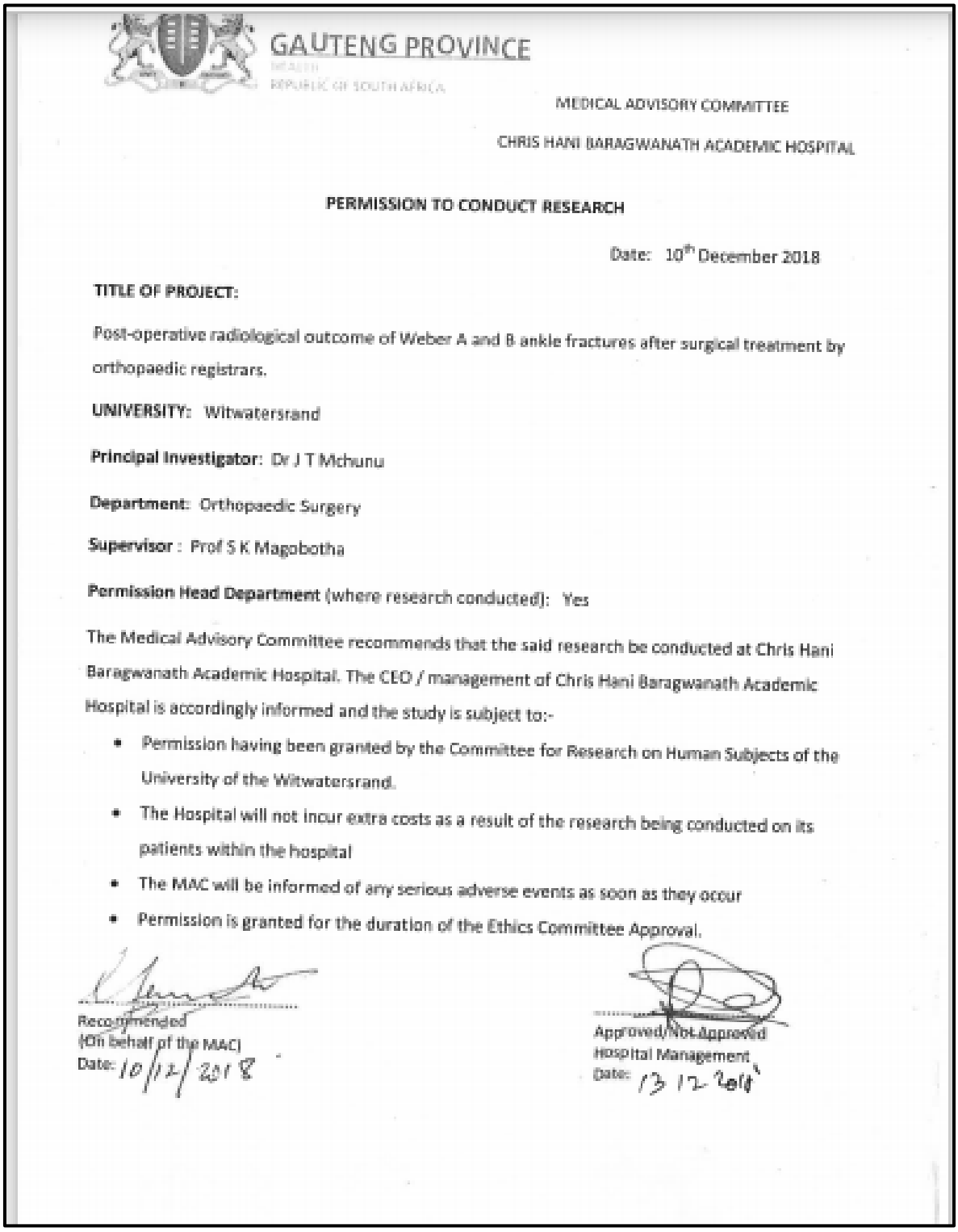
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. I agree to submit a yearly progress report. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in October and will therefore reports and re-certification will be due early in the month of October each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

07/04/2019
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: CHBAH Permission Letter



GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 10th December 2018

TITLE OF PROJECT:

Post-operative radiological outcome of Weber A and B ankle fractures after surgical treatment by orthopaedic registrars.

UNIVERSITY: Witwatersrand

Principal Investigator: Dr J T Mchunu

Department: Orthopaedic Surgery

Supervisor : Prof S K Magobotha

Permission Head Department (where research conducted): Yes

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Academic Hospital. The CEO / management of Chris Hani Baragwanath Academic Hospital is accordingly informed and the study is subject to:-

- Permission having been granted by the Committee for Research on Human Subjects of the University of the Witwatersrand.
- The Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- The MAC will be informed of any serious adverse events as soon as they occur
- Permission is granted for the duration of the Ethics Committee Approval.

Recommended
(On behalf of the MAC)
Date: 10/12/2018

Approved/Not Approved
Hospital Management
Date: 13 12 2018