Identifying a specific fracture pattern on x-ray film in adult patients with fragility fractures of the ankle seen at Chris Hani Baragwanath Academic Hospital

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand in Johannesburg, as part of the requirements for the Master of Medicine degree.

Johannesburg, 2025

Declaration

I, Ntswe Geelbooi Mofokeng declare that this report is my own, unaided work. It is being submitted for the Master of Medicine degree in the branch of orthopedic surgery at the University of the Witwatersrand Johannesburg. It has not been submitted for a degree or examination at any other university.

ntswe mofokeng

(Signature of candidate)

30 day of September 2025 in Johannesburg

To God

be the Glory.

To my sons

Teboho, Onalenna and Tsebo

In Memory of my father

Teboho Mofokeng

1939 - 2022

Abstract

Purpose: The study aimed to identify a specific fracture pattern on x-ray film that characterises bone fragility of ankle fractures in adult patients seen at Chris Hani Baragwanath Academic Hospital from 01 January 2022 to 31 December 2024.

Method: Data was collected from 276 adult patients seen at Chris Hani Baragwanath Academic Hospital with ankle fractures from 01 January 2022 to 31 December 2024. The population age range was from 18 years old and above. Patient information and x-ray findings were recorded on a data collection sheet (Appendix A).

Results: A total of 276 observations were recorded, comprising 137 females (49.6%) and 139 males (50.4%). The largest age group represented was 29 − 39 years, with 105 individuals (38.0%). The Danis-Weber (D-W) B2 ankle fracture was the predominant type, accounting for 173 cases (62.7%), and also noted as a prevalent pattern statistically. Additionally, fragility fractures were observed in 66.7% of the participants, with a higher prevalence among females (76.64%) compared to males (53.83%). Out of the participants, 182 reported alcohol use (65.9%), while 82 were smokers (29.7%). The body mass index and age were found to be moderately and marginally significant risk factors, respectively.

Conclusion: The results of this study differ slightly from international studies, given the limitations and population age group. The predominance of D-W B2 fractures suggests fragility, particularly when associated with comminution and a history of a simple twist or fall. A more thorough assessment using objective measures, such as CT scans, DXA scans, or evaluations of cortical thickness, alongside X-ray films, could provide more specific insights into the fracture patterns. It is also essential to conduct individualised risk assessments for both males and females across various age groups while implementing strategies to minimise recall bias and social desirability bias.

Acknowledgements

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Nomenclature

BMD	Bone Mineral Density
BMI	Body Mass Index
CHBAH	Chris Hani Baragwanath Academic Hospital
CI	Confidence Interval
CT	Computerised Tomography
DVT	Deep Vein Thrombosis
D-W	Danis-Weber
DXA	Dual-energy x-ray absorptiometry
FRAX	Fracture Risk assessment Tool
NOF	National Osteoporosis Foundation
UTI	Urinary tract infection
WHO	World Health Organisation

CHAPTER 1

1. INTRODUCTION AND LITERATURE REVIEW

1.1 Contextual Overview and Research Synthesis

Ankle fractures are a common and significant injury that can affect individuals of all ages, although certain factors may increase the risk. High-impact sports or activities, a history of previous ankle fractures, osteoporosis (a condition characterised by weakened bones), and accidents or trauma such as falls, or twists are among the risk factors. Both young and old still pose a unique challenge in appropriately managing these injuries. Comorbidities in elderly patients, especially those with poorly controlled diabetes, predispose them to higher complication rates. Ankle fractures are quite prevalent, with millions of cases reported worldwide each year. Additionally, they are estimated to affect 150 out of 100,000 people each year. According to studies, the incidence was 57 per 100,000 in 1970, and by 2030, it is predicted to rise to about 270 per 100,000. Therefore, the incidence is expected to increase by approximately 373.68% over 60 years. [1]

Ankle fractures can be devastating and negatively affect mobility and overall health quality. Unrelenting pain, swelling, instability, and difficulty walking or performing daily activities together with arthritis are some of the adverse events. Literature is scarce on ankle fractures and associated emerging variables, particularly in terms of the differences between elderly males and females and in those over 80. There was insufficient data to identify the optimal course of treatment for ankle fractures in both genders over 80, according to a recent systematic analysis by van Halsema et al. [2]

Fragility fractures, defined as fractures resulting from low-energy trauma such as a fall from standing height or less that would not normally cause a fracture in healthy bones, pose significant public health concerns in affluent nations with aging populations. In their three-year study of the hospitalisation rate for fragility fractures in ten major emergency departments in Italy, Tarantino et al. concluded that the burden is extremely high and that effective prophylactic measures are necessary. Over three years, they recorded 29,017

fractures, with hospitalisation rates for ankle fractures of 31.3%. Between 2004 and 2006, they calculated an annual incidence of 36,000 in those 45 years of age or older. [3-4]

Due to its asymptomatic nature, osteoporosis typically remains undiagnosed until fragility fractures occur, which indicates that the condition has already progressed to an advanced stage. Research has shown that by the time fractures happen, about 50% of normal bone density may have already been compromised. Early identification of fragility or osteoporosis enables individuals to take preventive measures against further bone loss and fractures. Lifestyle changes, early treatment strategies, regular monitoring through bone density scans, education and awareness are added advantages. [5-6]

The ankle is the third most prevalent site of fragility fractures in the elderly, behind wrist and hip fractures. Because osteoporosis is more common and life expectancy and even obesity is rising, there are more of these fractures. Unlike Colles' fracture in the wrist, there is limited literature on a specific type of ankle fracture that reflects the fragile nature of the bone. Controversy remains regarding the optimal treatment of elderly individuals with associated osteoporosis, hence, knowledge of different fixation methods, fixation devices, and patient selection should help improve outcomes. [7]

Willet, Hearn, and Cuncins observed that these injuries often went on to lose reduction and drift into valgus malalignment and end up with malalignment or malunion. Buckingham, Hepple, and Winson also observed that those managed non-operatively were more likely to develop complications from prolonged immobilisation, especially pressure sores, deep vein thrombosis (DVT), pneumonia, and urinary tract infection (UTI). [8] Studies have also shown that fractures of the foot and ankle are also twice as likely to experience subsequent skeletal fractures elsewhere. This confirms that all fragility fractures should be regarded as an indication for an evolving disease. [9]

In an attempt to reduce fracture risk, clinician's knowledge and understanding on mechanisms that underline the higher incidence of fractures with increasing age are essential, over and above other bone pathology that leads to compromised bone stock. Research has also shown that a number of other factors besides bone mineral density influences bone strength. This brings to the picture other factors such as size, shape and microarchitecture of bone among others as equally important in the understanding of the concept fragility. Grasping the notion of bone quality presents a complex

phenomenon that involves an interplay between development and or remodelling and all other factors that leads to decreased strength, resistance to failure and load bearing capacity. Bone remodelling is also a coordinated process that seeks to achieve skeletal homeostasis such that any disturbances from either local or systemic factors could result in an exaggerated or an inhibition in the process which will weakens the skeleton. [10-11]

Having a well-organised set of instructions is crucial in addressing the widespread lack of secondary fracture prevention care. It ensures that individuals who are prone to fragility fractures undergo proper evaluation and intervention to reduce the risk of future fractures. The International Osteoporosis Foundation has endorsed the establishment of a Fracture Liaison Service (FLS) and created Capture the Fracture, which has proven to be a vital factor in enhancing patient care and decreasing escalating global costs associated with fracture treatment. Likewise, a low threshold for pharmacologic treatment guideline would be an added benefit in the challenging dilemma for future fragility fracture prevention. [12]

1.2 Danis-Weber Classification

The primary focus is the structural soundness of the syndesmosis that joins the ankle mortise. The broken fibula line in relation to the syndesmosis can be divided into three groups. Danis-Weber A is an infrasyndesmotic disease that manifests itself in two stages, i.e. stages 1 and 2. Stage 1 is an avulsion of the lateral malleolus beneath the syndesmosis whereas stage 2 invoves an oblique fracture of the medial malleolus in addition to the lateral malleolus fracture.

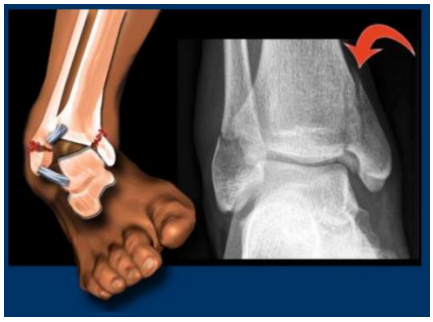

Figure 1.1: Depicting a medial malleolar fracture that may or not be coupled with a lateral malleolus fracture distal to the syndesmosis. [13]

Danis-Weber B trans syndesmotic fracture causes the syndesmosis to rupture partially, and less frequently completely. Stages 1 to 4 include: avulsion of the medial malleolus, anterior syndesmosis rupture, oblique fibular fracture, posterior syndesmosis rupture or posterior malleolus fracture (see Figure 1.2). The subtypes are B1, which involves no medial tissues, B2, which involves a fracture of the medial malleolus or only the deltoid ligament damage, and B3, which involves a posterior malleolus fracture. [14]

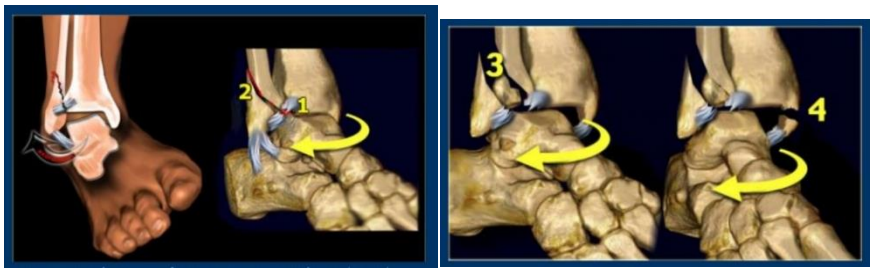

Figure 1.2: Showing bone damage caused by a rotating force, trans syndesmotic fracture of lateral malleolus, and a ruptured syndesmotic ligament. [14]

The oblique or vertical fracture of the fibular results from a push-off mechanism during external rotation force. Danis-Weber C, which is suprasyndesmotic, has a full syndesmosis rupture and ankle instability (induced by external rotation force while the foot is in a prone posture). Avulsion of the medial malleolus or ligament rupture, anterior syndesmosis rupture, fibula fracture above the level of the syndesmosis, and avulsion of the posterior syndesmosis are also stages 1 to 4 of Danis-Weber C type. Figure 1.3 shows an eversion injury with avulsed medial malleolus, force transmitted *via* the syndesmosis, rupture of the interosseous membrane, and a suprasyndesmotic lateral malleolus fracture. [15]

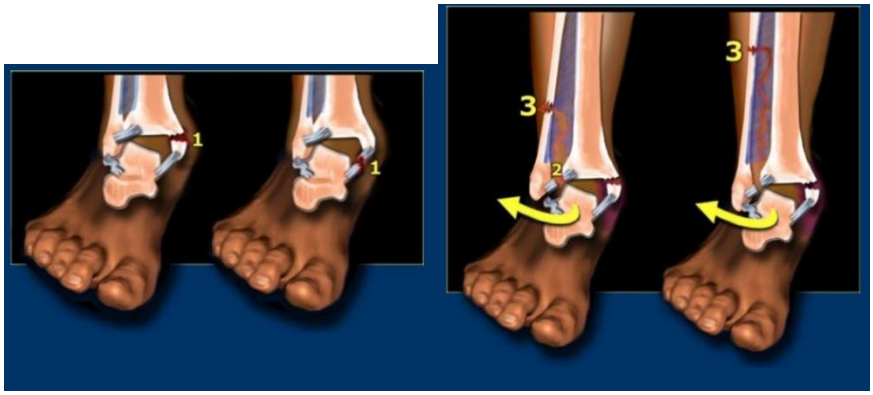

Figure 1.3: Illustration of an eversion injury with avulsed medial malleolus, force transmitted *via* the syndesmosis, rupture of the interosseous membrane, and a supra syndesmotic lateral malleolus fracture. [14-15]

Lauge-Hansen Classification

This system uses bi-word descriptors in classifying ankle fractures. The initial word characterizes the foot's position during the injury, indicating either pronation or supination. The subsequent word denotes the direction of the deforming force, which can be abduction, adduction, or external rotation. The Lauge-Hansen classification of ankle fractures is categorised into four types as outlined subsequently: [16]

- Supination-adduction,
- Supination-external rotation,
- Pronation-external rotation and
- Pronation-abduction.

Supination-adduction leads to a vertically oriented fracture medially along with damage to either talus or tibial plafond. The inward talus shifts potentially causing compression on the antero-medial plafond and a resultant transverse fracture of the fibular.

Supination-external rotation being the most common injury, the fracture starts antero-inferior on the fibular to postero-superior. This injury type has four stages , from injury to the anterior tibiofibular ligament to the fibular itself going superior to the posterior tibiofibular ligament to end on the medial aspect with medial malleolus fracture or deltoid ligament injury.

Pronation-external rotation is the equivalent of Weber C ankle injury with fracture line from antero-superior to postero-inferior and usually above the joint line. Pronation-external rotation also has four stages but starting medially to end on the lateral aspect.

Pronation-abduction usually results in a transverse or comminuted fibular fracture. However, on x-ray films, there may be only syndesmosis injury without a fibular fracture. Sequentially starts on the medial aspect and may progress to damage the medial collateral ligament, syndesmosis and lateral structures lastly. [16-18]

In addition to the fracture patterns described, several eponyms or fragments related to the distal tibia may be associated with ankle fractures. Commonly encountered eponyms or fragments and their anatomical characteristics and patterns are:

- Pilon fracture refers to a fracture of the distal tibia involving the articular surface. It is typically caused by high-energy trauma, such as a fall from a significant height or a motor vehicle accident.
- Volkmann's fragment is a bony avulsion of the posterior aspect of the distal tibia. It is often seen in association with Pilon fractures.
- Wagstaffe-Le Fort involves avulsion of the anterolateral corner of the distal tibia. It typically occurs due to an external rotation force applied to the ankle joint.
- Chaput fragment is an avulsion fracture of the anterolateral distal tibia caused by the attachment of the anterior inferior tibiofibular ligament. It is commonly associated with Maisonneuve fractures.
- The Volkmann triangle is a fragment of the posterior malleolus that is separated from the main tibial fragment. It occurs due to avulsion of the posterior tibiofibular ligament. [19-24]

1.3 Risk Evaluation

Risk assessment is aimed at identifying those individuals with an increased probability for a fracture and to overcome anticipated fracture in the event that an insult has occurred already. Women who reached menopause appears to be more likely to be affected by osteoporosis and thus should raise the level of suspicion on assessment. Given the fact that osteoporosis is considered a silent disease and since a percentage of vertebral fractures are said to be asymptomatic, a low threshold is essentially needed in assessing the risk. [25-27]

Loss of bone mass results from alcohol's stimulation of bone resorption. Long-term use can cause several undesirable side effects, such as hormonal imbalances and a drop in oestrogen and testosterone levels, which are critical for bone health. Malnutrition, including insufficiencies in calcium, vitamin D, and other vital minerals for bone health, can result from alcohol consumption. Smoking can hinder bone growth and repair, resulting in a loss of bone mass, and is also associated with decreased bone density, especially in the hip and spine. In addition to smoking, excessive alcohol consumption was linked to an increased risk of osteoporosis, according to Osteoporosis International's 2019 Meta-Analysis. [28-31]

There is an array of local and systemic factors that independently contributes to the likelihood for a high occurrence rate of fragility fractures in addition to decreased Bone

Mineral Density (BMD). An understanding of these factors and their role in bone turnover should help clinicians to critically look at other factors and signs suggestive of an impending fragility fracture. [32-34]

1.4 Bone Quality – BMD

The quality of bone is determined by a well-coordinated balance between bone resorption and remodelling processes. There are few parameters and methods which could be employed in an evaluation for a possible fracture , among others, a radiological imaging scan report (Dual Energy X-ray Absorptiometry (DXA)), quantitative CT scans, risk evaluation, bone resorption to remodelling process or ratio and molecular patterns to name a few, with bone mineral density being the mostly used parameter. The bone mineral density can be interpreted in terms of either the T or Z-scores depending on whether a reference value is for a young normal individual or an individual of the same sex and age, respectively. The likelihood of fracture occurrence is doubled with T-scores ranges from -2.5 or less, as per World Health Organisation (WHO). Therefore, decreased BMD continues to be a reliable indicator of the likelihood of experiencing fractures in future. [35-36]

1.5 WHO - FRAX model

The Fracture Risk Assessment (FRAX) tool came into being based on studies that were conducted to eliminate the clinical risk factors for osteoporosis. FRAX determines the likelihood of experiencing a fracture within a 10-year timeframe looking at: patient demographics, BMI (Body Mass Index), previous experience of a minor trauma injury, medications, comorbidities and underlying factors contributing to osteoporosis. [37]

Fracture Risk Assessment is contraindicated in individuals who are already on medical treatment for osteoporosis. The NOF (National Osteoporosis Foundation) advises utilizing FRAX as a means to assess fracture risk in patients with T-scores ranging from -1.0 to -2.5 on the lumbar spine, the hip, or total hip procedures. This tool is useful for risk assessment in areas with known fractures and mortality incidences. It is thus crucial that its validity and use is explored in our clinical setting. This particular study will be groundbreaking in our clinical environment, as it will be the first of its kind to add valuable insights to the existing knowledge on this topic in South Africa. [38-39]

1.6 Study Aim and Objectives

1.6.1 Study Aim

To identify a specific fracture pattern on x-ray film that characterises bone fragility of ankle fractures in adult patients seen at Chris Hani Baragwanath Academic Hospital from 01 January 2022 to 31 December 2024.

1.6.2 Objectives

i. The primary objective is to identify a specific fracture pattern of fragility fractures on selected patients.
ii. Secondary objectives are to determine the prevalence of fragility fractures among patients with ankle fractures, to compare clinical characteristics of fragility versus non-fragility fractures as well as to determine the potential risk factors for fragility fractures.

CHAPTER 2 - METHODOLOGY

2.1 Research question

Is there a relationship between a specific fracture pattern on x-ray films of fractures of the ankle and bone fragility?

2.2 Research design

This is a prospective observational cross-sectional study of adult patients with ankle fractures seen at CHBAH.

2.3 Data collection

All registrars, medical officers and consultants in the orthopaedic department at CHBAH were responsible for identifying patients with ankle fractures. Data were collected and recorded on the collection sheet by the principal researcher (Dr Mofokeng). The study included 276 patients who presented with ankle fractures at CHBAH, either through the casualty or outpatient departments. Their X-ray films were reviewed by the principal researcher in consultation with orthopedic trauma specialists, and relevant medical history was systematically documented using a data collection sheet (Appendix A). Before recruitment into the study, the patients gave consent to participate (Appendices B and C). Age, gender, mechanism of injury, body mass index, habits (smoking and alcohol use), and Danis-Weber ankle fracture classification were recorded on the data collection sheet. Our study obtained WITS Human Research Ethics Committee clearance and Hospital Chief Executive Officer permission prior to any data collection (Appendices D – F).

2.4 Selection Criteria

2.4.1 Inclusion criterion:

All adult patients from the age of 18 years with ankle fractures regardless of the mechanism of injury were included in the study.

2.4.2 Exclusion criterion:

All patients who could not give a proper account of how the injury happened and all distal tibia fractures that extend into the ankle joint (difficult to classify as ankle fractures and will need more classification systems other than the Danis-Weber).

2.4.3 Fragility Fracture Diagnostic Criteria

- Occurrence of a fracture resulting from low-energy trauma, such as a fall from standing height or less, or minor mechanical forces that would not normally cause fractures in healthy bones.
- Common fracture sites include the proximal femur (hip), vertebrae, ankle, distal radius (wrist), pelvis, and proximal humerus.
- Evidence or history of underlying bone weakness or osteoporosis, which may be confirmed through bone mineral density (BMD) testing (typically a T-score ≤ -2.5 on DXA scan), although fragility fractures may also occur in patients without this threshold.
- Clinical evaluation including patient history of previous fragility fractures, risk factors such as age, comorbidities, medication use, and lifestyle factors.
- Diagnostic imaging such as X-rays to confirm fracture presence and assess typical patterns seen in fragility fractures. Advanced imaging (CT or MRI) may be indicated if initial evaluation is inconclusive.

  For the purpose of this study, confirmatory modalities or advanced imaging such as DXA, CT or MRI scans will not be used.

High energy trauma injuries typically result from more severe forces, such as high-speed motor vehicle accidents, falls from significant heights or high velocity sports impacts.

2.4.4 Body Mass Index (an estimation of body fat using a person's weight and height)

BMI Table

Underweight (< 18.5)

Normal weight (18.5 – 24.9)

Overweight (25.0 – 29.9)

Obese (30.0 – 39.0)

Morbidly obese (> 40.0).

For the purpose of this study, the descriptions of Low (underweight), Normal, and High (Overweight, Obese, and Morbidly obese) will be used.

CHAPTER 3

RESULTS

A Microsoft Excel sheet containing data was imported to STATA-SE® version 15.1 for data cleaning and analysis. Continuous variables (age and weight) in the study were converted to categorical variables. Age was divided into 5 categories of 10-year-old age groups (18-28; 29-39; 40-49; 50-59; 60+). Categorical variables, such as Classification codes were combined to create sufficient observations with sub-categorical groups.

The final analysis was done on STATA-SE® version 15.1. Frequencies and percentages were used to summarise categorical variables in the study. Pearson's chi-square was used to test for statistical association between categorical variables at a significance level of 5%. To assess the relationship between the outcome variable "fragility fracture" and the potential risk factors, a linear regression analysis was used. In the bivariate analysis, a simple linear regression assessed if there was a statistically significant association between fragility fracture and potential risk factors. Factors that were found to be significant at a 5% level (95% confidence interval (CI) were used in the multivariable analysis). Those that were found to remain significant ($p < 0.05$) were retained in the final model. The results are presented as coefficient (β), at a 95% CI.

3.1 Demographics and clinical data of the study participants

Table 3.1 outlines the key characteristics of the study participants. There were 276 observations, with 137 (49.6%) being female and 139 (50.4%) males. The majority of the population was in the age group 29 − 39 years (n = 105; 38.0%). About 182 patients in the study used alcohol (65.9%) and 82 smoked (29.7%). Low-energy trauma accounted for a majority of cases (184) with 92 cases of high-energy trauma injuries. A fairly equal distribution was observed across the sites of injury, with the majority of patients (65%) having a high body mass index (25.0 and above), while 46% had other medical comorbidities.

Table 3.1: Showing Demographics and clinical data of the study participants

Variable	**Characteristic**	**Total (*n*; %)**
Sex	Female	137 (49.6)
	Male	139 (50.4)
Age (years)		
	18-28	29 (10.5)
	29-39	105 (38.0)
	40-49	59 (21.4)
	50-59	54 (19.6)
	60+	29 (10.5)
Lifestyle Factors		
Alcohol use	Yes	182 (65.9)
	No	94 (34.1)
Smoking	Yes	82 (29.7)
	No	194 (70.3)
BMI	Low (< 18.0)	4 (1.5)
	Normal (18.0 - 24.9)	91 (33.0)
	High (25.0 and above)	181 (65.5)
Clinical Characteristics		
MOI	Low energy trauma	184 (66.7)
	High energy trauma	92 (33.3)
ClassID	B1	5 (1.8)
	B2	173 (62.7)
	B3	52 (18.8)
	C1	24 (8.7)
	C2	21 (7.6)
	C3	1 (0.4)
Site	Left foot	139 (50.4)
	Right foot	137 (49.6)
Comorbidities	Yes	127 (46.0)
	No	149 (54.0)

3.1.1 Breakdown of ankle fracture classification by age and gender

Table 3.2 shows that the male-to-female distribution of the Danis-Weber classification is equal, with more B2 and fewer C1, C2 ankle fractures in patients over 40 years old.

Table 3.2: Gender and age group classification breakdown

Danis-Weber Cl	Males *n*	Percentage %	Females *n*	Percentage %	Age < 40 *n*	Age > 40 *n*
A	-	-	-	-	-	-
B1	2	1.4%	3	2.2%	4	1
2	88	63.3%	85	62%	72	101
3	19	14%	33	24.1%	25	27
C1	17	12%	7	5.1%	17	7
2	12	8.6%	9	6.6%	15	6
3	1	0.7%	0	-	1	0
TOTAL	139		137		134	142

Danis-Weber B2 fractures were primarily observed in individuals aged 40 years and older (n = 101), as shown in **Figure 3.1**, compared to those aged 40 years and younger (n = 73) in **Figure 3.2**. In contrast, Danis-Weber C fractures occurred equally in both age groups.

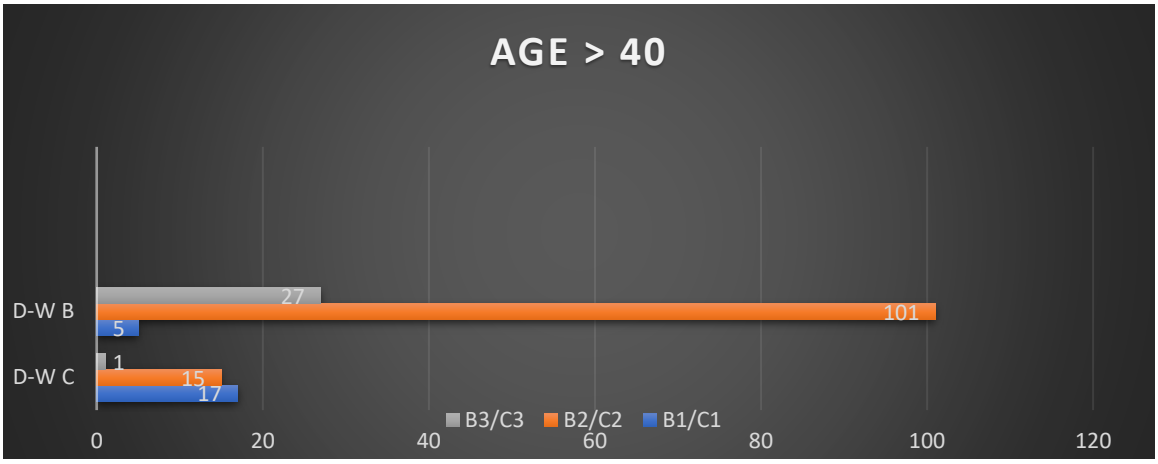

Figure 3.1: Danis-Weber classification in > 40 years age group

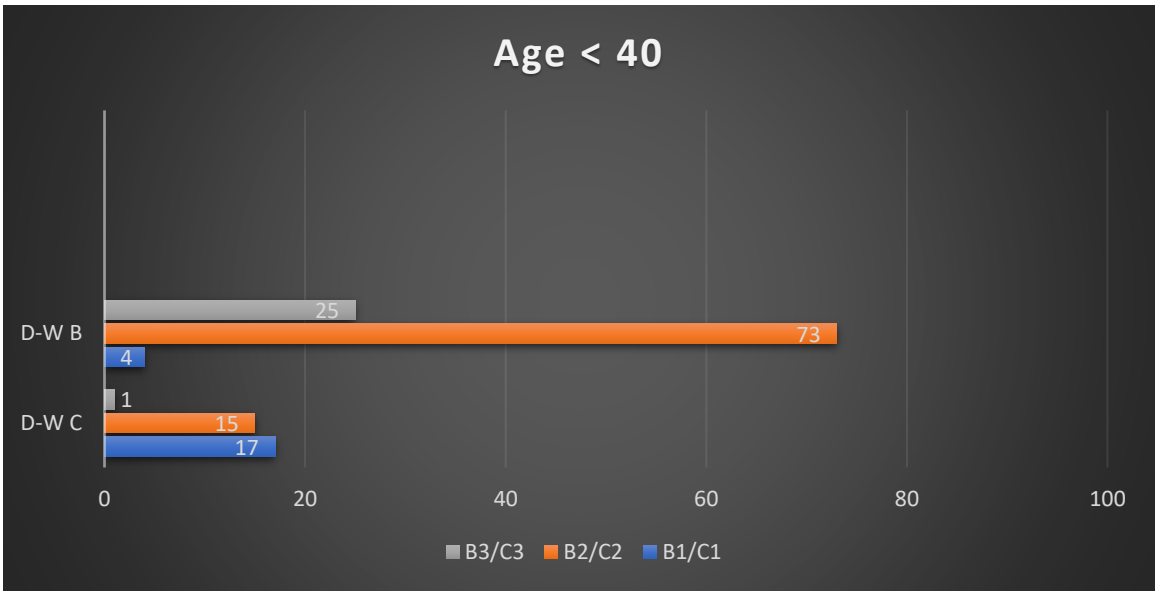

Figure 3.2: Danis-Weber Classification in < 40 years age group

3.1.2 Mechanism of injury.

Within each trauma mechanism, Danis-Weber B2 fractures represent the most common fracture type. Low-energy trauma injuries show a higher proportion of D-W B2 fractures compared to high-energy trauma injuries, with 65.8% and 56.5% of cases, respectively. (**Table 3.3**).

Table 3.3: Breakdown based on high versus low energy trauma injuries

Danis-Weber Classification	High energy trauma (*n*)	Percentage (%)	Low energy trauma (*n*)	Percentage (%)
B1	0	-	5	2.7
B2	52	56.5	121	65.8
B3	20	21.7	32	17.4
C1	12	13.1	12	6.5
C2	8	8.7	13	7,1
C3	0	-	1	0.5
Total	**92**		**184**	

3.2 RELATIONSHIP BETWEEN FRAGILITY FRACTURES AND A DISTINCTIVE PATTERN

3.2.1 Prevalence of fragility fractures

Pearson chi-squared test was used and found the prevalence of fragility fractures in our study population to be 66.7%. Observation from the breakdown indicates that fragility fractures are more prevalent in females (76.64%) than in males (56.83%) (**Table 3.4**). The significant *p*-value from the Pearson chi-squared test (66.7%) confirms that the observed association between fragility fractures and gender is statistically significant. Pearson chi-squared test demonstrated no significant differences across the Tables.

Table 3.4: Prevalence of fragility fractures (1 = Low energy trauma; 2 = High energy trauma)

	GENDER		
MOI	F	M	Total
1	105	79	184
	76.64	56.83	66.67
2	32	60	92
	23.36	43.17	33.33
Total	137	139	276
	100.00	100.00	100.00

Pearson chi2(1) = 12.1818 Pr = 0.000

3.2.2 To identify the distinctive patterns of fragility fractures on selected patients

Ankle fracture classification was found to be equally distributed among males and females across age groups, as depicted in Table 3.5, with a slight increase in C1 in males, which is likely due to chance. **Tables 3.6** and **3.7** looked at the site of injury and anatomical description of the fracture morphology and still did not show any difference in the groups. **Table 3.4** presents a comparison of fracture classifications between high-energy and low-energy trauma injuries, showing that D-W B2 fractures accounted for a larger proportion of cases in the low-energy trauma group (43.9%) compared to the high-energy trauma

group (19.2%) among the total 276 patients. Comparing the total numbers of high-energy (92) and low-energy trauma (184) cases makes this difference almost insignificant

Table 3.5: Pearson chi-squared of D-W classification on both genders

CLASSIFICATION & ID	GENDER F	M	Total
B1	3 2.19	2 1.44	5 1.81
B2	85 62.04	88 63.31	173 62.68
B3	31 22.63	21 15.11	52 18.84
C1	9 6.57	15 10.79	24 8.70
C2	9 6.57	12 8.63	21 7.61
C3	0 0.00	1 0.72	1 0.36
Total	137 100.00	139 100.00	276 100.00

Pearson chi2(5) = 5.0894 Pr = 0.405

Table 3.6: Pearson chi-squared of foot laterality on both genders (1 = Left foot; 2 = Right foot)

SITE	GENDER F	M	Total
1	73 53.28	66 47.48	139 50.36
2	64 46.72	73 52.52	137 49.64
Total	137 100.00	139 100.00	276 100.00

Pearson chi2(1) = 0.9293 Pr = 0.335

Table 3.7: Anatomical description (fractured fragments) of ankle fractures

ANATOMICAL	GENDER F	M	Total
BI-MAL	90 65.69	98 70.50	188 68.12
LAT-MAL	17 12.41	17 12.23	34 12.32
TRI-MAL	30 21.90	24 17.27	54 19.57
Total	137 100.00	139 100.00	276 100.00

Pearson chi2(2) = 0.9927 Pr = 0.609

3.3 COMPARING CHARACTERISTICS OF FRAGILITY VERSUS NON-FRAGILITY FRACTURES

Table 3.8 below presents data on high-energy trauma ankle fractures, with a total of 92 cases, which is half the number of low-energy ankle fractures, totaling 184 cases. Additionally, D-W C fractures occur predominantly in males; however, there is no significant difference in the injured site between genders. Furthermore, D-W B2 fractures are the most common type identified.

Table 3.8: Clinical characteristics of fragility versus non-fragility fractures

Variable	**Characteristics**	**F (n; %)**	**M (*n*; %)**	**Total**	***p*-value**
MOI	Low-energy trauma	105 (76.6)	79 (56.8)	184 (66.7)	<0.001
	High-energy trauma	32 (23.4)	60 (43.2)	92 (33.3)	
ClassID	B1	3 (2.2)	2 (1.4)	5 (1.8)	0.405
	B2	85 (62.0)	88 (63.3)	173 (62.7)	
	B3	31 (22.6)	21 (15.1)	52 (18.8)	
	C1	9 (6.6)	15 (10.8)	24 (8.7)	
	C2	9 (6.6)	12 (8.6)	21 (7.6)	
	C3	0 (0)	1 (0.7)	1 (0.4)	
Injured site	Left foot	73 (52.3)	66 (47.5)	139 (50.4)	0.335
	Right foot	64 (46.7)	73 (52.5)	137 (49.6)	

Anatomical description	Bi-MAL	90 (65.7)	98 (70.5)	188 (68.1)	0.609
	LAT-MAL	17 (12.4)	17 (12.2)	34 (12.3)	
	TRI-MAL	30 (21.9)	24 (17.3)	54 (19.6)	

3.4 POTENTIAL RISK FACTORS FOR FRAGILITY FRACTURES

Table 3.9 presents the results of a simple linear regression analysis exploring potential risk factors for fragility fractures of the ankle. Male sex showed a highly significant positive association with fragility fractures. Other factors, including age groups, alcohol use, smoking, BMI, and comorbidities, did not demonstrate significant associations in this model.

Table 3.9: A simple linear regression showing the association between fragility fracture of the ankle and potential risk factors

Variable	**Characteristic**	**Coefficient (β)**	**95% CI**	***p*-value**
Sex	Female	Ref (0)		
	Male	0.198	0.088 – 0.307	<0.001**
Age	18-28	0.270	-0.226 -0.766	0.285
	29-39	0.083	-0.356 – 0.552	0.727
	40-49	0.123	-0.353 – 0.599	0.612
	50-59	-0.065	-0.054 – 0.412	0.789
	60+	0.129	-0.362 – 0.621	0.605
Alcohol use	No	Ref (0)		
	Yes	-0.054	-0.172 – 0.064	0.371
Smoking	No	Ref (0)		
	Yes	-0.081	-0.203 – 0.041	0.194
BMI	Low	Ref (0)		
	Normal	0.179	-0.293 – 0.650	0.457
	High	0.037	-0.430 – 0.504	0.875
Clinical Characteristics				
ClassID	B1	0.311	-0.108 – 0.730	0.145
	B2	Ref (0)		
	B3	0.038	-0.108 – 0.183	0.610
	C1	0.169	-0.032 – 0.370	0.099
	C2	0.235	0.021 – 0.448	0.031*
	C3	-0.289	-1.215 – 0.637	0.539
Site	Left foot	Ref (0)		
	Right foot	0.019	-0.092 – 0.131	0.735
Anatomy	Bi-Mal	Ref (0)		
	Lat-Mal	0.207	0.035 – 0.379	0.018*
	Tri-Mal	0.078	-0.065 – 0.220	0.283

Comorbidities	No	Ref (0)		
	Yes	0.034	-0.146 – 0.078	0.552

***p<0.001 – highly significant difference *p<0.05Significant difference*

A multivariable model is shown in **Table 3.10** (R-squared = 0.0855 interpreted as the proportion of variability in the outcome variable indicates that the model explains 8.5% of the variability of potential risk factors of fragility fracture). The model examined the relationship between the outcome variable fragility fracture and the potential risk factors including demographic characteristics (age and sex), lifestyle factors (alcohol use and smoking status) and clinical characteristics. The model with 276 observations explained approximately 8.5% of the variability of the identified risk factors. The results suggest that fragility fracture increases in males (β = 0.199 unit; $p < 0.001$). Moreover, a marginally significant relationship was seen between fragility fracture and classification C2.

Table 3.10: A multivariable logistic regression showing the association between fragility fracture of the ankle and potential risk factors

Variable	**Characteristic**	**Coefficient (β)**	**95% CI**	***p*-value**
Sex	Female	Ref (0)		
	Male	0.199	0.089 – 0.309	<0.001**
Clinical Characteristics				
ClassID	B1	0.199	0.241 – 0.639	0.374
	B2	Ref (0)		
	B3	-0.042	-0.255 – 0.172	0.702
	C1	0.061	-0.164 – 0.286	0.593
	C2	0.201	-0.010 – 0.413	0.063*
	C3	-0.371	-1.279 – 0.535	0.420
Anatomy	Bi-Mal	Ref (0)		
	Lat-Mal	0.152	-0.050- 0.353	0.139
	Tri-Mal	0.135	-0.074 - 0.345	0.206

***p < 0.001 – highly significant difference * p < 0.08 magically difference*

In our study, the distribution of Danis-Weber classification in males and females with low-energy trauma injuries did not differ across the two groups. The majority of males (88) and females (85) were classified as D-W B2. While there were some variations in the distribution of other classifications, no significant differences were observed between males and females (Pearson chi-squared = 5.0894, $p = 0.405$). Any observed differences may be due to chance.

The distribution of fragility fractures by foot laterality also presented similar results:

- 56 women and 38 men sustained left foot injuries.
- 49 women and 41 men sustained right foot injuries.

The distribution of fragility fractures by foot laterality among males and females does not differ statistically significantly, according to the results of a Pearson chi-squared test that was used to investigate the relationship between gender and foot laterality (Pearson chi-squared = 0.9293, $p = 0.335$).

CHAPTER 4

DISCUSSION

4.1 DEMOGRAPHICS AND CLINICAL CHARACTERISTICS OF PATIENT

The study included a diverse group of participants with a balanced gender distribution and a wide age range, primarily middle-aged adults. Many of the participants reported lifestyle factors such as alcohol use and smoking. Most injuries were caused by low-energy trauma, and the injury sites were fairly evenly distributed throughout the studied population. Additionally, a majority of participants had a high body mass index, and nearly half had other medical conditions. This demographic and clinical profile provides valuable context for understanding the patient outcomes assessed in the study.

4.2 RELATIONSHIP BETWEEN FRAGILITY FRACTURES AND A DISTINCTIVE PATTERN

4.2.1 PREVALENCE OF FRAGILITY FRACTURES IN PATIENTS WITH ANKLE FRACTURES

There is a paucity of literature about fragility fractures of the ankle. The majority of studies covered the incidence and prevalence of fragility fracture causes as well as all fragility fractures. According to Smith et al., vitamin D deficiency is one of the most frequent causes of ankle and foot fragility fractures as well as poor fracture healing. In their study, where they compared the serum 25-OH Vitamin D levels with those of ankle sprain patients who did not sustain a fracture, they found Hypovitaminosis D to be common among patients with a foot and ankle injury. They concluded that patients with a low-energy fracture of the foot or ankle were at particular risk for low vitamin D, especially if they smoked, were obese, or had other medical risk factors. (52)

The study population experienced a significant incidence of low-energy fractures with an overall prevalence of 66.7% (*p*-value from Pearson chi-squared test). This suggests that fragility fractures are a substantial concern in this population. The overall prevalence and fracture pattern proportions differ slightly, possibly due to demographic, environmental, and lifestyle factors unique to the local population in South Africa. For example, higher rates of alcohol use (65.9%) and smoking (29.7%) among participants can influence fragility fracture epidemiology differently than in Western countries cohorts.

4.2.2 ASSESSING A DISTINCTIVE PATTERN OF FRAGILITY FRACTURES IN SELECTED PATIENTS

Lee et al., in their study, were not specific about the fracture pattern seen on fragility fractures of the ankle. They only showed that the older age group had a larger proportion of low-energy trauma than the younger age group, however, the difference was only significant for females ($p = 0.011$). Compared to the lower age group, the older age group displayed a more intricate fracture pattern. The predominance of the Danis-Weber B2 fracture pattern as a marker of bone fragility aligns with international studies indicating this fracture type is commonly associated with low-energy fragility fractures in elderly.

This suggests that fragility fractures are equally likely to occur in either the left or right foot, regardless of gender. These findings have implications for clinical practice, as they suggest that treatment approaches should not be influenced by foot laterality or gender. However, further research is needed to explore potential differences in hand dominance and site of injury. A more descriptive terminology or use of more than one classification system for ankle fractures may also be as inclusive and help identify fracture patterns.

4.5 COMPARING CHARACTERISTICS OF FRAGILITY VERSUS NON-FRAGILITY FRACTURES

In the low energy trauma group (184 in total) 105 were females and 79 males, while high energy trauma group (92 in total) had 32 females and 60 males. Fragility fractures group had 39 (21%) patients who were smoking, 112 (60.8%) used alcohol and 89 (48%) with other medical comorbidities. The two groups did not show any significant difference in all potential risk factors even on the BMI.

4.6 POTENTIAL RISK FACTORS FOR FRAGILITY FRACTURES

Fractures in frail people can occur for a variety of reasons, but osteoporosis is a common underlying cause. Increased fragility results from osteoporosis's severe microarchitecture-related bone deterioration, which lowers bone mineral density (BMD). Klotzbuecher et al. found that the chance of a subsequent fracture is doubled in postmenopausal women, and they proved that the increased fracture risk is highest following any clinical fracture. In the same study, age was one of the most important risk variables, which heightens fracture

risk regardless of BMD. This is due to both the comorbidities of older patients and bone ageing. In comparison to men, women also showed a higher risk of falling.

According to Holmberg et al. middle-aged men and women had somewhat different risk factors for ankle fractures. Diabetes and hospitalisation for mental health issues were the risk variables most closely linked to low-energy fractures in men. Other factors that were linked included smoking, poor self-rated health, sleep difficulties, and poor appetite. Diabetes and prior fractures were the risk variables most strongly linked to low-energy fractures in women. While a high BMI decreased the risk of forearm fractures, it dramatically raised the risk of proximal humerus and ankle fractures. This pattern of risk factors points more towards poor health with mental health problems playing a significant role in fracture risk, especially for men.

The current study found a significant relationship between fragility fractures and gender ($p < 0.001$). This finding indicates that males and females have distinct differences in the likelihood of experiencing fragility fractures. MOI and BMI had a moderately significant correlation ($p = 0.062$) according to a stratified analysis, indicating that although there may be a correlation between MOI and BMI, it is not statistically significant. The age population in our study (18 years and older) and the fact that majority were in 29 – 39 years group could have had an effect on the results. Given the likelihood of low to normal BMI in this group and the fact that most of the literature reports on postmenopausal or elderly groups 55 years and older.

Two possible risk factors were found to have marginally significant relationships with the mechanism of injury (MOI) in additional analyses. This implies that those with higher BMIs might be more susceptible to specific kinds of injuries, while more investigation is required to validate this conclusion. As was already noted, a marginally significant correlation between MOI and age group was found by the stratified analysis ($p = 0.073$). According to this research, older persons might be more prone to specific kinds of injuries. These correlations point to possible patterns or relationships that need more research, even though a substantial relationship was not observed at the traditional level ($p < 0.05$).

A simple linear regression model examined the relationship between the outcome variable fragility fracture and the potential risk factors and the bivariate analysis showed that males

are more likely to experience fragility fractures compared to females. This could be on account of other independent factors like excessive alcohol use in males and or the younger age group majority in our study population.

Scott et al. found that, compared to other fragility fractures, patients with ankle fragility fractures were generally younger (average age of 67.6 years), predominantly female (81.4%), more frequently non-Caucasian (11.7%), and had a higher average BMI (30.6). They also concluded that as age and BMI increased, so did the likelihood of a low-energy ankle fracture. Additionally, in the current study, a multivariable model, **Table 3.10** examined the relationship between the outcome variable fragility fracture and the potential risk factors including demographic characteristics (age and sex), lifestyle factors (alcohol use and smoking status) and medical comorbidities. The model didn't show any significant association other than male risk factor. The younger age group inclusion in our study may account for differences in statistical significance seen with age and BMI associations compared to older cohorts internationally.

4.7 STUDY LIMITATIONS

The study relied on participant reports of the mechanism of injury, which might be subject to recall bias or inaccurate descriptions. This could lead to underestimation or overestimation of the impact at the time of injury, potentially affecting the analysis of fracture patterns. The use of a single fracture classification system might not capture the full range of injury patterns. This limitation could result in incomplete or inaccurate classification of fractures, potentially influencing the study's findings. Participants' self-reported smoking and alcohol use might be subject to social desirability bias, leading to underreporting or inaccurate reporting. This could impact the analysis of risk factors associated with fragility fractures.

4.8 RECOMMENDATIONS

Objective measures, such as DXA scans, CT scans, or cortical thickness measurement software, to assess bone density might yield a better correlation with fracture patterns. This could provide more accurate insights into the relationship between bone health and fragility fractures. Future aims are to employ two or more fracture classification systems to capture a broader range of injury patterns. This could enhance the accuracy and completeness of fracture classification, leading to more reliable findings. Design a scoring system to quantify the severity of ankle fracture patterns. This could facilitate more nuanced analysis and comparison of fracture patterns, ultimately informing clinical decision-making and treatment strategies.

Larger sample sizes or different statistical techniques should be used in future studies to examine these connections in greater detail. Furthermore, investigating how MOI, BMI, and age group interact may offer important new perspectives on the intricate variables influencing injury risk.

CHAPTER 5

CONCLUSION

Clinical observations, literature, and the pathophysiology of bone fragility indicate that complex ankle fracture patterns seen in X-ray films, combined with low-impact trauma, suggest fragility in the elderly population. In this study, Danis-Weber B2 ankle fractures were observed more frequently in individuals over 40 years old compared to younger patients. However, the ratio of D-W B2 fractures to other fracture types was similar between the two age groups, possibly due to a higher average age among the younger patient cohort. Although the statistical analysis did not reveal a significant difference in the classification distribution between low-impact and high-impact trauma ankle fractures, the predominance of D-W B2 and B3 fractures suggests fragility, particularly when associated with comminution and a history of a simple twist or fall, thus a specific fracture pattern.

The study showed a significant association between fragility fractures and gender ($p < 0.001$), with a prevalence of 66.7% in females (76.64%) compared to males (53.83%). This finding indicates distinct differences between males and females in terms of the likelihood of experiencing fragility fractures. Low-energy trauma accounts for the majority of ankle fractures ($p < 0.001$), with D-W B2 fractures being the most common type in the elderly population. Bi-malleolar ankle fractures were also identified as a prevalent pattern.

Although age and BMI showed borderline associations with fragility fractures ($p = 0.073$ and $p = 0.062$, respectively), these relationships did not reach statistical significance ($p < 0.05$).

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APPENDICES

Appendix A: Data Collection Sheet

Patient Study Number			
Age			
Gender			
BMI		Weight =	Height=
MOI			

DXA scan

Medical comorbidities (Diagnosis and Treatment)

Comorbidities

Surgical history (Previous trauma / Operations)

Chronic medications

Habits

Smoking	
Alcohol use	

KEY: BMI = Body mass index; MOI = Mechanism of injury; DXA = Dexa scan (Dual energy x-ray absorptiometry)

Appendix B: Patient information sheet

STUDY INFORMATION DOCUMENT

Study title: Identifying a specific fracture pattern in adult patients with fragility fractures of the ankle seen at Chris Hani Baragwanath Academic Hospital

Greeting Sir/Madam

Introduction:

I am Dr NG Mofokeng, a registrar in the department of orthopaedic surgery at Chris Hani Baragwanath, doing research on ankle fractures from a low energy or minor injuries in adult patients. Research is a process used in seeking new knowledge. In this study, I want to learn a fracture pattern that is characteristic of low energy fractures on plain x-ray films. This is a research study aimed at increasing the yield for early identification, investigation and management of osteoporosis.

Invitation to Participate: I am inviting you to take part in the research study.

What is involved in the study? This could include but would not necessarily be limited to features such as:

1. This is a Cross-sectional study of patients at Chris Hani Baragwanath Academic Hospital and your role involves giving history on ankle injury sustained and any other relevant medical history, social, habits and recreational activities.
2. No procedures nor blood samples are involved in this research project, since only x-rays of the involved limb will be reviewed in the process.
3. I will do the data collection and it will take five (5) minutes to be completed.
4. You will be asked to answer questions such as how the injury happened, any other medical conditions or chronic medications you are taking, any previous operations and whether you smoke or use alcohol.

Risks of being in the study: None

Benefits of being in the study: There are no direct benefits, although indirectly, those with fragility fractures could benefit from early identification and treatment of osteoporosis given the outcome of the study.

You will be given pertinent information on the study while involved in the study and when results are available, either telephonically or can request the information on your follow up visits at the hospital.

Participation is voluntary, that refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled to; you may discontinue participation at any time without penalty, or loss of benefits to which you are entitled. There is no requirement to provide a reason for withdrawing and any data collected on you will in default be destroyed, unless you specifically consents to its retention.

Confidentiality: Normally personal information will be treated in the strictest confidence and will only be available to me and supervisors. The only exceptions - and all of them are rare - would normally be:

1. personal information may be disclosed if required by law
2. the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit

If results are published, this may, exceptionally, lead to cohort, or more rarely, individual identification. All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years, if there is no publication. Thereafter it will be destroyed accordingly. Names will only appear on the consent form, you will have a study number assigned to your data collection sheet and all these will not appear on the research paper but kept in a locked office at the hospital.

Anonymity can usually only be guaranteed in my data collection sheet, whether in hard copy or online, since only study numbers will be used and personal names will not be recorded.

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Prof S.K. Magobotha, Primary Supervisor, on telephone no. 083 229 7300, or by e-mail at sebastianmagobotha22@gmail.com

Dr Z. Mayet, Co-Supervisor, on telephone no. 082 408 3768, or by e-mail at bonedoc.zm@gmail.com

Dr M. Jingo, Co-Supervisor, on telephone no. 011 717 2202, or by e-mail at Maxwell.Jingo@wits.ac.za

Outputs

Outputs of the study will determine if there is a fracture pattern on plain x-ray films that characterizes the fragile nature of the bone involved and these will be disclosed to you after the study is completed. These may be published or presented at meetings.

Contact details of HREC administrator and chair – for reporting of complaints / problems.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Paul Ruff. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Study Information Sheet.

Date: 01/08/ 2024

APPENDIX C: PARTICIPANT CONSENT FORM

Project Title: Identifying a specific fracture pattern in adult patients with fragility fractures of the ankle seen at Chris Hani Baragwanath Academic Hospital

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto.
2. I was given time to read it, or had it read to me, in the language I best understand.
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory.
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be.
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time.
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained.
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study, I am free to speak to any of these contacts.

Contact details:

Dr N.G. Mofokeng, Principal Investigator, telephone no.082 418 3087, or by e-mail at ntswemofokeng@gmail.com

Prof S.K. Magobotha, Primary Supervisor, on telephone no. 083 229 7300, or by e-mail at sebastianmagobotha22@gmail.com

Dr Z. Mayet, Co-Supervisor, on telephone no. 082 408 3768, or by e-mail at bonedoc.zm@gmail.com

Dr M. Jingo, Co-Supervisor, on telephone no. 011 717 2202, or by e-mail at Maxwell.Jingo@wits.ac.za

Professor Paul Ruff, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand.

Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za o

Name of participant ……

Date…….....

Time…….

Place……

Signature or mark……..

Witnessed by

Name of witness: ……

Signature……

Date……

Time…….....

Appendix D: HUMAN RESEARCH ETHICS CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Ntswe Geelbooi Mofokeng

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M240122 M240612-A-0001

NAME: (Principal Investigator)	Dr Ntswe Geelbooi Mofokeng
DEGREE:	MMed in Orthopaedic Surgery
DEPARTMENT:	Orthopaedic Surgery Chris Hani Baragwanath Academic Hospital
TITLE:	*Identifying a specific fracture pattern on x-ray film in adult patients with fragility fractures of the ankle seen at Chris Hani Baragwanath Academic Hospital*
DATE CONSIDERED:	19/04/2024
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	HREC (Medical) Application Number: MED21-05-030
SUPERVISOR:	Drs Sebastian Magobotha, Ziyaad Mayet and Maxwell Jingo

APPROVED BY:

Professor Paul Ruff, Chairperson, HREC (Medical)

DATE OF APPROVAL: 24/06/2024 **EXPIRY DATE:** 24/06/2029

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

DECLARATION OF INVESTIGATOR(S)

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned 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 resubmit the application to the Committee. **I agree to submit a yearly progress report** in the month date of convened meeting each year until study is closed. Failure to submit annual report will result in ethics clearance certificate suspension. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. Unreported changes to the application may invalidate the clearance given by the HREC (Medical). Login to upload signed copy of this ethics clearance certificate prior to commencing with the study https://www.witsethics.co.za/login.aspx. Email a signed copy of ethics clearance certificate to HREC-Medical.ResearchOffice@wits.ac.za.

Principal Investigator Signature

26-06-2024
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix E: HOD APPROVAL LETTER

health and social development
Department: Health and Social Development
GAUTENG PROVINCE

Division of Orthopaedic Surgery
P.O. Bertsham
Soweto
2013
23/11/2023

Enquiries: Prof M.T. Ramokgopa
Tel: 011 933-8914
Email:Mmampapatla.ramokgopa@wits.ac.za

TO: WITS ETHICS COMMITTEE,MEDICAL

Re: Permission to conduct a study for Dr. NTSWE GEELBOOI MOFOKENG
Persal no 19134967

I hereby give the above-mentioned staff member, Dr. NG Mofokeng to conduct the study in the Orthopaedic Surgery Department at Chris Hani Baragwanath Hospital. He will be doing a cross-sectional study on **Identifying a specific fracture pattern on x-ray film in the adult patient with fragility fractures & the ankle seen at Chris Hani Baragwanath Academic Hospital.**

Thanking you in advance

APPROVED ☒ NOT APPROVED ☐

Prof M.T. Ramokgopa
Head of Orthopaedic Department
Chris Hani Baragwanath Academic Hospital

Appendix F: CHBAH CEO APPROVAL LETTER

Date: 5th March 2024

TITLE OF PROJECT:

Identifying a specific fracture pattern in adult patients with fragility fractures of the ankle seen at Chris Hani Baragwanath Academic Hospital.

UNIVERSITY: Witwatersrand

Principal Investigator: DR N G Mofokeng

Department: ORTHOPAEDIC SURGERY

Supervisor : Prof S Magobotha

NHRD Number: GP_202310_029

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: 05/03/2024

.....
Approved / Not Approved
Hospital Management
Date: 11/03/2024