THE AETIOLOGY OF ACUTE TRAUMATIC OCCUPATIONAL HAND INJURIES 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, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Orthopaedic surgery

Johannesburg, 2017.

Declaration

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

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Andrew Stewart

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Presentations arising from this research project

This research was presented at the South African Society for Surgery of the Hand (SASSH) 47th annual congress on the 27th August 2016 at the CSIR International Convention Centre, Pretoria.

Publications arising from this research project

This research has been accepted by the South African Orthopaedic Journal (SAOJ) for publication in November 2017.

Abstract

Introduction:

Acute traumatic occupational hand injuries are the second most common cause of all traumatic hand injuries in both developed and developing countries and the most commonly injured body part during occupational accidents. Traumatic hand injuries account for approximately one third of all traumatic injuries seen at state hospitals in South Africa. The aetiology of occupational hand injures in South Africa is unknown.

Aim:

The purpose of this research was to highlight the patient demographics and types of hand injuries sustained on duty and to identify the common causes and risk factors for these injuries.

Materials and Methods:

An observational cross sectional study was done at Chris Hani Baragwanath Academic Hospital (CHBAH) between January and July 2016. A total of 35 patients over the age of 18 years were interviewed using a specially designed questionnaire.

Results:

The results showed that the patients were predominantly male (88,5%) between the ages of 20 - 61 years old (average 35 years), 54% dropped out of school before grade 11. The average monthly income was low (R1000 - R9000 pm) and 85% were the primary breadwinner in the household. Only 51% of the patients had ‘formal’ employment, the rest were either self-employed, contract workers or had intermittent ‘piece’ jobs. The majority of injuries occurred to machine operators, general manual labourers and construction workers. Of the patients, 80% had never received any occupation specific training and 71% of the patients were not using any gloves for protection at the time of injury. The three most common sources of injury were power tools, powered machines and building material. Lacerations, crush injuries and fractures were the most common type of injury seen, involving predominantly the index,

middle and ring finger. Twenty eight percent sustained minor injuries, 34% moderate, 20% severe and 17% major as defined by the Hand Injury Severity Score.

Conclusion:

Patients with traumatic work related hand injuries are poorly trained and often aren't provided with protective gloves. They typically injure their index, middle and ring finger using either a power tool, powered machine or by handling building material. The injuries sustained are most commonly lacerations, fractures and crush injuries. As a result, occupational health and safety must be improved to reduce the socio-economic burden of these injuries. Novel ways of improving safety in the informal labour market are required.

Acknowledgments

I would like to thank my supervisors, Dr. Grant Biddulph and Dr. Gregory Firth, for their guidance and assistance in the completion of this research project.

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Nomenclature

CHBAH: Chris Hani Baragwanath Academic Hospital

COIDA: Compensation for Occupational Injuries and Diseases Act

HISS: Hand Injury Severity Scoring System

MHISS: Modified Hand Injury Severity Scoring System

ISMN: Integument, Skeletal, Motor, Neural

TOW: Time off Work

NEISS: National Electronic Injury Surveillance System

WHO: World Health Organisation

Technikon: An institution offering technical and vocational education at a tertiary level.

Piece Job: Any type of employment in which a worker is paid a fixed wage for each unit produced or action performed regardless of time.

Contract Worker: An employee who is hired for a specific job at a specific rate of pay. A contract worker is not considered a permanent employee.

Formal Employment: Permanent Employee.

Breadwinner: A person who earns money to support their family, typically the sole one.

Manual Labourer: A person employed to do physical work, often with the hands.

Bandsaw: A saw consisting of an endless moving steel belt with a serrated edge.

Angle Grinder: A device with a rotation abrasive disc, used to grind, polish or cut metal and other materials.

Preface

Acute traumatic occupational hand injuries are especially common in South Africa. They account for significant time off work, loss of income, change in or loss of occupation and residual functional impairment. In a developing country, like South Africa, with high unemployment rates, a loss of income can be particularly devastating.

Chris Hani Baragwanath Academic Hospital (CHBAH), the third largest hospital in the world, is situated on the border of Soweto, one of the poorest urban areas in Johannesburg. Due to the scale of poverty in Soweto and its outlying regions, the hospital's emergency department is known as one of the busiest worldwide. As a result of the high unemployment rate and poverty levels, the residents of Soweto are often employed in the informal labour market, in jobs in which they are given no specific training. This puts them at high risk of traumatic occupational injuries.

It has been shown that there are shortfalls in the implementation of the Compensation for Occupational Injuries and Diseases Act (COIDA) in the informal labour market. This results in employees being unable to access the correct channels of health care and compensation following their injuries. Hospitals such as CHBAH are therefore overburdened with these types of patients.

Employees are often expected to work in a hazardous environment or with dangerous machines and tools without the correct training and appropriate safety equipment. If an injury occurs they often experience difficulties registering as having an injury on duty, and therefore struggle to claim compensation for their injury.

Chapter 1 - Introduction

1. Introduction

The primary purpose of this study is to describe the demographics of patients admitted to CHBAH with occupational hand injuries as well to identify the patterns of injuries and the most common causes of these injuries. The purpose is also to identify any common risk factors for injuries on duty as well as to describe the types of hand injuries sustained on duty.

1.2 Background

Occupational injuries are an important cause of morbidity and mortality across the world. Hence, they account for significant time off work, loss of income, change in or loss of occupation and residual functional impairment [(1)]. In a developing country, like South Africa, with high unemployment rates, a loss of income can be particularly devastating [(2)].
South Africa has an unemployment rate of 25% [(3)], therefore competition for employment is high, especially in the country's agriculture, mining and manufacturing sectors [(2)].

Chris Hani Baragwanath Hospital (CHBAH), the third largest hospital in the world, is situated on the border of Soweto, one of the poorest urban areas in Johannesburg [(4)]. Due to the scale of poverty in Soweto and its outlying regions, the hospital's emergency department is known as one of the busiest worldwide [(4)]. As a result of the high unemployment rate and poverty levels, the residents of Soweto are often employed in the informal labour market, in jobs in which they are given no specific training. This puts them at high risk of traumatic occupational injuries [(5)].

It has been shown that there are shortfalls in the implementation of the Compensation for Occupational Injuries and Diseases Act (COIDA) in the informal labour market [(6)]. This results in employees being unable to access the correct channels of health care and compensation following their injuries. Hospitals such as CHBAH are therefore overburdened with these types of patients.

Acute traumatic occupational hand injuries are especially common in South Africa. According to the COIDA report (1999), these injuries accounted for approximately 55% of all occupational injuries [7]. At CHBAH, according to the consolidated morbidity and mortality data for a year, approximately 34% of all orthopaedic trauma admissions are hand injuries.

Acute traumatic hand injuries are also one of the leading causes of reported days off work [1] and are responsible for significant losses in productivity to South Africa's economy [2]. According to the National Department of Labour website, in 1999. There were 223 614 cases of occupational injuries reported in South Africa, accounting for a total of 13 147 071 Man Days lost, which is an average of 20 days lost per injury reported. The estimated total cost of compensation and medical aid in 1999 was R1, 360 011 254. Of these injuries – hands (including wrists and fingers) accounted for 55% of the total [7].

Despite the obvious burden of disease that these injuries present to South Africa as a society, there is a great deal to learn about the potential risk factors, causes and preventative measures that can be taken in the future.

1.3 Research question

What are the common causes and associated risk factors for acute traumatic occupational hand injuries seen at Chris Hani Baragwanath Academic Hospital?

1.4 Aim

To analyse the acute traumatic occupational hand injuries seen at CHBAH.

1.5 Objectives

1. To describe the demographics of patients admitted with acute traumatic occupational hand injuries.
2. To identify the patterns, causes and effects of acute traumatic occupational hand injuries.
3. To identify common risk factors for occupational hand injuries.

1.6 Literature review

Causes of acute traumatic hand injuries:

The aetiology of acute traumatic hand injuries has been shown to vary slightly depending on whether the country is a developing nation or not and with reference to the geographical location (rural vs. urban) where the study was completed. Regardless of these variables, acute traumatic occupational hand injuries account for one of the top three causes of hand injuries in general [9]. The other major causes are motor vehicle accidents and violent trauma

In Europe, Larsen et al., (2004) did a study in Denmark and the Netherlands (developed nations) which showed that the leading cause of acute traumatic hand injuries results from accidents around the house including leisure activities, with occupational injuries being the second most common [10]. In the United States of America, Jackson, found that out of 3.6 million occupational injuries treated in a hospital environment in 1998, injuries to the fingers and the hand were the most common [9]. Whereas in Africa, a study done in Nigeria, a developing country, showed that motor vehicle accidents were the most common cause of hand injuries and occupational injuries were the second most common [11]. Furthermore a study done in Kenya (another African developing nation) showed that occupational injuries were the most prevalent cause of hand injury [12].

Injury severity and predicted outcome:

Campbell et al. (1996) introduced the Hand Injury Severity Score (HISS) as a research tool. Their aim was to design a score that would grade hand injuries according to their severity as a guide to likely outcomes. The Modified Hand Injury Severity Score (MHISS) is a similar scoring system which includes a wrist and forearm assessment. The HISS or MHISS evaluates anatomical components of the forearm, wrist and hand in four domains known as the ISMN: Integument (skin and nail), Skeletal (bone and ligament), Motor (tendon) and Neural (nerve and vascular). The total scores are converted to four categories: minor (<20), moderate (21–50), severe (51–100) and major (>100). The research tool was peer reviewed and then validated in a retrospective study of 100 hand injuries in the United Kingdom [13].

The HISS was retrospectively applied to a group of patients with occupational hand injuries by Van der Molen et al.,(1996) to test its efficacy. They showed that even patients with minor injuries (<20) had a median healing time of 49 days and only 57% returned to work in less than eight weeks, whereas those patients with more severe injuries, with a HISS score of > 20, had a median healing time of 133 days and only 20% had returned to work in under eight weeks [14]. The mean injury score in the Van der Molen series was higher than the original study described by Campbell et al.,(1996) but this was likely due to the fact that the Van der Molen study only included occupational hand injuries which tend to be more severe.

In a similar study, Lin et al.,(2012) showed that the HISS could be an adequate predictor of post injury hand strength. They demonstrated that patients with hand injuries had poor hand strength post injury despite adequate rehabilitation. This study was a retrospective study in which they were able to use the uninjured hand as a control when measuring palmar pinch, lateral pinch and cylindrical grip strength [15]. Using the patient's uninjured hand as a control gives a good objective comparison, but does not allow for normal differences in hand strength between dominant and non-dominant hands. They were also unable to measure the hand strength prior to injury to estimate the percentage of function lost.

Matsuzaki et al.,(2009) used the HISS to investigate the effect of severity and type of mutilating hand injuries on functional recovery and return to work. They found that as the HISS score increased, the chance of returning to work changed from original job, to job change, to being unable to work which was statistically significant. When the HISS score was less than 50, 11 of the 12 patients were able to return to their original job. When HISS was between 50 and 150, 17 of the 23 returned to their original jobs. When HISS was more than 150, only four of the 14 patients returned to their original jobs [16]. The problem with this data is that it does not take into account the patient's economic situation, number of dependents, age and necessity to go back to work. These variables play an important role in return to work following injury.

In Asia, Jin et al.,(2010) and Choi et al.,(2012) found very similar results of which Jin noted that the most severe injuries occurred in the manufacturing sector and more specifically when working with machinery and metal work as well as with food products [17]. Choi et al.,(2012) noted that the mean duration of time off work (TOW) was 127 days for patients with a mild MHISS, 108 days for a moderate score, 160 days for a severe score and 236 days for those with a major score [18]. They did not include the estimated cost to company or loss of income due to TOW.

In a much larger study done in Asia with the longest follow up period of 13 years, 1000 patients were followed between 1987 and 2000 to determine their long-term functional impairment after severe mutilating hand injuries. They found that 58.5% of their patients suffered some residual functional impairment [16]. The limitation of this research is that they did not quantify how they calculated the functional impairment. There are however scoring systems available such as the Tamai scoring system used to quantify functional impairment of the hand. This particular scoring system has predominantly been used to evaluate functional impairment post upper extremity replants [19]. The Tamai score consists of both objective criteria, such as range of motion and sensory evaluation, and subjective criteria, such as working ability and patient satisfaction. Both doctors and patients therefore provide information about the impairment of function and disabilities, at work and in the activities in daily living.

Incidence of hand injuries in a clinical setting:

Hand injuries account for a significant amount of hospital and clinic visits each year. Most of the time non-hand specialists see these patients. In South Africa, the actual incidence rates are difficult to find as we don't currently have an adequate surveillance system for data capture. In the United States, the National Electronic Injury Surveillance System (NEISS) was used to investigate the incidence rates of upper extremity injuries presented to emergency departments in 2009. They found that 53.6% of all upper extremity injuries involved the hand and fingers [20]. This equates to 1.13 per 100 person-years. Injuries to the fingers alone accounted for 38.4%, and were by far the most common injury encountered. These results are, however, only an estimate based on the results of a few emergency departments used to represent the entire US population. In a comparative study done in Europe (Denmark) with over 50 000 patients, a similar incidence rate of 1.6 per 100 person years was found [21]. These results are comparative because both studies used a selection of hospitals as a representative of the entire population to estimate the incidence.

In a study done in India between 1983 and 1988, Mathur et al.,(1988) found the incidence of hand injuries amongst workers to be 36 per 10 000 workers per year [22]. The problem with this data is that it is relatively old and newer data for India has not been released. In a more recent epidemiological study of work-related burns injuries published in 2000, the incidence of wrist and hand burns accounted for 7.6 per 10 000 workers [23]. The drawback of this study is that the data was taken from a workers' compensation database. This database may not be an accurate representation of all the work-related burn injuries, as in some instances the patient may not have claimed compensation for the injury from the workers compensation fund.

Incidence of hand injuries in an industry specific setting:

In a review of the NEISS, an American study by Sorock et al.,(2002) found that the highest incidence of hand injuries occurred in the machine trade followed by service work and structural work. These injuries most commonly occurred from metal items such as nails, metal stock and burrs, followed by hand tools and power tools. The majority of injuries recorded were lacerations followed by crush, avulsion, puncture, fracture, contusion, amputation and dislocation in descending order of frequency [24]. Trybus et al.,(2006) also found that the second most common place of injury in America was at work where machine trauma caused most of the most injuries. The majority of their participants were manual labourers which therefore explains why machine trauma and lacerations were the most common causes of hand injuries [5].

In contrast, a study done in the United States to assess hand injuries amongst adolescents in the work place, it was found that the retail trade (predominantly food preparation and service) produced that largest number of hand injuries. The majority of these were due to lacerations and burns [25]. The second largest number of injuries occurred in the service industry including health services, amusement, educational and recreational services [25]. These two studies are not comparable as they are done on two significantly different populations, but they do however highlight the broad spectrum of causes of occupational hand injuries. Garg et al., (2012) reported that amongst 250 workers with hand injuries, 45% were due to construction and metal work, whilst 20% occurred when handling or preparing food. For those workers injured whilst using a machine, 16% reported receiving no training, whilst 61% reported having only been briefed as to how the machine operated and only 22% received formal, structured training. Carelessness (37%) and fatigue (24%) were considered the main attributing factors to injury by the workers [26].

In Asia, two contrasting studies were performed on two very similar populations. Amongst workers in Hong Kong, it was found that 58% of all acute traumatic hand injuries occurred in workers with less than one year of experience [26], whereas in China it was found that the mean work experience of injured patients was 160 weeks (+- 3 years) [17]. This result implies

that work experience alone may have little impact on the incidence of occupational hand injuries. In fact Sorock et al.,(2004) demonstrated that a worker in America was almost twice as likely to get injured if they had three years of experience compared to one year [27]. Furthermore, Garg et al.,(2012) also showed that 59% of the workers with these types of injuries were illiterate [26]. It is therefore assumed that occupation specific training, safety equipment and higher literacy rates are more preventative of hand injuries than work experience.

In a survey of construction workers with more than five years of work experience, who had sustained an occupational injury, it was found that daily alcohol use (43%), low education levels (60%) and current smoking habits (53.5%) were all significantly associated with occupational injury [28].

Garg et al.,(2012) also studied the social and industrial factors associated with acute traumatic occupational hand injuries. Socially they found that immigrants were the most likely to injure themselves, and that inadequate training and lack of safety equipment are the main contributors to industrial factors [26]. It is possible that language and literacy difficulties could be the reason that immigrants were more likely to injure themselves.

Chapter 2 - Materials and Methods

2. Materials and Methods

2.1 Ethics

This study was approved by the Human Research Ethics Committee of the University of the Witwatersrand. The clearance number obtained was M150423.

2.2 Study design

An observational, cross-sectional study was done on 35 patients admitted to the orthopaedic trauma wards at CHBAH using a specially designed questionnaire. (Appendix C)

2.3 Study setting

Patients were interviewed by a single interviewer (the principal researcher) in a private room in the orthopaedic wards at CHBAH. A translator was provided for any patient who preferred to be interviewed in a language other than English or Afrikaans. The translator was a health-care worker fluent in the patient's home language. An information sheet was provided to each participant explaining the objectives of the study and what they should expect. The participant could ask questions to clarify any aspects of the study he/she did not fully understand. The interviewer read the questions and answers from the questionnaire and the participant was asked to choose the most appropriate answer. It was mandatory that every question on the questionnaire was answered by the participant. Any participant that was unable/unwilling to answer a particular question, the data for that participant was then excluded from the study. No participants were unwilling to answer all the questions.
The study took place between January 2016 and July 2016.

2.4 Study population

The study included 35 male and female patients over the age of 18 years who were admitted to the orthopaedic wards at CHBAH with acute traumatic occupational hand injuries. The patients were predominantly residents from Soweto, Johannesburg, but also included participants from other regions of Gauteng.

2.5 Sampling

The sample size was calculated using the estimated prevalence of occupational hand injuries amongst all orthopaedic hand patients admitted to CHBAH. The incidence of work-related hand injuries was calculated to be 5% of all trauma related hand admissions based on the analysis of admission data from weekly Morbidity and Mortality meetings presented by the Hand Unit at CHBAH. During this time, 35 patients were recruited.

2.6 Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
• 18 years old or older. • In-patient at CHBAH • Consent to participate in study • Acute traumatic hand injury as the primary diagnosis	• Incomplete questionnaire

2.7 Informed consent

A patient information sheet was created using a template provided by the University of Witwatersrand (Appendix A). Written informed consent was obtained from each patient. The consent form was created using a template provided by the World Health Organisation (WHO) (Appendix B).

2.8 Data Collection

The questionnaire was designed using a sophisticated web based application for building and managing online surveys and databases called REDCap. The questionnaire was completed online using the principal researcher's tablet (iPad). The principal researcher asked the patient each question on the questionnaire and then read out the available answers to them. The patient's answer of choice was then marked on the questionnaire.

Each question on the questionnaire was assigned a predetermined answer option, and the participant was able to either choose only one most applicable option or multiple choices depending on the type of question. The options were in the format of 'CHECKBOX', 'DROPDOWN MENU' or 'RADIO BUTTONS'.

The injury characteristics were documented by reviewing the patients' clinical notes, X-rays and by doing a thorough clinical examination. The Hand Injury Severity Score was then calculated by the principal researcher.

All data is electronic and only the principal researcher, the research supervisors and a statistician have had access to the data which has been de-identified.
The first patient was designated as "patient 1"
REDCap provides an automated export procedure in order to download data to Excel for statistical analysis in the form of a spreadsheet.

2.9 Statistical Analysis

The data was sorted on the spreadsheet so that each patient was in numerical order based on the number assigned to them. Each question was assigned a column and the answers were labeled as either ‘CHECKED’ or ‘UNCHECKED’ based on whether the patient had chosen the answer or not.

A total was assigned to each instrument and the results were tabulated. Due to the descriptive nature of the study the results for each instrument were illustrated in the form of a graph and the mean and/or median was calculated where appropriate. The median was calculated when the frequency distribution of the data was skewed by outliers. In other cases when the data was distributed normally the mean was used.
Where appropriate, measures of variability such as the range and percentage were calculated. No statistical comparative data was performed due to the small sample size.

Chapter 3 - Results

Patient Demographics

The majority of the participants were young males, the mean age of the participants was 35 years old (Range 20 - 61 years) which included 31 males and four females.

The average level of education amongst the patients was poor. There were 13 patients who had dropped out of school at a level of grade 8 or less, six participants had achieved a level of grade 9 or 10 and twelve participants had achieved a level of grade 11 or 12. Only four participants had achieved a higher education which included either a university degree, diploma or attendance at a technikon.

Fourteen patients were not married and 21 patients were either married or living with their partner.

The majority of patients admitted to being the sole income earner in their household, which was referred to in the questionnaire as the 'primary breadwinner'. Only five patients had additional financial support from someone else in the household.

Almost all of the patients had a dependent relying on them for financial support. Twenty-two patients had more than one dependent. The median number of dependents was two. (range 0 - 10 dependents).

The average annual income varied between R1000 and R9000 per month. The majority earned between R1600 and R8000 per month, which in most cases represented the total household income as there was no other source of income. Four participants lived on less than R1600 per month, and three received more than R8000 per month.

Table 3.1: Patient demographics

	n = 35	%
Age (yr)		
<25	9	25,7
25-34	11	31,4
35-44	5	14,2
45-54	6	17,1
55-64	4	11,4
Mean	35	
Range	20 - 61	
Gender		
Male	31	88,5
Female	4	11,5
Marriage status		
Yes	13	37,2
No	15	42,8
Living with partner	7	20
Handedness		
Right	34	97,1
Left	1	2,9
Level of education		
Grade 8 or less	13	37,1
Grade 9 - 10	6	17,1
Grade 11 - 12	12	34,3
Higher education	4	11,4
Specific Higher education		
Diploma	2	5,7
University degree	1	2,8
Artisan training	0	0
Apprenticeship	1	2,8
Number of dependents		
None	2	5,7
One	11	31,4
Two	7	20
Three	5	14,3
Four	5	14,3
> Four	5	14,3
Median	2	
Range	0 - 10	

	n = 35	%
Primary ‘breadwinner'		
Yes	30	85,7
No	5	14,3
Average annual income		
< R20 000	4	11,4
R20 000 - R40 000	15	42,9
R40 000 - R100 000	13	37,1
> R100 000	3	8,6

Occupational Data

The majority of participants were either self-employed, contract workers or had intermittent piece jobs. Only 18 patients had what would be considered ‘formal employment', with a written contract.

The majority of injuries occurred to machine operators, general manual labourers or construction workers, but also included butchers, cooks and carpenters.

For most of the patients this was their first work-related hand injury. Only three patients had sustained an acute traumatic occupational hand injury in the past year.

There was an even distribution regarding how long each patient had been employed at their current job, ranging from one month to more than 31 years, with a median employment time of four years.

Of the patients, 28 of the 35 reported having never received any formal occupation-specific training.

Only two of the 35 patients were performing an unusual task at the time of injury.

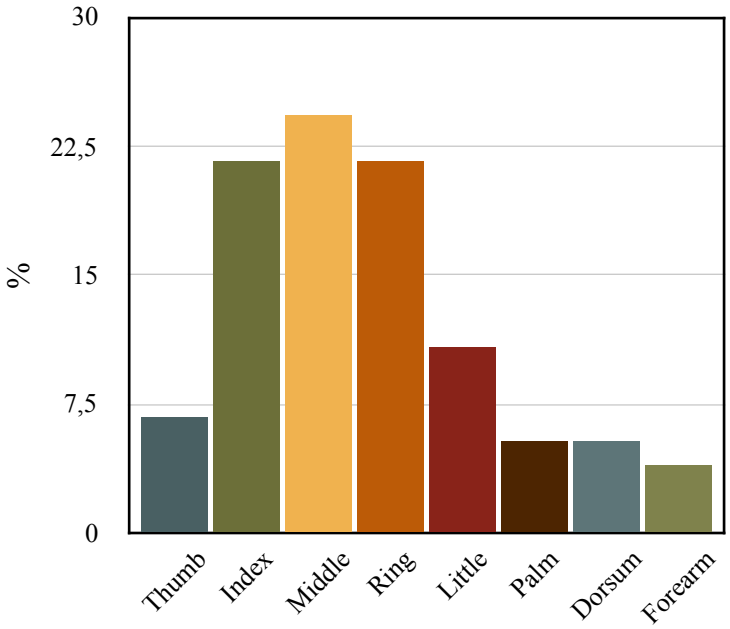

Figure 3.1: Distribution of injuries according to anatomical location

Although almost all patients were right handed (n = 34), there was an equal distribution between which hand was injured.

Although 60% of the participants were provided with protective equipment, 10% of these chose not to use the protective equipment and only 28% were using protective gloves at the time of injury.

Most of the patients were not performing an unusual task at the time of injury, nor were they using an unfamiliar machine.

Table 3.2: Occupational data

	n = 35	%
Occupation		
Butcher	2	5,7
Carpenter	3	8,5
Construction	6	17,1
Machine operator	12	34,2
Packaging	1	2,8
Mechanic	3	8,5
General Manual Labourer	4	11,4
Chef / Kitchen worker	2	5,7
Other	2	5,7
Employment type		
Formal employment	18	51,4
Contract worker	6	17,1
Self employed	8	22,9
Piece job	3	8,6
Job Tenure		
< 6 months	7	20
6 months - 1 year	4	11,4
1 year - 5 years	11	31,4
> 5 years	13	37,4
Median duration (months)	48	
Range	1 month - 31 years	
Occupation specific training		
Yes	7	20
No	28	80
Duration of training	1 week - 4 years	
Provided with protective equipment		
Yes	21	60
No	14	40
Using protective equipment (n = 21)		
Yes	19	90,5
No	2	9,5
Using protective gloves		
Yes	10	28,6
No	25	71,4
Performing an unusual task		
Yes	2	5,7
No	33	94,3

Injury Characteristics

The most common source of injury was a power tool, followed by a powered machine and building material. Other sources included hand tools, vehicles, knives and electrical burns. The most common power tool associated with injuries was the angle grinder. The machine press was the most likely powered machine to cause an injury.

Lacerations, crush injuries and fractures were the most common type of injuries seen, followed by tendon and nerve injury. Twenty-five patients sustained a combination of multiple types of injuries. Fractures and lacerations were often associated resulting in a total of 22 open fractures (78,5%). There was a total of two amputated thumbs, two amputated index fingers and one amputated middle finger (two separate patients). There was one mangled extremity resulting in an amputation through the wrist.

The index, middle and ring finger were most commonly affected, followed by the little finger and thumb. The palm and dorsum of the hand were occasionally involved as well as the forearm.

Table 3.3: Injury Characteristics

	n = 35	%
Hand Injured		
Right	18	51,4
Left	17	48,6
Hand injury in previous year		
Yes	3	8,6
No	32	91,4

	n = 35	%
Source of injury		
Power Tool	14	40
Powered Machine	10	28,5
Building Material	6	17,1
Hand Tool	1	2,8
Vehicle	1	2,8
Other	3	8,5
Injury characteristics		
Laceration	28	80
Fracture	27	77,1
Crush	15	42,8
Tendon Injury	7	20
Nerve Injury	6	17,1
Contusion	3	8,5
Mangled Extremity	2	5,7
Puncture	1	2,8
Amputation	3	8,5

Injury Severity

The injury severity was calculated using the Hand Injury Severity Score (HISS) (Appendix D) introduced by Campbell et al., (1996). The HISS evaluates anatomical components of the forearm, wrist and hand in four domains known as the ISMN: Integument (skin and nail), Skeletal (bone and ligament), Motor (tendon) and Neural (nerve and vascular). The total scores are converted to four categories: minor (<20), moderate (21–50), severe (51–100) and major (>100).

The severity of the injuries were fairly equally distributed between the categories. Ten patients sustained minor injuries, 12 patients sustained moderate injuries, seven patients sustained severe injuries and six patients sustained major injuries. The severity scores ranged from three to 175. The most severe injury resulted in a complete through wrist amputation after failed salvage procedures.

Patients who injured their left hand on average sustained a moderate injury (ave score = 45), whereas those patients who injured their right hand sustained a severe injury (ave score = 57) On average males sustained more severe injuries than females. The average injury severity score for males was 53,2 (severe). The average injury severity score for females was 24,8 (moderate).

The average HISS score for patients wearing protective gloves was 50. The average HISS for patients not wearing protective gloves was 49.

Although job tenure did not seem to affect the risk of sustaining a work related hand injury, it did affect the severity of the injury incurred. Those patients who were injured in their first year of work sustained a mean injury severity score of 75 (severe), whereas those patients who were injured after they had been at their current job for at least one year sustained a mean injury severity score of 32 (moderate).

Table 3.4: Injury Severity

Injury Severity	n =	%
Minor (<20)	10	28,5
Moderate (21 - 50)	12	34,2
Severe (51 - 100)	7	20.2
Major (>100)	6	17,1

Chapter 4 - Discussion

Who gets an occupational hand injury?

This research has shown that the causes of occupational hand injuries have correlated with individual patient characteristics such as young age, male gender, poor education and lack of training which is consistent with findings in similar studies from around the world [28].

The predominant male population in this study conformed to most other studies on this subject and fits in with the typical young, working class individual. In South Africa, young working class men are typically involved with manual labour type jobs, whereas females are often required to stay at home and look after the family or are employed as domestic workers or cleaners. Therefore men are at more risk of sustaining a traumatic hand injury.

Work related hand injuries are particularly common in younger individuals. Olsen et al., (1986) demonstrated that young workers of 24 years or younger had the highest risk of occupational hand and finger trauma [29].

Most of the patients in this study are poorly educated - evidenced by the fact that 90% had failed to progress past a high school education. This is in keeping with similar studies such as that by Chau et al., (2004) which demonstrated that 60% of injuries occurred in those with only a primary school education [28]. Garg et al.,(2012) showed a 59% illiteracy rate amongst workers with traumatic hand injuries [26].
Young, poorly educated males in South Africa are more likely to be employed as manual labourers in the manufacturing, mining, maintenance or agriculture sectors [3], thus putting them at an increased risk for traumatic hand injuries.

Most of the patients in this study would be considered to be in the low to middle income bracket and the majority of them were the sole income earners in the household. These patients were often responsible for the financial security for multiple other dependents at home. These dependents included biological children, adopted children, other family members and spouses.

It was found in this study that about half of the patients were either married or living with their partner. Being married may improve financial stability if the partner is also employed, but as demonstrated, most of these patients were the primary breadwinners in their households. The other half of the patients in this study were either not married, divorced or widowed. This also creates financial difficulty in the event of unemployment. Therefore any loss of income due to injury can cause significant financial stress and may be potentially devastating if the patient is left permanently disabled.

It has been demonstrated in the literature that patients with hand injuries will have residual hand weakness despite adequate rehabilitation, and as the severity of the injury increases the chance of returning to work decreases [15, 16]. This is significant in our patient population as South Africa has rising unemployment and poverty levels.

The high unemployment rate in South Africa, means that often people are required to work in the informal labour market, either as temporary workers or performing 'piece' jobs for which they are often poorly trained.
Very few patients in our study population reported receiving any occupation specific training before injuring themselves. Formal training programmes may prevent incorrect or negligent use of potentially hazardous machines thus decreasing the risk of injury. This is especially relevant in a population with poor literacy rates where the worker may not be able to read or understand the instructions for use and / or warning labels on a machine or powered tool.

A lack of formal structured training programmes has shown in the literature to be associated with a higher incidence of occupational hand injuries [17, 26-28]. In a study by Choi et al.,(2012) where the majority of patients had received formal occupation-specific training, the majority (93%) of the injures sustained were minor with an injury severity score of less than 20 [18]. Therefore it seems that a formal structured training program may prevent severe hand injuries from occurring.

There seems to be no consensus in the literature as to whether work experience alone may put someone at risk for an occupational hand injury. Garg et al.,(2012) showed that 58% of all

workers with hand injuries in Hong Kong had less than one year of work experience, whereas in China it was found that the mean work experience of injured patients was approximately three years [17, 26]. In fact Sorock et al.,(2004) demonstrated that a worker in America was almost twice as likely to get injured if they had three years of experience compared to one year [27].

Our study showed that the median job tenure was four years, with a range of between one month and 31 years. Work experience may provide workers with knowledge of potential hazards as well as familiarity with the machine or tool which they are required to use. However the cumulative risk of injury may also increase the longer a worker is exposed to a specific hazard.
The results showed that there was no significant difference in the mechanism of injury or the injury severity between those patients with more work experience versus those who had less work experience. This implies that work experience alone may not play such an important role in the incidence or the aetiology of occupational hand injuries.

More than 50% of the injured workers in this study had permanent employment, with a signed contract. The rest were either self-employed, contract workers or did 'piece' jobs. In South Africa it is mandatory for all permanent and casual employees to be registered as per the Compensation for Occupational injuries and Diseases Act (COIDA). If an employee is injured in an accident, resulting in a disablement or death, the employee or the dependents of the employee shall be entitled to the benefits prescribed in the act. This may include the cost of medical aid at a private health care facility and subsequent financial compensation. Often permanent employees and contract workers are not registered in terms of the COIDA or struggle to claim compensation following injury, or they are unaware that they are entitled to private health care. These patients then end up at state institutions such as CHBAH which shifts costs to workers and overburdens an already busy health care system. It also promotes an under-reporting of occupational injuries by employers and medical practitioners [30].

The economic burden of these injuries is substantial. The direct and indirect costs for a hand injury have been shown to be approximately $6000 [5, 31]. Direct costs include surgical

interventions, laboratory investigations, medications, outpatient visits and rehabilitation. Indirect costs include time away from work, loss of income, and compensation for injury fees. Indirect costs are generally far higher than the direct costs [5, 31].

To the author's knowledge there are no studies in South Africa which look at the percentage of injured workers who are not registered with the COIDA. It was beyond the scope of this study to determine which workers were registered and which were not; this is potentially an aim for a future study.

By ensuring that all formal employees and contract workers are registered with the COIDA, the burden of disease at such state institutions may be reduced.

How do occupational injuries occur?

There have been studies done outside of South Africa looking at the most common causes of occupational injuries. Throughout the literature the three most common causes are powered tools, powered machines and building material, therefore affecting construction workers, mechanics, carpenters and food handlers most frequently [11, 17, 24, 26, 32, 33].
The results of this study are in keeping with similar studies from around the world. In our study the most common cause was due to power tools (40%), most commonly the angle grinder.
Angle grinders are versatile tools which make them extremely popular. What commonly occurs is that the safety guard is removed from the grinder or a non-standard cutting or grinding disc is used to increase the versatility of the grinder. When these tools are altered or adjusted it increases the risk of them failing, which can lead to frequent and severe injuries.

Powered machines, especially the machine press and cutting machines such as the bandsaw contributed to almost 30% of the total hand injuries. When compared to injuries due to power tools, injuries resulting from a powered machine were most commonly not due to equipment malfunction, but most likely due to human error.

Similar studies from around the world have investigated the effects of transient risk factors which may lead to an injury of this nature. The most prevalent transient risk factors which have been described are the use of unfamiliar machinery or performing an unfamiliar task [18, 32].

Other significant transient risk factors include fatigue, alcohol use, smoking, rushing the task, distracted and feeling ill [18, 26, 32].

Regarding this study population, the vast majority (94%) were not performing an unusual task at the time of injury or using an unfamiliar machine, meaning that they were performing a routine task at the time of injury. This implies that other transient risk factors such as those described above may have been the cause of the injuries. Chau et al.,(2004) reviewed 880 injured workers and found that 12% had poor vision, almost 30% had some form of sleeping disorder or regularly consumed sleeping pills and more than 43% consumed alcohol every day [28]. Therefore one can assume that that the risk factors associated with these types of injuries produce a mechanical or physically unsafe environment which predisposes to injury.

In South Africa, the Department of Labour has stipulated that it is mandatory for all employers to provide and maintain a working environment that is safe and without risk to the health of the employees, this includes providing appropriate safety equipment [34].

In our study only 60% of the workers were provided with some form of protective equipment by their employers. This figure includes any form of protection such as headgear, eye protection, protective clothing or boots. Strangely, even though more than half of the workers were offered protective equipment, protective gloves were seldomly included. Only 28% of all the injured workers were using protective gloves at the time of injury. In previous studies it has been shown that wearing no or ill-fitting gloves is associated with an increased risk of an occupational hand injury, thus the use of protective gloves may also decrease the risk of injury [18, 32].

Of the 21 workers who were provided with protective equipment, only two chose not to use the equipment. This shows that the compliance with using provided protective equipment is

high. Therefore, it can be assumed that if gloves were provided to these workers, the chances are good that they would be used and possibly prevent injuries from occurring.

Injury Characteristics

Although the overwhelming majority of patients in this study were right hand dominant, there was a fairly equal distribution between right and left hand injuries. No patients sustained injuries to both hands. These results are in keeping with results of similar studies from around the world [5, 11, 17, 18, 28, 32].

For more than 90% of the patients this was their first work-related hand injury in the past year. This is in keeping with the expected annual incidence of between 4% and 11% [35]. Recurrent injuries within one year may be unlikely because hand injuries can result in significant time off work and often lead to a forced change in occupation or permanent disability, therefore decreasing the chances of a subsequent injury occurring [5, 36].

Ahmed et al.,(2010) showed that 19% of injured hands had a significant loss of function despite adequate rehabilitation [36]. Trybes et al.,(2005) found that approximately 10% of patients never returned to their original occupation, either due to permanent disability or due to a change in occupation [5]. In the same study he also found that 58,5% of all hand injuries had residual functional impairment despite adequate rehabilitation.

Lacerations, crush injuries and fractures were the most common types of injuries documented. Most patients had a combination of a laceration and a fracture resulting in an open fracture, which may lead to increased risk of infection as well as complications in wound healing. These injury patterns are in keeping with the most common source of injury (power tool, powered machine) which result in a relatively high energy injury.

Power tools, such as angle grinders, have more than one mechanism of injury. They cause cutting of flesh and bone because of the sharp, abrasive rotating blade, and a simultaneous crushing and tearing effect. Powered machines can result in combination type injuries due to a rotating and crushing mechanism.

The crush injuries that were documented were predominantly of the distal phalanx resulting in a nail bed injury or associated fracture.

Injury Severity

There was a fairly equal distribution between the different categories of injury severity using the HISS system. Similar studies have reported vastly different distributions of the HISS score, this is predominantly due to where their subjects were recruited from. Predominantly minor and moderate severity scores were reported when patients were recruited from either primary care or outpatient clinics. Tertiary and quaternary care institutions reported more severe injuries [18, 24, 36, 37].

The Emergency Department at CHBAH accepts both walk-ins and referrals from level 1 and level 2 referral centers, it also has a dedicated hand unit with a 24 hour re-implantation team on standby. Therefore, it acts as both a primary care and tertiary/quaternary institute. The diverse injury severity scores in this study are therefore likely to be more representative of the population in general.

The mean HISS score and the overall range were higher than that reported in the original study by Campbell and Kay (1996) despite a very similar study population in terms of overall patient number, age, gender and handedness. This may be due to other variables such as the nature of the work carried out at the time of injury or the source of injury [13].

The highest average injury severity score occurred in the patient group with a level of education between grade 11 and 12 (HISS = 73), the lowest average severity score occurred in the group who had achieved a higher education (HISS = 31).

The average HISS score for patients wearing protective gloves was 50. The average HISS for patients not wearing protective gloves was 49, therefore there was no difference in injury

severity between the glove wearing and the non-glove wearing patients. This does not allow for what the severity of the injury may have been had the patient not been wearing gloves at the time of injury.

The males in this study population sustained more severe injuries than the females. The average injury severity score for males was 53,2 (severe). The average injury severity score for females was 24,8 (moderate). This was in keeping with the fact that the males were more likely to be employed as manual labourers or work with an angle grinder.

In the literature, there is a statistically significant correlation between the HISS and the resultant time off work and ability to return to the original occupation. Patients with a minor or moderate injury, which constituted more than 60% of our study population, are likely to be off work for between four and 18 weeks, but are highly likely to return to their original job. Patients with a severe or major injury were likely to be off work for between 17 and 33 weeks, but less than 60% will return to their original job [16, 37, 38]. However return to work is a multifaceted phenomenon which should take into account the age of the patient, the socioeconomic situation, and the skill level of the job that needs to be performed. Hand strength is a key component in the ability to return to a physical occupation. Lin et al.,(2011) showed that the HISS system could be an adequate predictor of post-injury hand strength, with more severe injuries resulting in a lower post-injury hand strength [15].

Chapter 5 - Conclusion and Recommendations

Conclusion

The typical patient who presents to CHBAH with an acute traumatic occupational hand injury is a young male, who is poorly educated, with a low income and multiple dependents. This patient is poorly trained for the type of work he is required to do and often he is not provided with protective gloves. These patients typically injure their index, middle and ring finger using either a power tool, powered machine or by handling building material.

The occupational categories which present the highest risk of injury include construction work, general manual labour, carpentry and working as a mechanic.

The injuries sustained are most commonly lacerations, fractures and crush injuries, but may also include tendon and nerve injuries as well as amputations.

The highest percentage of injuries were of moderate severity, followed by minor, severe and then major.

Recommendations

Due to the high rate of occupational related hand injuries in this South African population, occupational health and safety must be improved to reduce the socio-economic burden of these injuries. Novel ways of improving safety in the informal labour market are required.

It is recommended that in order to reduce the incidence of acute traumatic occupational hand injury, employer and employee awareness regarding the causes and risk factors for these injures should be improved.

To improve the protection of employees from injury, mandatory occupation-specific safety training should be implemented and sufficient safety equipment, most specifically protective gloves, should be provided.

Power tools and powered machines should be regularly serviced and should be in proper working order to ensure that they do not malfunction and result in injury.

Workers should also be registered for compensation in the event of an occupational injury or illness. This process should also be made more transparent and user friendly so that it is easier for injured workers to claim compensation.

Appendices

Appendix A

PARTICIPANT INFORMATION DOCUMENT

The aetiology of acute traumatic occupational hand injuries at Chris Hani Baragwanath Academic Hospital

Dear Patient,
We are inviting you to take part in a research study currently being done at Chris Hani Baragwanath Academic Hospital.
We are doing research on injuries to the hand or wrist area that have occurred at work. Research is a way of finding out an answer to a question. In this study we want to learn what happened when you injured your hand at work, why it happened and what could have been done to prevent the injury from happening.

What is involved in the study?
Participants who agree to be involved in this study will need to answer questions about themselves such as age, marital status, number of children etc. as well as questions about their current job and what happened when the participant injured themselves. this information will be completely anonymous, which means that we will not write down your name or date of birth so your answers cannot be linked back to you. All efforts will be made to keep personal information confidential
It will not take more than 30 minutes to answer all the questions and you will not be asked to answer them more than once.

We, the researchers, also request to read your hospital notes which the doctors have written and look at hospital X-rays of your hands. We also ask to examine the injuries on your hand when the dressings are being changed.

There will not be any payment for being in the study and there are no risks involved.

The results of the study will be made available at the participants request.

Participation is voluntary. Should you refuse to participate or discontinue participation at anytime there will be no penalty or loss of benefits.

Contact details of researcher: **Dr. A Stewart**
0824485953
stwand010@gmail.com
1225881@students.wits.ac.za

Appendix B

Informed Consent

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Print Name of Participant_____

Signature of Participant _____

Date _____

Day/month/year

<u>If illiterate:</u>

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness_____

Signature of witness _____

Thumb print of participant

Date _____

Day/month/year

Statement by the researcher/person taking consent:

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands what is entailed in the research.
I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this Informed Consent Form has been provided to the participant.

Name of Researcher/person taking the consent_____

Signature of Researcher /person taking the consent_____

Date _____

Day/month/year

Appendix C

Questionnaire

Participant ID _____

Participant Number _____

Age of participant _____

Gender
◯ Male
◯ Female

Are you right or left handed? Or ambidextrous?
◯ Right
◯ Left
◯ Ambidextrous

What is your highest level of education?
◯ grade 8 or less
◯ grade 9 - 10
◯ grade 11 - 12
◯ Higher education

Specific higher education.
☐ Diploma
☐ University Degree
☐ Artisan Training institute
☐ Apprenticeship

What is your marriage Status?
◯ Married
◯ Unmarried
◯ Divorced / separated
◯ Widowed
◯ Living with partner

How many dependants do you have? _____

Are you the primary 'breadwinner'?
◯ Yes
◯ No

What is your average annual income?
◯ < 20 000
◯ 20 000 - 40 000
◯ 40 000 - 100 000
◯ >100 000

What type of employment do you have?
◯ Self employed
◯ Piece Job
◯ Formal employment with a contract and salary
◯ Contract worker

Which category fits your current occupation?
◯ Machinery operator or assembly
◯ Construction
◯ Packaging
◯ Carpentry
◯ Agriculture / Fishery
◯ Mining
◯ Butchery
◯ Security / Police
◯ Other

Other occupational category _____

Source of injury
☐ Hand Tool (hammer, chisel, spanner, blade)
☐ Power tool (angle grinder, bandsaw, circular saw)
☐ Parts and Materials (bricks, glass, concrete)
☐ Powered Machine (Presses, slicers, harvesters)
☐ Chemicals and chemical products
☐ Vehicle
☐ Other

Other source _____

How long have you been working at your current job? _____
(Months)

Did you receive formal occupational specific training? ◯ Yes
◯ No

What was the duration of the training? _____
(Days / weeks / months)

Were you performing an unusual task when you were injured? ◯ Yes
◯ No

Were you provided with personal protective equipment? ◯ Yes
◯ No

Were you using the protective equipment? ◯ Yes
◯ No

Were you wearing gloves? ◯ Yes
◯ No

Have you injured your hand in the past year? ◯ Yes
◯ No

Injury characteristic ☐ Laceration
☐ Crush
☐ Avulsion
☐ Puncture
☐ Fracture
☐ Contusion
☐ Mangled Extremity
☐ Dislocation
☐ Tendon Injury
☐ Nerve Injury

Amputation ☐ Thumb
☐ Index Finger
☐ Middle Finger
☐ Ring Finger
☐ Little finger
☐ Whole / part of hand

MESS Score _____

Which hand was injured? ◯ Right
◯ Left
◯ Both

Part of hand injured ☐ Thumb
☐ Index Finger
☐ Middle Finger
☐ Ring Finger
☐ Little finger
☐ Palm
☐ Dorsum
☐ Forearm

Hand Injury Severity Score _____
(Calculated by researcher)

Appendix D

Hand Injury Severity Scoring Chart

Integument				Score
Skin Loss	Absolute values (hand)	Dorsum	<1cm2 >1cm2 >5cm2	5 10 20
		Palm	<1cm2 >1cm2 >5cm2	10 20 40
	Weighted Values (fingers)	Dorsum	<1cm2 >1cm2	2 3
		Finger pad	<25% >25%	3 5
Skin cut			<1cm >1cm	1 2
Fingernail damage				1

Bone		Score
Fractures	Simple shaft fracture Comminuted shaft fracture Transarticular fracture involving DIP joint Transarticular fracture involving PIP/IP joint Transarticular fracture involving MCP joint	1 2 3 5 4
Dislocation	Open Closed	4 2
Tendon Injury	Strain Rupture	2 3

Motor		Score
Extensors	Proximal to PIP joint Distal to PIP joint	1 3
Flexor profundus	Zone 1 Zone 2 Zone 3	6 6 5
Flexor superficialis		5
Intrinsics		2

Neural		Score
Absolute Values	Recurrent branch of median nerve Deep branch of radial nerve	30 30
Weighted values	Digital nerve x 1 Digital nerve x 2	3 4

	Integument	Skeletal	Motor	Neurological	Total
Thumb					x 6 =
Index					x 2 =
Middle					x 3 =
Ring					x 3 =
Little					x 2 =
			Final severity score		

Appendix E

Human Research Ethics Committee (Medical)

Research Office Secretariat: Senate House Room SH 11004, 10th floor, Tel +27 (0)11-717-1252
Medical School Secretariat: Philip Tobias Building, 2nd Floor, Tel +27 (0)11-717-2700
Private Bag X, Wits 2050, www.wits.ac.za. Fax +27 (0)11-717-1235

05 June 2015

To Whom It May Concern

SUBJECT: CONFIRMATION OF STUDY APPROVAL

Protocol Ref No: M150423

Protocol Title: The Epidemiology of Acute Traumatic Occupational Hand Injuries Seen at Chris Hani Baragwanath Academic Hospital

Principal Investigator: Dr Andrew Stewart

Department: Orthopaedic Surgery

This letter serves to confirm that the Human Research Ethics Committee (Medical) has approved the above mentioned study. In order for a clearance certificate to be issued, the researcher is required to submit written approval to conduct the study in your district/institution.

Should you have any queries, you may contact me at tel 011 717 1252/1234/2700 or by email Zanele.ndlovu@wits.ac.za.

Yours Faithfully,

Ms Zanele Ndlovu
Administrative Officer
Human Research Ethics Committee (Medical)

UNIVERSITY OF THE WITWATERSRAND
OFFICE OF THE DEPUTY VICE CHANCELLOR RESEARCH
01 JUN 2015
RESEARCH OFFICE HREC (Medical)
JOHANNESBURG

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