Antegrade vs Retrograde nailing for humeral shaft fractures. A clinical audit

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Declaration

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

Signed: 

Date: 28/07/22

Dedication

This research report is dedicated to my wife and children. Thank you for your patience.

Abstract

Study design: This is a retrospective review of patient data.

Objectives:

Primarily to analyse the demographics of all humeral nails done at our centre

Secondarily to determine if there is any association between:

Mode of injury

Classification

Choice of fixation

Background: Humeral nails are a routine procedure done at the Helen Joseph Hospital.

The choice between fixation options is often influenced by surgeon experience.

Methods: Thirty-one patient folders and x-rays were reviewed retrospectively spanning a period of two years (2014-2016). The information collected included age, gender, classification, mechanism of injury and choice of fixation. The data were then entered on to an excel spread sheet and analysed using Stata software. Numbers and correlations were then noted.

Results: Of the thirty-one patients included in the study, twenty-one patients were males and 10 were females. The youngest patient was 21 years and the eldest was 45 years. The mean age was 34.5 years with a range of 21 – 45 years. Five open fractures were noted in the clinical notes. Two were graded Gustillo Anderson type 1 with the three gunshots each being graded Gustillo Anderson type 3B. The most common mechanism of injury observed was between falls and assault. The most common fracture pattern seen was the AO A2 subtype (simple oblique). The association between the mechanism of injury and classification was statistically significant ($p = 0.017$). There was no correlation between fracture classification and choice of fixation, ($p = 0.569$).

Conclusion: Both antegrade and retrograde humeral nail techniques are effective ways of managing humerus shaft fractures. Antegrade nails by far outnumber retrograde nails possibly based on surgeon experience and potential complications.

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Table of Contents

List of Figures

List of Tables

Nomenclature

AO – Arbeitsgemeinschaft fur Osteosynthesefragen (Association of the study of internal fixation)

GSW - Gunshot wound

HJH - Helen Joseph Hospital

MVA - Motor Vehicle Accident

ORIF - Open reduction and internal fixation

PACS - Picture archiving and communication system

PVA - Pedestrian vehicle accident

WITS – University of the Witwatersrand

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 ANATOMY

Intramedullary nailing of long bones in general is a skill that every orthopaedic surgeon should have in their armamentarium. It is a technique that is undoubtedly a work horse as far as managing long bone fractures such as femur shaft and tibia shaft fractures in our units is concerned. Nailing of the humeral shaft goes without saying. The Humeral shaft is defined as the interval extending distally between the proximal border of Pectoralis major insertion to the supra-condylar ridge.[1] Proximally it is cylindrical in cross section and the medullary canal tapers to an end towards the supra-condylar expansion.[1] The shaft also provides origin and attachment points for a number of muscles including, pectoralis major, coracobrachialis, deltoid, biceps, brachialis, and triceps.[2] Figure 1.1 below shows the humeral shaft and its divisions into three surfaces.

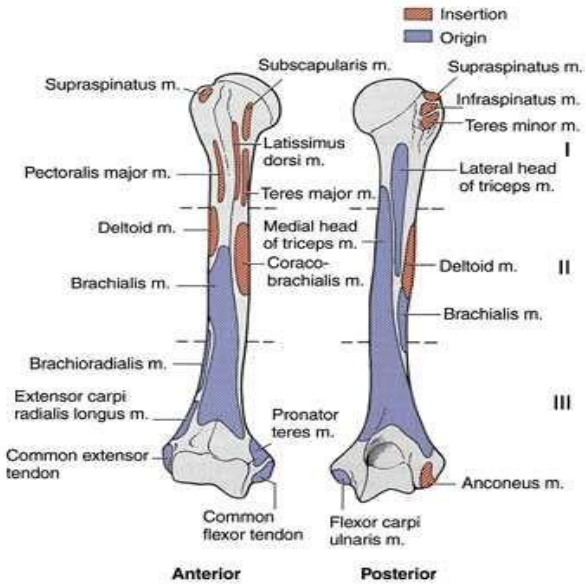


Figure 1.1. The shaft of the humerus showing the division into three surfaces (Browner BD, Jupiter JB, Levine AM, Trafton PG (eds): *Skeletal Trauma, ed 2.* Philadelphia, PA, WB Saunders Company, 2002, p 1524).

1.2 EPIDEMIOLOGY

Fractures in this area represent between 3 % – 5% of all fractures. They display a bi-modal distribution with the peak incidence occurring in elderly females aged between 60 and 80 secondary to falls.[1,2] This is followed by a high incidence in young males aged between 25 and 35 years and is usually secondary to high-energy trauma e.g. contact sports, and motor vehicle accidents.[2]

1.3 CLASSIFICATION

There are a number of classification systems available for humeral shaft fractures. The descriptive classification denotes each fracture pattern according to 1 - Fracture location (proximal, middle, distal) and 2 - Fracture pattern (Spiral, transverse, comminuted).[3] The more commonly used and universally accepted classification is the AO classification system as shown in Figure 1.2. This is a numerical based system that divides all fractures in the body into: 1. Bone number, 2. Fracture location and 3. Fracture pattern (A-simple, B-wedge, C- complex).[3]

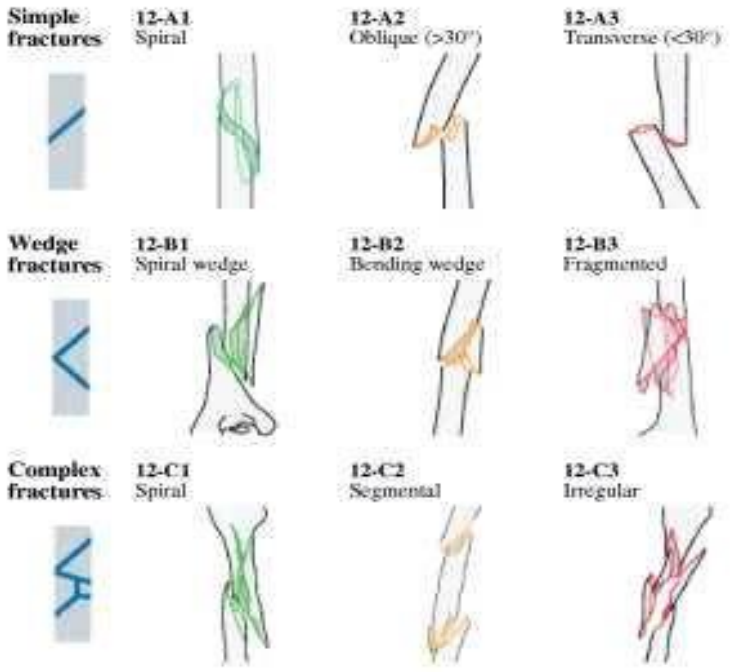


Figure 1.2. AO-Classification of humerus shaft fractures according to Muller et al. [21]

1.4 MANAGEMENT

A large majority of these fractures will heal with appropriate conservative care. Acceptable radiographic parameters for conservative care are, 30 degrees of angulation in the coronal

plane, 20 degrees of angulation in the sagittal plane and up to 3cm of shortening.[3,4] In our unit at The Helen Joseph Hospital (HJH), conservative management involves the immobilisation in a coaptation splint or "U-slab" in the casualty setting. Immediate post immobilisation x-rays are done and if in accordance with the above-mentioned radiological parameters, the patient is discharged to follow up in a week's - time for control x-rays to ensure that adequate alignment has been maintained. Patients are typically immobilised for a period of eight to twelve weeks at which time fracture union in most cases should have occurred. This is then followed by a period of physiotherapy tailored to the specific need of each patient. The minimal effect from minor shortening and the wide range of radiographic mal-union as a rule, are generally acceptable with little or no residual functional deficit.[4] This being said, adequate immobilisation of humeral fractures can be quite difficult, particularly in elderly and obese patients. Conservative treatment is long and laborious for the patient and can result in stiffness of neighbouring joints.

There are certain situations where surgical management is indicated. These instances include:

Poly-trauma patient - (This is any patient subjected to two or more injuries to organ systems that may be life threatening)[3]

Open fractures - (In accordance with the Gustillo-Anderson classification of open fractures- Typically Grade II -III)[3]

Vascular injury - (Any fractures associated with vascular injury especially to the brachial artery that may need surgical repair)[3]

Ipsi-lateral and contra-lateral upper / lower limb fractures (Associated upper and lower limb fractures to the same or opposite sides)[3]

Floating shoulder /elbow injuries (These are injuries involving not only the humerus shaft but shoulder girdle as well)[3]

Failed nonsurgical management (Non- union – Any fractures that fail to heal within the expected time to union – > 8- 12 weeks)[3]

1.5 ADVANTAGES OF SURGICAL FIXATION

The advantages of surgical management include providing a rigid fixation allowing for early range of motion for both the shoulder and the elbow.[4,5] Other advantages include the fact that the angular deformity that commonly occurs with bracing can be effectively prevented with surgical alignment.[5] Patients also have an added advantage in that personal hygiene (cleaning of axillae) can be attended to with ease, comfort with regards to sleeping/dressing is allowed and generally, basic activities of daily living can be performed as tolerated without the hindrance of a cumbersome brace.

1.6 SURGICAL FIXATION OPTIONS FOR HUMERAL SHAFT FRACTURES

Fixation options for humeral shaft fractures are quite broad and no single implant has been shown to be superior to the other.[6] The options available include:

1.6.1 External fixation

This involves spanning the fracture site with a combination of pins and rods. Staged external fixation is indicated with severe soft-tissue injury, bone defects, vascular injury with acute repair, the medically unstable patient, and infected non-unions. This is typically a temporary measure until either the injured soft tissues have had ample time to regenerate or the patients' physiology has improved to a state where open reduction and internal fixation with a plate and screw construct or an intramedullary nail can be used as a definitive means of treatment.

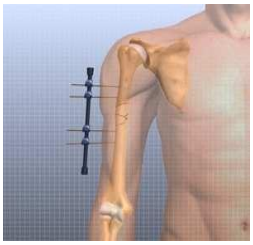


Figure 1.3. An external fixator of the humerus. <http://medicalmultimediagroup.com> - Image accessed March 2015. [22]

1.6.2 ORIF (Open reduction and internal fixation)

By and large this is the most common surgical treatment of humeral shaft fractures.[6,7] Plate and screw constructs offer union rates ≥94%, with low infection rates (0% to 6%), low

incidence of iatrogenic nerve injury (0% to 5%), and the ability for the multiply injured patient to weight bear through the injured extremity.[7]

Figure 1.4. Open reduction internal fixation of the humerus. .<http://aaos.org> - Image accessed March 2015.[23]

1.6.3 Intra-medullary Nailing (Antegrade and Retrograde)

This technique is typically indicated in the medically unstable patient to avoid a large exposure, with segmental fractures, with the multiply injured patient to limit positioning changes, and with pathologic fractures.[6] Compared to plating, intramedullary nailing has not shown a higher incidence of malunion or nonunion.[7]

Figure 1.5. Antegrade and retrograde nailing techniques of the humerus.[24]

1.7 PROS AND CONS OF ANTEGRADE APPROACH

Most rigid humeral nails are inserted using the Ante-grade approach.[1,8] This method is theoretically much easier to perform than the retrograde approach and is thus more popular with most surgeons. Patient positioning and ease of entry into the humerus all support this

theory. The main position used most commonly is the so called "beach chair" position.[7] This position affords the anaesthetist easier access to the patients' airway throughout the procedure, however at times this may be obstructed due to draping. The major complication during "beach chair" positioning is cerebral hypo-perfusion secondary to hypotension. This often necessitates an invasive method of monitoring blood pressure.[17] This is commonly done through an arterial line placed in the wrist.

With regard to the surgery itself, land marks for the entry point can be easily accessed through a proximal incision on the shoulder. The major pitfall to this approach is having to violate the rotator cuff during entry.[9] This coupled with prominent nails have been shown to significantly limit shoulder functional recovery.[9] Cheng et al. showed patients who had antegrade nails took on average 8 to 10 months to achieve final functional shoulder recovery.[6]

With regard to patient satisfaction the main complaint from patients following antegrade humeral nailing is shoulder pain.[8] Shoulder pain has been reported after ante grade intramedullary nailing in 16% to 37% of patients in more recent studies, and Dietz et al. found that reoperation and shoulder impingement were significantly more common after intramedullary nailing than after plate fixation.[8] Over judicious dissection, poor repair of rotator cuff and direct pressure from prominent nails may result in devastating shoulder functional impairment.[8.9] Rotator cuff injury occurring during antegrade nail insertion may result in postoperative restrictions during abduction and elevation of the upper arm that delay rehabilitation significantly.

1.8 PROS AND CONS OF RETROGRADE APPROACH

The retrograde approach is a well described method of addressing humeral shaft fractures. This approach is however not favoured by most surgeons and is considered more technically demanding than the Ante-grade. Besides difficult patient positioning (Lateral decubitus / prone) the procedure carries the potential risk of elbow joint injury and intra-operative iatrogenic fracture especially at the insertion point.[10,11] Nails are inserted in a retrograde fashion with the entry point being at the level of the olecranon fossa. Poor nail trajectory can easily result in fracturing of the posterior aspect of the distal humerus. [10,11,12] Moreover, despite the fact that these particular positions are favourable in terms of entry point for the

surgeon, in some studies the prone position especially has been shown to decrease cardiac output.[17] Quick and access to the patients' airway can be limited especially during an emergency resuscitation.

With regards to the lateral decubitus position Knight showed that perfusion is greatest in the dependent lung with ventilation greatest in the non-dependent lung resulting in V-Q mismatch.[17] This could lead to hypoxia in patients with already compromised lungs.[17]

Surgically the entry point for the retrograde approach is quoted as having a steep learning curve.[11,12,15] Males typically have a larger canal diameter compared to females. The harder cortical bone at that level and the trajectory of the insertion point combined with the canal size differences between males and female can potentially lead to iatrogenic fractures of the distal humerus as mentioned ealier.[12]

1.9 COMPARISON BETWEEN ANTEGRADE AND RETROGRADE APPROACHES

Cheng et al.'s prospective randomised study in 2008 found that most rigid humeral nails are inserted antegrade. Despite that, both antegrade and retrograde nailing can achieve equally good results for middle humeral shaft fractures, including how well they heal and eventual recovery with regard to function.[6] The majority of their patients were male with humeral shaft fractures secondary to motor cycle accidents. Falls accounted for 5% of the injuries. Biomechanical studies suggest that the Ante-grade approach is favoured for more proximal fractures and the retrograde approach for the more distal fractures.[6,7,16] Cheng demonstrated that increased fixation stability is achieved if the nail is inserted from the shorter to longer fragment.[16] They also found that retrograde humeral nailing had significantly longer surgical times due to the technicality of the procedure and careful selection of the approach used was based primarily on fracture configuration or pattern. The predominant fracture pattern noted was type A1.

Romens.et al however concluded that retrograde locked nailing appears to be a better solution for the stabilization of fractures of the humeral shaft than antegrade.[11] The study found that functional recovery of the elbow was quicker in retrograde nailing than functional recovery of the shoulder in antegrade nailing. They also concluded that retrograde humeral

nailing has more potentially devastating complications than antegrade and the procedure should be reserved for more senior experienced surgeons.[11] Less than half of their cases we retrograde humeral nails and the large majority of complications were noted to have occurred from the patients done by “less” experienced surgeons.[11]

Ekholm concluded that retrograde nails should be inserted for more distal humeral fractures whereas antegrade nailing should be reserved for proximal ones.[5] Complications stemming from the retrograde approach result in a significantly higher more morbidity rate. Most humeral nails are inserted using the antegrade approach due to ease of access. The majority of the study group consisted of elderly females from simple falls. Type A1 pattern formed the majority fracture type.

Prasad on the contrary to the above studies noted that humeral nails can be inserted with both antegrade and retrograde techniques regardless of the pattern of the fracture or its location.[19] Retrograde nailing however has a long learning curve and should be done very meticulously due to the risk of fracture.[19] This study had a relatively equal number of antegrade to retrograde nails done. Fifty-two to forty-eight percent respectively. Males were the majority accounting for seventy-two percent of the injuries whilst females accounted for twenty-eight percent.

CHAPTER 2: RESEARCH QUESTION

2.1 Background:

HJH is a tertiary level three institution located in Auckland Park Johannesburg and is an accredited teaching hospital for the University of the Witwatersrand (WITS). As far as the department of orthopaedics is concerned, it is considered our main upper limb unit. Being our primary upper limb unit, most humerus fractures simple or complex are managed at HJH and therefore we felt this was an ideal place to compare the two surgical approaches in order to determine if the choice of fixation is influenced by some of the pros and cons mentioned earlier. As this is one of the only units in our circuit that does retrograde humeral nailing this makes HJH an ideal place to conduct an audit in terms of having a favourable number of both antegrade and retrograde humeral nails.

2.2 Aim:

To conduct a clinical audit of all ante-grade and retrograde humeral nails done at HJH over a two year period. In an attempt to provide the frame work for a detailed comparative study at a later date between the two methods of fixation.

2.3 The objectives were:

1. To analyse the demographics of all humeral nails done at our center specifically looking at the frequency of each method.

2. To secondarily determine if there is any association between:

    - Mode of injury
    - Classification
    - Choice of fixation

2.4 Significance:

Ante-grade humeral nails are a routine procedure done at most WITS training hospitals. Retrograde humeral nail procedure are not commonly done as reflected in the literature referred to earlier and in our training hopsitals.[6.8.10.12] Humeral nailing especially the retrograde approach is more technically demanding and requires a rather long learning curve.[6] There appears to be a wide spread reservation against retrograde nailing due to its morbidity in terms of fracture formation around the entry hole.[10] The role of Ante-grade and retrograde nailing of humerus fractures in general is the subject of continuous debate amongst orthopaedic surgeons. As a registrar who has rotated in the circuit, we are on most occasions exposed to the ante-grade method. This study is a starting point in attempting to understand why this is so.

CHAPTER 3: STUDY DESIGN AND METHODOLOGY

Study Design and Methods

We performed a retrospective review of all humeral nails done at HJH between 1 January 2014 and 1 January 2016. This involved accessing patient hospital files and x-rays. Consent to proceed with the study at the chosen facility was granted by the Human Research Ethics Committee (Medical) (WITS) and the Helen Joseph Ethics and Research Committee (refer to Appendix A1 and A2, respectively). Access to hospital files and x-rays was granted by the hospital super-intendant. All humeral nails done during that time period were logged in the orthopaedic theatre surgical register. The patient files were then accessed from the records department. Data collected from the files included age, gender, mechanism of injury and procedure done. Patient x-rays were analysed on the Picture Archiving and Communication System (PACS). Those that were not available on the PACS were analysed from films retrieved from archives. Only the initial admission or pre-operative x-rays were analysed and the fractures were classified according to the AO- classification system.
Fracture patterns were sub-grouped as being Simple, Wedge or complex.

Inclusion criteria:

- Patients > 18 years – 65years old
- Humeral shaft fractures in accordance to the AO Classification

Exclusion criteria

- Patients with concomitant humeral shaft and head fractures
- Patients with concomitant humeral shaft and supracondylar elbow fractures
- Fractures of a pathologic nature e.g. Tumours

CHAPTER 4: RESULTS

A total of 59 humeral nails were done over 1 January 2014 to 1 January 2016. A total of 31 patient files were retrieved (28 patient folders were not retrievable and were therefore excluded from the study). Data were collected using *Microsoft excel* and analysed using *Stata* software. A *Chi-squared test* was used to determine if there was any association

between the mechanism of injury and classification and between classification and the choice of fixation. Our null hypothesis aimed to show that there was no association between mechanism of injury and classification and no association between classification and choice of fixation.

4.1 Demographics

Thirty-one patients in total were logged in our study of which 21 were males and 10 females. The youngest patient was 21 years of age and the eldest 45 years of age. Our mean age was 34.5 years old with a range of 21. On average the large majority of patients came from the 30-39 years old age group. The most common mechanism of injury observed was between a fall (N=9) and assault (N=9). Falls ranged from minor falls during walking to falls sustained during sporting activities. e.g. (soccer/rugby). Fall injuries were grouped together under the umbrella term of "falling on an out stretched hand".

The most common fracture pattern seen was the AO A2 subtype (simple oblique). Of the 31 patients included in the study, nine presented with this fracture pattern. Twenty-seven (27) ante-grade and four (4) retrograde nails were noted. Of the four (4) retrograde nails done, three of them were done in male patients whereas only one was done in a female patient. There was no association between the classification and the choice of fixation ($p = 0.569$). In contrast there was an association between mechanism of injury and classification ($p = 0.017$). Five fractures in total were open fractures of which two were graded Gustillo Anderson type 1 and three resulting from gunshots were graded as Gustillo Anderson type 3B. The Gustillo Anderson grading system used is shown in Table B.1 (Appendix B).

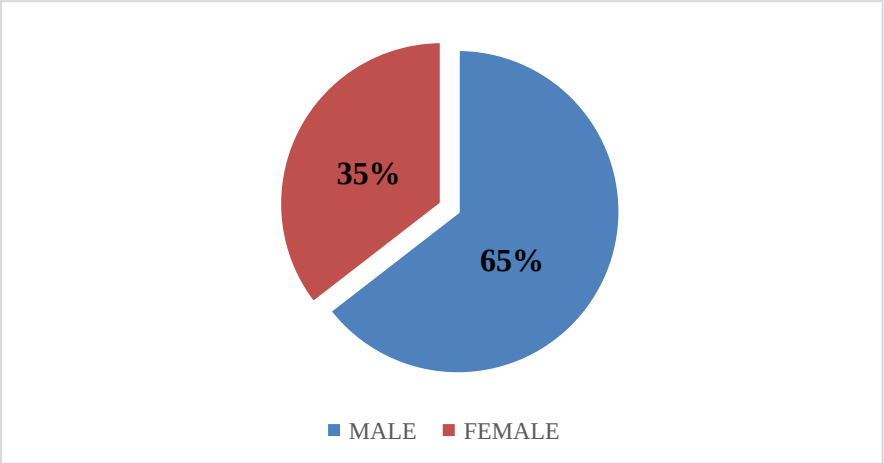


Figure 4.1. A pie chart showing the percentage of male (blue) and female (red) patients included in the study (N = 31).

Table 4.1. Frequency and percentage of broad group of fracture patterns.

FRACTURE PATTERN	FREQUENCY	PERCENTAGE
SIMPLE	18	58.06
WEDGE	7	22.58
COMPLEX	6	19.35

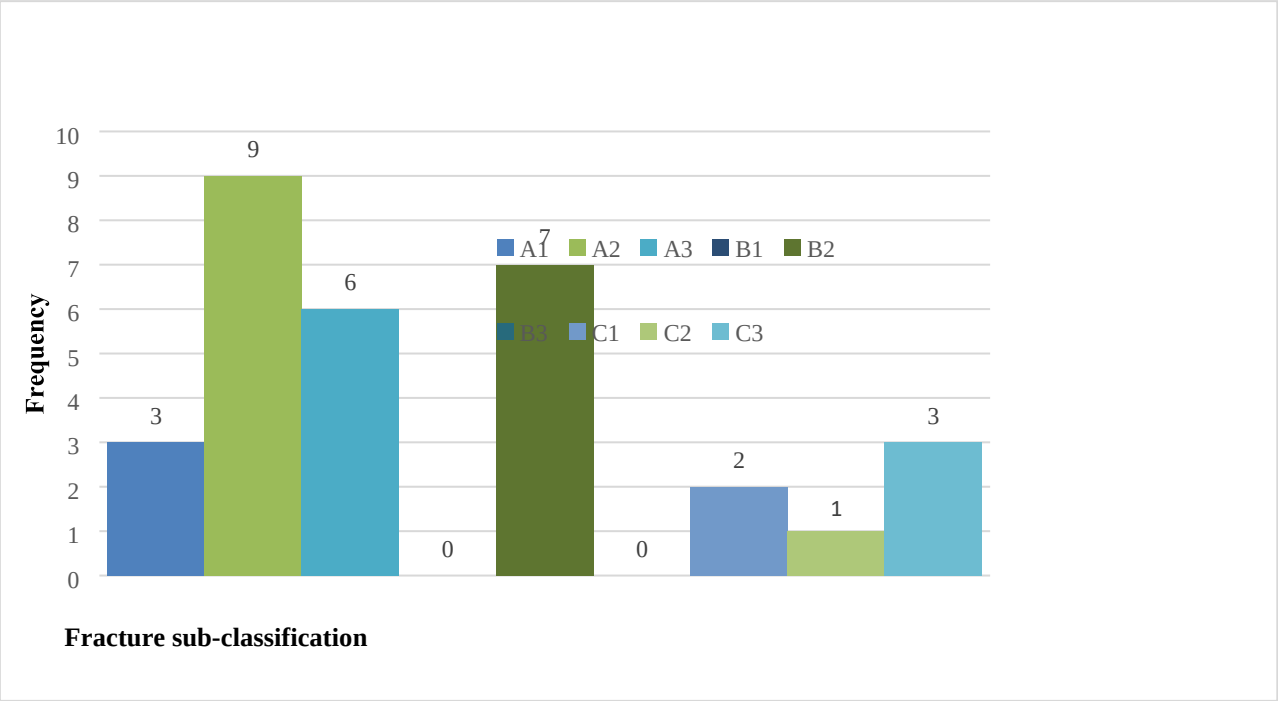


Figure 4.2. A histogram showing fracture sub-classification frequency. Subtype AO A2 accounted for 29% of all fracture subtypes. No A0: A3 OR B3 subtypes were reported.

Table 4.2. The frequency and percentage of mechanism of injury. Assault and Falls accounted for the majority of numbers.

MECHANISM	FREQUENCY	PERCENT
ASSAULT	9	29.03
FALL	9	29.03
GSW	3	9.68
MVA	4	12.90
PVA	6	19.35
TOTAL	**31**	**100.00**

Table 4.3. The association between the mechanism of injury and classification. The majority of fractures were simple fractures that rose from assault whereas gun shots accounted for the majority of all complex fracture patterns.

	CLASSIFICATION			P = 0.017
MECHANISM	**COMPLEX**	**SIMPLE**	**WEDGE**	**Total**
ASSAULT				
Frequency	0	6	3	9
Row percentage	0.00	66.67	33.33	100.00
FALL				
Frequency	2	4	3	9
Row percentage	22.22	44.44	33.33	100.00
GSW				
Frequency	3	0	0	3
Row percentage	100.00	0.00	0.00	100.00
MVA				
Frequency	0	3	1	4
Row percentage	0.00	75.00	25.00	100.00
PVA				
Frequency	1	5	0	6
Row percentage	16.67	83.33	0.00	100.00
Total				
Frequency	16	18	7	31
Row percentage	19.35	58.06	22.58	100.00

Table 4.4. The association between fracture classification and choice of fixation – there was no association between the fracture pattern and the choice of fixation.

	FIXATION		P = 0.569
CLASSIFICATION	**ANTEROGRADE**	**RETROGRADE**	**Total**
COMPLEX			
Frequency	6	0	6
Row percentage	100.00	0.00	100.00
SIMPLE			
Frequency	15	3	18
Row percentage	83.33	16.67	100.00
WEDGE			
Frequency	6	1	7
Row percentage	85.71	14.29	100
Total			
Frequency	27	4	31
Row percentage	87.10	12.90	100

CHAPTER 5: DISCUSSION

Intramedullary nailing is a proven and effective way of managing humerus shaft fractures. Both the antegrade and retrograde techniques have been shown to achieve equally good treatment results especially for middle shaft fractures.[6,15]

Although our sample size of 31 patients was quite small, our theatre records showed a total number of 59 humeral nails were done over the two-year period (average of 29.5 per annum). The number of humeral nails done in our study is approximately half the number done by Li et al. as the authors showed a total number of 106 humeral nails done over a period of seven years (1999-2006) (average of 15 humeral nails per annum).[15] Furthermore, Bencic et al. averaged 21.3 nails per annum from 2003-2014.[18] Our total number of cases done over a two-year period by far outnumber the cases done in the aforementioned studies. Our record

keeping or the problems associated thereof may account for the smaller sample size in our study.

In our study population the use of antegrade nails for fixation by far outnumbered the use of retrograde. Of the 31 patients included in the study, only four (4) retrograde nails were done. Three of them in males and one females. This could be due to the influence of the technical difficulties often experienced when retrograde nails are used. These technical difficulties involve both the surgical and the anaesthetic aspects of the procedure and can result in a number of complications for the patient.

The aforementioned, when combined with surgical experience may influence the decision taken when choosing the method of fixation to be used with most surgeons opting for the lesser complication of shoulder pain rather than the patient having an iatrogenic fracture.

In terms of fracture pattern, the most common pattern noted was the Type A (Simple) group. The subtype AO A2 (simple oblique) was the most common pattern in this group followed by subtypes AO A3 (simple transverse) and AO A1 (simple spiral). Type A accounted collectively for 58.1% of all the fracture patterns. This was followed by type B and C, respectively. The fracture pattern findings are in keeping and show a direct correlation to our mechanism of injury. Assault and falls were the main mechanism of injury as previously stated. These simple mechanism of injury are typically associated with a simpler fracture pattern. The more severe GSW, PVA and MVA mechanisms are typically higher energy and are associated with more complex injury patterns. Ekholm et al. in 2006 showed in their cohort of 361 fractures, type A fractures accounted for 61% of the total.[4] Type AO A2 was also the predominant subtype but this was followed by AO A1 and lastly AO A3.[4]

The literature mentions that the mechanism of injury has a bimodal distribution pattern between older females and younger males.[2] Typically, injuries with low energy mechanisms tend to occur in older females whereas the higher energy injuries tend to occur in younger males.[1,2] Our audit showed that males by far outnumbered females by a ratio of 2:1. This ratio coupled with assault (one of the highest mechanisms of injury), might explain the higher number of injuries in males as they are typically involved in more violent acts than females. Of the nine assault victims included in the study, six of them were male.

When investigating if there was any association between fracture type and choice of fixation, the results showed a negative association ($p = 0.569$). Prasad noted that humeral nails can be inserted with both antegrade and retrograde techniques regardless of the pattern of the fracture or its location.[19] HJH being a training unit, most registrars would more than likely opt for the simpler antegrade approach rather than the retrograde regardless of the fracture morphology. Lin et al. suggested that the antegrade approach is the preferred choice of fixation of proximal fractures whereas the retrograde approach is preferred for the fixation of more distal fractures. Furthermore, they demonstrated the biomechanical benefit offered by each approach.[16] In a study by Bencic et al., the authors recommended that comminuted fractures of the upper and lower parts of the humerus be treated using the antegrade and retrograde approaches respectively.[18] They concluded that fracture type dictated the choice of nail used. Our data suggests that the surgeons' decision of whether to use the antegrade or retrograde approach may be influenced by surgical experience and preference.

When investigating if there was any association between mechanism of injury and classification, the results showed a positive association ($p = 0.017$). Simple fractures were the predominant fracture pattern resulting from various mechanisms of injury with the exception of Gun shots which accounted for the majority of all complex fracture patterns.

A major limitation in this study was the difficulty experienced when accessing patient folders and X-rays. This limited the study sample size.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

Both antegrade and retrograde humeral nails are effective for the management of humerus shaft fractures. Antegrade nails was the predominant approach used in this study. The potential complications associated with the use of retrograde nails may influence the chosen approach. With proper patient selection, the use of the correct approach for the fixation of each specific fracture pattern is beneficial to the patient.

Recommendations

We suggest implementing a prospective randomised study to compare the complications and long-term outcomes in patients treated with the antegrade and retrograde approaches.

REFERENCES

1. Rockwood C, Green D, Bucholz R. Fractures in adults. Philadelphia: Lippincott 7th Edition. Volume 1:999-1038

2. Liporace F. Fractures of the humeral shaft and distal humerus. American Academy Of Orthopaedic surgeons. 2013 Volume 2:52:1-15

3. Carroll E, Schweppe M, Langfitt M, Miller A, Halvorson J. Management of humeral shaft fractures. J Am Acad Orthop Surg 2012;20:423-433

4. Ekholm R. Adami J, Tidermark J, Hansson K, Tornkvist H, Ponzer S. Fractures of the shaft of the humerus. JBJS 2006;88:1469-1473

5. Ingman A, Waters D. Locked intramedullary nailing of humeral shaft fratures. JBJS 1994;76-B:23-9

6. Cheng H, Linn J. Prospective randomized comparative study of Antegrade and Retrograde locked nailing for middle humeral shaft fracture. J Trauma.2008;65:94-102

7. Ajmal M, O'Sullivan M, McCabe J, Curtin W. Antegrade locked intramedullary nailing in humeral shaft fractures. Injury. 2001 Nov;32(9):692-4.

8. Dietz S, Haartman F, Shwartz T, Nowak T, Enders A, Khun S, Hofmann A, Rommens P. Retrograde nailing versus locked plate osteosyhthesis of proximal humeral fractures: a biomechanical study. J Shoulder Elbow Surg. 2012;21:618-624

9. Park J, Pandher D, Chun J, Lee S. Antegrade Humeral nailing through the rotator cuff interval. A new entry portal. J Orth Trauma 2008;22:419-425

10. Halder S, Chapman J,Choudry G, Wallace W. Retrograde fixation of fractures of the neck and shaft of the humerus with the “Halder humeral nail”. Injury ,Int, J Care Injured
2001;32:695-703

11. Rommens P, Verbruggen J, Broos P. Retrograde locked nailing of humeral shaft fractures. JBJS 1995; 77-B: 84-9

12. Bieber R, Zirngibl B, Bail H, Stedtfeld H. An innovative technique of rear entry creation for retrograde humeral nailing: How to avoid iatrogenic comminution. JINJ 2013; 5238:1-4

13. Petsatodes G, Karataglis D, Papadopoulos P, Christoforides J, Gigis J, Pournaras J. Antegrade interlocking nailing of humeral shaft fractures. J Orthop Sci. 2004;9(3):24752.

14. Pogliacomi F, Devecchi A, Costantino C, Vaienti E. Functional long-term outcome of the shoulder after antegrade intramedullary nailing in humeral diaphyseal fractures. Chir Organi Mov. 2008 May;92(1):11-6. Epub 2008 Mar 1.

15. Li WY, Zhang BS, Zhang L, Zheng SH, Wang Sm. Comparative study of antegrade and retrograde intramedullary nailing for the treatment of humeral shaft fractures. China journal of orthopaedics and traumatology. 2009 Mar;22(3):199-201

16. Lin J, Inoue N, Valdevit A, Hang YS, Hou SM, Chao EY. Biomechanical comparison of antegrade and retrograde nailing of humeral shaft fracture. Clin Orthop Relat Res. 1998 Jun;(351):203-13

17. Knight D, Mahajan R. Patient positioning in anaesthesia. Contin Educ Anaesth Crit Care Pain (2004) 4 (5): 160-163.

18. Bencic L, Cengic C, Prenc J, Bulatovic N, Matejcic A. Humeral Nail: Comparison of the antegrade and retrograde application. Acta Clin Croat. 2016 Mar;55(1):110-6

19. Prasad D, Singh P, Ingle N, Akram M, Saji A, Rabari Y, Gupta R: Comparative study of retrograde versus Antegrade nailing in humeral diaphyseal fractures. IJOS. 2017; 3(4):544-547

20. Browner B, Jupiter J, Levine A, Trafton P (eds): Skeletal Trauma, ed 2. Philadelphia, PA, WB Saunders Company, 2002, p 1524).

21. <.http://aofoundation.org> - Image accessed March 2015

22. <http://medicalmultimediagroup.com> - Image accessed March 2015

23. <http://aaos.org> - Image accessed March 2015

24. <http://sadco-jo.com> - Image accessed July 2017

Appendix A - Ethics

A.1 University of the Witwatersrand - Human Research Ethics Committee (Medical)

R14/49 Dr Peter Ojwang

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M160862

NAME: (Principal Investigator)	Dr Peter Ojwang
DEPARTMENT:	Orthopaedics Surgery Helen Joseph Hospital
PROJECT TITLE:	Antegrade Vs Retrograde Locked Nailing For Humeral Shaft Fractures: A Clinical Audit
DATE CONSIDERED:	26/08/2016
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Araden Aden

APPROVED BY: Professor P Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 29/08/2016

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

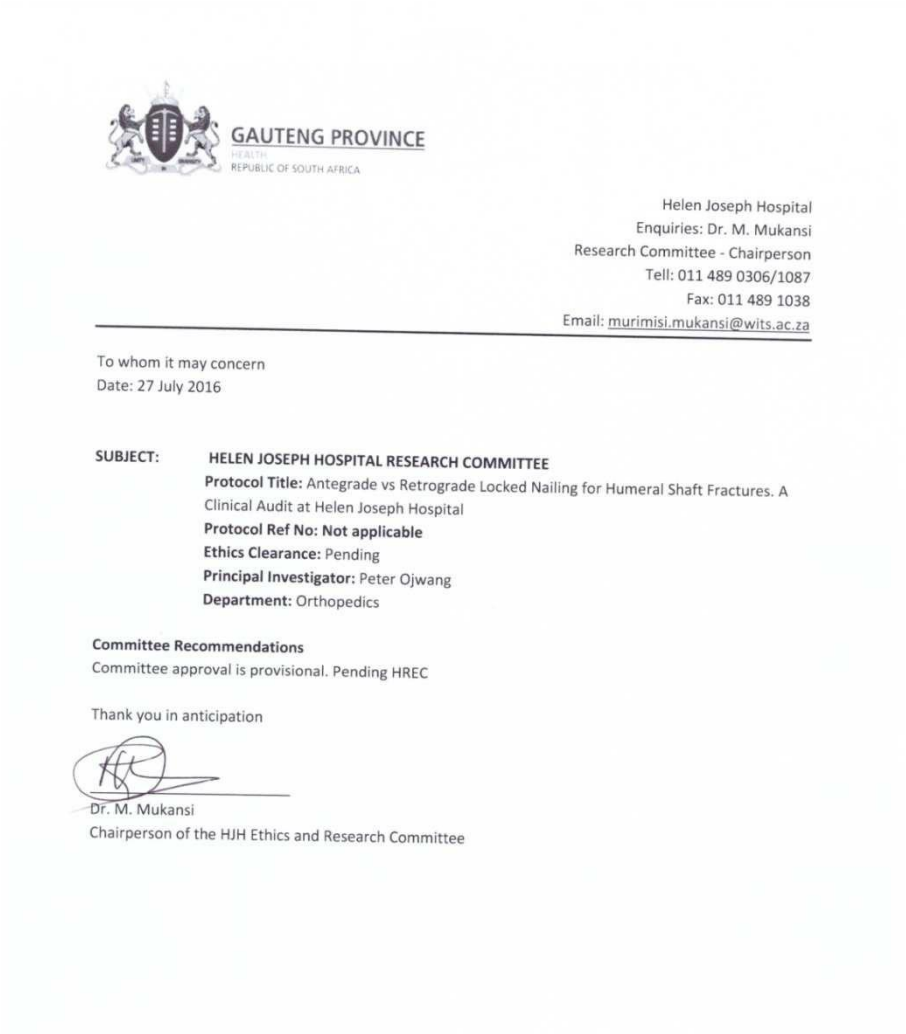
DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 10004, 10th floor, Senate House/2nd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in August and will therefore be due in the month of August each year.

Principal Investigator Signature Date 29/08/16

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

A.2 Helen Joseph Hospital - Ethics and Research Committee



GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Helen Joseph Hospital
Enquiries: Dr. M. Mukansi
Research Committee - Chairperson
Tell: 011 489 0306/1087
Fax: 011 489 1038
Email: murimisi.mukansi@wits.ac.za

To whom it may concern
Date: 27 July 2016

SUBJECT: **HELEN JOSEPH HOSPITAL RESEARCH COMMITTEE**
Protocol Title: Antegrade vs Retrograde Locked Nailing for Humeral Shaft Fractures. A Clinical Audit at Helen Joseph Hospital
Protocol Ref No: Not applicable
Ethics Clearance: Pending
Principal Investigator: Peter Ojwang
Department: Orthopedics

Committee Recommendations
Committee approval is provisional. Pending HREC

Thank you in anticipation

Dr. M. Mukansi
Chairperson of the HJH Ethics and Research Committee

Appendix B - Gustillo Anderson grading system

B.1 Gustillo Anderson Grading System

Table B.1. The Gustillo Anderson grading system used to classify open fractures. <.http://aofoundation.org> - Image accessed March 2015

Type	Description
I	Skin wound less than 1 cm
	Clean
	Simple fracture pattern
II	Skin wound more than 1 cm
	Soft-tissue damage not extensive
	No flaps or avulsions
	Simple fracture pattern
III	High-energy injury involving extensive soft-tissue damage
	Or multifragmentary fracture, segmental fractures, or bone loss irrespective of the size of skin wound
	Or severe crush injuries
	Or vascular injury requiring repair
	Or severe contamination including farmyard injuries

Gustilo and Anderson classification of open fractures