Analysis of the complications of volar plate fixation for the treatment of distal radius fractures Frykman type 3 – 6

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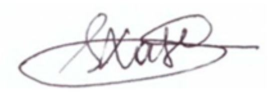
Declaration

I, Sibulele Xaso, declare that this research report is my own, unaided work. It is being submitted for the Degree of Masters 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 any other University.

……  …..

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Presentations and publications arising from this project

1. South African Orthopaedic association 65th annual congress from 02 – 06 September 2019 at Durban International Convention Centre.

Abstract

The aim of our study was to analyse complications after open reduction and internal fixation (ORIF) using a volar plate in distal radius fractures. Our study's hypothesis was that "complications" rates after ORIF using a volar plate were lower at Chris Hani Baragwanath Academic Hospital (CHBAH) than those reported in the current literature. We conducted a retrospective study with prospective recall, with a sample-size of 62 patients. The selected patients were those who were managed operatively between 01 July 2015 and 31 June 2017. Moreover, these participants were 18 years of age and older, active male and female patients and had Frykman types 3 – 6 distal radius fractures. Data collection was done during the orthopaedic trauma upper limb and hands clinics. Data analysis was done using STATA software package, version 14 and frequency Tables were used. Our results showed variable complication rates in comparison to those reported in the literature. In terms of the relationship between the complications *versus* (i) surgical and (ii) patient-related factors, it was noted that senior surgeons had the least complications and better functional scores than their junior counterparts. We also found that, patients with increased number of complications had poor hand functional scores. Finally, our study's hypothesis was disproved after we got a higher incidence of complications than that reported in available literature.

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Nomenclature

AP - anterior-posterior

EPL - extensor pollicis longus

FPL - flexor pollicis longus

PA - posterior-anterior

DASH - disability of the arm, shoulder and hand

HGD - handgrip dynamometer

CRPS - complex regional pain syndrome

ORIF - open reduction and internal fixation

Definition

Active patient - is a patient that is able to perform activities of daily living without any assistance.

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1 Distal radius fractures

1.1.1 Introduction

Distal radius fractures are amongst the most common of all skeletal injuries and constitute up to 16% of all the extremity fractures (1). They represent about one-sixth of all fractures treated in the emergency departments. The incidence of distal radius fractures in elderly correlates with osteopenia and increases with increasing age almost in parallel with the increased incidence of hip fractures. These fractures are more common in females and have a bimodal distribution. In men aged 35 years and older, the incidence remains constant until the age of 70 where a slight increase is observed. In women of age 40 years and older, the incidence is higher than in younger women (1).

Intra-articular fractures constitute about 50% of these fractures. The restoration of the anatomy of the distal radius is very crucial in achieving normal wrist function. This is achieved through open reduction and internal fixation (ORIF) with a plate which could be placed on the volar (palmar) or dorsal (back) side of the distal radius. Risk factors for fractures of the distal radius in the elderly patients are female sex, white race, family history, decreased bone mineral density and early menopause (1).

1.1.2 Anatomy

The distal radius has three articular surfaces namely; scaphoid facet, lunate facet and sigmoid notch. The sigmoid notch articulates with the distal ulnar to form the distal radio-ulnar joint. The lunate and scaphoid fossa on the distal radius articulate with the proximal carpal row as shown in Figure 1.1. The distal radius has ligamentous attachments, which remain intact during distal radius fractures and aid in ligamentotaxis. The distal radius supports about 80% of the axial load and in addition, the ulnar and triangular fibrocartilage support the remaining 20% (2).

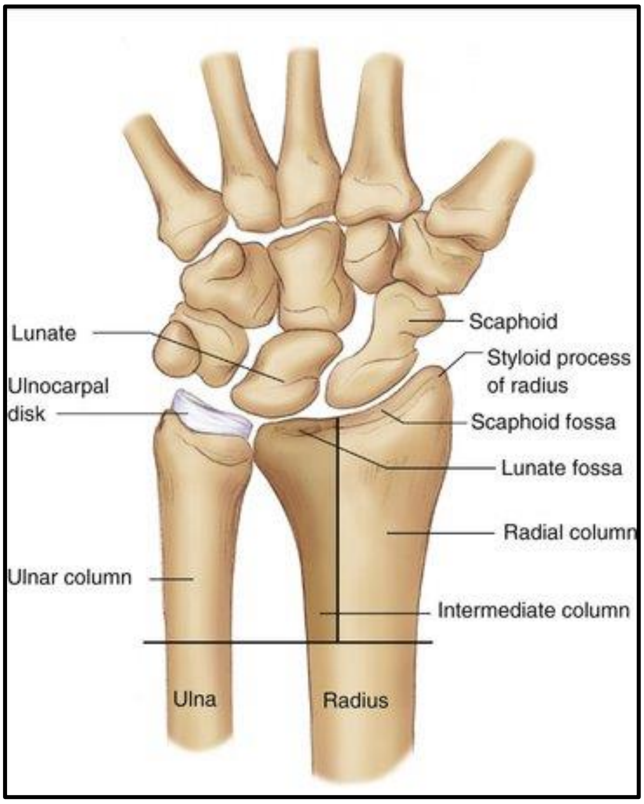


Figure 1.1: Distal radius articular surface and proximal carpal row (3).

1.1.3 Mechanisms of injury

In younger individuals common mechanisms of distal radius fractures include falls from a height, motor vehicle accidents, or injuries sustained during athletic involvement. In the elderly these fractures arise from low energy mechanisms such as a fall from a standing height, hence, they are named fragility fractures. A fall onto an outstretched hand with the wrist in dorsiflexion has been found to be the most common mechanism of injury. These fractures occur when the dorsiflexion of the wrist varies between angles, 40 and 90°. It has been reported that high-energy injuries may result in significantly highly comminuted or displaced unstable fractures to the distal radius (1).

1.1.4 Clinical evaluation

Bucholz *et al*. (2010) reported that the majority of physical findings in distal radius fractures may be related to the shortening of the distal radius relative to the ulnar. These patients typically present with a wrist deformity and displacement of the hand in relation to the wrist. The patient’s wrist will be swollen with ecchymosis, tenderness and pain with range of motion. A careful neurovascular assessment must be performed with attention paid to the median nerve function. Carpal tunnel syndrome has been found to be common due to traction during forced hyperextension of the wrist, increased compartment pressure, direct trauma from the fracture fragments and/or haematoma formation. The ipsilateral elbow and shoulder must be examined for associated injuries such as Essex Lopresti (2).

1.1.5 Diagnostic evaluation

The posterior-anterior or anterior-posterior (PA or AP) and lateral views must be taken for every patient with a distal radius fracture. The radiographs and the initial injury form the basis of further treatment of the distal radius after closed reduction. Standard measurement in the AP view shows radial inclination as well as the relationship of the distal radius to the ulnar. The lateral views obtained post injury will show either the more common dorsal displacement or the less frequent volar (palmar) displacement of the distal radius columns. Both views provide the following normal radiographic relationships: radial inclination average of 23° (angle range: 13 – 30°), radial length of average 11 mm (range: 8 – 18 mm) and palmar/volar tilt which averages between 11 and 12° (angle range: 0 – 28°). In patients with a distal radius fracture, the AP and lateral views also help identify articular step off or gap, distal radio ulnar joint subluxation/dislocation, sigmoid notch step off or gap and the presence and extent of displacement of ulnar styloid fractures (1, 2). The radiographic parameters show individual variability and this is solved by obtaining X-rays of the contralateral wrist. A computed tomography (CT) scan is usually significant in demonstrating the extent of intra-articular extension (2).

1.1.6 Classification of distal radius fractures

There are various classification systems used to classify distal radius fractures, our study specifically used the Frykman classification system (see Figure 1.2). The classification of fractures is crucial in the diagnostic communication and management.

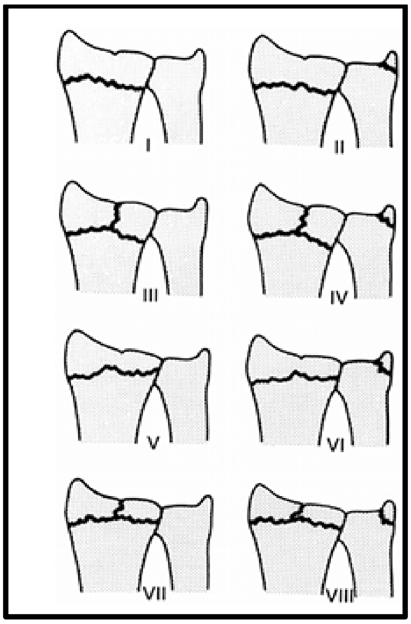


Figure 1.2: Frykman classification of distal radius fractures (3).

Frykman classification of the above distal radius fractures is described below:

I – *1st row, Left diagram above*: Frykman type 1: transverse and extra-articular fracture

II –*1st row, Right diagram above*: Frykman type 2: Frykman type 1 + ulnar styloid fracture

III –*2nd row, Left diagram above*: Frykman type 3: Intra-articular radiocarpal joint

IV –*2nd row, Right diagram above*: Frykman type 4: Frykman type 3 + ulnar styloid fracture

V –*3rd row, Left diagram above*: Frykman type 5: intra-articular distal radioulnar joint

VI –*3rd row, Right diagram above*: Frykman type 6: Frykman type 5 + ulnar styloid fracture

VII –*4th row, Left diagram above*: Frykman type 7: Intra-articular radiocarpal + distal radioulnar joint

VIII –*4th row, Right diagram above*: Frykman type 8: Type 7 + ulnar styloid fracture (1, 2).

1.1.7 Treatment of distal radius fractures

The goal of treatment is to achieve a wrist that provides sufficient pain free motion and stability to allow vocational and avocational activities in all age groups, as well as to prevent the development of degenerative changes in young patients (2). The acceptable radiographic parameter for a healed distal radius in an active healthy patient is a radial length within 2 – 3 mm of the contralateral wrist. Furthermore, a palmar tilt in a neutral position, intra-articular step off of less than 2 mm and radial inclination of less than 5° loss are considered acceptable parameters. Several factors have been associated with re-displacement post closed manipulation of the distal radius fracture. These include the initial displacement of the distal radius fracture, in which a greater degree of displacement predisposes to a higher likelihood that closed treatment will be unsuccessful. Another factor is the age of the patient where elderly patients with osteopenic bones tend to displace late (1, 2).

There are two modalities of treatment: (i) non-operative and (ii) operative treatment. These methods of treatment are discussed below:

(i) Non-operative treatment (Cast immobilisation)

All distal radius fractures should undergo closed reduction regardless of the expected surgical intervention that might be needed (5). This helps limit post-injury swelling, provides pain relief and relieves compression on the median nerve (1). Indications of non-operative treatment include: non-displaced or minimally displaced distal radius fractures, displaced distal radial fractures with a stable fracture pattern where union is expected within acceptable radiographic parameters and low demand elderly patients in whom functional impairment is less of a priority than immediate health concerns or operative risk (5).

(ii) Operative Treatment

The indications for operative treatment include:

- Articular comminution, step off and gap,
- Secondary loss of reduction,
- Metaphyseal comminution or bone loss,
- Open fractures,
- Associated carpal fractures,
- Associated neurovascular or tendon injury and
- Bilateral distal radius fractures.

In cases where there are acute fractures, the fractures must be reduced immediately by closed reduction in order to minimise complications, followed by an operative fixation modality. There are three operative techniques and these are described below:

(a) Percutaneous pinning

Percutaneous pinning is primarily used for extra-articular fractures or two-part intra-articular fractures (see Figure 1.3). It is done using two or three Kirschner wires (K-wires) directed across the fracture site, from the radial styloid, directed towards the shaft of the radius and from the Lister's tubercle on the dorsal aspect directed proximally. This technique is generally used to supplement the short arm cast (3, 6).

Figure 1.3: Percutaneous pinning of distal radius (3)

(b) External fixation

This technique of fixation is not used often since the advent of volar locked plating (see Figure 1.4). Despite the low complication rates and long-term outcomes offered by external fixation, there are some cases where it may not offer sufficient stability to prevent the degree of collapse and loss of palmar tilt, especially in fractures with comminution and in osteopenic bone. In such instances, supplemental K-wire fixation or bone graft can be used as adjunctive measures (3, 6).

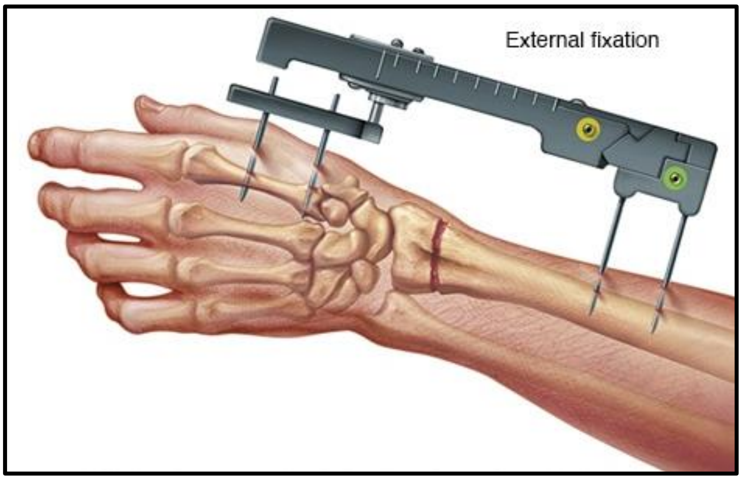


Figure 1.4: External fixation of distal radius (3)

(c) Open reduction and plate fixation

This technique comprises of dorsal plating and volar plating (see Figure 1.5). Dorsal plating has theoretical advantages of avoidance of neurovascular structures on the palmar side, fixation on the compression side of the fracture and provides a buttress against collapse. A disadvantage of using this technique is that the dorsal approach has been associated with extensor tendon complications. The technique is less commonly used since the advent of volar locked plating, which is the most commonly, used type of plating. Volar locked plating has increased in popularity because of its proven ability to stabilise distal radius fractures with dorsal comminution. It has also been shown to allow early range of wrist motion (1).

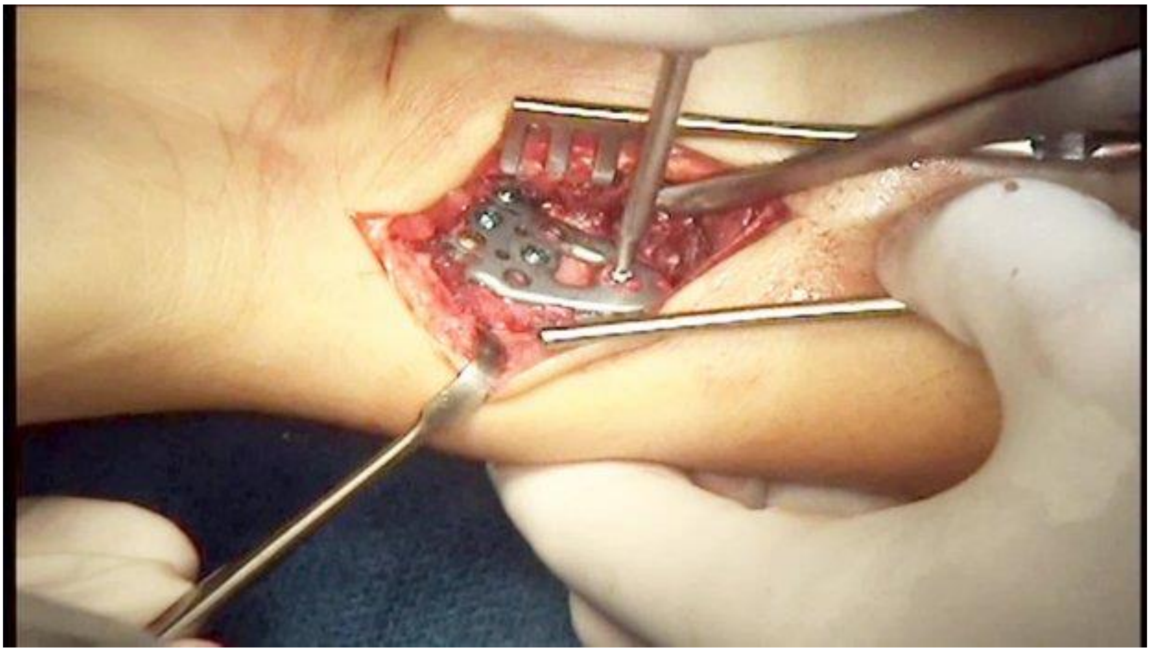


Figure 1.5: Open reduction and internal fixation (ORIF) of distal radius with volar plate (3).

1.1.8 Complications

Distal radius plating (both volar and dorsal) is associated with various complications and these are discussed below:

(a) Extensor and Flexor tendon injury and synovitis:

Both dorsal and volar tendon ruptures following use of volar plates have been reported (1, 7). This is because of two mechanisms: i) screws protruding beyond the dorsal cortex and irritating the dorsal tendons and ii) displacement of the plate distally or towards the wrist past the watershed area (see Figure 1.6) with impingement of the plate on the flexor tendons. In a study by Arora *et al*. (2007), complications following internal fixation of unstable distal radius fracture with a volar locking plate were studied using a retrospective analysis (7). The study included 114 participants who were followed for a year or longer. The results of the study showed a complication rate of 27%. The most frequent complications were flexor and extensor tendon ruptures, with two cases of both extensor pollicis longus (EPL) and flexor pollicis longus (FPL) ruptures. The authors also showed four and nine cases of extensor and flexor tendon synovitis, respectively (7). One good aspect of the study was the long and frequent follow up of the patients with close monitoring. A study done by Hershman *et al*. (2012) investigated the effect of pronator quadratus repair on outcomes after volar plating of distal radius fractures. Their results showed a 0.02% (2/112) rate of extensor tendon rupture, as well as a case of flexor tendon irritation (8). The difference in the expertise used (surgeon experience) could have led to a discrepancy in the complications that arose, i.e. the more experienced the surgeon, the fewer the complications. Tarallo in 2013 showed one case of infection, but this was after the removal of the distal radius plate (9). The only criticism about their finding was the inability to determine whether an injury was incurred during plate application or removal. Javed *et al.* found one case of tenosynovitis out of 118 patients (12).

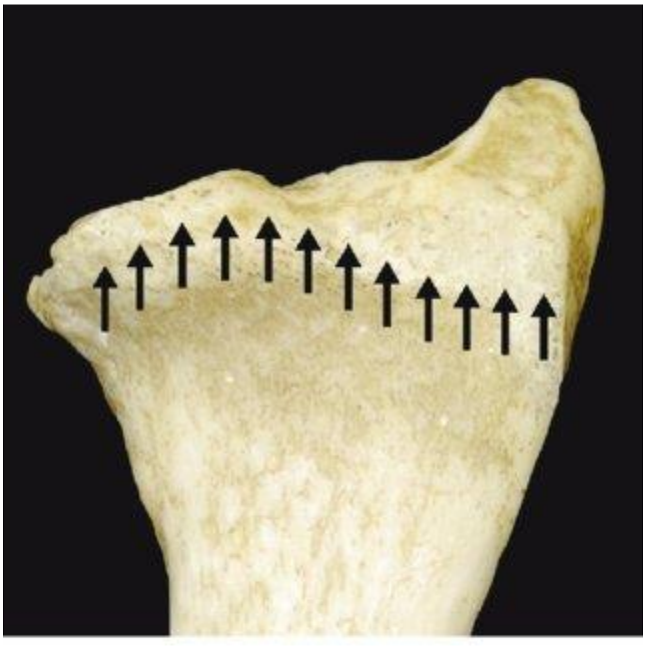


Figure 1.6: Watershed area of the distal radius (3)

In a retrospective study published by Tarallo *et al*. (2013), the authors analysed the adverse events of volar plate fixation for the treatment of distal radius fractures (9). The study reported that adverse events were observed in 5.9% of the 315 participants. Extensor tendon impairment was the most frequent complication and occurred in five (0.015%) cases of extensor tenosynovitis and three (0.009%) cases of extensor pollicis ruptures. Flexor tendon impairment was the second most common complication with two (0.006%) cases of flexor tenosynovitis and two (0.006%) cases of flexor pollicis longus rupture. A challenge may have been the inclusion of both intra-articular and extra-articular fractures, which could result in the use of different fixation techniques. Intra-articular fractures are more challenging to reduce and this could increase the risk of tendon piercing especially on the dorsal aspect of the wrist (9).

(b) Loss of reduction

In a review article by Berglund *et al*. (2009), it was reported that a loss of reduction is typically the result of three mechanisms: dorsal collapse, radial length loss and/or loss of reduction involving the lunate facet (10). In addition, Tarallo *et al*. (2013) found three cases out of 303 that had loss of reduction (9).

(c) Joint Stiffness

Arora in 2007 reported an average 54 degrees extension (82% as compared with the uninjured side) and 46 degrees flexion (72% as compared with the uninjured side). The average pronation was 81 degrees (95 % as compared with the uninjured side) and the average supination was 82 degrees (95% as compared with the uninjured side) (7). Tarallo *et al*. (2013) found a higher rate of stiffness (2.9%) in patients who were not reduced before the operation while the reduced group had a rate of 1.9% (9). The problem with their study was the fact that the direction of motion where stiffness occurred was not mentioned. In a retrospective study published by Javed *et al*. (2015), the authors reported on 13 out of 62 patients who had wrist stiffness (11). The limitations of their study were that, (i) there was a limited number of participants and (ii) no mention of the direction of motion where stiffness occurred.

(d) Infection

A retrospective study by Javed *et al*. (2015), of prospectively collected data published in 2012 showed no case of infection in 112 participants that were included in their study (11). A prospective study published by Matschke *et al.* (2011) looked at surgical treatment of unstable distal radius fractures and found one case of deep infection out of 118 patients (12). A prospective study by Navarro *et al.* (2015) investigated the complications after distal radius fracture surgery and found that five out of 11617 patients had deep infections (13). One criticism about their study was the inability to define deep infection.

(e) Median Nerve injury

Javed *et al*. in 2015 reported on four patients out of 62 with median nerve symptoms (11).

(f) Complex Regional Pain Syndrome (CRPS)

In a review article published by Berglund (2009), it was mentioned that the incidence of CRPS was 3 – 10% (10). Javed *et al.* 2015 reported on two patients out of 62 who had CRPS (11).

Chris Hani Baragwanath Academic Hospital (CHBAH) surgically treats approximately 60 distal radius fractures per year. On average, CHBAH admits 10 patients with distal radius fracture per month and five of these are treated operatively and mostly with volar fixation, while the other five are treated with cast and percutaneous pinning. The CHBAH protocol emphasises fracture reduction regardless of the treatment modality afterwards. A greater number (percentage) of patients seen at CHBAH are treated by junior surgeons (junior registrars) on the emergency list and a minority of cases on the elective list are operated by senior surgeons (consultants). Currently, there has been no study in South Africa that has investigated the complications of distal radius fractures after the application of the volar plates.

1.2 Study Aim

To analyse the complications of distal radius fractures Frykman type 3 – 6 after open reduction and internal fixation (ORIF) using a volar plate. The reason for the choice of using Frykman type 3-6 is based on limiting the number of participants in our study since CHBAH sees a wide-range of patients with distal radius fractures requiring ORIF.

1.3 Study Objectives

- To determine the incidence of complications post volar plate application
- To investigate the relationship between the complications *versus*
    - (i) surgical factors and
    - (ii) patient related factors
- To investigate the functional outcome using the disability of the arm, shoulder and hand (DASH) score

CHAPTER 2

METHODOLOGY

2.1 Research Question

What is the incidence of complications of distal radius fractures at CHBAH after volar plate fixation in comparison with the literature average rate of between 5.9 – 27%?

2.2 Research design

Retrospective study with a prospective recall

2.3 Selection Criteria

2.3.1 Inclusion criteria:

- Patients 18 – 80 years old
- Active male and female patients
- Patients with Frykman type 3 – 6 fractures

2.3.2 Exclusion criterion:

- Patients with carpal bone involvement

2.4 Data collection and Analysis

Data were collected by the principal investigator (Dr Xaso), during clinic days after obtaining the CHBAH permission and the University of the Witwatersrand Human Research Ethics Council (HREC) (Medical) Clearance (see Appendices A and B). The patients were called telephonically and were asked to visit the hospital on a day they felt convenient. Furthermore, the patients were seen on any day during the week. The data were collected using a data collection sheet (see Appendix C), patient's X-rays and goniometer. Complications were measured through clinical examination, in comparison to the normal contralateral side, and radiologically where the involved wrist x-rays were done. The data were collected on a six months period and the patient sample-size was 62. The data were captured by the principal investigator and were entered on Microsoft Excel spreadsheet after consultation with a biostatistician. The latest version of STATA 14 was used for the data analysis. Frequency Tables were computed for the categorical data (complications) to determine the proportion of the study participants with post-operative complications.

CHAPTER 3

RESULTS

Table 3.1 shows surgeon's level of training and the number of cases done. Junior registrars (1st and 2nd year registrars) operated most of the cases shown in Table 3.1 and medical officers, 3rd, 4th year registrars and consultants, respectively did few.

Table 3.1: Surgeon's level of training and the number of cases done

Surgeon's Level of training	Number of cases done
Medical officers	6
First year registrars	11
Second year registrars	32
Third year registrars	11
Fourth year registrars	1
Consultants	1
Total	**62**

Figure 3.1 below shows the number of complications per patient seen. It shows there were 3% of patients without complications, 23% had two complications and only 3% of patient had eight complications each. The deciding factors for complications lied on the surgical skill of the surgeon and the complexity of the fracture. Most of the fractures were operated by junior surgeons (see Table 3.1), who were still consolidating their surgical skills.

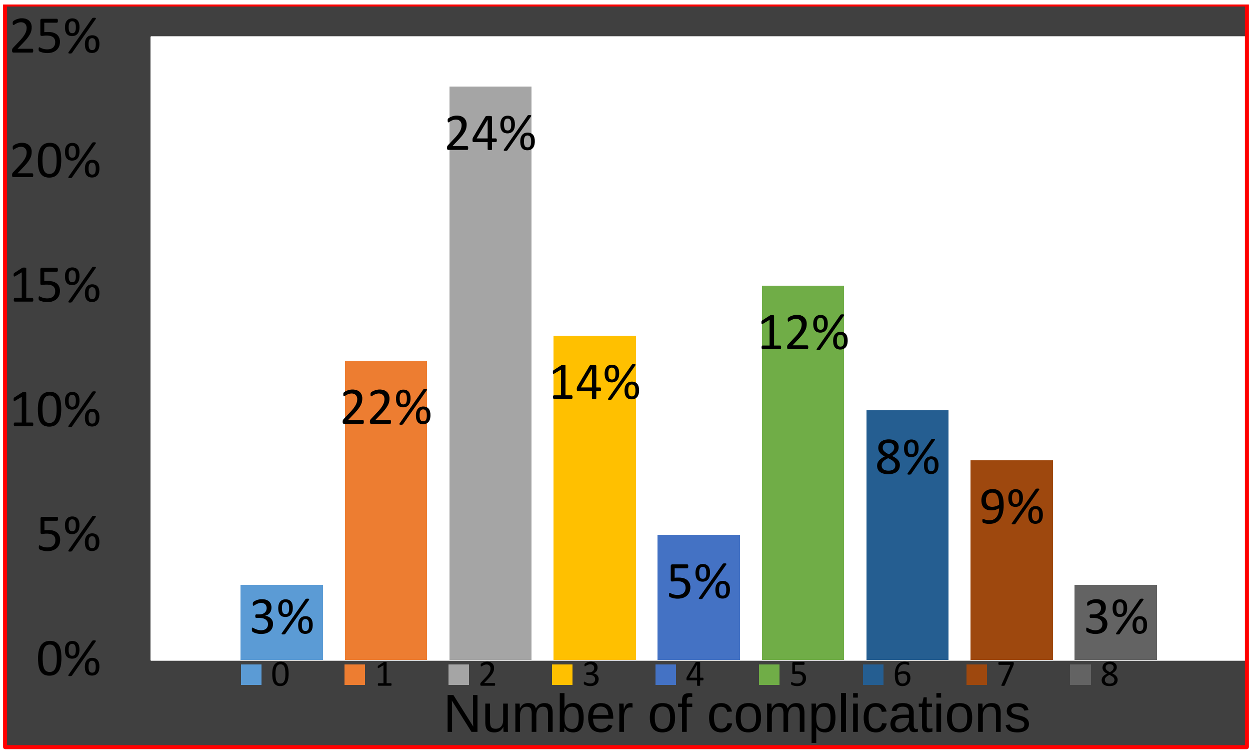


Figure 3.1: Number of complications per patient seen.

The frequency of each complication and comparison of range of motion with the normal contralateral side is shown in Table 3.2, with wrist flexion limitation being the most frequent complication and deep infection, complex regional pain syndrome (CRPS) and non-union being the least common complications.

Table 3.2: Frequency of each complication and range of motion in comparison with normal contralateral side.

Complications	Percentage (%)	Wrist function	Comparison of range of motion with normal contralateral side (%)
Loss of wrist flexion	66.13	Palmar flexion	47 – 81

Loss of wrist extension	43.6	Extension	44 – 98
Loss of ulnar deviation	48.4	Ulnar deviation	32 – 86
Loss of radial deviation	24.2	Radial deviation	27 – 75
Loss of pronation	22.3	Pronation	31 – 91
Loss of supination	25.8	Supination	14 – 90
Flexor tendon injury	12.9		
Extensor tendon injury	1.6		
Loss of reduction	43.6		
Superficial infection	12.9		
Deep infection	0		

Complex regional pain syndrome (CRPS)	0		
Median nerve injury	27.4		
Mal-union	8.1		
Non-union	0		

Table 3.3 shows complication rates compared with surgical experience. The most complications were found amongst junior registrars and the least common were amongst fourth year registrars, consultants and medical officers. There was no significant difference in complication rates between 2nd and 3rd year registrars with 21 and 22%, respectively.

Table 3.3: Complication rates compared to surgical experience.

Surgeon's Level of training	Complication percentage (%)
Medical officer	6
1st year registrars	25
2nd year registrar	21
3rd year registrar	22
4th year registrar	13
Consultant	13

Table 3.4 depicts a comparison between number of complications *versus* age, with number of complications grouped into 0 − 2, 3 − 5 and 6 − 8 in average ages of 48, 45 and 47 years old, respectively.

Table 3.4: Number of complications in comparison with age

Number of complications	Average age (years)
0 − 2	48 years
3 − 5	45 years
6 − 7	47 years

Table 3.5 shows the number of complications *versus* gender. As shown below, females had a higher number of complications compared to males. The clear-cut difference is shown on the third group of complications (6 − 8).

Table 3.5: Number of complications *versus* gender

Number of complications	Gender:	
	Female	Males
0 − 2	14	15
3 − 5	10	10
6 − 8	10	3
Total	**34**	**18**

Figure 3.2 shows the frequency of complications in comparison with complexity of the fracture. Most of the complications were found in patients with Frykman type 4 (68%). Patients with Frykman type 5 had the least of complications sitting at 5%. Frykman types 5

and 6 had complication rates of 5 and 6%, respectively and these fractures were operated by senior registrars and by consultants. Frykman type 3 fractures contributed up to 21% of complications and were generally operated by junior registrars.

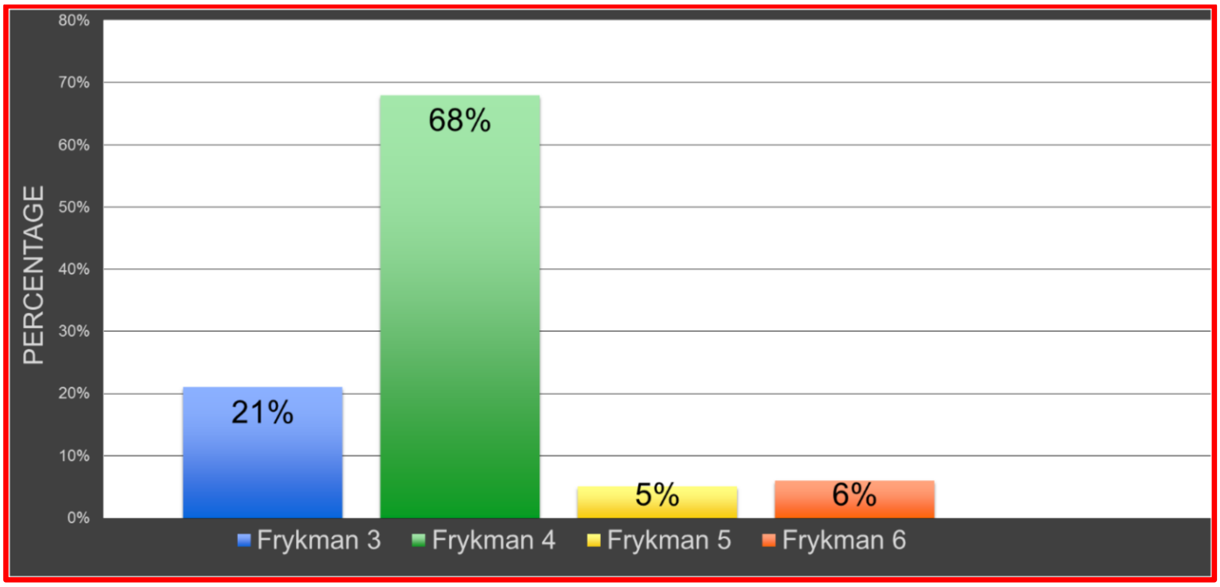


Figure 3.2: Frequency of complications compared to complexity of the fracture

Table 3.6 compares DASH score with number of complications per patient seen. The results showed that patients with higher DASH scores had worst function of the hand. Complications per patient seen were grouped into 0 – 2, 3 – 5 and 6 – 8 score bands. As shown, patients with 0 – 2 complications had a DASH score of 7, which was the lowest and meant good function of the hand. The second group was patients with 3 – 5 complications, with DASH score of 16. The third group was a group of patients with 6 – 8 complications with a DASH score of 26, implying that these patients had very poor (limited) hand function.

Table 3.6: Dash score compared to number of complications

Number of Complications	Median Dash Score
0 – 2	7
3 – 5	16
6 – 8	26

CHAPTER 4

DISCUSSION

Table 3.1 showed surgeon's level of training and the number of cases done. Junior registrars operated most of the cases, as they are always responsible for cases operated on the emergency list. This is the usual case as most of the patients with distal radius fractures are operated on the emergency list and the junior registrars usually do these. Senior registrars and consultants usually operate the more complex cases. Medical officers often get an opportunity to do emergency cases, with the registrar on call.

The frequency of each complication was shown in Table 3.2 where loss of wrist flexion regardless of the percentage was found in 66.1% of patients and was the most frequent complication. The loss of radial deviation, pronation, supination and median nerve injury were found in 22 to 27% of the patients. Deep infection, complex regional pain syndrome and non-union had the least frequency of complications each (0%). Many causes might have contributed to the loss of wrist flexion in these patients. These include patient's compliance and dedication to physiotherapy post operatively, complications of loss of reduction intra-operative leading to disruption of wrist biomechanics, and injury to flexor tendons.

In addition, the limited wrist flexion may also have been accounted for by screw in the radiocarpal joint but this is not a common complication. The second most common complication was reduced ulnar deviation and was attributed to the formation of fibrous tissue post-surgery during the process of healing. Stiffness due to lack of post-operative physiotherapy might have been another cause of the decrease in ulnar deviation in these patients. Loss of wrist extension was amongst the common complications. The causes include extensor tendon injury, stiffness following lack of physiotherapy post operatively and volar soft tissue fibrosis as the approach was volar. Included amongst the common complication was loss of reduction, which could have been failure to reduce the fracture from the beginning, or loss of reduction. This is commonly seen in some of the complex fracture patterns.

The flexor tendons low frequency of complication may be justified by the fact that a volar approach was used for all the patients involved in the study, so visualisation of the tendon during the approach could have contributed significantly to the results. Another reason may be the fact that, there are fewer tendons on the radial side than the ulnar side of the wrist, hence less interaction with the flexor tendons. One of the reasons for extensor tendons' low frequency of complication rate can be attributed to non-interaction with extensor tendons except during drilling of the bone for screw placement. This is usually prevented when the surgeon encounters the second resistance during drilling, alerting them of the possible violation of the dorsal soft tissues. The zero incidence of non-union could have been accounted for by the fact that there were very few patients with risk factors such poor nutritional status, steroid, anti-coagulant use, previous history of radiation etc. There was no patient with deep infection i.e. infection requiring plate removal as this complication is not so common in these patients (8, 12, 14, 15) or complex regional pain syndrome.

In addition, Table 3.2 showed wrist function with comparison of the range of motion on the normal contralateral side. The available literature looked for the impairment of the wrist flexion and in comparison to our study, we found out that, the literature reported 55 – 83%

palmar flexion of the total palmar flexion of the contralateral side (12, 16), while our study showed 47 – 81% palmar flexion of the total palmar flexion of the contralateral side. Extension range was 44 – 98% of the total extension of the contralateral side in our study while literature reported 59 – 91% of the extension of the contralateral side (7, 8, 12, 16). Ulnar deviation measured 32 – 86% of the total of the contralateral side while literature reported 85 – 92% ulnar deviation of the total of the contralateral side (8, 12). Radial deviation showed 27 – 75% of the amount of radial deviation on the contralateral side while literature reported 77 – 94% of the total radial deviation of the contralateral side (8, 12). Pronation was found to be 31 – 91% of the amount of pronation of the contralateral side while literature reported 82 – 95% of pronation of the contralateral side (7, 16). Supination was found to be 14 – 90% of the amount of supination of the contralateral wrist whilst literature reported 95 – 98% of the total supination of the contralateral side (7, 8, 16).

Our results showed a higher rate of flexor tendon injury compared to literature findings (9, 7, 16). We found extensor tendon injury complication rate of 1.6%, while literature reported 1.8 – 3.2% (7, 8, 9). Some studies show total tendon (flexor and extensor) rupture of 0.1 – 3.3% (12, 14). Loss of reduction was found to be very high (44%) compared to literature rates ranging between 0.3 and 4.9% (9, 10). Superficial infection incidence was 12.9% and there was no patient with deep infection, whereas the literature reported infection rates of 0.1 – 0.7% with both superficial and deep infection rates combined (8, 12, 14, 15). Our results showed no cases of CRPS, while literature reported rates between 1.7 and 10% (7, 10, 11, 12). Median nerve injury was found to be affected in 27% of our cases. In contrast to this, the literature reported significantly low rates ranging between 0.3 and 6.5% (9, 11). There was no case of non-union in our study and these results are comparable with literature rates (16).

Table 3.3 showed complication rates compared with surgical experience. Medical officers contributed only 6% to the complication rate. The reason for the low incidence amongst medical officers is explained by the fact the majority of them had an opportunity to operate prior to CHBAH experience in terms of surgical cutting exposure. The highest number of complications was found amongst 1^{st} year registrars and could be attributed to the limited surgical skills experience. Second (2^{nd}) and 3^{rd} year registrars had fairly similar complication rates but less than first year registrars, reflecting their better surgical exposure or experience. Fourth (4^{th}) year registrars and consultants had fairly lower rates of complications, despite them doing mostly the more complex fractures. The reason for low incidence amongst 4^{th} year registrars and consultants is the extensive experience and improved surgical skills.

Age was one of the patient's factors that were investigated closely to see the impact on these complications (see Table 3.4). The youngest patient recruited in our study was 21 years and the oldest was 76 years. The average age for all the groups of our patients (with their complications) was between 45 and 48 years. There was no significant difference between the number of complication per patient and patient's average age. Patients with no complications or with lowest number of complications were actually older (average age) than the rest of the group of patients and their complications.

In the study, we also looked at how gender affected complications as a patient factor. Table 3.5 showed that for the groups of patients with 0 − 2 and 3 − 5 number of complications, there was no significant difference in terms of the gender affected. The difference was more clearly observed on the 3^{rd} group (6 – 8 complications) of patient, with female patients being affected more than their male counterparts. A significant number of female patients seeking medical attention compared to their male counterparts could explain this.

Figure 3.2 showed the frequency of complications in comparison with complexity of the fracture. As mentioned above, most of the complications were found in patients with Frykman type 4 with 68% incidence. One factor that must have contributed, is that Frykman type 4 fractures were mostly operated by junior registrars, specifically 2nd year registrars. The least contribution (5%) to complications in terms of fracture types came from patients with Frykman type 5.

In terms of the functional outcomes post operatively, our study showed an average DASH score of 19.8 (see Table 3.6) while literature reported ranges between 11.2 and 13 (7, 8, 12). The higher the DASH score, the worse the function of the wrist. Patients with higher numbers of complications had higher DASH scores, implying worse function of the wrist compared to patients with lower DASH scores.

The average complication rate in our study was 23%, comparable with the literature average rate reported to be between 5.9 and 27% even though there is no mention of specific type of fractures (1, 7, 8, 9, 10). In addition, even the smallest difference in terms of functional difference, i.e. difference in flexion percentage of the involved side compared to the contralateral normal side was considered as a complication. As an alternative to rescue those patients who experienced significant complications resulting in significant functional impairment, re-operations were suggested but surprisingly not even a single patient was willing to undergo revision surgery or removal of hardware. In contrast to our study, the literature reported a re-operation rate of 6.6% with all modalities of surgical treatment included, i.e. K-wires, external fixation and plating (13).

Limitations

Amongst the limitations in our study is the limited number of patients, which was 62, but with 63 distal radius fractures since one patient had bilateral distal radius fractures. One reason to account for the limited number is the fact that not all patients managed to come back as the study was a retrospective study with prospective recall. Another possible reason is the patient's perspective of not feeling pain or having problems with their wrist, hence, seeing no need for any further hospital review.

CHAPTER 5

CONCLUSION

In summary the results showed that the rate of complications after ORIF for distal radius fracture using a volar plate at CHBAH was comparable to literature results, even though our rate was higher. The most common number of complications per patient seen was two in each patient (23%). Limited wrist flexion was the most common complication while deep infection, CRPS and non-union were the least common. The impact of surgical factors was closely looked at; where amongst the fracture types Frykman type 4 fractures had the most complications while Frykman type 5 had the least number of complications. First year registrars had the highest number of complications while 4th year registrars and consultants had the least. As far as patients factors are concerned, age did not seem to be a factor when it comes to complications. Females had greater number of complications than males. In terms of functional outcomes, the DASH scores were lower in patients with low numbers of complications, implying good function. Patients with higher numbers of complications had higher DASH scores implying poor function of the wrist.

Quite a good number of complications were looked for in our study and being the only study nationally that solely focused on complications post ORIF of distal radius fractures will at least give an idea of the consequences post ORIF thus assisting in follow up studies with larger sample sizes. In our study, complication rates were correlated with both surgeon's experience and fracture types. This will provide scientific evidence of which surgeons and fracture types are at risk of ending up with complications. As for the surgeons at risk, a helpful measure such as assistance by senior surgeons could be considered with the intention to lower the risk of complications.

Recommendations

i) In terms of future directions, a couple of issues pertaining management of distal radius fractures could add value to management of distal radius fractures with ORIF: a study with a large patient sample-size re-assures better results.

ii) ii) In terms of improvement on the quality of data being collected, more time and patience with patients would be of great significance as different patients have different challenges. Even though this study might not be totally a true representation of the complications post ORIF for distal radius fractures, operations of more complicated fractures by senior surgeons or supervision of juniors by senior surgeons is pivotal. Furthermore, studies looking at the comparison between:

(a) ORIF *versus* K-wires and

(b) Volar plate *versus* dorsal plate at CHBAH could bring about better insight of the best treatment modality at our health institution.

Appendices

Appendix A: CHBAH CEO permission

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE
CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 16 Aug 2017

TITLE OF PROJECT: Analysis of the complications of volar plate fixation for the treatment of distal radial fractures Frykman types 3-6

UNIVERSITY: Witwatersrand

Principal Investigator: S Xaso

Department: Orthopaedics

Supervisor (If relevant): MT Ramokgopa, SK Magobotha

Permission Head Department (where research conducted): Yes

Date of start of proposed study: Aug 2017
Date of completion of data collection: Dec 2019

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

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

Recommended
(On behalf of the MAC)
Date: 16 August 2017

Approved/Not Approved
Hospital Management
Date: 21/08/17

Received by:
Date: 25/08/17

Appendix B: HREC clearance certificate

R14/49 Dr Sibulele Xaso et al

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M170622

NAME: (Principal Investigator)	Dr Sibulele Xaso et al
DEPARTMENT:	Orthopaedic Surgery Chris Hani Baragwanth Academic Hospital
PROJECT TITLE:	Analysis of the Complications of Volar Plate Fixation for the Treatment of Distal Radius Fractures
DATE CONSIDERED:	30/06/2017
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof M.T. Ramokgopa
APPROVED BY:	Professor P. Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	11/12/2017

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

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/We fully understand the conditions under which I am/we are authorised 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 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 review June and will therefore be due in the month of June each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature   Date 12/12/2017

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: Data collection sheet

Questionnaire - Complications following distal radius open reduction and internal fixation using volar plate

Right Left

Patient number: __

1. Extensor tendon injury :
2. Flexor tendon injury :
3. Loss of reduction :
4. Joint Stiffness :

   Wrist flexion______________________________degrees

   Wrist extension_______degrees

   Ulnar deviation_______ degrees

   Radial deviation______degrees

   Pronation__________ degrees

   Supination___________degrees

5. Infection :

   Superficial

   Deep

6. Complex regional pain syndrome:

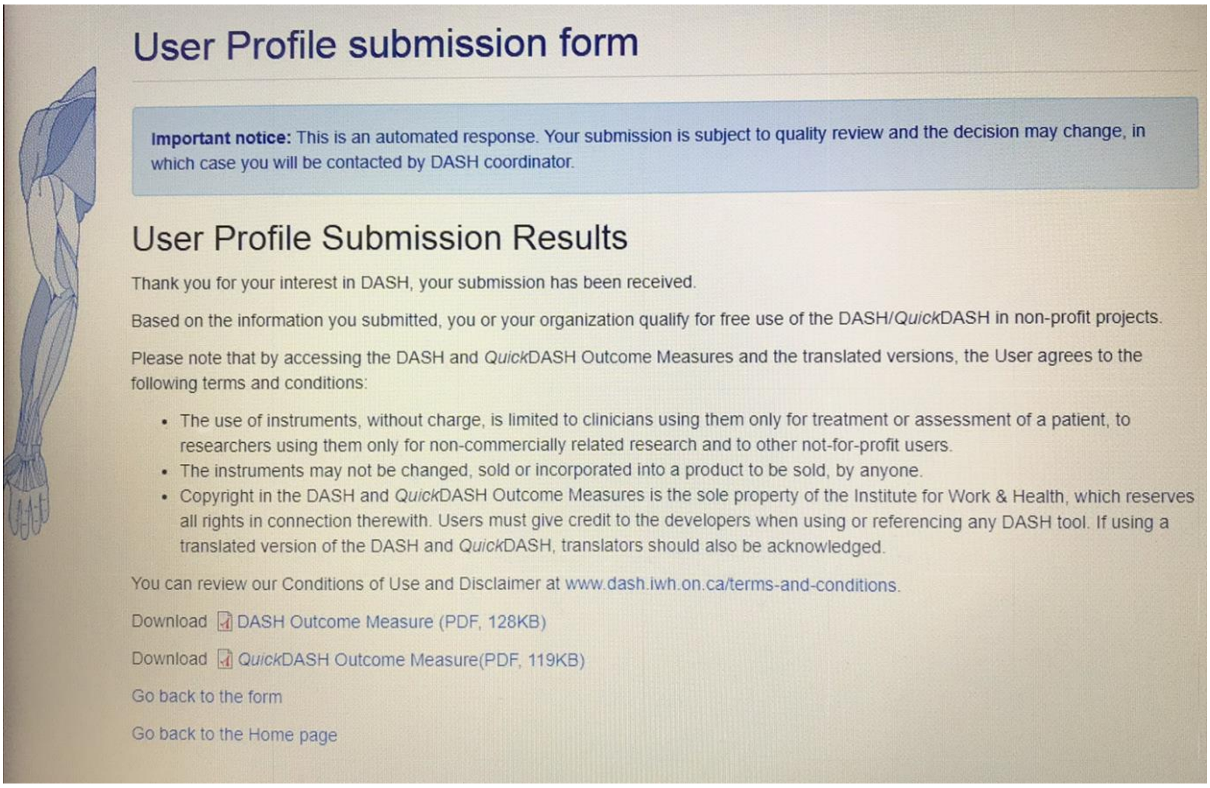
7. Median Nerve______________________

8. Malunion__________________________

9. Non-union__________________________
10. DASH score [ ]

Total number of complications: [ ]

Appendix D: Permission to use DASH score



User Profile submission form

Important notice: This is an automated response. Your submission is subject to quality review and the decision may change, in which case you will be contacted by DASH coordinator.

User Profile Submission Results

Thank you for your interest in DASH, your submission has been received.

Based on the information you submitted, you or your organization qualify for free use of the DASH/*Quick*DASH in non-profit projects.

Please note that by accessing the DASH and *Quick*DASH Outcome Measures and the translated versions, the User agrees to the following terms and conditions:

- The use of instruments, without charge, is limited to clinicians using them only for treatment or assessment of a patient, to researchers using them only for non-commercially related research and to other not-for-profit users.
- The instruments may not be changed, sold or incorporated into a product to be sold, by anyone.
- Copyright in the DASH and *Quick*DASH Outcome Measures is the sole property of the Institute for Work & Health, which reserves all rights in connection therewith. Users must give credit to the developers when using or referencing any DASH tool. If using a translated version of the DASH and *Quick*DASH, translators should also be acknowledged.

You can review our Conditions of Use and Disclaimer at www.dash.iwh.on.ca/terms-and-conditions.

Download DASH Outcome Measure (PDF, 128KB)

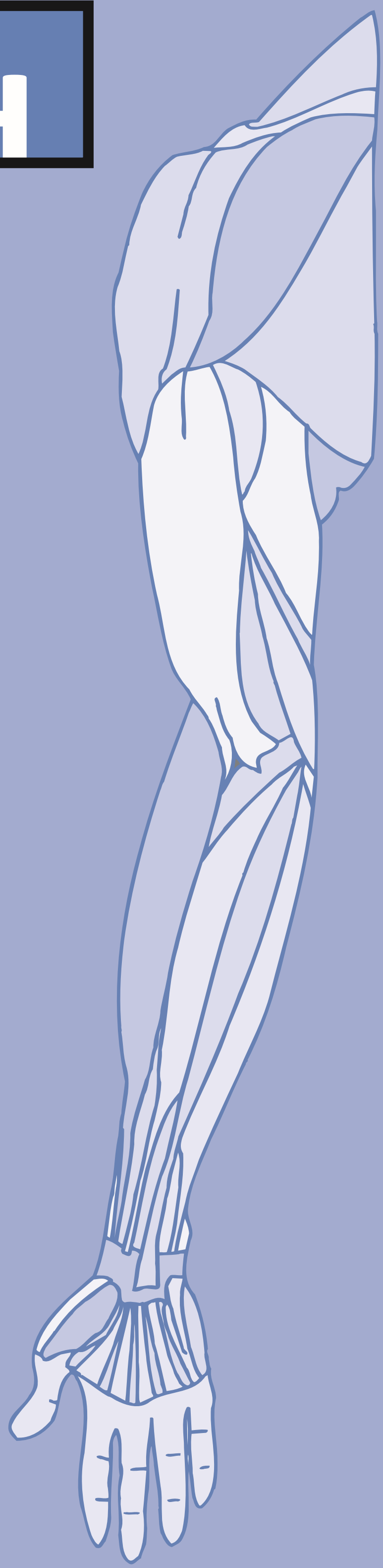
Download *Quick*DASH Outcome Measure(PDF, 119KB)

Go back to the form

Go back to the Home page

Appendix E: DASH Score

THE DASH



INSTRUCTIONS

This questionnaire asks about your symptoms as well as your ability to perform certain activities.

Please answer *every question*, based on your condition in the last week, by circling the appropriate number.

If you did not have the opportunity to perform an activity in the past week, please make your *best estimate* on which response would be the most accurate.

It doesn't matter which hand or arm you use to perform the activity; please answer based on your ability regardless of how you perform the task.

DISABILITIES OF THE ARM, SHOULDER AND HAND

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABL
1. Open a tight or new jar.	**1**	**2**	**3**	**4**	**5**
2. Write.	**1**	**2**	**3**	**4**	**5**
3. Turn a key.	**1**	**2**	**3**	**4**	**5**
4. Prepare a meal.	**1**	**2**	**3**	**4**	**5**
5. Push open a heavy door.	**1**	**2**	**3**	**4**	**5**
6. Place an object on a shelf above your head.	**1**	**2**	**3**	**4**	**5**
7. Do heavy household chores (e.g., wash walls, wash floors).	**1**	**2**	**3**	**4**	**5**
8. Garden or do yard work.	**1**	**2**	**3**	**4**	**5**
9. Make a bed.	**1**	**2**	**3**	**4**	**5**
10. Carry a shopping bag or briefcase.	**1**	**2**	**3**	**4**	**5**
11. Carry a heavy object (over 10 lbs).	**1**	**2**	**3**	**4**	**5**
12. Change a lightbulb overhead.	**1**	**2**	**3**	**4**	**5**
13. Wash or blow dry your hair.	**1**	**2**	**3**	**4**	**5**
14. Wash your back.	**1**	**2**	**3**	**4**	**5**
15. Put on a pullover sweater.	**1**	**2**	**3**	**4**	**5**
16. Use a knife to cut food.	**1**	**2**	**3**	**4**	**5**
17. Recreational activities which require little effort (e.g., cardplaying, knitting, etc.).	**1**	**2**	**3**	**4**	**5**

18. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	**1**	**2**	**3**	**4**	**5**
19. Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.).	**1**	**2**	**3**	**4**	**5**
20. Manage transportation needs (getting from one place to another).	**1**	**2**	**3**	**4**	**5**
21. Sexual activities.	**1**	**2**	**3**	**4**	**5**

DISABILITIES OF THE ARM, SHOULDER AND HAND

QUITE	NOT AT ALL	SLIGHTLY	MODERATELY	A BIT	EX
22. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? *(circle number)*	1	2	3	4	

2
3
.

D

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED

uring the past week, were you limited in your work or other regular daily activities as a result of your am,

shoulder or hand problem? *(circle number)* 1 2 3 4

Please rate the severity of the following symptoms in the last week. *(circle number)*

	NONE	MILD	MODERATE	SEVERE
24. Arm, shoulder or hand pain.	1	2	3	4
25. Arm, shoulder or hand pain when you performed any specific activity.	1	2	3	4
26. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4
27. Weakness in your arm, shoulder or hand.	1	2	3	4
28. Stiffness in your arm, shoulder or hand.	1	2	3	4

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	S D CA

29. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand?

		STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
	(circle number)	**1**	**2**	**3**	**4**	**5**
30.	I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. *(circle number)*	**1**	**2**	**3**	**4**	**5**

DASH DISABILITY/SYMPTOM SCORE = [(sum of n responses) - 1] x 25, where n is equal to the number of completed responses. n

A DASH score may not be calculated if there are greater than 3 missing items.

SCORING THE OPTIONAL MODULES: Add up assigned values for each response; divide by 4 (number of items); subtract 1; multiply by 25.

An optional module score may not be calculated if there are any missing items.

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