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Influence of Preoperative Diagnosis on Short-term Outcomes Following Reverse Total Shoulder Arthroplasty

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Influence of Preoperative Diagnosis on Short-term Outcomes Following Reverse Total Shoulder Arthroplasty



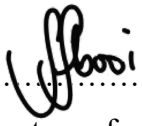
Dr Sarah Athelia Swartbooi

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Medicine

Johannesburg, 2025

Declaration

I, Sarah Swartbooi, declare that this research report is my own, unaided work. It is being submitted for the Master of Medicine degree 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.



……
(Signature of candidate)

……07……day of ……August……20.25……in……Johannesburg……

Dedication

This study is dedicated to my family; this journey was yours as much as mine.

My mother, Patricia Ethel Jegels, thank you for your prayers. You watched over me with unwavering support and continued to believe in me. I will be forever grateful for the sacrifices you made for me over the years.

My beautiful son, Matthew Martin Kakhobwe, your existence and being have served as my yellow brick road and compass to see this to the end.

My niece, Gabriella Lesedi Swartbooi, your beautiful glow was my guiding light through the hard times.

Abstract

Reverse Total Shoulder Arthroplasty (RTSA) was initially employed exclusively for elderly, low-demand patients experiencing advanced rotator cuff tear arthropathy. Due to its encouraging results in these instances, the indication for this surgical procedure has expanded considerably to include a variety of preoperative shoulder conditions. It is being increasingly utilised as an effective intervention for the management of irreparable rotator cuff injuries, glenohumeral osteoarthritis in patients with an intact rotator cuff, acute proximal humerus fractures, complications stemming from proximal humerus fractures, tumours involving the proximal humerus, inflammatory joint diseases, young patients, and cases of unsuccessful anatomic total shoulder arthroplasty or hemiarthroplasty. This study aimed to analyse the one-year outcomes of patients undergoing RTSA for various indications at a single institution, explicitly focusing on pain relief, range of motion, and patient-reported outcome measures. We hypothesised that the preoperative aetiology would significantly influence the results.

Methodology

Our study was a retrospective analysis of patient records, surgical registry, and mortality reports of all patients who underwent shoulder arthroplasties at Chris Hani Baragwanath Academic Hospital (CHBAH) between 01 January 2019 and 31 December 2022. The documented functional outcomes were evaluated for objective and subjective parameters using the American Shoulder and Elbow Surgeons Score (ASES), Visual Analogue Score (VAS), and range of motion, focusing primarily on the preoperative assessment and the assessment performed at one-year follow-up.

Results

In 77 shoulders, RTSA was performed for rotator cuff arthropathy (n = 32), primary osteoarthritis (n = 18), avascular necrosis of the humeral head (n = 7), massive irreparable cuff tear (n = 6), rheumatoid arthritis (n = 4), failed rotator cuff repair (n = 4), chronic locked dislocation (n = 2), sequelae of proximal humerus fracture (n = 2) and revision arthroplasty (n = 2). The mean subjective pain scores in the overall series decreased from 8 preoperatively to 1.8 at the one-year follow-up. The average preoperative ASES score was 40 and improved to a mean of 70 points at 12 months. The shoulder diagnosis was not a significant predictor of the change in the VAS score or ASES scores. Patients with Rotator Cuff Arthropathy (RCA)

achieved the most superior results in the categories of active shoulder abduction, forward flexion, and external rotation compared to other aetiological groups analysed 12 months after surgery.

Conclusion

The range of forward flexion and abduction motion, pain relief, and functionality were improved after RTSA across all aetiological groups, with the most favourable results seen for the diagnosis of RCA and the least advantageous results in primary osteoarthritis. This research report highlights the importance of recognising that the impact of preoperative diagnosis on the outcomes of RTSA is crucial for clinicians. This understanding not only enhances preoperative risk stratification but also plays a vital role in aligning patient expectations with potential surgical results.

Nomenclature

ASES: American Shoulder and Elbow Surgeons Shoulder Score

ATSA: Anatomic Total Shoulder Arthroplasty

BMI: Body Mass Index

CEO: Chief Executive Officer

CHBAH: Chris Hani Baragwanath Academic hospital

FDA: Food and Drug Administration

GH: Glenohumeral

GHJ: Glenohumeral Joint

HIV: Human Immunodefiency Virus

HREC: Human Research Ethics Committee

PROM: Patient Reported Outcome Measures

RCA: Rotator Cuff Arthropathy

ROM: Range Of Motion

RTSA: Reverse Total Shoulder Arthroplasty

TSA: Total Shoulder Arthroplasty

VAS: Visual Analogue Score

WITS: University of the Witwatersrand

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Chapter 1

Introduction and Literature Review

1.1 Introduction

Joint Replacement surgery is a well-established reconstructive speciality in orthopaedic surgery. Total Shoulder Arthroplasty (TSA) forms a large part of this discipline and is widely recognised as a reliable option for various conditions involving the shoulder. Studies to date have reported favourable outcomes, citing more than 90% survivorship in long-term follow-up (1).

Arthroplasty of the shoulder is lauded for its success rate and reproducibility and remains the gold standard in therapy when conservative treatment for specific shoulder pathologies has failed. This procedure has afforded orthopaedic surgeons worldwide the ability to provide patients who suffer from debilitating conditions the opportunity for long-term pain relief, enhanced mobility, and a measure of independence (2). Reverse Total Shoulder Arthroplasty (RTSA) was crafted to tackle the biomechanical challenges related to severe rotator cuff deficiency, for which conventional TSA proved ineffective. Surgeons acknowledged the importance of the rotator cuff in shoulder stability, leading to research into a shoulder prosthesis that could address these concerns. The functional outcomes of RTSA have been excellent, with new national joint registries showing a 10-year survivorship before revision surgery of approximately 94.1% (3). RTSA achieved global recognition and profound popularity over the last two decades. Since gaining approval from the Food and Drug Administration (FDA) in 2004, the number of procedures being performed worldwide has skyrocketed (4). Serial follow-up studies have consistently reported good clinical outcomes. Consequently, the indications for its use have broadened to encompass a range of shoulder diagnoses previously considered challenging to manage effectively and reliably, with younger, high-demand population groups also included. With advances in implant design and performance, the demand for RTSA is set to rise, motivated by increased demand for a better quality of life within both the young and older populations (5).

The auditing of TSA is an evidence-based process that seeks to review the delivery of patient care and monitor outcome measures of shoulder replacements. Auditing can advance the quality of care and establish international consensus on best practices by evaluating set criteria such as patient-reported outcomes, prosthetic-related radiological measurements, and implant longevity. Though RTSA is increasingly being utilised for the management of an array of shoulder pathologies, literature regarding functional outcomes still predominantly focuses on patients with Rotator Cuff Arthropathy (RCA). The existing literature lacks comprehensive reporting on the outcomes following RTSA for the indications beyond RCA. It is imperative that further research be conducted in this area to enhance understanding and inform clinical practice. More effort must be placed into researching the outcomes following RTSA, which are inclusive of shoulder afflictions beyond that of RCA. Thus, this research study compares outcomes following RTSA across the various presenting shoulder diagnoses. Ultimately, the goal is to provide patients with a better understanding of the expected outcome regarding function post-RTSA, depending on their presenting diagnosis.

1.2 Literature review

1.2.1 Anatomy and biomechanics of the shoulder

The shoulder is the most mobile joint among all diarthrodial joints in the human body. Shoulder mobility plays a pivotal role in how we functionally interact with our environment and perform ordinary activities of daily living. The bony architecture includes the clavicle, scapula, and humerus, which are connected by four articulating joints that allow the three-dimensional mobility required for everyday function (see Figure 1.1). The shoulder girdle provides six degrees of freedom, with the characteristic motion being abduction-adduction, flexion-extension, and internal-external rotation (see Figure 1.2). The acromioclavicular joint (ACJ), the glenohumeral joint (GHJ), the sternoclavicular joint, and the scapulothoracic joint work in unison, enabling composite movement of the upper arm and increasing the overall mobility (6). The most fundamental component is the GHJ, which provides the most considerable amount of movement due to a unique set of anatomical and biomechanical features. It is a synovial ball and socket articulation where the sizeable humeral head articulates with a small, shallow glenoid fossa. The surface area ratio of head to glenoid of 3:1 has often been likened to a golf ball on a tee. The high degree of mobility comes at the sacrifice of stability; the shoulder thus

relies on the encompassing muscles and surrounding ligaments to provide constraint. These tissues span the joint and are broadly divided into dynamic and static stabilisers (6).

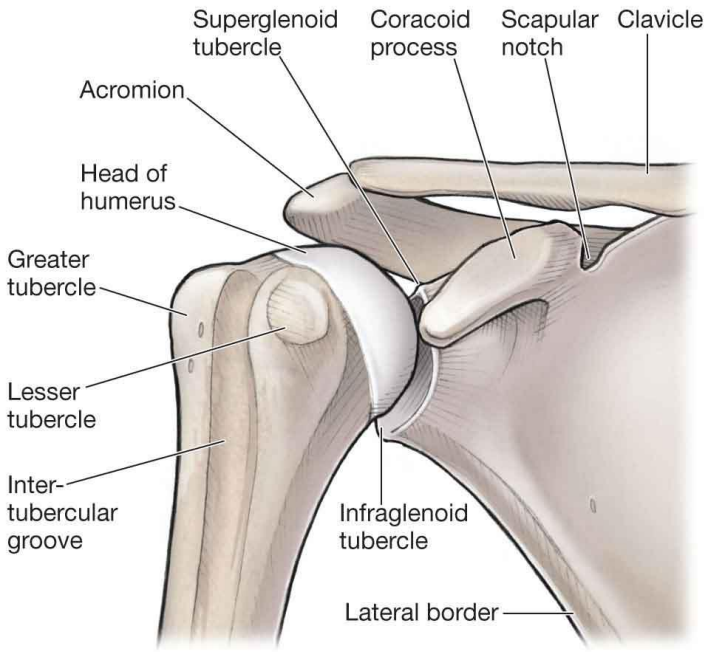


Figure 1.1: The Glenohumeral joint (7).

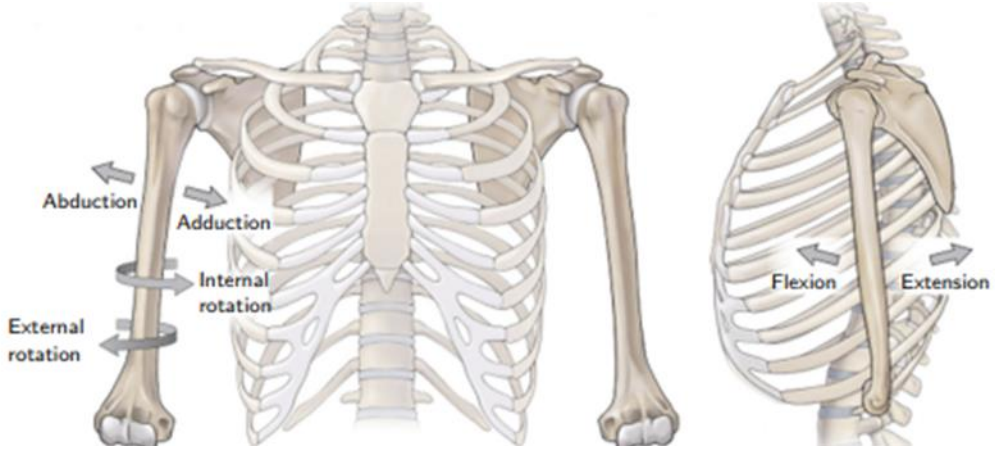


Figure 1.2: The shoulder joint and characteristic humeral movements (7).

The primary dynamic stabilisers include the rotator cuff muscles, the long head of the biceps, and the deltoid muscle. The rotator cuff comprises four muscles: the supraspinatus, infraspinatus, subscapularis, and teres minor (see Figures 1.3 and 1.4). They originate from the scapula body, spanning the joint, encasing the entire humeral head and attaching to the greater and lesser tuberosities. This muscle group provides joint stability by compressing the humeral

head into the glenoid fossa during shoulder motion. During the initiation of arm elevation, the deltoid contracts, producing a force directed superiorly; this could dislocate the joint if not for the contraction of the rotator cuff, which works synergistically to compress the humeral head within the glenoid fossa. This action opposes the deltoid forces and keeps the GH joint stable throughout motion, termed the concavity-compression mechanism (8). The long head of the biceps provides stability by depressing the humeral head, with the deltoid being the primary powerhouse of movement across the GH joint (7).

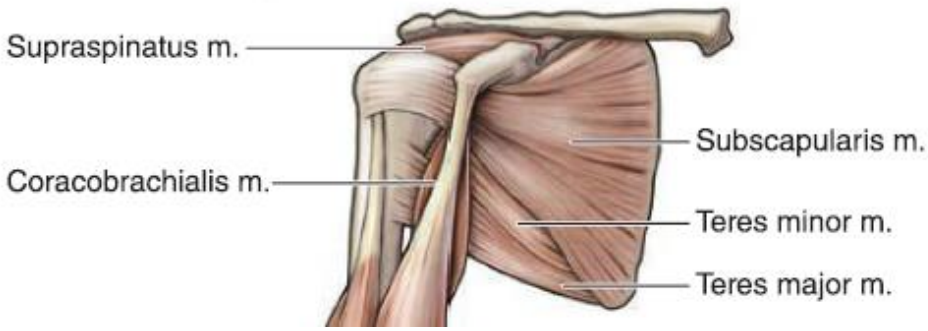


Figure 1.3: The anterior view of the rotator cuff muscles (7).

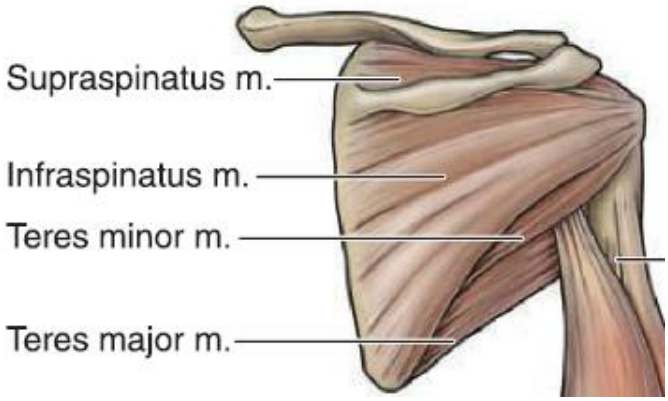


Figure 1.4: The posterior view of the rotator cuff muscles (7).

The GH joint's static support includes the glenoid labrum, a fibrocartilaginous structure that aids in deepening the concavity of the glenoid fossa and widening the surface area to which the humeral head articulates; the joint capsule, which exerts negative intra-articular pressure, causing a suction cup effect within the joint; and the three GH ligaments, which provide

stability throughout various positions of the arm (9). The complex interplay between static soft tissue and dynamic muscular stabilisers lends it more inherent stability (see Figure 1.5) (10).

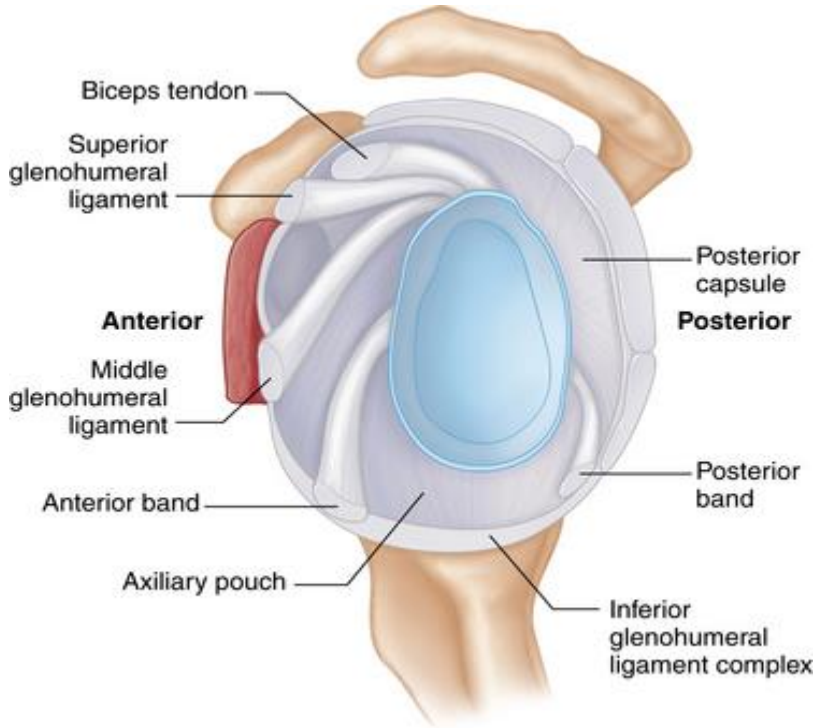


Figure 1.5: The static stabilisers of the shoulder (7).

1.2.2 Reconstructive procedures of the shoulder

Arthroplasty has gained widespread acceptance as an effective treatment option for a range of degenerative, traumatic, and neoplastic pathologies involving the GH joint. Arthroplasty of the shoulder is the third most common type of joint replacement procedure performed worldwide after hip and knee arthroplasty (4). The first shoulder replacement dates to 1893, Jules-Émile Péan was a prominent French surgeon who attempted this procedure on a patient inflicted with tuberculous arthropathy of the shoulder. The procedure was initially documented to be a success, providing good function and pain relief; however, this was short-lived as the prosthesis became infected and required removal. This was followed by half a century of a paucity of positive contributions to the research of shoulder replacement. It was not until the 1950s that Dr Charles Neer engineered the first non-constrained shoulder prosthesis, which ushered in the evolution of the modern-day design (11). Shoulder replacement systems fall into two distinct categories, namely anatomic and non-anatomic prostheses. Anatomic prosthetic systems are

designed to recreate the native shoulder anatomy, thus affording it the ability to reproduce normal GH kinematics (8). The anatomic group can be further subclassified into total or partial replacement. In hemiarthroplasty, which is partial shoulder replacement, only the humeral head is replaced while the patient's glenoid is preserved. This procedure is recognised as a reliable method for managing humeral head pathology, particularly in cases where the glenoid is largely unaffected. Anatomic total shoulder arthroplasty (ATSA) uses an implant design that mimics the typical bony architecture of the GH joint, substituting both the damaged humeral head and glenoid fossa with a prosthesis. ATSA is an effective surgical option for addressing conditions such as primary and secondary osteoarthritis, being utilised when the rotator cuff is intact and in the presence of good glenoid bone stock. Dr Neer's anatomical designs became the mainstay of treatment, offering a long track record of successful outcomes. Wilde et al. conducted a meta-analysis encompassing 646 replacements performed on patients with osteoarthritis of the shoulder. Their findings indicated that 89% of patients reported satisfactory pain relief at the 10-year follow-up (12). The RTSA falls under the non-anatomic designs, as the name denotes; the inherent anatomy is inverted in that the glenoid becomes the ball, and the humerus becomes the socket (11). This prosthesis was originally developed to address complex conditions related to rotator cuff deficiency, which conventional TSA failed to address dismally. The RTSA system overcame rotator cuff deficiency by biomechanically activating shoulder motion solely reliant on the deltoid muscle as an alternative to the rotator cuff (13).

1.2.3 Reverse Total Shoulder Arthroplasty

1.2.3.1 Background

RTSA, in its current form, is the culmination of many years of evolving arthroplasty designs. Understanding the history and limitations of previous implant models can offer helpful insights into the design and evolution of contemporary and future reverse arthroplasty systems. In 1983, Dr Neer identified a set of distinct clinical and radiographical findings specific to the shoulder, introducing the term RCA. It was defined as a condition that manifests clinically with symptoms such as pain, limited active range of motion, crepitus, and weakness. Radiographic features include degeneration of the GHJ coupled with superior migration of the humeral head due to significant attrition or tear of the rotator cuff complex (14). Conventional shoulder arthroplasty procedures demonstrated high failure rates in patients with this condition. In a

pioneering article on RCA, Neer et al. acknowledge that the surgical management of this pathology was exceptionally challenging and defined the outcomes as unsatisfactory. Before the development of RTSA, options for managing RCA were limited. Hemiarthroplasty and ATSA had suboptimal outcomes in this population, with high rates of complications and dissatisfaction (15). RCA posed a unique set of challenges for shoulder surgeons, generating keen interest in developing a prosthesis that would restore ROM and improve function in the presence of a dysfunctional cuff. Numerous reversed polarity implants were designed, which increased constraint across the shoulder; it was postulated that increasing stability would offset the lack of a rotator cuff. Regrettably, all these implants failed as the added constraint produced excessive shearing forces within the implant, resulting in the loosening of the glenoid component and, ultimately, the catastrophic failure of the prosthesis (14).

French surgeon Paul Grammont developed the first successful RTSA design in the 1980s. The design addressed the failings of previous implants by not only reversing the anatomical configuration of the GH joint but introducing a large glenoid sphere and a small humeral cup; this configuration altered the joint mechanical function (16). In his inaugural published report detailing his experience with the reverse prosthesis, Grammont described the outcomes of eight patients with RCA. All eight patients reported exceptional pain relief; however, only four had acceptable functional results, that being, the ability to elevate their arm above 100 degrees (17). While only 50% of the patients in this study demonstrated better functional outcomes, it was a distinct improvement to the known existing data on outcomes for that era. It spurred Grammont to modify and improve his prosthetic design further. In 1993, he introduced the Delta III prosthesis (see Figure 1.6). It reliably relieved pain and markedly improved functional outcomes, thus completely revolutionising the approach to treating patients with RCA. It was adopted across Europe, providing predictable positive results (15). The first significant publication reporting on the results of the Grammont prosthesis was by Sirveaux et al. in 2004. In a series of 80 individuals, the authors reported pain relief in 96% of the cohort and good functional outcomes evidenced by an increased mean active elevation from 73 to 138 degrees (18). In a multicentre study, Favard et al. evaluated 484 patients with RCA, illustrating a 10-year survivorship of 89% after RTSA (3).

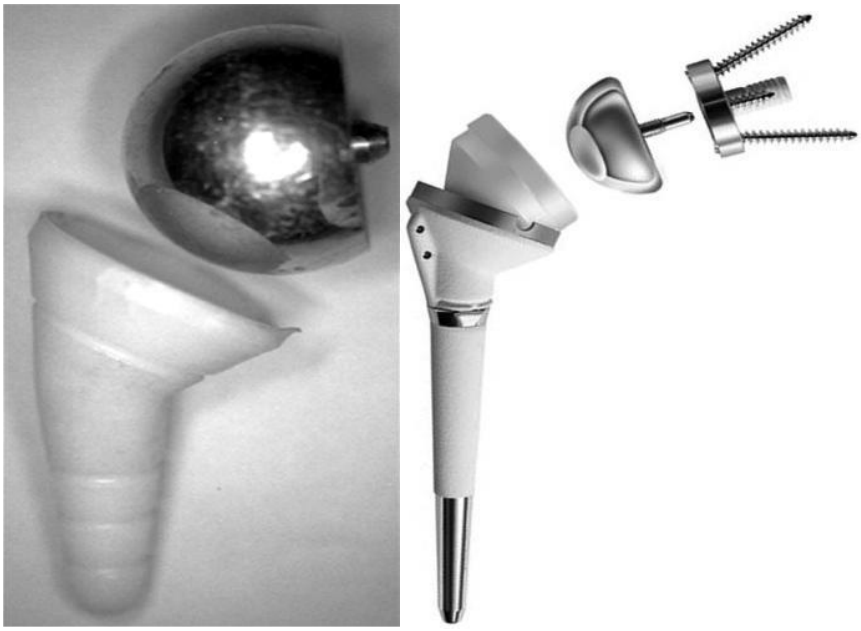


Figure 1.6 *Left*: The original Grammont prosthesis. *Right*: Modern design of the Grammont prosthesis (11).

1.2.3.2 Biomechanics of RTSA

Four fundamental biomechanical principles are employed in the Grammont reverse prosthesis design, which offers critical advantages over the native shoulder when rotator cuff pathology is present. The first principle focuses on the joint's centre of rotation (CoR); shifting it to a more medial and inferior position lengthens the deltoid muscle's lever arm, increasing tension within the deltoid (see Figure 1.7). The action recruits more muscle fibres, allowing the deltoid to power the function of arm elevation more efficiently and requiring less muscle force and effort. Secondly, the prosthesis relies on the principle of intrinsic stability. This is achieved through the structurally constrained configuration of the prosthesis. The spherical glenoid component acts as a mechanical block and an immobile pivot, inhibiting upward displacement of the humeral component when the deltoid is activated, therefore maintaining stability. Thirdly, the implant employs a fixed fulcrum mechanism, maintaining GH stability throughout shoulder movement. Lastly, there are reduced torque forces generated at the GH joint, mitigating the complication of glenoid loosening (19).

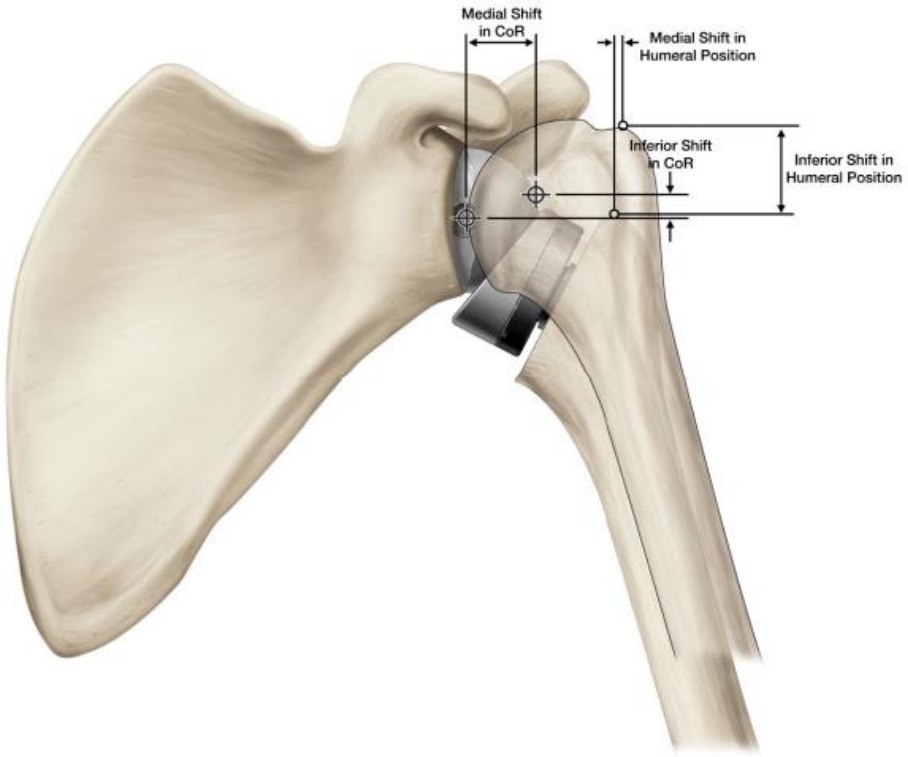


Figure 1.7: Biomechanical differences between the native shoulder and RTSA (19).

1.2.3.3 Indications

The reverse prosthesis was solely designed to address RCA; historically, it was typically only considered for elderly patients over the age of 70 with low functional demand. This decision was based on studies such as one conducted by Guery et al., which analysed the survivorship of eighty replacements followed for ten years, noting a rapid decline in shoulder function around eight years after implantation (20). RTSA undertaken in infirm elderly patients displayed improvement in GH function higher than anticipated, with short-term clinical outcome data confirming the reverse prosthesis' capability to restore overhead arm elevation in patients with RCA consistently (14). The reported success of the prosthesis resulted in an expansion of indications to include a broader spectrum of complex shoulder conditions beyond RCA. Seebauer et al. conducted a study on outcomes involving 57 patients with RCA who received RTSA; their analysis revealed a 98% satisfaction rate, with most patients reporting no pain symptoms and improved functional independence (21). Emerging indications for RTSA comprise extensive and irreparable cuff tears, non-reconstructable acute humerus fractures, primary osteoarthritis with severe glenoid erosion, rheumatoid arthritis, posttraumatic arthritis,

and revision arthroplasty after failed ATSA and hemiarthroplasty. While earlier publications focused mainly on RTSA implanted for RCA, in a landmark paper, Boileau was one of the first authors to evaluate the outcomes for the expanded range of indications. The study showed significant improvement in pain, range of motion, and functional scores without a high rate of complications across an array of presenting shoulder pathologies (22). The broadened indication has inadvertently expanded the patient demographic from beyond elderly patients to younger population groups. Young patients will require decades of future shoulder function, and the use of RTSA within this age group is still a moot point. Contemporary academic consensus has shifted toward greater acceptance of the reverse shoulder prosthesis for use in certain end-stage shoulder disorders in younger patient populations. A study conducted by Matthews et al. observed the 4-year outcomes of RTSA performed on individuals younger than 65 years and demonstrated that the substantial clinical improvements initially achieved were maintained up to the 4-year mark (23). Holcomb et al. published on the practical application of RTSA in managing rheumatoid arthritis, similarly finding significant improvements in pain, motion, and function. He reiterated the importance of careful patient selection and thorough preoperative planning, considering that factors such as bone quality, soft tissue integrity, and functional demands are critical to achieving optimal outcomes (24). In a retrospective review, Kilic et al. conducted a comparative study on the use of ATSA and RTSA for proximal humerus fracture sequelae. The study showed that patients within the RTSA cohort had markedly better postoperative shoulder strength and motion (25). Mulieri et al. reviewed 60 patients who underwent RTSA, the primary indication being a massive rotator cuff tear. At an average follow-up of 52 months following surgery, the entire cohort exhibited improved forward flexion and abduction.

1.2.3.4 Contraindications

RTSA is contraindicated in the presence of deltoid muscle dysfunction and excessive glenoid bone loss that would preclude stable fixation of the glenoid prosthetic component, neuromuscular conditions that may impair upper extremity function, and infection (26).

1.2.3.5 Complications Following Shoulder Arthroplasty

Arthroplasty has positive and negative attributes; despite the well-described clinical outcomes, one must be cognizant of the potentially devastating complications that may occur. RTSA is frequently employed to salvage complex conditions; thus, it goes without saying that complication rates in these situations would be relatively high. While initial reports estimated the complication rate for RTSA to range from 15 – 24%, more recent studies have demonstrated a decline in complications over the past decade to an overall rate of 6%. This improvement has been attributed to advancements in surgical techniques, modifications of implant designs, a deeper understanding of the prosthetic device and diligent rehabilitation (27). The prevalence of complications varies depending on several aspects; this includes patient factors such as age, the presence of comorbid disease and obesity. Surgical factors include the level of surgical experience, appropriate soft tissue balancing and accurate prosthetic component placement (28). In a meta-analysis performed in 2018, Ascione et al. implicated infection at 4.1% as the most frequent adverse event met, followed by instability at 3% and glenoid component failure at 2.3% (29).

1.2.3.6 Outcomes following RTSA

The literature consistently supported the benefits of the RTSA for RCA, consequently motivating approval of the FDA for its use within the United States. This catapulted the clinical application of the reverse prosthesis worldwide. With advances in the improvement of the prosthesis design alongside new technological innovations, the past two decades have seen an exponential surge in its use. Data on the number of replacements executed in the United States demonstrated a threefold increase in the annual incidence of RTSA from 2009 to 2019, with a substantial decrease in hemiarthroplasty. Notably, 2014 was the year that RTSA outnumbered ATSA (4, 23). The Australian National Joint Registry reported increased use of RTSA from 42.2% in 2009 to 77.9% in 2023 (30).

1.3 Study Aim and Objectives

This research sought to determine whether the preoperative shoulder aetiology influences the short-term clinical and functional outcomes following RTSA.

The objectives of this study were to:

I. To present a detailed description of the most frequently encountered indications leading to RTSA
II. To assess Patient Reported Outcome Measures (PROM) and functional outcome measures of patients who underwent RTSA and compare findings based on the primary shoulder diagnosis
III. To review the early postoperative complications

1.4 Hypothesis

The preoperative diagnosis significantly influences the short-term postoperative outcomes following reverse total shoulder arthroplasty.

Chapter 2
Methodology

2.1 Research Question

Does the preoperative diagnosis influence the short-term outcomes following reverse total shoulder arthroplasty?

2.2 Research Design

A retrospective comparative study was carried out on patients who underwent RTSA at Chris Hani Baragwanath Academic Hospital (CHBAH) between 01 January 2019 and 31 December 2022. All surgeries were carried out by one of two orthopaedic surgeons, one of whom is fellowship-trained in shoulder surgery. After consulting with a statistician, it was determined that a meaningful data analysis could be conducted with a sample size of 50 cases. Additionally, published studies within this area of research were evaluated and noted to have similar comparative sample sizes (3, 31, 32).

2.3 Materials and Methods

Patient medical records, the sports unit theatre registry, and Morbidity and Mortality reports conducted biweekly at CHBAH constituted the primary sources for this research study. The medical records contain a wealth of information due to the consistent implementation of standardised evaluation and record-keeping within the sports unit. All patients undertaking RTSA undergo a comprehensive preoperative clinical and radiological assessment. This includes a detailed history-taking, a thorough shoulder examination, and a preoperative evaluation of their functional impairment through patient-reported outcome measures (PROMs). The findings from this assessment are documented in writing within the patient's medical record. This thorough evaluation process is repeated the day before surgery, at six weeks, three months, six months, and annually thereafter.

Demographic and surgical data were retrieved, including age at the time of surgery, gender, comorbid diseases, and hand dominance. Surgical variables will include the aetiological preoperative diagnosis, laterality, and early and late postoperative complications.

The study examined various functional outcome measures obtained from the patient's medical records, including preoperative scores taken a day before surgery and postoperative scores taken at a one-year follow-up. These measures encompassed both subjective and objective metrics. The Visual Analogue Score (VAS) is a tool used to assess the patient's pain level, ranging from zero, indicating no pain, to ten, representing the worst imaginable pain. The American Shoulder and Elbow Surgeons Shoulder Score (ASES) is a validated instrument that quantifies both the degree of shoulder pain and the level of an individual's shoulder function in activities of daily living. This score spans from 0 to 100, with 0 representing severe pain and substantial functional limitations and 100 denoting complete absence of pain and unrestricted shoulder capabilities. The final functional score captured from the medical records was the active range of motion comprising abduction, forward flexion, and external rotation. The patients were divided into cohorts based on their indication for surgery, and the functional outcomes were compared between these clusters.

2.4 Selection Criteria

2.4.1 Inclusion criteria:

I. Patients ≥ 18 years
II. All patients who undergo RTSA at CHBAH
III. A minimum patient follow-up of 12 months

2.4.2 Exclusion criteria:

I. Patients with incomplete records
II. RTSA not performed within the sports unit
III. A minimum follow-up of less than 12 months

2.5 Data Collection

The study required authorisation from several regulatory authorities. Approval from Chris Hani Baragwanath Academic Hospital's management to conduct this research and use and access patient records was obtained in August 2024. Data collection was initiated in August 2024 after permission was received from the Human Research Ethics Committee (HREC) (Medical) of the University of the Witwatersrand, Ethics clearance number: **M240964**.

This research project drew upon patient hospital records, the Orthopaedic Sports unit's surgical registry, and the institution's biweekly Morbidity and Mortality reports as the primary data sources. These documents provided the necessary information about the patients who underwent the surgical procedure under investigation. The primary researcher, Dr. Swartbooi, gathered data for all patients who underwent RTSA during the specified timeframe. The relevant data was extracted and tabulated on a data collection sheet (see Appendix B). The collected information was securely stored on a password-protected computer. To maintain anonymity and confidentiality, participants were assigned unique study numbers.

Chapter 3

Results

The raw data was then transferred to Microsoft Excel® spreadsheets, and statistical investigations were run using R software (version 4.00; www.R-project.org). The study's data sets comprised categorical variables, so non-parametric analyses were used. Tests were two-tailed, and model significance was set at 0.05. Data were reported descriptively as counts and percentages and presented in appropriate charts, Tables, and text.

Patients were grouped according to their aetiological diagnosis, and an analysis of variance was utilised to evaluate the variations in outcome scores and range of motion within each allotted group from the preoperative state to the time of the one-year review. Pearson's goodness of fitness tests were used to analyse the distribution of socio-demographic variables against an expected (null) model. To investigate differences in preoperative shoulder diagnosis and preoperative and postoperative outcome scores, a general linear model (GLM, Poisson family, log link) with a repeated measures design was used, in which preoperative shoulder diagnosis was the fixed effect, time (preoperative and one-year postoperative scores) was the repeated measures variable and age, and gender were included as predictor variables. Appropriate post hoc tests (e.g. Tukey) were used to analyse pairwise contrasts for significant outcomes.

Following consultation with a statistician and a thorough review of pertinent published literature with analogous sample sizes, it was determined that 50 cases would suffice for the intended data analysis. In determining the appropriate sample size, it was crucial to consider the prevalence rate and statistical power. A power calculation was completed to validate whether the sample size was suitably powered to confirm or negate the hypothesis. Based on published studies with similar endpoints evaluated, a sample size of 48 participants would be necessary to achieve 80% power, assuming a problem prevalence of 5% (33).

3.1 Sample Summary

This study observed 81 reverse shoulder arthroplasty surgeries performed at the CHBAH Sports Unit period between 01 January 2019 and 31 December 2022, of which 79 cases were primary and 2 were revision surgeries. This study considered 77 prostheses implanted into seventy-two patients, with five patients having staged bilateral procedures within the study period. The following patients were excluded: two patients due to incomplete records and two patients who died of unrelated causes before a one-year follow-up.

3.2 Indication for surgery

RCA was the most common indication for RTSA, representing 42% of the total participants, followed by primary osteoarthritis, making up 23.3% and avascular necrosis of the humeral head, being third at 9.2% (see Table 3.1). The less common indications for surgery were grouped collectively into the category of Other, as individually, these indications were not statically significant (p = 0.127). Thus, the three main groups were categorised into RCA, Primary OA, and Other for the remainder of the study. These diagnoses included rheumatoid arthritis, chronic dislocation, massive irreparable rotator cuff tear, and revision arthroplasty surgery.

Table 3.1: Indication for surgery.

Preoperative diagnosis	**Number**	**Prevalence**
Avascular necrosis	7	9.2%
Chronic locked dislocation	4	5%
Failed rotator cuff repair	2	2.5%
Massive irreparable cuff tear	6	8%
Primary Osteoarthritis	18	23.3%
Rotator cuff arthropathy	32	42%
Revision arthroplasty	2	2.5%
Rheumatoid arthritis	4	5%
Sequalae of proximal humerus fracture	2	2.5%
Grand Total	**77**	**100%**

3.3 Age

Figure 3.1 depicts the patients' age distribution. The majority (77%) were aged 61 to 80, followed by 13 patients aged under 60 (23.4%). The mean age of the participants was 65.01 years (standard deviation (SD) = 8.06).

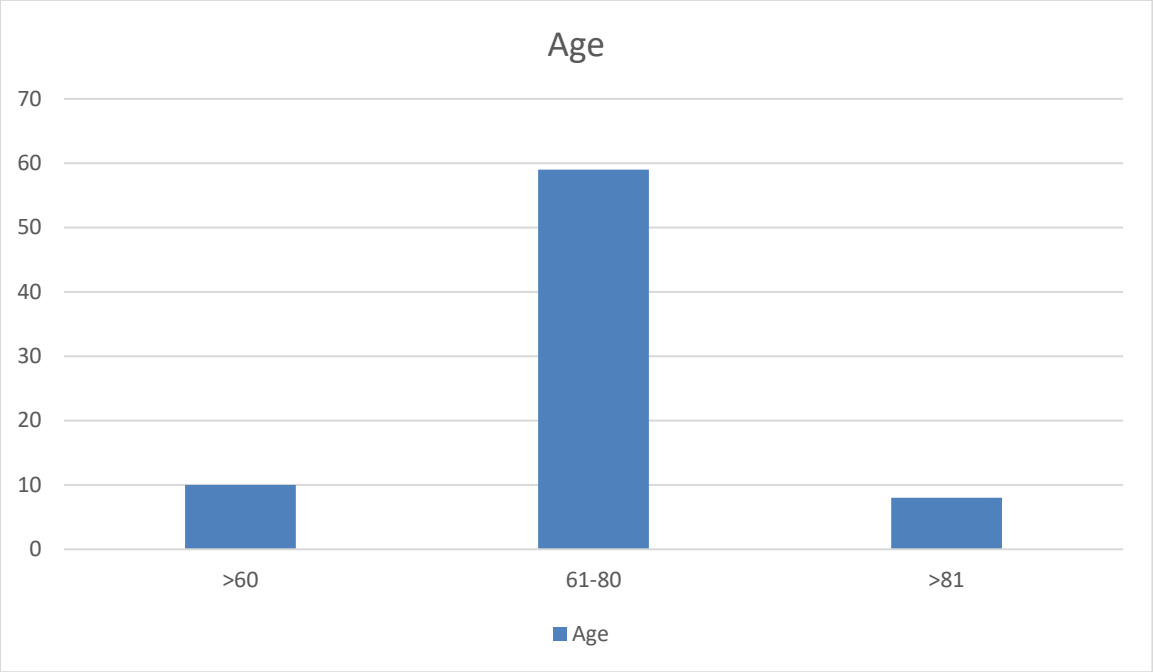


Figure 3.1: Age distribution of participants.

3.4 Gender

Figure 3.2 below depicts the gender distribution of the patients. A significantly greater number of patients were female (n = 52; 67.5%) than male (n = 25; 32.5%) (p = 0.002).

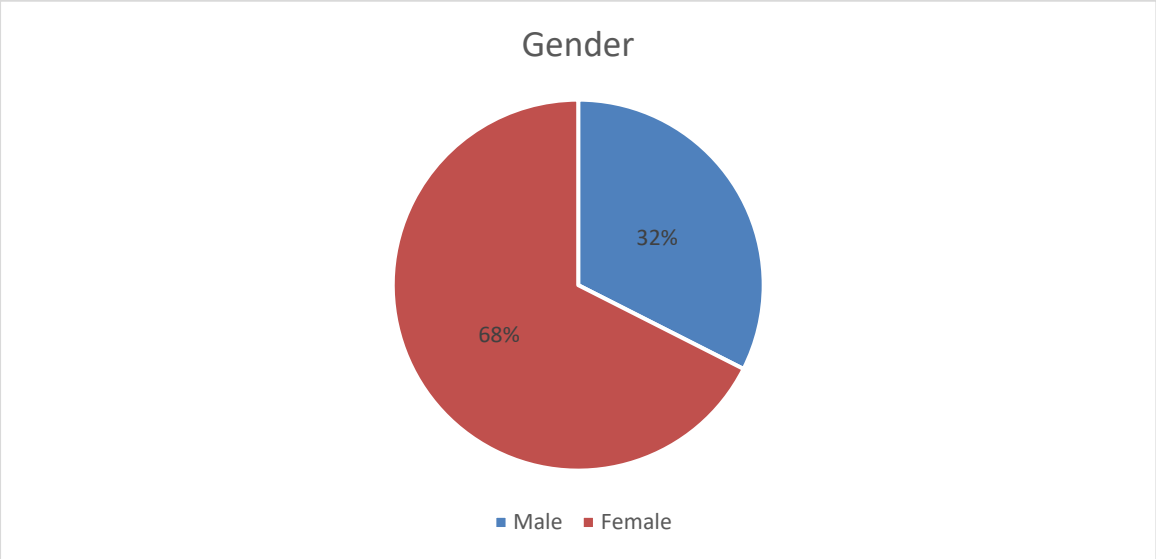


Figure 3.2: Gender distribution of participants.

3.5 Laterality and Hand Dominance

Figure 3.3 illustrates that significantly more patients were right-handed (n = 65; 84.4%) than left-handed (n = 12; 15.6%) (p < 0.001). Conversely, the variance in laterality was not statistically meaningful (p = 0.087), although more patients had surgery performed on the right (n = 46; 59.7%) than left (n = 31; 40.3%).

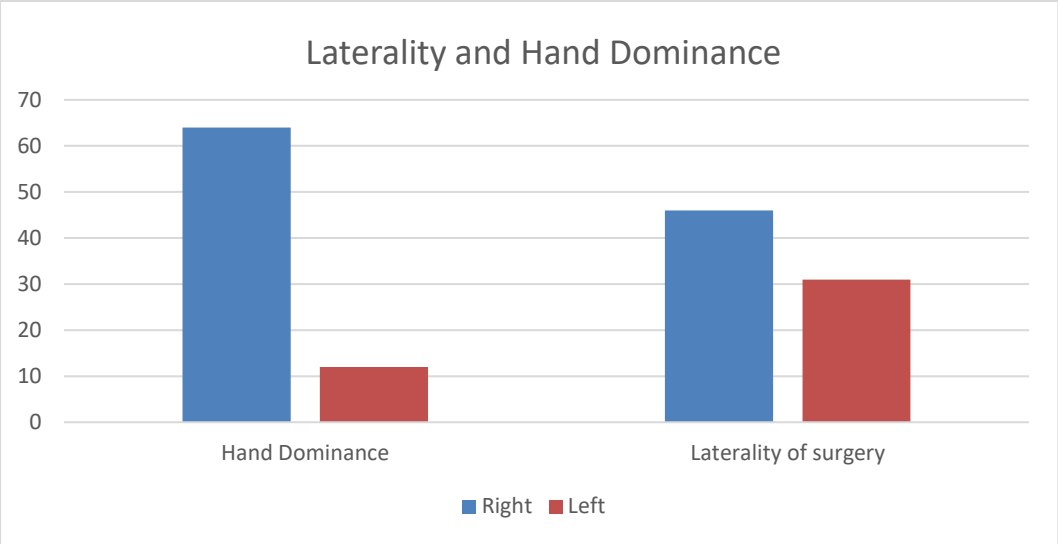


Figure 3.3: Laterality and Hand Dominance.

3.6 Outcome Scores

3.6.1 Visual Analogue Score

Patient pain scores averaged 8 points before surgery and improved to 1.8 at the one-year postoperative assessment ($p < 0.001$; see Figure 3.4). This improvement was noted across all aetiological groups. The mean postoperative scores were 65% lower than the preoperative scores. The shoulder diagnosis was not a conclusive predictor of the change in the VAS score ($p = 0.299$). In addition, the age of patients ($p = 0.291$) and their gender ($p = 0.124$) were not significant predictors of VAS scores.

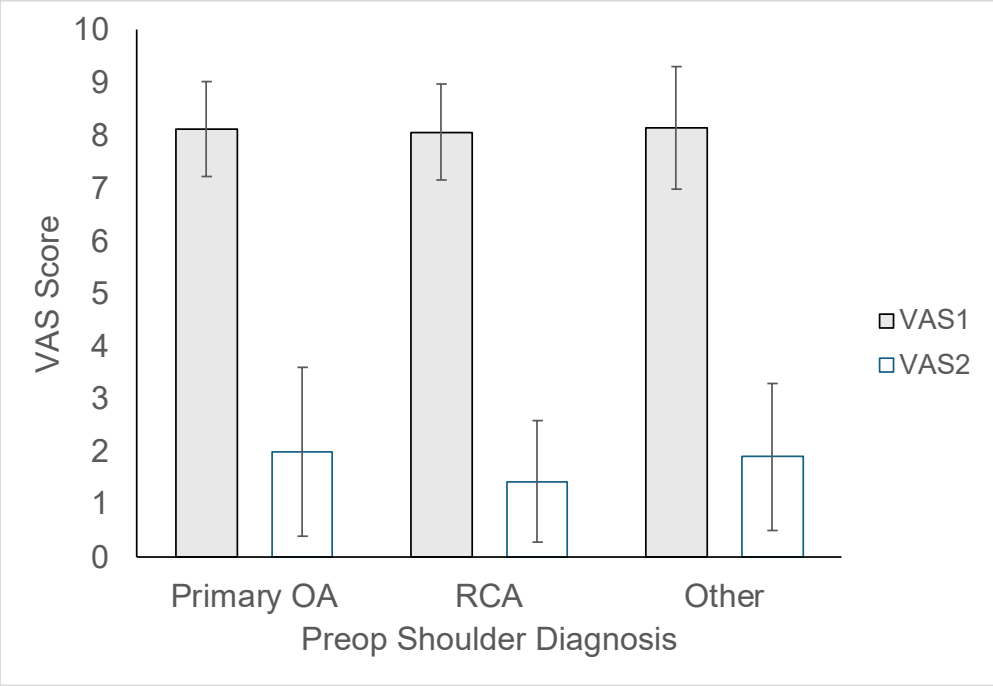


Figure 3.4: Preoperative VAS scores (VAS1) and postoperative (VAS2) for three categories of preoperative shoulder diagnoses. Bars are means, and error bars are standard deviations.

3.6.2 ASES scores

The average preoperative ASES score was 40 and improved to 70 at one-year follow-up ($p < 0.001$; see Figure 3.5). The mean postoperative scores were 29% greater than the preoperative scores. The preoperative shoulder diagnosis did not significantly predict ASES scores ($p = 0.414$). In addition, the age of patients ($p = 0.756$) and their gender ($p = 0.488$) were not significant predictors of ASES scores.

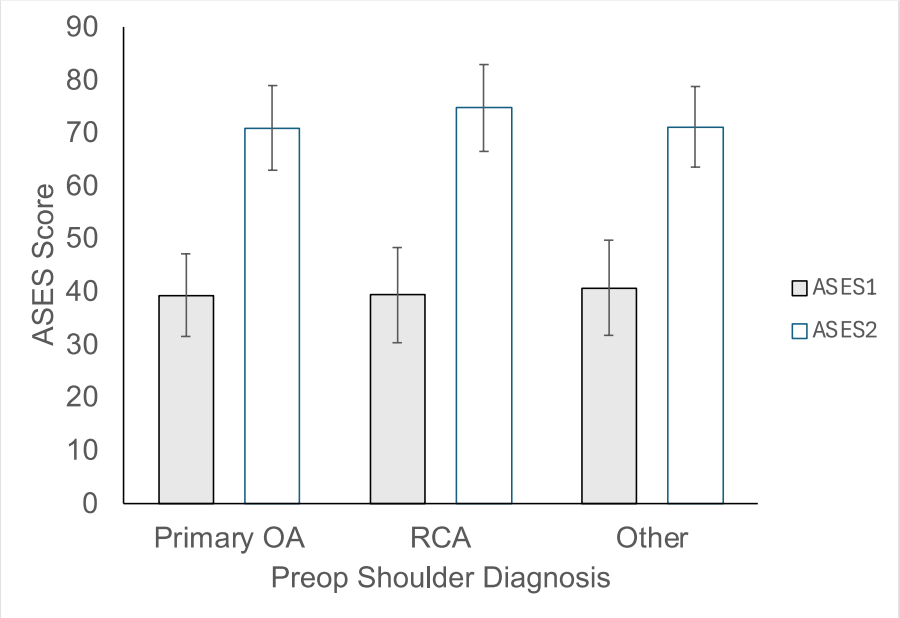


Figure 3.5: ASES scores preoperative (ASES1) and postoperative (ASES2) for three categories of preoperative shoulder diagnoses. Bars are means, and error bars are standard deviations.

3.7 Abduction

The degree of abduction increased significantly from preoperative to postoperative review ($p < 0.001$; see Figure 3.6). The mean postoperative abduction was 52% greater than the preoperative review. The mean change in the degree of abduction from preoperative to postoperative was most significant for the RCA group (58%), followed by the Other group (56%) and lowest in the Primary OA group (40%). In addition, the type of preoperative shoulder diagnosis ($p = 0.019$) and the interaction between preoperative shoulder diagnosis and time (Abduction1 to Abduction2) was a significant determinant of the magnitude of abduction ($p < 0.001$). Posthoc tests showed that the overall RCA and Primary OA groups had a greater degree of abduction than the Other group (see Figure 3.7). In combination with time, the RCA group had the lowest degree of abduction in the preoperative assessment (Abduction1), followed by the Other group and then Primary OA.

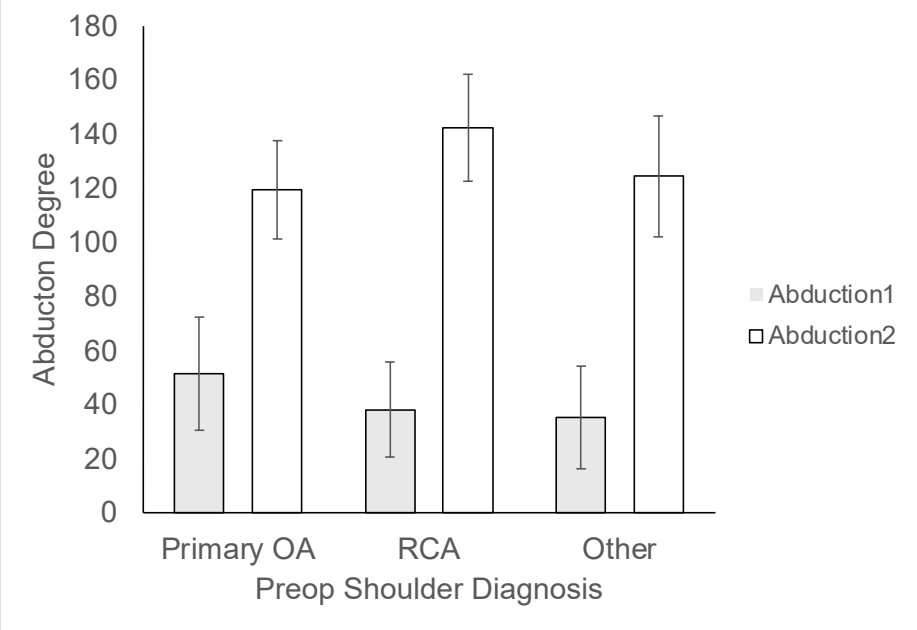


Figure 3.6: The degree of Abduction preoperative (Abduction1) and postoperative (Abduction2) for three categories of preoperative shoulder diagnoses. Bars are means, and error bars are standard deviations.

3.8 Forward Flexion

The degree of flexion increased significantly from preoperative to postoperative assessment ($p < 0.001$; see Figure 3.7). The mean postoperative degree of flexion was 47% greater than the preoperative review. The mean change in the degree of flexion from preoperative to postoperative was most remarkable for the RCA group (52%), followed by the Other group (50%) and lowest in the Primary OA group (35%). The type of preoperative shoulder diagnosis was not a significant predictor of the degree of flexion ($p = 0.061$). However, the interaction between the type of preoperative shoulder diagnosis and time (Flexion1 to Flexion2) was a noteworthy factor in predicting the range of flexion ($p < 0.001$). In combination with time, the Other group showed the most reduced flexion in the preoperative assessment (Flexion1) compared to the RCA and Primary OA groups.

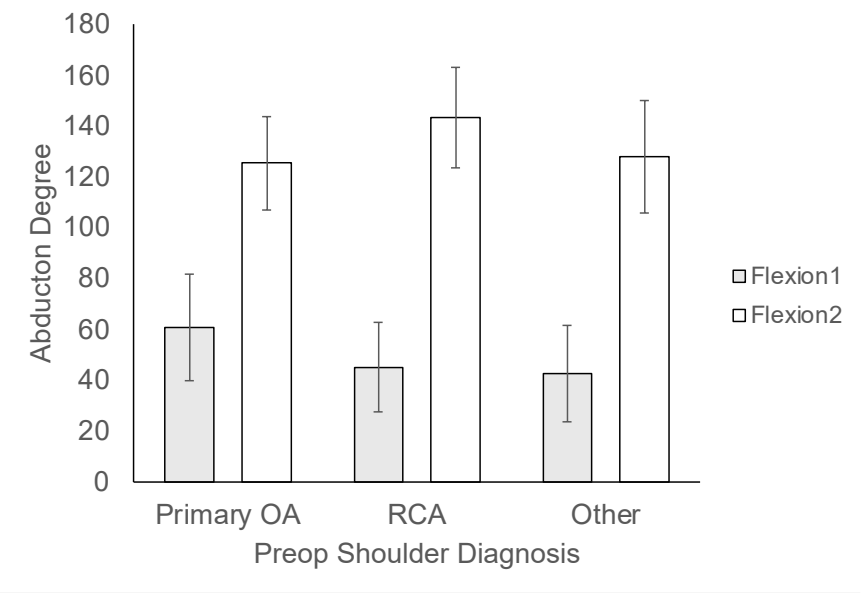


Figure 3.7: The degree of Flexion preoperative (Flexion1) and postoperative (Flexion2) for three categories of preoperative shoulder diagnoses. Bars are means, and error bars are standard deviations.

3.9 External Rotation

The degree of external rotation increased significantly from preoperative to postoperative assessment ($p < 0.001$; see Figure 3.8). The mean postoperative range of motion was 31% greater than the preoperative degree. In addition, the type of preoperative shoulder diagnosis was a noteworthy factor in predicting the range of external rotation ($p = 0.001$). Posthoc tests showed that the RCA group had a more remarkable improvement in external rotation than the Other and Primary OA groups (see Figure 3.8). The age of patients ($p = 0894$) and gender ($p = 314$) were not meaningful predictors of external rotation degree.

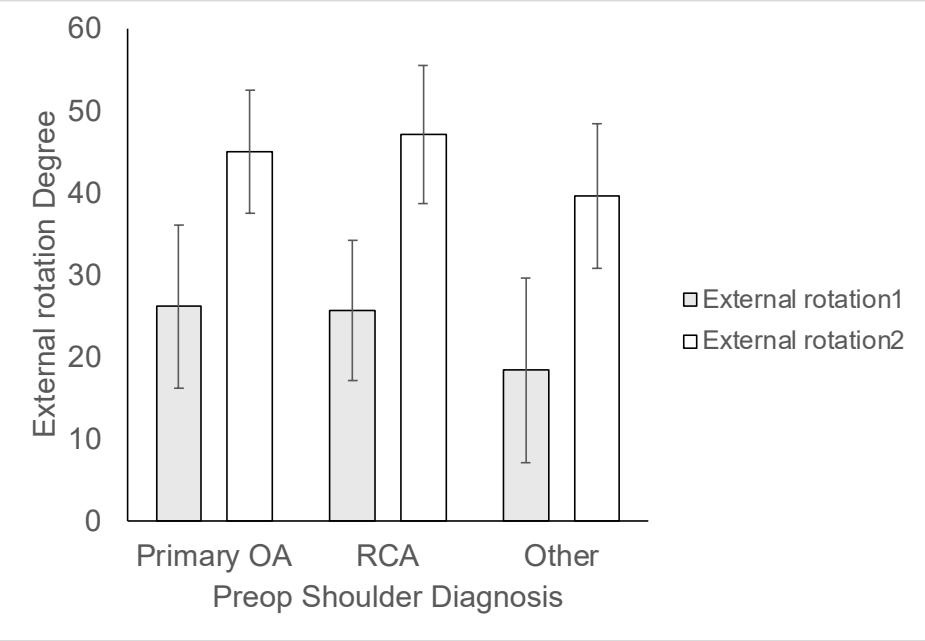


Figure 3.8: The degree of External rotation preoperative (ER1) and postoperative (ER2) for three categories of preoperative shoulder diagnoses. Bars are means and error bars are standard deviation.

3.10 Postoperative Complications

The overall complication rate of all participants who underwent RTSA during our study was 15% (n = 12), of which humeral stem fracture instability, wound dehiscence and venous thromboembolism were the more commonly encountered (see Table 3.2).

Table 3.2: The number of patients with complications in the study.

Pathological Cause	**Number**	**Prevalence**
Acromial Fracture	1	1.3%
Axillary Nerve Injury	1	1.3%
Humeral Stem Fracture	3	3.8%
Instability	2	2.6%
Peri-prosthetic joint Infection	1	1.3%
Wound dehiscence	2	2.6%
Venous thromboembolism	2	2.6%
Total	**12**	**15%**

Chapter 4

Discussion

Reverse total shoulder arthroplasty (RTSA) has emerged as a dependable treatment option for managing advanced glenohumeral pathology. The Grammont prosthesis was initially developed to address glenohumeral arthritis stemming from significant rotator cuff disease. Since its inception, the criteria for performing RTSA have broadened beyond rotator cuff arthropathy to encompass a range of other shoulder disorders, including primary osteoarthritis, massive cuff tears, rheumatoid arthritis, acute fractures, and revision arthroplasty (3).

This study comprehensively analysed the outcomes following RTSA in a cohort of 77 patients treated at a major academic institution in South Africa. The primary focus was on the preoperative assessment and the examination conducted 12 months after surgery. The participants presented with diverse shoulder conditions characterised by significant functional deficits due to debilitating pain and loss of motion, having exhausted all forms of non-operative therapy. Rotator Cuff Arthropathy (RCA) was the most prevalent indication for RTSA, followed by primary osteoarthritis as the second (see Table 3.1). The participants had a mean age of 65 years, with 77% of individuals between 61 and 80 years (see Figure 3.1). The cohort comprised 25 male and 52 female patients, indicating a significant female predominance, constituting 67.5% of the total cases. This observation underscores the higher incidence of shoulder arthroplasty among females compared to males within the parameters of this study (see Figure 3.2). A notable observation from our research is that 84.4% of the patients exhibited right-hand dominance, indicating a predominant use of their right hand in daily activities. Although a higher number of replacements were performed on the right-hand side (59.7%), statistical analysis revealed that the difference in the distribution of surgeries based on laterality did not reach the conventional threshold for statistical significance, with a p-value of 0.087 (see Figure 3.3). This suggests that the observed preference for performing surgeries on the right side may be due to various factors rather than a definitive trend or preference in surgical practice. These findings further enhance our understanding of the demographic characteristics associated with shoulder surgery and may inform future clinical practices.

In the entire series, the average subjective pain ratings and ASES scores at 12 months post-surgery showed improvements across all aetiological groups, albeit to varying degrees (see Figures 3.4 and 3.5). The most significant findings were observed within the RCA group, which

exhibited superior outcomes in shoulder abduction, forward flexion, and external rotation in comparison to the other aetiological groups analysed (see Figures 3.6, 3.7 and 3.8). These findings align with the conclusions of other international researchers. For instance, Frankle et al. reported improvements in functional outcomes, visual analogue scale scores, and range of motion for forward flexion and abduction at the 2-year review in a cohort of 60 participants with RCA. Additionally, they noted favourable results in 57 patients, with a rate of complication recorded at 17% (15). Similarly, in a prospective review, Cuff et al. recounted an improvement in functional outcomes, including increased range of motion in forward flexion, abduction, and external rotation, as well as high patient satisfaction rates of 94% among a cohort of 96 individuals with RCA (34). Our study demonstrated that the preoperative shoulder diagnosis directly influenced the short-term clinical outcomes following RTSA, with patients presenting with RCA demonstrating the most favourable results compared to individuals with other shoulder pathologies. This observation substantiates our initial hypothesis and underscores the critical role of precise preoperative assessment in enhancing patient outcomes. Though the participants diagnosed with primary osteoarthritis who took part in our study demonstrated enhancements in their functional scores, their average one-year measurements for forward flexion, abduction, and external rotation were the lowest compared to all other aetiologies. This result suggests that individuals receiving RTSA for this specific indication might see only modest subjective improvements in shoulder function postoperatively. Consequently, it is essential for orthopaedic surgeons to manage patient expectations within this patient population undergoing surgery effectively. It is important to note that avascular necrosis was the third greatest indication for RTSA (see Table 3.1). This indication is not in keeping with globally reported norms by any standard; we hypothesised that this prevalence of the Human Immunodeficiency Virus (HIV) endemic in Southern Africa was the primary contributing factor. Recognising the significance of the preoperative diagnosis in relation to the outcomes of RTSA allows clinicians to perform more effective preoperative risk stratification. This understanding allows for a thorough evaluation of whether the surgical intervention justifies the anticipated outcomes

Our study demonstrated a complication rate of 15%, with humeral stem fracture being the most common postoperative surgical complication (see Table 3.2). This complication rate is lower than the rates reported in international literature pertaining to RTSA. Despite our thorough investigation and analysis, we found no evidence to suggest a connection between the event of

complications and the preoperative shoulder diagnosis. Our research did not reveal any patterns or correlations that could link the initial assessment to the subsequent complications experienced by the patients. Based on current research, complication rates after RTSA vary between 19% and 68%, including a range of problems such as acromial fractures, hematomas, infections, and instability, with the latter being the most prevalent complication observed. In a retrospective analysis of 87 primary RTSAs, Werner et al. discovered that 33% to 45% of patients did not achieve a patient-acceptable symptom state (29). Complication rates following RTSA may be influenced by several factors, including the design of the prosthetic components, the surgeon's level of experience, and the inclusion of revision procedures in the patient cohort under analysis (35). Wall et al. reported a 13% complication rate for primary RTSA and a complication rate of double that at 37% for revision procedures (36, 37).

Chapter 5
Conclusion

RTSA has revolutionised the management of previously intractable shoulder conditions. Patients report high satisfaction, receive pain relief and achieve an improved level of function. Our research showed that the preoperative diagnosis of the shoulder significantly affected the short-term clinical results following RTSA, with patients suffering from RCA achieving the best outcomes compared to those with other shoulder pathologies. While individuals with alternative preoperative diagnoses also experienced notable improvements in mobility, pain relief, and overall functionality following RTSA, these enhancements were not as pronounced as those observed in RCA patients. This finding highlights the importance of accurate preoperative evaluation in improving patient outcomes.

This retrospective investigation encountered limitations stemming from the accuracy and completeness of medical records, including incomplete, inconsistent, or inaccurate documentation, which posed significant analytical and interpretational challenges. Furthermore, confounding variables, such as variations in postoperative rehabilitation and physiotherapy protocols across facilities, were observed to influence functional outcomes potentially. While the potential for selection bias was considered, the large sample size lent confidence to the credibility and applicability of the results. The lack of a control group precluded direct comparisons to alternative surgical approaches, though the substantial cohort size compensated for this limitation. Additionally, the 12-month minimum follow-up duration was relatively short for assessing arthroplasty results, necessitating longer-term follow-up to evaluate implant longevity adequately.

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Appendices

Appendix A: Data Collection Sheet

Demographics	
Study Number	
Preoperative shoulder diagnosis	
Age	
Gender	
Laterality	
Hand Dominance	

Outcome Scores	**Pre-op**	**Post-op**
VAS		
ASES		

Range of motion	**Pre-op**	**Post-op**
Abduction		
Forward flexion		

External Rotation at 0° of Abduction		

Complications	
Acromial Fracture	
Peri-prosthetic fracture	
Wound dehiscence	
Dislocation/Instability	
Peri-prosthetic joint Infection	
Nerve injury	
Deep vein thrombosis	
Pulmonary embolism	
Urinary tract infection	
Myocardial infarction	

Appendix B: Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

EC-250208-004 Dr Sarah Swartbooi

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M240964

NAME: (Principal Investigator)	Dr Sarah Swartbooi
DEGREE:	MMed (Orthopaedic Surgery)
DEPARTMENT:	Surgery
STUDY SITE(S):	Chris Hani Baragwanath Academic Hospital
TITLE:	Influence of Preoperative Diagnosis on Short-term Outcomes Following Reverse Total Shoulder Arthroplasty
DATE CONSIDERED:	27/09/2024
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	Original Application Number MED24-06-327. Subsequent Online Application Number M241211-I-0001.
SUPERVISOR:	Prof Sebastian Magobotha and Dr Maxwell Jingo
APPROVED BY:	Professor P. Ruff, Chairperson, HREC (Medical)

DATE OF APPROVAL: 11/12/2024 **EXPIRY DATE:** 10/12/2029

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

DECLARATION OF INVESTIGATOR(S)

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report** in the month date of convened meeting each year until study is closed. Failure to submit annual report will result in ethics clearance certificate suspension. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. Unreported changes to the application may invalidate the clearance given by the HREC (Medical). Email a signed copy of ethics clearance certificate to HREC-Medical.ResearchOffice@wits.ac.za.

Principal Investigator Signature — Date: 12/12/2024

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: CHBAH Approval letter

Find text c

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL
RESEARCH COMMITTEE
Inquiries: Ms Patience Daza
Email: patience.daza@gauteng.gov.za
Tel: 011 9330807

DATE: 12 November 2024

PERMISSION TO CONDUCT RESEARCH
(Subject to approval by the relevant Human Research Ethics Committee)

TITLE OF PROJECT: Influence of preoperative diagnosis on short term outcomes following reverse total shoulder arthoplasty.

DETAILS OF THE INVESTIGATOR

UNIVERSITY	University of the Witwatersrand
DEPARTMENT AT CHBAH	Orthopaedics Department
PRINCIPAL INVESTIGATOR	Dr. Swartbooi
SUPERVISOR	Dr. Professor Magobotha & Dr. Jingo
NHRD NUMBER	GP 202406 088

The Chris Hani Baragwanath Academic Hospital Research Committee recommends that the said research be conducted at Chris Hani Baragwanath Academic Hospital (CHBAH). The Chief Executive Officer (CEO) of CHBAH is accordingly informed, and gives permission for the study to be conducted subject to the following: -

1. Permission having been granted by the Human Research Ethics Committee of the University of the Witwatersrand.
2. The Hospital will not be incurring extra costs as a result of the research being conducted on its patients within the hospital.
3. Permission being granted for the duration of the Ethics Committee Approval.
4. The results of the study being shared with the CHBAH department where the study will be conducted.

Recommended
Dr Mvuyiso Talatala
Chairperson of the CHBAH Research Committee
Date: 12/11/2024

Approved / Not Approved
Dr Nthabiseng Makgana
Chief Executive Officer
Date 2024/11/14