

Short-term Outcomes in obese patients undergoing anterior minimally invasive total hip arthroplasty



UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Nabila Goga

MBChB, FC Orth (SA)

Student number 0503841V

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, 2023

Declaration

I, Dr Nabila Goga, declare that this research report in the format of a “submissible” paper is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Orthopaedic Surgery at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



.....
(Signature of candidate)

19th day of July 2023 in Johannesburg

Dedication

This research paper is dedicated to my family, both by blood and choice.

Presentations and publications arising from the research project

SAOA

September 2022

Cape Town

Wits Orthopaedic Research Day

November 2022

Johannesburg

Acknowledgements

This paper would not have been possible without my supervisors who sacrificed time and energy for this project; Dr JRT Pietrzak for his encouragement and guidance through each step of the process, Dr JN Cakic who trusted me to utilize his data and provided support and feedback despite his busy schedule and Prof SK Magobotha who availed himself as both a mentor and supervisor. I would also like to mention Dr M Jingo for his assistance, enthusiasm and efficiency and Dr I Cassimjee who assisted with the data visualisation.

Table of contents

Declaration	i
Dedication.....	ii
Presentations and publications arising from the research project	iii
Acknowledgements	iv
Table of contents.....	v
List of Figures	vi
List of Tables.....	vii
Nomenclature	viii
“Submissible” format of a paper.....	1
Appendices	21

List of Figures

Figure 1: A. Obese patient positioned on conventional surgical table. B. Obese patient positioned on AMIS® Mobile Leg Positioner.....4

Figure 2: Perioperative Findings: A. Surgical duration. B. Estimated blood loss. C. Radiation dose. D. Radiation exposure. E. Length of stay.....8

Figure 3: Radiographic Outcomes: A. Preoperative limb length discrepancy. B. Postoperative limb length discrepancy. C. Acetabular cup inclination. D. Acetabular cup version. E. Femoral stem version. F. Femoral offset differential.....9

List of Tables

Table 1: Patient demographics.....	7
Table 2: Clinical and Functional Outcomes.....	10
Table 3: Complications.....	11

Nomenclature

AMIS	Anterior minimally invasive surgery
ASA	American Society of Anesthesiologists
AVN	Avascular Necrosis
BMI	Body Mass Index
CI	Confidence Interval
COPD	Chronic obstructive pulmonary disease
DAA	Direct anterior approach
DVT	Deep vein thrombosis
FAI	Femoroacetabular impingement
FJS	Forgotten joint score
mHHS	Modified Harris Hip Score
LLD	Limb length discrepancy
LOS	Length of stay
OR	Odds ratio
PE	Pulmonary embolus
PJP	Patient joint perception
PROM	Patients reported outcome measures
SD	Standard deviation
THA	Total Hip Arthroplasty
TJA	Total Joint Arthroplasty
UPAT	Universal Pain Assessment Tool
WHO	World Health Organization

“Submissible” format of a paper

Short-term outcomes in obese patients undergoing anterior minimally invasive total hip arthroplasty

Authors and affiliations:

Nabila Goga^a (FC Orth (SA), MBChB), Jurek Rafal Tomasz Pietrzak^a (FC Orth (SA), MMed (Orth), MBBCh), Josip Nenad Cakic^{a,b} (PhD, FCS (Orth) SA, MMed (Orth), MD), Sebastian Keith Magobotha^{a,c} (FCS (Orth) SA, MBChB, BSc Hons)

^a Division of Orthopaedic Surgery, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

^b Life Fourways Hospital, Fourways, Johannesburg, South Africa

^c Netcare N17 Hospital, Springs, South Africa

ABSTRACT

Introduction

Obesity affects over 774 million individuals worldwide. It is associated with an accelerated onset and progression of osteoarthritis, resulting in an increased need for total hip arthroplasty (THA). Obese patients have a higher risk of perioperative complications. The direct anterior approach (DAA) for THA is gaining popularity globally, however, there are concerns over its suitability for obese individuals. This study compares short-term clinical, functional, and radiological outcomes of obese and non-obese patients undergoing THA *via* the DAA.

Methods

We conducted a retrospective study of 356 consecutive patients who underwent elective primary THA *via* the DAA using a specialised leg positioner (Medacta International, Switzerland) and intraoperative fluoroscopy. Obese patients (BMI ≥ 30 kg/m²) were compared to the control group using baseline patient information, perioperative data and postoperative outcomes at minimum one-year follow-up.

Results

The study included 107 (30%) obese patients. Cohorts were well-matched for age, sex, preoperative diagnosis and baseline PROMs. In the obese cohort, surgical time and blood loss increased by a mean of 8.32 ± 6.9 minutes ($p = 0.03$) and 58.19 ± 25.37 ml ($p = 0.0003$) respectively. There were no significant differences in intraoperative radiation (mGys), time to discharge and discharge destination between the groups. Obese patients had a higher incidence of wound-related complications (5.6% *versus* 2.4%), however overall complication rates were similar (9.3% *versus* 6.8%, $p = 0.67$). Functional outcomes were equivalent with a mean postoperative mHHS of 97.57 ± 4.86 and 98.05 ± 5.59 in the obese and non-obese cohorts respectively ($p = 0.54$). PROMs including the Forgotten Joint Score ($p = 0.34$), Patient Joint Perception score ($p = 0.2$) and patient satisfaction rates ($p = 0.085$) were comparable.

Conclusion

The AMIS® DAA is a safe and effective approach for obese patients with excellent short-term outcomes, however an increased risk of wound-related complications remains.

Keywords: Total hip arthroplasty, Direct anterior approach, Obesity, Anterior minimally invasive total hip arthroplasty, AMIS

1. INTRODUCTION

The worldwide prevalence of obesity has risen exponentially over the last few decades with obesity affecting over 774 million individuals.¹ Within South Africa, 41% of women and 11% of men are classified as obese.² Obesity is associated with an earlier onset of osteoarthritis due to physiological and biomechanical mechanisms.^{3,4} Obesity results in a state of chronic inflammation, which contributes to the severity, and progression of osteoarthritis by reducing pain tolerance, accelerating cartilage degradation, and stimulating osteophyte formation.³⁻⁵ Affected individuals typically have altered gait patterns and abnormal joint loading.^{4,5} The relative risk of undergoing total joint arthroplasty (TJA) correlates with increasing body mass index (BMI).^{3,4} Morbidly obese patients are 8.5 times more likely to require THA than non-obese individuals.^{3,4} Obese and morbidly obese individuals respectively are likely to require THA two and nine years earlier than their non-obese counterparts.^{3,4}

Obesity is associated with a cluster of comorbidities, which contribute to increased perioperative risk.⁴ Obese individuals typically have increased surgical duration, length of stay (LOS) and analgesic requirements.^{3,6-9} Obesity is an independent risk factor for complications during TJA including combined complications; systemic complications; hip dislocation; re-intubation; re-operation; surgical site and deep infections.^{3,4,6-8,10-13} A 2019, meta-analysis by Onggo *et al.* of over two million patients found an increased risk of all complications in obese patients undergoing THA (OR = 1.53, 95% CI:1.30 – 1.80, $p < 0.001$).⁸

THA is a highly regarded and cost-effective surgical intervention with reported survivorship of up to 95% at 10 years, > 80% at 25 years and patient satisfaction of > 96% at 10 years.^{10,14-16} Utilisation of THA continues to grow and current projections suggest a perpetuation of this trend as demand, eligibility, technology, and skills evolve, however there is still no consensus on the optimal surgical approach.^{14,17}

The DAA has seen a recent surge in popularity with DAA utilisation for primary THA amongst American Association of Hip and Knee Surgeons' members increasing from 12% in 2009 to 45% in 2020.^{18,19} The DAA is an anterior-based minimally invasive surgical approach that accesses the hip via intermuscular and internervous planes, potentially limiting muscle damage.²⁰⁻²² Reported advantages include reduced postoperative pain, LOS and dislocation risk; improved mobility; and superior HHS during the early postoperative period.^{20,21,23-26} Despite these benefits, the DAA is not the panacea as it has been associated with a steep learning curve, longer surgical duration, and a higher rate of certain complications, most notably surgical site infections (SSI) and intraoperative fractures.^{7,10,12,13,19-21,24-27} Fifty-three percent of DAA surgeons consider obesity to be a relative contraindication for DAA use.¹⁹

While common, the use of specialised leg positioners for the DAA remains controversial.^{28,29} The AMIS® mobile leg positioner (Medacta International, Switzerland) was developed for use with the AMIS®DAA technique to allow controlled intraoperative manipulation of the hip.³⁰ A potential benefit of this device in obese patients, is that the suspended thigh allows some of the excess adipose tissue to fall away from the surgical site compared to a conventional table on which the excess adiposity is supported by the table and pushes up towards the surgical site thus making exposure more challenging (Fig. 1).²⁸

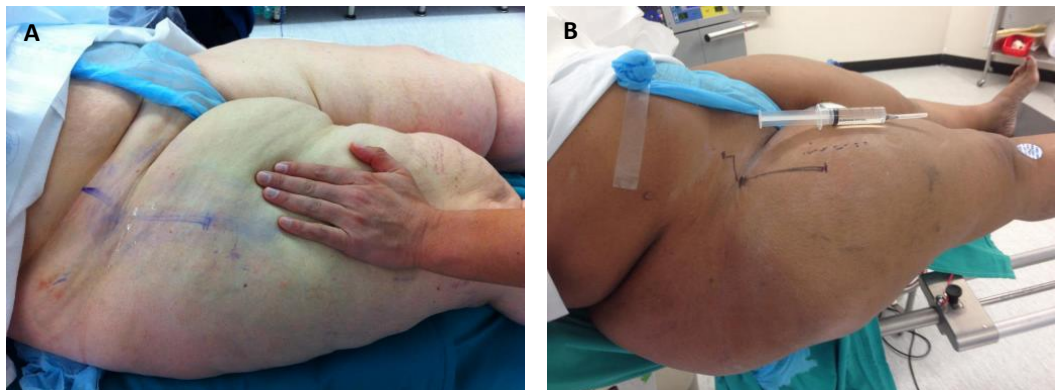


Figure 1.
A. Obese patient positioned on conventional surgical table. B. Obese patient positioned on AMIS® Mobile Leg Positioner

Considering the trifactor of THA demand, DAA utilisation and the global obesity epidemic outlined above, we sought to compare short-term outcomes of obese and non-obese patients undergoing THA *via* the AMIS® DAA.

2. MATERIALS AND METHODS

2.1 Study Design

This was a retrospective analysis using prospectively collected data from a single-surgeon, evaluating 356 consecutive, adult patients who underwent elective, unilateral primary THA *via* the AMIS® DAA, between 01 January 2018 and 31 December 2020. Exclusion criteria included patients who declined or were incapable of giving informed consent, and/or did not complete a minimum one-year follow-up. Ethics clearance was obtained from the Human Research Ethics Committee, University of the Witwatersrand.

2.2 Surgical Protocol

A standardised protocol was utilised with all patients undergoing preoperative medical evaluation and optimisation by a single physician. All patients were operated on in a single laminar-flow theatre under general anaesthesia and a lumbar plexus block, administered by a fellowship-trained anaesthetist. Patients were positioned supine with padded perineal support. The affected leg was placed in the AMIS® Mobile Leg Positioner, controlled by an experienced table-operator. A weight-adjusted dose of intravenous antibiotic prophylaxis (Cefazolin or Clindamycin in cases of a known allergy) was administered preoperatively and for 24 hours postoperatively.

A longitudinal skin incision of 6 – 10cm was made 2 – 3 cm lateral and parallel to a line between the anterior superior iliac spine and Gerdy's tubercle. The underlying perimysium was divided to allow access to the interval between tensor fascia lata and sartorius. The lateral aspect of the rectus femoris was retracted medially to expose the joint capsule. An anterior capsulotomy was used to enter the joint. The femoral neck was osteotomised under traction while protecting the posterior capsule. The acetabular labrum was preserved where possible, and the acetabulum prepared as per conventional THA. Preparation of the femur was done in a position of extension and external rotation, optimising access to the proximal femur. Soft tissues were released as necessary to allow adequate access to the femoral canal while protecting the ligaments. Femoral broaching was performed using AMIS® broaches *via* conventional broaching techniques. Uncemented implants with 36 mm ceramic femoral heads and highly cross-linked polyethylene cups were used preferentially as allowed by patient anatomy.

Intraoperative fluoroscopy (Philips, BV Pulsera) was performed by a single radiographer at three different time points: 1) to assess optimal positioning of the acetabular cup; 2) to assess optimal sizing and position of the femoral component during broaching; and 3) after reduction of the implants, prior to soft tissue closure. An intra-articular negative-pressure drain was placed intraoperatively and removed within 24 hours. Intermittent pneumatic compression devices were employed postoperatively until discharge and inpatient physiotherapy provided twice daily. Patients were required to be ambulatory on crutches before discharge. Patients were discharged on oral thromboprophylaxis (Rivaroxaban 10 mg daily) for two weeks.

The surgical site was assessed by a clinical associate 10 days postoperatively and all suspicious wounds reviewed by the primary surgeon. A routine duplex Doppler was performed three weeks postoperatively to assess for occult deep vein thrombosis (DVT). The surgeon conducted follow-up assessments at six weeks, six months and one year postoperatively.

2.3 Variables and outcome measures

Preoperatively, the following baseline patient information was captured for all patients: age (years), sex, primary diagnosis, comorbidities, and BMI. Limb length discrepancy (LLD) was measured radiographically using Woolson's technique.³¹ Patients' preoperative functional status were evaluated using the mHHS – a validated tool that factors in pain, gait and activities.³² Pain was quantified using the Universal Pain Assessment Tool (UPAT); a combination tool comprising the verbal numeric rating scale, the verbal descriptor scale and the Wong-Baker FACES® pain rating scale.^{33,34}

Intraoperatively, the following data was collected: surgical duration in minutes from incision to completion of the last suture; estimated blood loss in millilitres and fluoroscopy use (radiation exposure in milligrays and duration of exposure in seconds). Perioperative data included: the use of blood products; LOS in days measured from date of admission to date of discharge and discharge destination; home or step-down facility.

Postoperatively, at minimum one year, clinical, functional and radiographic outcomes were assessed using the following tools: mHHS, UPAT, Forgotten Joint Score (FJS), joint functionality, Patient Joint Perception (PJP) and a Likert-type patient satisfaction scale. The FJS is a validated PROM, designed to determine patient awareness of the artificial joint.³⁵ The PJP is a single-question PROM that correlates moderately with FJS.³⁶ Standard radiographic imaging was used to assess LLD, component position and component loosening.

Complications were classified as intraoperative or postoperative; medical (related to the patients' baseline and physiological effect of the surgery) or surgical (directly related to the surgery); and temporal (early ≤ 4 weeks, late > 4 weeks).

2.4 Data Analysis

The study compared the outcomes of obese (BMI ≥ 30) and non-obese (BMI < 30) patients, based on a series of parameters.¹ The means of these parameters were compared using t-tests with statistical significance at $p < 0.05$. Confidence intervals were calculated at 95%, and used in conjunction with the p -values to determine clinical significance. Groups were tested for linear model assumptions: normality and homogeneity of variances. In the event of a violation of the linear model assumptions, the Wilcoxon rank-sum alternative was used to hypothesis test between the two cohorts. The statistical package used was the R version 4.0.4 (2021-02-15); University of Auckland, New Zealand.

3. RESULTS

3.1 Demographics

In total, there were 356 patients of which 107 (30%) were obese and 205 (57.6%) were female ($p = 0.05$). The mean age of the obese group was 60.19 years *versus* 60.82 years in non-obese patients. The most common diagnosis was primary osteoarthritis, affecting 67.1% of non-obese and 74.8% of obese patients ($p = 0.7$). For further demographic details see *Table 1*.

Table 1: Patient Demographics

	Total <i>n</i> = 356 (%)	Obese <i>n</i> = 107 (%)	Non-obese <i>n</i> = 249 (%)	<i>p</i>-value
<u>Sex (<i>n</i>; %)</u>				0.05
Male	151 (42.4%)	56 (52.3%)	95 (38.2%)	
Female	205 (57.6%)	51 (47.7%)	154 (61.8%)	
<u>BMI (kg/m²) (± SD)</u>	27.95 ± 5.37	35.34 ± 3.7	25.21 ± 3.2	< 0.000
<u>Age, years (± SD)</u>	60.33 ± 12.75	60.19 ± 11.65	60.82 ± 13.23	0.73
<u>Diagnosis (<i>n</i>; %)</u>				
Primary Osteoarthritis	247 (69.4%)	80 (74.8%)	167 (67.1%)	0.7
Congenital hip dysplasia	37 (10.4%)	12 (11.2%)	25 (10.0%)	
AVN	22 (6.2%)	5 (4.7%)	17 (6.8%)	0.66
Inflammatory arthritis	16 (4.5%)	5 (4.7%)	11 (4.4%)	
FAI	16 (4.5%)	3 (2.8%)	13 (5.2%)	0.84
Previous trauma	4 (1.1%)	1 (0.9%)	3 (1.2%)	
Other	12 (3.4%)	1 (0.9%)	11 (4.4%)	
<u>Comorbidities (<i>n</i>; %)</u>				
Hypertension	69 (19.4%)	23 (21.5%)	46 (18.5%)	0.48
Asthma/COPD	34 (9.6%)	9 (8.4%)	15 (6.0%)	
Diabetes	33 (9.3%)	12 (11.2%)	21(8.4%)	0.21
Cardiac	26 (7.3%)	11(10.2%)	15 (6.0%)	1
Epilepsy	19 (5.3%)	6 (5.6%)	13 (5.2%)	
Thyroid	19 (5.3%)	4 (3.7%)	15 (6.0%)	0.51
Previous DVT/PE	12 (3.4%)	3 (2.8%)	9 (3.6%)	
Cancer	7 (2%)	2 (1.9%)	5 (2.0%)	0.21
Other	25 (7.0%)	7 (6.5%)	18 (7.6%)	
<u>ASA grade (<i>n</i>; %)</u>				
1	132 (37.1%)	34 (31.8%)	98 (39.4%)	
2	204 (57.3%)	66 (61.7%)	138 (55.4%)	
3	20 (5.6%)	7 (6.5%)	13 (5.2%)	

BMI, Body mass index; AVN, avascular necrosis; FAI, Femoroacetabular impingement; COPD, chronic obstructive pulmonary disease; DVT, Deep vein thrombosis; PE, Pulmonary embolus; ASA, American Society of Anaesthesiologists

3.2 Perioperative findings

Mean surgical duration was 92.71 ± 24.24 minutes for obese and 84.39 ± 23.92 minutes for non-obese patients ($p = 0.03$). Blood loss averaged 233.05 ± 100.93 ml and 174.86 ± 99.11 ml for obese and non-obese individuals respectively ($p = 0.0003$). One obese patient required a transfusion. Intraoperatively, the mean radiation dose was 3.51 ± 1.16 mGy in the obese cohort (range 1.87 – 7.91 mGy) with an average exposure time of 28.31 seconds (range 17.61 – 51.17 seconds). The mean radiation dose in the non-obese cohort was 3.13 ± 1.81 mGy (range 1.58 – 7.21 mGy) and average exposure time was 24.56 seconds (range 14.9 – 46.75 seconds). The average LOS of obese patients was 2.4 ± 0.49 days and non-obese patients 2.5 ± 0.72 days ($p = 0.16$). Two obese and four non-obese patients required discharge to a step-down facility ($p = 1$). For further details, see Fig. 2.

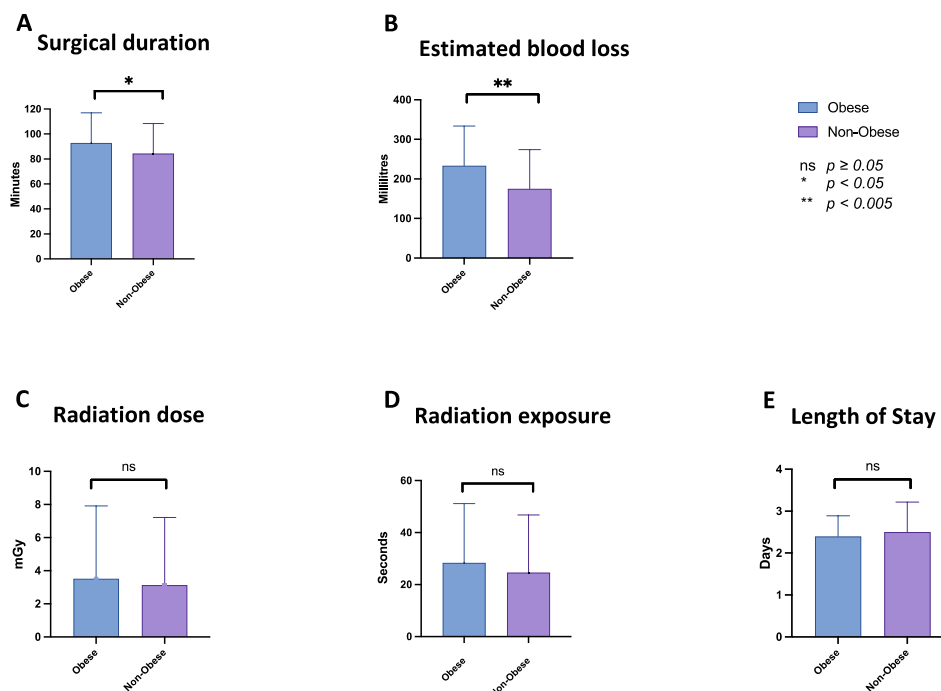


Figure 2. Perioperative Findings

A. Surgical duration ($p = 0.03$). B. Estimated blood loss ($p = 0.0003$). C. Radiation dose ($p = 0.2$). D. Radiation exposure ($p = 0.17$). E. Length of stay ($p = 0.16$)

3.3 Radiographic outcomes

Eight (7.5%) obese patients and two (0.8%) non-obese patients had acetabular cup inclination of 31° – 40° ($p = 0.01$) with an inclination of 41° – 55° achieved in 99.2% of the non-obese cohort versus 90.7% of the obese cohort ($p = 0.02$). LLD and other aspects of the implant placement demonstrated no statistical difference (*see Fig. 3*).

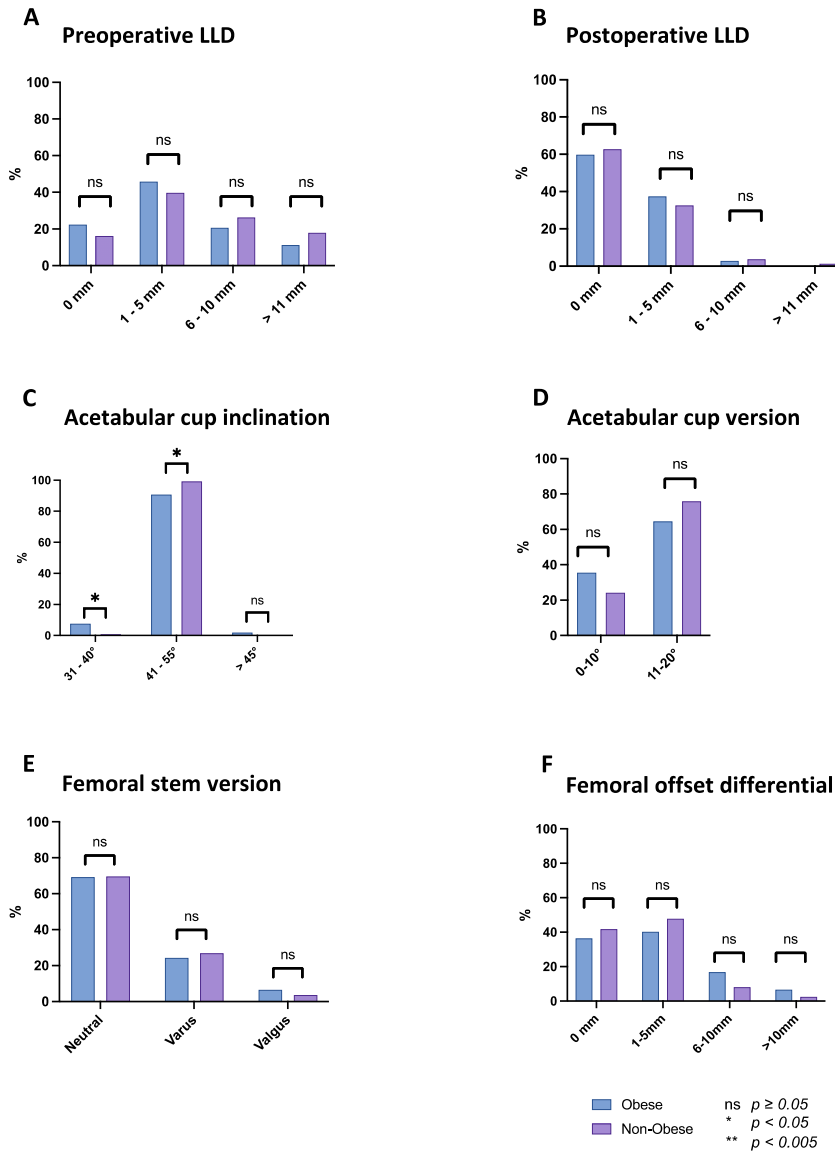


Figure 3. Radiographic Outcomes

A. Preoperative limb length discrepancy. B. Postoperative limb length discrepancy. C. Acetabular cup inclination. D. Acetabular cup version. E. Femoral stem version. F. Femoral offset differential

3.4 Clinical and Functional Outcomes

Postoperative mHHS scores were 97.57 ± 4.86 and 98.05 ± 5.49 in the obese and non-obese cohorts, respectively ($p = 0.54$). The mean FJS in obese patients was 77.81 ± 22.19 versus 71.43 ± 28.56 in the non-obese ($p = 0.34$). Satisfaction was $> 92\%$ in both cohorts ($p = 0.085$). For details on other PROMS, see Table 2.

Table 2: Clinical and Functional outcomes

	Total <i>n</i> = 356 (%)	Obese <i>n</i> = 107 (%)	Non-obese <i>n</i> = 249 (%)	<i>p</i> -value
<u>mHHS</u>				
Preoperative \pm SD	51.74 \pm 12.02	49.92 \pm 13.44	52.51 \pm 11.22	0.19
Postoperative \pm SD	97.91 \pm 5.3	97.57 \pm 4.86	98.05 \pm 5.49	0.54
Change in mHHS	46.17	47.65	45.54	
<u>FJS \pm SD</u>	73.34 \pm 25.67	77.81 \pm 22.19	71.43 \pm 28.56	0.34
<u>Satisfaction rate (<i>n</i>; %)</u>				
Overall satisfaction	333 (93.5%)	99 (92.6%)	234 (94%)	0.085
Very dissatisfied	7 (2.0%)	2 (1.9%)	5 (2.0%)	
Dissatisfied	6 (1.7%)	2 (1.9%)	4 (1.6%)	
Neutral	10 (2.8%)	4 (3.7%)	6 (2.4%)	
Satisfied	66 (18.5%)	22 (20.6%)	44 (17.7%)	
Very satisfied	267 (75%)	77 (72.0%)	190 (76.3%)	
<u>PJP (<i>n</i>; %)</u>				0.2
Natural joint	216 (60.7%)	62 (57.9%)	154 (61.8%)	
Artificial joint, no restriction	71 (19.9%)	22 (20.6%)	49 (19.7%)	
Artificial joint, minimal restriction	61 (17.1%)	19 (17.8%)	42 (16.9%)	
Artificial joint, major restriction	5 (1.4%)	2 (1.9%)	3 (1.2%)	
Non-functional joint	3 (0.8%)	2 (1.9%)	1 (0.4%)	
<u>Joint Functionality (<i>n</i>; %)</u>				0.53
Severely limited	8 (2.2%)	2 (1.9%)	6 (2.4%)	
Limited	17 (4.8%)	4 (3.7%)	13 (5.2%)	
Can do most things	136 (38.2%)	40 (37.4%)	96 (38.6%)	

Can do anything	195 (54.8%)	61 (57.0%)	134 (53.8%)	
<u>UPAT ± SD</u>				
Preoperative day	5.81 ± 1.98	5.99 ± 1.79	5.44 ± 2.3	0.13
Postoperative day	0.4 ± 1.28	0.45 ± 1.43	0.28 ± 0.82	0.29
Change day	5.39 ± 2.31	5.49 ± 2.24	5.2 ± 2.47	
Preoperative night	5.15 ± 2.62	4.92 ± 2.54	5.28 ± 2.65	0.42
Postoperative night	0.35 ± 1.33	0.23 ± 0.96	0.41 ± 1.46	0.32
Change night	4.82 ± 2.64	4.91 ± 2.32	4.78 ± 2.79	
Preoperative sport/activity	7.16 ± 2.21	7.13 ± 2.75	7.17 ± 2.06	0.97
Postoperative sport/activity	1.31 ± 3.19	0.43 ± 1.33	1.59 ± 3.58	0.2
Change sport/activity	5.64 ± 4.01	5.33 ± 4.73	5.72 ± 4.05	

mHSS, modified Harris Hip Score; FJS, forgotten joint score; LLD, Limb length discrepancy; PJP, Patient joint perception; UPAT, Universal pain assessment tool

3.5 Complications

Overall, the complication rate was 7.6% ($n = 27$), 9.3% and 6.8% of the obese and non-obese groups respectively ($p = 0.67$). Twenty-six of the complications were surgical and resulted in eight re-admissions (two obese (1.8%) and six (2.4%) non-obese). Three cases were revised at a mean follow-up of 29.45 months (one obese and two non-obese). Twelve patients presented with wound complications, six (5.6%) obese and six (2.4%) non-obese patients. In the obese cohort, one prosthetic joint infection (PJI) and one intraoperative fracture were diagnosed. Three postoperative periprosthetic fractures (1.2%), two dislocations (0.8%) and one confirmed DVT were documented in the non-obese cohort. Aseptic loosening occurred in two obese (1.9%) and five (2.0%) non-obese patients (2%). (See Table 3).

Table 3: Complications

	Total <i>n</i> = 356	Obese <i>n</i> = 107	Non-obese <i>n</i> = 249	<i>p</i>-value
<u>Total</u>	27 (7.6%)	10 (9.3%)	17 (6.8%)	0.67
Early (<4 weeks)	15 (4.2%)	4 (3.7%)	11 (4.4%)	0.4
Late (>4 weeks)	12 (3.4%)	6 (5.6%)	6 (2.4%)	

Medical	1 (0.3%)	0	1 (0.4%)	0.8
DVT	1 (0.3%)	0	1 (0.4%)	
Surgical	26 (7.3%)	10 (9.3%)	16 (6.4%)	
Wound Problems	12 (3.4%)	6 (5.6%)	6 (2.4%)	
Wound dehiscence	11 (3.1%)	5 (4.7%)	6 (2.4%)	
Surgical site infections	1 (0.3%)	1 (0.9%)	0	
Deep PJI	1 (0.3%)	1 (0.9%)	0	
Aseptic loosening	7 (2.0%)	2 (1.9%)	5 (2.0%)	
Acetabular loosening	1 (0.3%)	0	1 (0.4%)	
Femoral component loosening	6 (1.7%)	2 (1.9%)	4 (1.6%)	
Dislocation	2 (0.6%)	0	2 (0.8%)	
Periprosthetic Fractures	4 (1.1%)	1 (0.9%)	3 (1.2%)	
Intraoperative Fractures	1 (0.3%)	1 (0.9%)	0	
Postoperative Fractures	3 (0.8%)	0	3 (1.2%)	
Vancouver B2	2 (0.6%)	0	2 (0.8%)	
Vancouver C	1 (0.3%)	0	1 (0.4%)	
Readmissions	8	2 (1.9%)	6 (2.4%)	
<30 days	3 (0.8%)	1 (0.9%)	2 (0.8%)	
31 – 60 days	2 (0.6%)	0	2 (0.8%)	
61 – 90 days	3 (0.8%)	1 (0.9%)	2 (0.8%)	
Re-operations	3 (0.8%)	1 (0.9%)	2 (0.8%)	
< 4 weeks	2 (0.6%)	0	2 (0.8%)	
> 4 weeks	1 (0.3%)	1 (0.9%)	0	

DVT, Deep vein thrombosis; PJI, prosthetic joint infection

4. DISCUSSION

To our knowledge, this is the first study in South Africa to compare outcomes between obese and non-obese patients undergoing THA via the AMIS®DAA. Cohorts were well-matched in terms of age, gender, primary diagnosis, and comorbidities. No differences were found in LOS, discharge destination, intraoperative fluoroscopy use, functional outcomes, PROMS and overall

complication rates however, increases in surgical duration, blood loss and risk of wound complications were noted in the obese group.

In this study, mean surgical duration was longer in the obese cohort by 8.32 minutes. Obesity adversely affects surgical time regardless of approach.^{6-8,10,28,37,38} Onggo *et al.* calculated a difference in the mean surgical duration of 8.71 minutes between obese and non-obese patients, which widened further with increasing BMI, without assessing specific approaches.⁸ In the DAA, Russo *et al.* reported an increased surgical duration of 12.7 minutes in obese patients.⁷ Prolonged surgical duration is associated with increased perioperative risks including: prolonged admission; re-admission and re-operation; surgical site complications; systemic complications; and the need for blood transfusion.^{9,39}

Despite the increased intraoperative blood loss noted in the obese cohort, only one patient required a transfusion implying limited clinical impact. Blood transfusions in THA are associated with a higher risk of PJI, increased LOS and cost.⁴⁰ Neither Argyrou *et al.* nor Hartford *et al.* found a relationship between BMI and blood loss in the DAA, however, Antoniadis *et al.* noted increased blood loss in severely obese patients (BMI $\geq 35\text{kg/m}^2$) undergoing the DAA.^{10,28,37} Onggo *et al.*, did not find a significant difference in blood loss between obese and non-obese patients regardless of approach.⁸

There were no statistically significant differences in average fluoroscopy duration or dosage between the obese and non-obese cohorts. Previous research by Curtin *et al.* identified a relationship between radiation dose and BMI based on the energy required to create the image.⁴¹ While the average fluoroscopy duration and dosage was greater than elsewhere in the literature, with Baksh *et al.* noting a mean fluoroscopy time of 21.4 seconds and a mean patient radiation dose of 1.8 mGy; the radiation dose across both cohorts remained within safe limits.^{41,42} Intraoperative fluoroscopy improves the accuracy of component positioning at the expense of radiation exposure to patient and staff.⁴²

The authors found no difference in LOS or need for step-down facilities. Antoniadis *et al.* reported a longer LOS in both cohorts than found in this study and further noted a higher LOS in the severely obese cohort (7.3 *versus* 5.3 days).¹⁰ In obese patients, Russo *et al.* noted an increased LOS (2.4 *versus* 2.6 days) and need for step-down care (7.6% *versus* 15.4%).⁷ Hartford *et al.* noted

equivalent outcomes regardless of BMI in terms of LOS ($p = 0.70$) and discharge destination ($p = 1.7$).³⁷

There was a significant improvement in UPAT score in both cohorts ($p < 0.000$). Postoperatively, obese patients reported higher levels of day pain (0.45 ± 1.43 versus 0.28 ± 0.82 , $p = 0.29$) and lower night (0.23 ± 0.96 versus 0.41 ± 1.46 , $p = 0.32$) and activity-related pain (0.43 ± 1.59 , $p = 0.2$) however this trend existed preoperatively and differences were statistically insignificant. Macheras *et al.* found equivalent postoperative pain scores for the obese and non-obese cohorts who underwent the DAA with both groups scoring significantly better than matched candidates who underwent the Hardinge approach.⁴³ Though statistically insignificant, we found a greater improvement in mHHS scores in the obese cohort, despite the mean postoperative mHHS remaining lower than those of the non-obese. This was similar to the findings of Argyrou *et al.*, Antoniadis *et al.* and Macheras *et al.*^{10,28,43} Macheras *et al.*, in an RCT, noted better mHHS in DAA patients than Hardinge patients regardless of BMI.⁴³ FJS in both of our cohorts reflected successful surgery but contrary to Singh *et al.*, who noted a trend of higher scores in non-obese patients, (68.11 versus 62.45 ; $p = 0.349$), our study demonstrated higher scores in the obese cohort (77.81 ± 22.19 versus 71.43 ± 28.57) however these findings were statistically insignificant ($p = 0.34$).⁴⁴ Other PROMS were similar indicating equivalent functional outcomes between obese and non-obese patients.

There were no statistically significant differences in overall complication rates, re-admissions or re-operations. These have all been associated with increased risk in obese patients, regardless of approach.^{7,8,10,13,28,37,38} In our study, obese patients were more likely to have late complications and more likely to have wound complications (5.6% versus 2.4% , OR 2.4). An increased risk of wound complications and PJI in the obese cohort is in keeping with previous literature.^{7,10,13,28,37} Russo *et al.* noted a 3.6 times risk for wound complications in obese patients with an 8.8 times risk of major complications.⁷ Purcell *et al.* noted an incidence of 2.5% for PJI and 2% for SSI in patients with a BMI of $\geq 35\text{kg/m}^2$; Argyrou *et al.* noted an SSI rate of 8.1% in the obese versus 1.2% in the non-obese and Antoniadis *et al.* documented a 2.3% incidence of deep infection and 4.7% incidence of SSI in the obese compared to 0.8% of each respective complication in the non-obese cohort.^{10,13,28} In our study, non-obese patients were more likely to have early complications, including fractures and dislocations. There were no dislocations in the obese cohort. Onggo *et al.* and Lui *et al.* both noted an increased dislocation risk for obese patients undergoing THA however, Verhaegen *et al.* who only assessed patients undergoing the DAA did not find a difference.^{8,45,46} In our population, potentially protective factors include the tendency towards a more closed acetabular cup in the obese cohort and the intermuscular nature of the approach.

There were several limitations to this study including its retrospective nature. As the dataset was limited to a single, high-volume hip surgeon at a single institution, results may not be replicable in settings without equivalent expertise or resources. The BMI was used to classify obesity due to widespread use and convenience however it is often considered to be a crude measure of obesity. While we used broad categories of obese and non-obese patients, the further grading of BMI would have allowed for a more refined analysis of the data and comparison to other literature.

5. CONCLUSION

This study shows that AMIS® DAA is a safe option for obese patients with equivalent outcomes to non-obese patients. As in other THA approaches, obese patients have a higher risk of wound-related complications, longer duration of surgery and increased volume of blood loss. This should be discussed during preoperative counselling and surgical planning.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethics approval and consent to participate

Ethics clearance was obtained from the Human Research Ethics Committee: University of the Witwatersrand (Ethics clearance No.: **M210819**).

Author contributions

NG: Analysis, Writing – original draft, Visualisation. JRTP: Conceptualization, Analysis, Writing - Review and editing, Supervision. JNC: Writing - Review and editing, Supervision. SKM: Writing - Review and editing, Supervision.

Declaration of competing interest

None. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

1. World Health Organization. *Obesity and Overweight.*; 2021. Accessed July 7, 2021. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
2. National Department of Health (NDoH), Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC)ICF. *South Africa Demographic and Health Survey 2016.*; 2019.
3. Haynes J, Nam D, Barrack RL. Hip arthroplasty: Avoiding and managing problems obesity in total hip arthroplasty does it make a difference? *Bone and Joint Journal.* 2017;99B(1):31-36. doi:10.1302/0301-620X.99B1.BJJ-2016-0346.R1
4. Bryan D, Parvizi J, Austin M, et al. Obesity and Total Joint Arthroplasty. *J Arthroplasty.* 2013;28(5):714-721. doi:10.1016/j.arth.2013.02.011
5. Messier SP. Obesity and Osteoarthritis: Disease Genesis and Nonpharmacologic Weight Management. *Rheumatic Disease Clinics of North America.* 2008;34(3):713-729. doi:10.1016/j.rdc.2008.04.007
6. Liu W, Wahafu T, Cheng M, Cheng T, Zhang Y, Zhang X. The influence of obesity on primary total hip arthroplasty outcomes: A meta-analysis of prospective cohort studies. *Orthopaedics & Traumatology: Surgery & Research.* 2015;101(3):289-296. doi:10.1016/j.otsr.2015.01.011
7. Russo MW, Macdonell JR, Paulus MC, Keller JM, Zawadsky MW. Increased Complications in Obese Patients Undergoing Direct Anterior Total Hip Arthroplasty. *J Arthroplasty.* 2015;30(8):1384-1387. doi:10.1016/j.arth.2015.03.002
8. Onggo JR, Onggo JD, de Steiger R, Hau R. Greater risks of complications, infections, and revisions in the obese versus non-obese total hip arthroplasty population of 2,190,824 patients: a meta-analysis and systematic review. *Osteoarthritis Cartilage.* 2020;28(1):31-44. doi:10.1016/j.joca.2019.10.005

9. Surace P, Sultan AA, George J, et al. The Association Between Operative Time and Short-Term Complications in Total Hip Arthroplasty: An Analysis of 89,802 Surgeries. *J Arthroplasty*. 2019;34(3):426-432. doi:10.1016/j.arth.2018.11.015
10. Antoniadis A, Dimitriou D, Flury A, Wiedmer G, Hasler J, Helmy N. Is Direct Anterior Approach a Credible Option for Severely Obese Patients Undergoing Total Hip Arthroplasty? A Matched-Control, Retrospective, Clinical Study. *J Arthroplasty*. 2018;33(8):2535-2540. doi:10.1016/j.arth.2018.03.071
11. Ward DT, Metz LN, Horst PK, Kim HT, Kuo AC. Complications of Morbid Obesity in Total Joint Arthroplasty: Risk Stratification Based on BMI. *J Arthroplasty*. 2015;30(9):42-46. doi:10.1016/j.arth.2015.03.045
12. Watts CD, Houdek MT, Wagner ER, Sculco PK, Chalmers BP, Taunton MJ. High Risk of Wound Complications Following Direct Anterior Total Hip Arthroplasty in Obese Patients. *J Arthroplasty*. 2015;30(12):2296-2298. doi:10.1016/j.arth.2015.06.016
13. Purcell RL, Parks NL, Cody JP, Hamilton WG. Comparison of Wound Complications and Deep Infections With Direct Anterior and Posterior Approaches in Obese Hip Arthroplasty Patients. *J Arthroplasty*. 2018;33(1):220-223. doi:10.1016/j.arth.2017.07.047
14. Pivec R, Johnson AJ, Mears SC, Mont MA. Hip arthroplasty. *The Lancet*. 2012;380(9855):1768-1777. doi:10.1016/S0140-6736(12)60607-2
15. Mariconda M, Galasso O, Costa GG, Recano P, Cerbasi S. Quality of life and functionality after total hip arthroplasty: a long-term follow-up study. *BMC Musculoskelet Disord*. 2011;12(1):222. doi:10.1186/1471-2474-12-222
16. Elmallah RK, Chughtai M, Khlopas A, et al. Determining Cost-Effectiveness of Total Hip and Knee Arthroplasty Using the Short Form-6D Utility Measure. *J Arthroplasty*. 2017;32(2):351-354. doi:10.1016/j.arth.2016.08.006
17. Singh JA, Yu S, Chen L, Cleveland JD. Rates of Total Joint Replacement in the United States: Future Projections to 2020–2040 Using the National Inpatient Sample. *J Rheumatol*. 2019;46(9):1134-1140. doi:10.3899/jrheum.170990
18. Abdel MP, Meneghini RM, Berry DJ. Current Practice Trends in Primary Hip and Knee Arthroplasties Among Members of the American Association of Hip and Knee Surgeons: An Update During the COVID-19 Pandemic. *J Arthroplasty*. 2021;36(7):S40-S44.e3. doi:10.1016/j.arth.2021.01.080

19. Patel NN, Shah JA, Erens GA. Current Trends in Clinical Practice for the Direct Anterior Approach Total Hip Arthroplasty. *J Arthroplasty*. 2019;34(9):1987-1993.e3. doi:10.1016/j.arth.2019.04.025
20. Petis S, Howard JL, Lanting BL, Vasarhelyi EM. Surgical approach in primary total hip arthroplasty: anatomy, technique and clinical outcomes. *Canadian Journal of Surgery*. 2015;58(2):128-139. doi:10.1503/cjs.007214
21. Kyriakopoulos G, Poultsides L, Christofilopoulos P. Total hip arthroplasty through an anterior approach. *EFORT Open Rev*. 2018;3(11):574-583. doi:10.1302/2058-5241.3.180023
22. Bergin PF, Doppelt JD, Kephart CJ, et al. Comparison of Minimally Invasive Direct Anterior Versus Posterior Total Hip Arthroplasty Based on Inflammation and Muscle Damage Markers. *Journal of Bone and Joint Surgery*. 2011;93(15):1392-1398. doi:10.2106/JBJS.J.00557
23. Wang Z, Hou J zhao, Wu C hua, et al. A systematic review and meta-analysis of direct anterior approach versus posterior approach in total hip arthroplasty. *J Orthop Surg Res*. 2018;13(1):229. doi:10.1186/s13018-018-0929-4
24. Sun X, Zhao X, Zhou L, Su Z. Direct anterior approach versus posterolateral approach in total hip arthroplasty: a meta-analysis of results on early post-operative period. *J Orthop Surg Res*. 2021;16(1):69. doi:10.1186/s13018-021-02218-7
25. Awad ME, Farley BJ, Mostafa G, Saleh KJ. Direct anterior approach has short-term functional benefit and higher resource requirements compared with the posterior approach in primary total hip arthroplasty. *Bone Joint J*. 2021;103-B(6):1078-1087. doi:10.1302/0301-620X.103B6.BJJ-2020-1271.R1
26. Jia F, Guo B, Xu F, Hou Y, Tang X, Huang L. A comparison of clinical, radiographic and surgical outcomes of total hip arthroplasty between direct anterior and posterior approaches: a systematic review and meta-analysis. *HIP International*. 2019;29(6):584-596. doi:10.1177/1120700018820652
27. Aggarwal VK, Elbuluk A, Dundon J, et al. Surgical approach significantly affects the complication rates associated with total hip arthroplasty. *Bone and Joint Journal*. 2019;101 B(6):646-651. doi:10.1302/0301-620X.101B6.BJJ-2018-1474.R1
28. Argyrou C, Tzefronis D, Sarantis M, Kateros K, Poultsides L, Macheras GA. Total hip arthroplasty through the direct anterior approach in morbidly obese patients. *Bone Jt Open*. 2022;3(1):4-11. doi:10.1302/2633-1462.31.BJO-2021-0166.R1

29. Sarraj M, Chen A, Ekhtiari S, Rubinger L. Traction table versus standard table total hip arthroplasty through the direct anterior approach: a systematic review. *HIP International*. 2020;30(6):662-672. doi:10.1177/1120700019900987
30. Medacta International. AMIS experience. Anterior minimally invasive surgery in hip replacement. Accessed February 16, 2023. <https://media.medacta.com/media/9998xp11-03.pdf>
31. Woolson ST, Hartford JM, Sawyer A. Results of a method of leg-length equalization for patients undergoing primary total hip replacement. *J Arthroplasty*. 1999;14(2):159-164. doi:10.1016/S0883-5403(99)90119-5
32. Kumar P, Sen R, Aggarwal S, Agarwal S, Rajnish RK. Reliability of Modified Harris Hip Score as a tool for outcome evaluation of Total Hip Replacements in Indian population. *J Clin Orthop Trauma*. 2019;10(1):128-130. doi:10.1016/j.jcot.2017.11.019
33. Gupta R, Dhiman U, Sharma K. Effect of a combination of oral midazolam and low-dose ketamine on anxiety, pain, swelling, and comfort during and after surgical extractions of mandibular third molars. *Indian Journal of Dental Research*. 2012;23(2):295. doi:10.4103/0970-9290.100460
34. Registered Nurses' Association of Ontario. *Assessment and Management of Pain*. 3rd edition. Registered Nurses' Association of Ontario; 2013. www.rnao.ca/bestpractices
35. Adriani M, Malahias MA, Gu A, Kahlenberg CA, Ast MP, Sculco PK. Determining the Validity, Reliability, and Utility of the Forgotten Joint Score: A Systematic Review. *J Arthroplasty*. 2020;35(4):1137-1144. doi:10.1016/j.arth.2019.10.058
36. Cieremans DA, Huang S, Konopka JA, Davidovitch RI, Schwarzkopf R, Slover JD. Validation of Single-Outcome Questionnaire in Primary TKA and THA. *J Arthroplasty*. 2022;37(10):1987-1990. doi:10.1016/j.arth.2022.04.036
37. Hartford JM, Graw BP, Frosch DL. Perioperative Complications Stratified by Body Mass Index for the Direct Anterior Approach to Total Hip Arthroplasty. *J Arthroplasty*. 2020;35(9):2652-2657. doi:10.1016/j.arth.2020.04.018
38. Matar HE, Pincus D, Paterson JM, Aktar S, Jenkinson R, Ravi B. Early Surgical Complications of Total Hip Arthroplasty in Patients With Morbid Obesity: Propensity-Matched Cohort Study of 3683 Patients. *J Arthroplasty*. 2020;35(9):2646-2651. doi:10.1016/j.arth.2020.04.044

39. Sikov M, Sloan M, Sheth NP. Effect of operative time on complications following primary total hip arthroplasty: analysis of the NSQIP database. *HIP International*. 2021;31(2):231-236. doi:10.1177/1120700020949701
40. Iacobelli DS, Syku M, Abutalib Z, et al. Transfusion Avoidance in Severely Anemic Total Hip and Total Knee Arthroplasty Patients: An Analysis of Risk. *Arthroplast Today*. 2022;14:128-132. doi:10.1016/j.artd.2022.01.033
41. Curtin BM, Armstrong LC, Bucker BT, Odum SM, Jiranek WA. Patient Radiation Exposure During Fluoro-Assisted Direct Anterior Approach Total Hip Arthroplasty. *J Arthroplasty*. 2016;31(6):1218-1221. doi:10.1016/j.arth.2015.12.012
42. Baksh N, Wei L, Ho ES, et al. Radiation exposure in fluoroscopy-guided anterior total hip arthroplasty: a systematic review. *European Journal of Orthopaedic Surgery & Traumatology*. 2022;32(5):891-897. doi:10.1007/s00590-021-03060-7
43. Macheras G, Stasi S, Sarantis M, Triantafyllou A, Tzefronis D, Papadakis SA. Direct anterior approach vs Hardinge in obese and nonobese osteoarthritic patients: A randomized controlled trial. *World J Orthop*. 2021;12(11):877-890. doi:10.5312/wjo.v12.i11.877
44. Singh V, Yeroushalmi D, Lygrisse KA, Schwarzkopf R, Davidovitch RI. Impact of Obesity on the Forgotten Joint Score Following Primary Total Hip Arthroplasty. *J Arthroplasty*. 2021;36(4):1342-1347. doi:10.1016/j.arth.2020.10.027
45. Liu W, Wahafu T, Cheng M, Cheng T, Zhang Y, Zhang X. The influence of obesity on primary total hip arthroplasty outcomes: A meta-analysis of prospective cohort studies. *Orthopaedics & Traumatology: Surgery & Research*. 2015;101(3):289-296. doi:10.1016/j.otsr.2015.01.011
46. Verhaegen JCF, Wei R, Kim P, Beaulé PE, Corten K, Grammatopoulos G. The Safety and Efficacy of the Anterior Approach Total Hip Arthroplasty as per Body Mass Index. *J Arthroplasty*. 2023;38(2):314-322.e1. doi:10.1016/j.arth.2022.08.021

Appendices

Appendix A: Data Collection Form

Appendix B: Ethics Certificate

Appendix C: Hospital Manager Consent

Appendix D: Universal Pain Assessment Tool

Appendix E: Journal guidelines

Appendix F: Student's contribution to research & writing of the "submissible" paper

Appendix G: Research protocol

Appendix A: Data Collection Form

Title: A Comparison of the Short-Term Outcomes of Obese and Non-obese Patients undergoing
Total Hip Arthroplasty using the Direct Anterior Approach

Demographic Data

Study Number:

Age: ____ years

Sex: M/F

Height: ____m

Weight: ____kg

BMI: ____kg/m²

Medical comorbidities:

Diabetes Hypertension Epilepsy Asthma Previous MI

Cardiac Arrhythmias Thyroid disease HIV

ASA grade: ____

Allergies:

Intraoperative Data

Surgical time: ____minutes

Cemented femoral component: Y/N

Intra-operative complication:

Femoral fracture Acetabular fracture Nerve injury

Vascular injury Need for cables

Blood loss: _____ml

Blood transfusion: Y/N

Acetabular component size: ____

Polyethylene component size: ____

Femoral component size: ____

Screws acetabular component: Y/N

Clinical Data

Preoperative

Modified Harris Hip Score: _____

UPAT score (at rest): _____

UPAT score (with activity): _____

LLD: _____mm

Postoperative

Length of hospital stay: _____days

Blood transfusion in ward: Y/N

6 weeks/6 months/1 year post operatively

Modified Harris Hip Score: _____

UPAT score at rest: _____

UPAT score on activity: _____

Complications

Early (<4weeks): Y/N

Late (>4weeks): Y/N

Type of complication: Medical Surgical

Medical complications

Cardiac Pulmonary Renal Deep vein thrombosis Other

Surgical complications

Intraoperative Postoperative

SSI Deep PJI Wound dehiscence

Periprosthetic fracture

Hip dislocation

Loosening. If Yes Acetabular component Femoral component

Nerve injury Vascular injury

Greater trochanter pain syndrome

Iliopsoas impingement

Leg length discrepancy ____mm

Radiological Evaluation

Fixation Type

Cemented Uncemented Hybrid

Acetabular Cup Inclination

<30° 30-40 41-55° >55°

Acetabular Cup Version

0° 1-10° 11-20° >20°

Femoral Stem Version

Neutral Valgus Varus

Appendix B: Ethics Approval



R49 Dr N Goga

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL) CLEARANCE CERTIFICATE NO. M210819

NAME:
(Principal Investigator) Dr N Goga

DEPARTMENT: School of Clinical Medicine
Department of Surgery
Division of Orthopaedic Surgery
Medical School
University

PROJECT TITLE: *Short-term outcomes in obese patients undergoing anterior minimally-invasive Total Hip Arthroplasty*

New study title noted on 2023/03/29

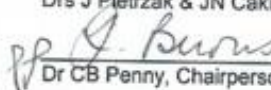
DATE CONSIDERED: 2021/08/27

DECISION: Approved unconditionally

CONDITIONS:

NOTE: If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>

SUPERVISOR: Drs J Pietrzak & JN Cakic; Professor SK Magombotha

APPROVED BY: 
Dr CB Penny, Chairperson, HREC (Medical)

DATE OF APPROVAL: 2021/12/02

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report.** When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **August** and therefore reports and re-certification will be due in the month of **August** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).


Signature of Principal Investigator

2023-03-31
Date

Appendix C: Hospital Manager Consent



Life Fourways Hospital Proprietary Limited
Cnr Cedar Road and Cedar Avenue West, Fourways 2055
Postnet Suite 141, Private Bag X033, Rivonia 2128
Telephone: +27 11 875 1000
Telefax: +27 11 875 1001
www.fourwayshospital.co.za

15 July 2021

Dr Nabila Goga
Per email: nabila.goga@gmail.com

Dear Dr Goga

RE: APPLICATION TO CONDUCT RESEARCH USING DR CAKIC'S PATIENT DATABASE | DR NABILA GOGA

This letter serves to confirm that Dr Goga has been granted permission to perform the following research using Dr J.N. Cakic's database of patients operated on at Life Fourways Hospital:

- ***Short-term Outcomes following Total Hip Arthroscopy in Obese versus Non-obese patients using the Direct Anterior Approach***

The Health Research Ethics Committee of Life Healthcare Group has granted permission to Dr Goga to collect information using the patient database of Dr Josip Cakic for their research. However, the researcher and surgeon must ensure the following:

- The information collected must be anonymised
- Comply with the POPIA in terms of data security and confidentiality
- The information collected must be for the sole use of the research project

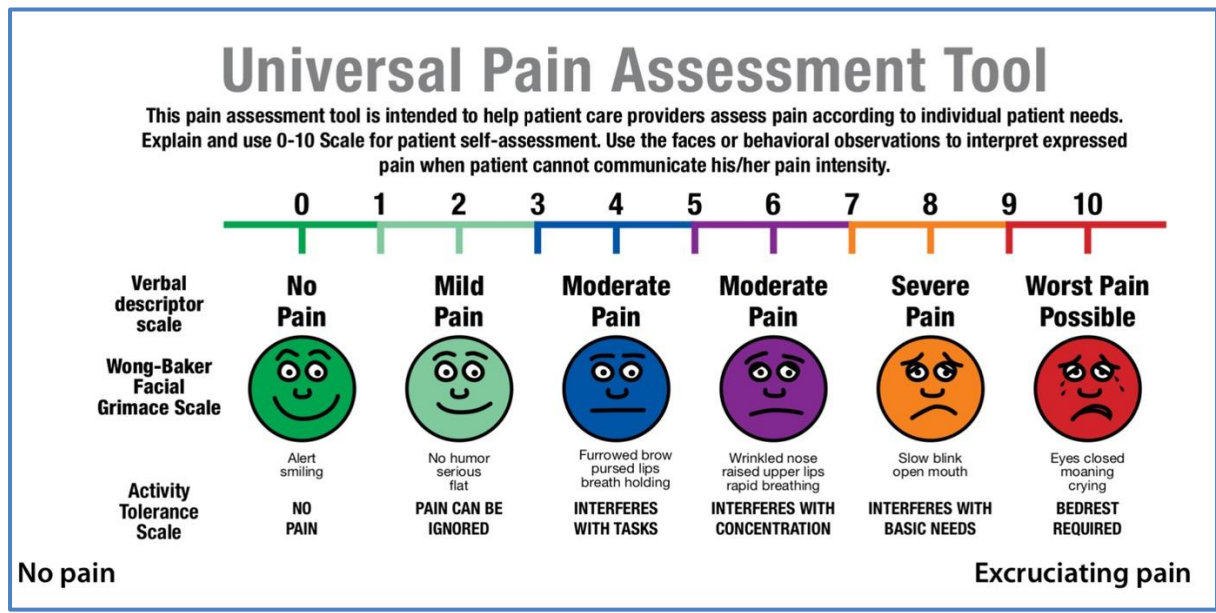
This letter has been issued in good faith and should you require any further information, please do not hesitate to contact the undersigned.

Yours sincerely

A handwritten signature in black ink, appearing to read "MacColl".

Carey MacColl
Hospital Manager
Life Fourways Hospital

Appendix D: Universal Pain Assessment Tool: Available from: South African Acute Pain Guidelines



Appendix E: Journal guidelines



JOURNAL OF ORTHOPAEDICS

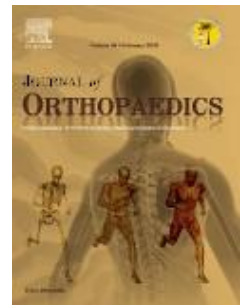
An official publication of the [Prof. PK Surendran Memorial Educational Foundation](#) and [Indo Korean Orthopaedic Foundation](#)

AUTHOR INFORMATION PACK

CONTENTS

- **Description** p.1
- **Abstracting and Indexing** p.1
- **Editorial Board** p.2
- **Guide for Authors** p.6

TABLE OF



ISSN: 0972-978X

DESCRIPTION

Journal of Orthopaedics aims to be a leading journal in orthopaedics and contribute towards the improvement of quality of orthopedic health care.

The journal publishes original research work and review articles related to different aspects of orthopaedics including Arthroplasty, Arthroscopy, Sports Medicine, Trauma, Spine and Spinal deformities, Pediatric orthopaedics, limb reconstruction procedures, hand surgery, and orthopaedic oncology. It also publishes articles on continuing education, health-related information, case reports and letters to the editor.

It is requested to note that the journal has an international readership and all submissions should be aimed at specifying something about the setting in which the work was conducted. Authors must also provide any specific reasons for the research and also provide an elaborate description of the results.

Benefits to authors

We also provide many author benefits, such as free PDFs, a liberal copyright policy, special discounts on Elsevier publications and much more. Please click here for more information on our [author services](#). Please see our [Guide for Authors](#) for information on article submission. If you require any further information or help, please visit our [Publishing Support Center](#).

ABSTRACTING AND INDEXING

PubMed/Medline

Scopus

Embase

Emerging Sources Citation Index (ESCI)

Web of Science

Gale Academic OneFile

EBSCOhost

PubMed Central

EDITORIAL BOARD

Editor-in-Chief

Raju Vaishya, Indraprastha Apollo Hospitals Institutes of Orthopaedics, New Delhi, India

Knee, Arthroplasty, Sports Medicine, Joint preservation, Bibliometric studies, Arthroplasty, Sports Medicine

Co Editor-in-Chief

Heiko Graichen, Asklepios Orthopaedic Hospital Lindenlohe, Department of Arthroplasty and General Orthopaedic Surgery, Schwandorf, Germany

Arthroplasty

Senior Editor

Ye Yeon Won, Ajou University School of Medicine, Ajou Medical Center, Department of Orthopaedic Surgery, Suwon, South Korea Arthroplasty

Managing Editor

Patinharayil Gopinathan, Kerala University of Health Sciences Government Medical College, Department of Orthopedics, Kozhikode, Kerala, India

Sports Medicine

Associate Editors

Manjula Bansal, Hospital for Special Surgery, New York, United States of America

MSK Tumors

Anil Bhat, Manipal Academy of Higher Education, Manipal, India

Hand and Microsurgery

Bancha Chernchujit, Thammasat University, Department of Orthopedics, Faculty of Medicine, Pathumthani, Thailand

Orthopaedics

Pascal Christel, Dr Sulaiman Al Habib Medical Group, Riyadh, Saudi Arabia

Orthopaedic Surgery

Riccardo D'Ambrosi, IRCCS Galeazzi Orthopaedic Institute, Milano, Italy

Arthroplasty, Sports Medicine

Ish Kumar Dhammi, University College of Medical Sciences, New Delhi, India
General Orthopaedics, Trauma

Mandeep S. Dhillon, Post Graduate Institute of Medical Education and Research, Chandigarh, India

Arthroscopy, Sports medicine, Foot & Ankle, Trauma

Jorg Eschweiler, RWTH Aachen University Hospital, Department of Orthopaedics, Trauma, and Reconstructive Surgery, Aachen, Germany

Bioengineering, Research

Vincenzo Filardi, University of Messina, Research and Internationalization, Messina, Italy

Bioengineering, Orthopedics, Medical devices, FE modelization

Brij Mohan Gupta, Council of Scientific & Industrial Research, New Delhi, India **Bibliometric Analysis, Research**

Hiroshi Hagino, Tottori University, Tottori, Japan

Bone Metabolism, Orthopaedics, Epidemiology, Rheumatoid Arthritis, Orthopaedic Surgery

Abid Haleem, Jamia Millia Islamia, New Delhi, India

healthcare Technologies, Additive Manufacturing, 3D Printing, advanced technologies, Supply chain management, Operations management

Chang Whan Han, Catholic University of Korea Daejeon St Mary's Hospital, Department of Orthopaedics, Daejeon, South Korea

Sports Medicine

Masayuki Iki, Kindai University, Faculty of Medicine, Department of Public Health, Sayama, Japan **Public Health**

Karthikeyan P. Iyengar, Southport and Ormskirk Hospital NHS Trust, Southport, United Kingdom **Upper limb, Trauma, General Orthopaedics**

Vijay Jain, Dr Ram Manohar Lohia Hospital Post Graduate Institute of Medical Education and Research Orthopaedics Department, New Delhi, India

General Orthopaedics, Trauma

Atul Joshi, Covenant Medical Center - 19th Street Campus, Lubbock, United States of America **Arthroplasty**

Darren Tay Keng Jin, Singapore General Hospital, Singapore, Singapore

Orthopaedic Surgery

Santosh Kumar, King George's Medical University, Lucknow, India

Arthroplasty, Trauma

Vinod Kumar, Maulana Azad Medical College, New Delhi, India

Sports Medicine, Trauma

Danilo Leonetti, University of Messina, Department of Orthopedics and Trauma Surgery, Messina, Italy **Foot and Ankle, Trauma**

Nicola Maffulli, Queen Mary University of London, London, United Kingdom **Sports Medicine**

Rajesh Malhotra, All India Institute of Medical Sciences, Department of Orthopaedics, New Delhi, India
Arthroplasty

Ajay Malviya, Northumbria Healthcare NHS Foundation Trust, Newcastle, United Kingdom

Arthroscopy, Hip dislocation, Hip Preservation

Filippo Migliorini, RWTH Aachen University Hospital, Department of Orthopaedics, Trauma, and Reconstructive Surgery, Aachen, Germany

Arthroscopy, Arthroplasty, Biologics, Cartilage and bone regeneration

Colin Nnadi, Oxford University Hospitals NHS Foundation Trust Nuffield Orthopaedic Centre, Oxford, United Kingdom

Orthopaedic Surgery

Sandeep Patwardhan, Sancheti Institute for Orthopaedics and Rehabilitation, Pune, India Paediatric
Orthopaedics

Rocco Paolo Pitto, The University of Auckland, Auckland, New Zealand
Orthopaedic Surgery

Shanmuganathan Rajasekaran, Ganga Medical Centre and Hospitals Pvt Ltd, Coimbatore, India Spine,
Trauma

Salvatore Risitano, University of Turin, City of Health and Science of Turin, Turin, Italy

Total knee Arthroplasty, Arthroscopy, Sports Medicine, Knee surgery, Trauma

Vinod Scaria, CSIR Institute of Genomics & Integrative Biology, New Delhi, India Technology,
Basic Science

Oliver Loannis Schmidt, HELIOS Park Hospital Leipzig, Department of Orthopedics, Leipzig, Germany
Orthopaedics

Hemant Sharma, University of Hull, Hull, United Kingdom

Adult Reconstruction, bone infections, Complex trauma, Non Unions

Ajoy P. Shetty, Ganga Medical Centre and Hospitals Pvt Ltd, Coimbatore, India Spine,
Trauma

Gautam M. Shetty, Mullaji Knee Clinic, Mumbai, India

Arthroplasty

Bijayendra Singh, Canterbury Christ Church University, Medway Foundation NHS Trust, Gillingham, United Kingdom

Upper Limb, Spine

Sibin Surendran, Kerala University of Health Sciences, Thrissur, India
Orthopaedic Surgery

Bruno Toussaint, Clinique Générale Ste Anne, Annecy, France
Upper Limb

Abhishek Vaish, Indraprastha Apollo Hospitals Institutes of Orthopaedics, New Delhi, India Arthroscopy,
Sports Medicine, Trauma

Piers Yates, Fremantle Hospital, Department of Orthopaedics, Fremantle, Australia Orthopaedic
Surgery

Yon Sik Yoo, Hallym University Medical College of Hallym University, Department of Orthopedic Surgery,
Hwaseong, South Korea Orthopaedic Surgery

Assistant Editors

Pawan Agarwal, Netaji Subhash Chandra Bose Medical College and Hospital, Department of Surgery, Jabalpur,
India

Plastic and Reconstructive surgery, Hand

Raju Ahluwalia, King's College Hospital, London, United Kingdom
Foot and Ankle

Alice Baroncini, RWTH Aachen University Medical Faculty, Aachen, Germany
Spine

Rajesh Botchu, Royal Orthopaedic Hospital, Birmingham, United Kingdom
MSK Radiology

Gautam Chakrabarty, Calderdale and Huddersfield NHS Foundation Trust, Huddersfield, United Kingdom
Arthroplasty

Bosco Francesco, University of Turin, Department of Public Health and Pediatric Sciences, Torino, Italy
Trauma and Knee surgery

Sudhir Kumar Garg, Government Medical College and Hospital, Chandigarh, India
MSK Tumors, Trauma

Prasad Gourineni, Advocate Children's Hospital, Oak Lawn, United States of America Paediatric Orthopaedics

Ariful Haque, Kunming Medical University, Kunming, China

Orthopedics, Sports Medicine, Trauma Surgery, Joint Surgery, Arthroscopy, Arthroplasty, 3D Orthopedics, Public Health, Mental Health, Occupational Health, Global Health

Madhan Jeyaraman, Sri Lalithambigai Medical College and Hospital, Department of Orthopaedics, Chennai, India

Arthroscopy, General Orthopaedics

Ashok Johari, Children's Orthopaedic Centre, Mumbai, India

Paediatric Orthopaedics

Raju Karuppal, Kerala University of Health Sciences Government Medical College, Department of Orthopedics, Kozhikode, India

Trauma, Arthroscopy and Arthroplasty

James Kigera, University of Nairobi School of Medicine, Nairobi, Kenya

Arthroscopy and Trauma

Philippe Landreau, Aspetar Orthopaedic and Sports Medicine Hospital, Doha, Qatar
Sports Medicine

Rujuta Mehta, Bai Jerbai Wadia Hospital for Children, Parel, India

Paediatric Orthopaedics

Samarth Mittal, Jai Prakash Narayan Apex Trauma Center AIIMS, New Delhi, India
Trauma

Raj M. Murali, Wrightington Hospital, Department of Orthopaedics, Wigan, United Kingdom Upper Limb

Mohit Kumar Patralekh, Vardhman Mahavir Medical College and Safdarjung Hospital Central Institute of Orthopaedics, New Delhi, India

Systematic Reviews, ,

S. Dilip Chand Raja, Fortis Hospital, Vadapalani, Chennai, India

Spine

Salvatore Risitano, University of Turin, City of Health and Science of Turin, Turin, Italy

Total knee Arthroplasty, Arthroscopy, Sports Medicine, Knee surgery, Trauma

Giuseppe Rovere, Catholic University of the Sacred Heart, Milano, Italy

Trauma, Hip and Knee surgery

Dhananjaya Sabat, MAMC and LNJP Hospitals, New Delhi, India

Arthroscopy, Trauma

Federico Sacchetti, University of Florence, Firenze, Italy

MSK Oncology

Abhijeet Salunke, The Gujarat Cancer and Research Institute, Ahmedabad, India

MSK Tumors

Saseender Shanmugasundaram, Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry, India

Arthroscopy and Arthroplasty

Amit Sinha, Spire Yale Hospital, Wrexham, United Kingdom

Hand, Trauma, Upper Limb (shoulder. elbow). Knee surgery

Norimasa Takahashi, Funabashi Orthopaedic Hospital Shoulder and Elbow Center, Funabashi, Japan

Orthopaedic Surgery

Vivek Tiwari, All India Institute of Medical Sciences - Nagpur, Nagpur, India

Trauma, General Orthopaedics

Amit Tolat, Medway Maritime Hospital, Gillingham, United Kingdom

Arthroscopy, Trauma

Jayesh Trivedi, Robert Jones and Agnes Hunt Orthopaedic Hospital NHS Foundation Trust, Oswestry, United Kingdom

Spine

Elizabeth Vinod, Christian Medical College and Hospital Vellore, Department of Physiology, Vellore, India Others

Karthik Vishwanathan, Parul University, Vadodara, India

Arthroplasty, Trauma

Editorial Board

Kunal Aneja, Max Super Speciality Hospital Shalimar Bagh, New Delhi, India

Arthroplasty, Sports Medicine, Arthroscopy, Trauma, Joint Preservation, Regenerative Medicine

Nicholas Antao, Holy Spirit Hospital, Mumbai, India

Sports Medicine, Arthroplasty

Giustra Fortunato, University of Turin, Maria Vittoria Hospital, Department of Orthopaedic and Traumatology,

Turin, Italy

Trauma and General orthopaedics

Nijith Govindan, MIOC Ortho Clinic, Kochi, India

Arthroplasty Upper and Lower limb, Arthroscopy and Sports Medicine

Nidhi Goyal, Indraprastha Apollo Hospitals, New Delhi, India

MSK Radiology

Amit Joshi, B & B Hospital Pvt. Ltd., Kathmandu, Nepal

Arthroscopy and Sports Medicine

Vikram Khanna, Akasha Institute, New Delhi, India

Trauma, General Orthopaedics

Rajiv Maharjan, BP Koirala Institute of Health Sciences, Dharan, Nepal

Trauma, General Orthopaedics, Arthroplasty, Spine

Anwar Marthya, IQRAA International Hospital and Research Centre, Kozhikode, India Orthopaedic surgery

Prem Haridas Menon, Kerala University of Health Sciences, Thrissur, India

Trauma, Arthroplasty, Arthroscopy, Geriatric fractures, Randomised Clinical Trials

Mubder Mohammed saeed, University of Basrah College of Medicine, Basrah, Iraq

Trauma, General Orthopaedics, Orthopaedics Trauma and Spine

Gaurav Neupane, Chitwan Medical College, Bharatpur, Nepal

Arthroplasty, Trauma

Raja Bhaskar Rajasekaran, Royal Orthopaedic Hospital, Birmingham, United Kingdom
MSK Tumors

Himanshu Rohilla, Rajiv Gandhi Cancer Institute and Research Centre, New Delhi, India MSK
Tumors

Binoti Sheth, Lokmanya Tilak Municipal Medical College and General Hospital, Mumbai, India Paediatric
Orthopaedics

GUIDE FOR AUTHORS

INTRODUCTION

We publish original research work across all disciplines of orthopedics and allied sciences, continuing education, evidence updates, students' pre-specified contributions, journal clubs, health-related information of interest to our readers and letters to editors are published. Journal of Orthopaedics seeks to be the pre-eminent Orthopaedics Journal. The content is aimed to deliver significant impact on the clinical practitioners and for improvement of the quality of health care. We are keen to encourage the submission of papers from authors whose first language is not English, although it is recommended that before submitting your manuscript to the journal you ask a colleague familiar with written English to read it through. This will greatly speed up the time taken to publish your paper. It is requested to note that the journal has an international readership and all submissions should be aimed at specifying something about the setting in which the work was conducted, why any specific reason for the research and also an elaborate description of the results.

Article categories

The categories of articles that are published in the Journal are listed and described below. Please select the category that best describes your paper. If your paper does not fall into any of these categories, please contact the Editorial Office.

You need to follow all the guidelines of this journal and the International guidelines, as per the article type (see table below):

Article Type	Word Limit (excluding References and Abstract)	Reference Limit	Key words	Author Limit	Abstract word limit	Limit of Figures/Tables	Mandatory Journal's Requirements	International Guidelines to follow
Original Research (Prospective/Retrospective studies)	3000	50	07	08	300 (Structured)	07	Institutional Ethical Committee approval	STROBE
Randomized Control Trial (RCT)	3500	60	07	08	350 (Structured)	07	Institutional Ethical Committee approval	CONSORT
Narrative Reviews	2500	50	07	06	250 (Structured)	05	--	--
<u>Systematic Review</u> and Meta-Analysis	3500	60	07	08	350 (Structured)	07	--	PRISMA
Case Reports	2000	20	05	04	200 (Structured)	05	Patient/Guardian Consent	CARE
Short Communication	1000	10	05	03	--	02	--	--
Letter to Editor	500	05	--	02	--	01	--	--
Clinical Practice Guidelines	3000	50	07	08	300 (Structured)	05	--	AGREE

JOO_article-specifications-list.jpg - Table with article specifications per article type

Original Research Article: Original, in-depth clinical research that represents new and significant contributions to medical science. The entire manuscript should not exceed 3000 words and should have maximum 50 references and 8 authors.

Randomized Control Trial (RCT): These studies should follow CONSORT guidelines and should not exceed 3500 words and 60 references. An Institutional Ethical Committee approval is required before the start of the study.

Systematic Review Article: These are comprehensive review articles on topics of current clinical interest in Orthopaedic targeting specialists. The entire manuscript should not exceed 3500 words with not more than 60 references. Please use structured abstract for all the review articles (including narrative reviews).

Narrative Reviews: These comprehensive reviews should cover upto date information about the subject. The manuscript should not exceed 2500 words and should have a maximum of 50 references and 6 authors.

Short Communication: Short communications can be personal opinions, or mini review on a burning topic, related to Orthopaedics. They should be up to 1000 words and can have up to 10 references, 3 authors and 2 figures/tables.

Case Reports: These should be novel, describing a new pathology, or management of a case. The manuscript should not exceed more than 2000 words and maximum limit of authors is 4 and

the references up to 20, for this category. Please use structured abstract for all case report articles.

Clinical Practice Guidelines: These articles summarize and suggest the guidelines for the clinicians about a common medical or surgical problem, based on currently available evidences from the literature. These should have a maximum of 300 words, 50 references, and up to 8 authors.

Editorials: The Editor usually commissions editorials but ideas or suggestions are welcomed.

Letters/Opinion: Are up to 500 words and are subject to copyediting, with the maximum of 2 authors and 5 references. Preference will be given to letters responding to points raised by articles published recently in this Journal. Authors will not receive proofs. Opinion articles relevant to newer developments in relation to Internet that would be of significance to medical profession are invited.

Address all correspondence to

Prof. Dr. Raju Vaishya, Editor-in-Chief, Journal of Orthopaedics at raju.vaishya@gmail.com.

Submission checklist

You can use this list to carry out a final check of your submission before you send it to the journal for review. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:

- E-mail address
- Full postal address

All necessary files have been uploaded:

Manuscript:

- Include keywords
- All figures (include relevant captions)
- All tables (including titles, description, footnotes)
- Ensure all figure and table citations in the text match the files provided
- Indicate clearly if color should be used for any figures in print

Graphical Abstracts / Highlights files (where applicable)

Supplemental files (where applicable)

Further considerations

- Manuscript has been 'spell checked' and 'grammar checked'
- All references mentioned in the Reference List are cited in the text, and vice versa
- Permission has been obtained for use of copyrighted material from other sources (including the Internet)
- A competing interests statement is provided, even if the authors have no competing interests to declare
- Journal policies detailed in this guide have been reviewed
- Referee suggestions and contact details provided, based on journal requirements

For further information, visit our [Support Center](#).

BEFORE YOU BEGIN

Ethics in publishing

Please see our information on [Ethics in publishing](#).

Studies in humans and animals

If the work involves the use of human subjects, the author should ensure that the work described has been carried out in accordance with [The Code of Ethics of the World Medical Association](#) (Declaration of Helsinki) for experiments involving humans. The manuscript should be in line with the [Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals](#) and aim for the inclusion of representative human populations (sex, age and ethnicity) as per those recommendations. The terms [sex and gender](#) should be used correctly.

Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

All animal experiments should comply with the [ARRIVE guidelines](#) and should be carried out in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, [EU Directive 2010/63/EU for animal experiments](#), or the National Research Council's [Guide for the Care and Use of Laboratory Animals](#) and the authors should clearly indicate in the manuscript that such guidelines have been followed. The sex of animals must be indicated, and where appropriate, the influence (or association) of sex on the results of the study.

Declaration of interest

All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential competing interests include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors must disclose any interests in two places: 1. A summary declaration of interest statement in the title page file (if double anonymized) or the manuscript file (if single anonymized). If there are no interests to declare then please state this: 'Declarations of interest: none'. 2. Detailed disclosures as part of

a separate Declaration of Interest form, which forms part of the journal's official records. It is important for potential interests to be declared in both places and that the information matches. [More information.](#)

Submission declaration

Submission of an article implies that the work described has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see '[Multiple, redundant or concurrent publication](#)' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright holder.

Use of inclusive language

Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences, and promotes equal opportunities. Content should make no assumptions about the beliefs or commitments of any reader; contain nothing which might imply that one individual is superior to another on the grounds of age, gender, race, ethnicity, culture, sexual orientation, disability or health condition; and use inclusive language throughout. Authors should ensure that writing is free from bias, stereotypes, slang, reference to dominant culture and/or cultural assumptions. We advise to seek gender neutrality by using plural nouns ("clinicians, patients/clients") as default/wherever possible to avoid using "he, she," or "he/she." We recommend avoiding the use of descriptors that refer to personal attributes such as age, gender, race, ethnicity, culture, sexual orientation, disability or health condition unless they are relevant and valid. When coding terminology is used, we recommend to avoid offensive or exclusionary terms such as "master", "slave", "blacklist" and "whitelist". We suggest using alternatives that are more appropriate and (self-) explanatory such as "primary", "secondary", "blocklist" and "allowlist". These guidelines are meant as a point of reference to help identify appropriate language but are by no means exhaustive or definitive.

Reporting sex- and gender-based analyses

Reporting guidance

For research involving or pertaining to humans, animals or eukaryotic cells, investigators should integrate sex and gender-based analyses (SGBA) into their research design according to funder/ sponsor requirements and best practices within a field. Authors should address the sex and/or gender dimensions of their research in their article. In cases where they cannot, they should discuss this as a limitation to their research's generalizability. Importantly, authors should explicitly state what definitions of sex and/or gender they are applying to enhance the precision, rigor and reproducibility of their research and to avoid ambiguity or conflation of terms and the constructs to which they refer (see Definitions section below). Authors can refer to the [Sex and](#)

[Gender Equity in Research \(SAGER\) guidelines](#) and the [SAGER guidelines checklist](#). These offer systematic approaches to the use and editorial review of sex and gender information in study design, data analysis, outcome reporting and research interpretation - however, please note there is no single, universally agreed-upon set of guidelines for defining sex and gender.

Definitions

Sex generally refers to a set of biological attributes that are associated with physical and physiological features (e.g., chromosomal genotype, hormonal levels, internal and external anatomy). A binary sex categorization (male/female) is usually designated at birth ("sex assigned at birth"), most often based solely on the visible external anatomy of a newborn. Gender generally refers to socially constructed roles, behaviors, and identities of women, men and gender-diverse people that occur in a historical and cultural context and may vary across societies and over time. Gender influences how people view themselves and each other, how they behave and interact and how power is distributed in society. Sex and gender are often incorrectly portrayed as binary (female/male or woman/man) and unchanging whereas these constructs actually exist along a spectrum and include additional sex categorizations and gender identities such as people who are intersex/have differences of sex development (DSD) or identify as non-binary. Moreover, the terms "sex" and "gender" can be ambiguous—thus it is important for authors to define the manner in which they are used. In addition to this definition guidance and the SAGER guidelines, the [resources on this page](#) offer further insight around sex and gender in research studies.

Author contributions

For transparency, we encourage authors to submit an author statement file outlining their individual contributions to the paper using the relevant CRediT roles: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing. Authorship statements should be formatted with the names of authors first and CRediT role(s) following. [More details and an example](#).

Changes to authorship

Authors are expected to consider carefully the list and order of authors **before** submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only **before** the manuscript has been accepted and only if approved by the journal Editor. To request such a change, the Editor must receive the following from the **corresponding author**: (a) the reason for the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed.

Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement of authors **after** the manuscript has been accepted. While the Editor considers the request,

publication of the manuscript will be suspended. If the manuscript has already been published in an online issue, any requests approved by the Editor will result in a corrigendum.

Article Transfer Service

This journal is part of our Article Transfer Service. This means that if the Editor feels your article is more suitable in one of our other participating journals, then you may be asked to consider transferring the article to one of those. If you agree, your article will be transferred automatically on your behalf with no need to reformat. Please note that your article will be reviewed again by the new journal. [More information](#).

Reporting clinical trials

Randomized controlled trials should be presented according to the CONSORT guidelines. At manuscript submission, authors must provide the CONSORT checklist accompanied by a flow diagram that illustrates the progress of patients through the trial, including recruitment, enrollment, randomization, withdrawal and completion, and a detailed description of the randomization procedure. The [CONSORT checklist and template flow diagram](#) are available online.

Copyright

Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (see [more information](#) on this). An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. [Permission](#) of the Publisher is required for resale or distribution outside the institution and for all other derivative works, including compilations and translations. If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has [preprinted forms](#) for use by authors in these cases.

Author rights

As an author you (or your employer or institution) have certain rights to reuse your work. [More information](#).

Elsevier supports responsible sharing

Find out how you can [share your research](#) published in Elsevier journals.

Role of the funding source

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement, it is recommended to state this.

Open access

Please visit our [Open Access page](#) for more information.

Language (usage and editing services)

Please write your text in good English (American or British usage is accepted, but not a mixture of these). Authors who feel their English language manuscript may require editing to eliminate possible grammatical or spelling errors and to conform to correct scientific English may wish to use the [English Language Editing service](#) available from Elsevier's Author Services.

Submission

Our online submission system guides you stepwise through the process of entering your article details and uploading your files. Editable article files (e.g., Word, LaTeX) are mandatory to use in the peerreview process and typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail.

Submit your article

Please submit your article via <https://www.editorialmanager.com/JOO/default.aspx>.

Suggesting reviewers

Please submit the names and institutional e-mail addresses of several potential reviewers.

You should not suggest reviewers who are colleagues, or who have co-authored or collaborated with you during the last three years. Editors do not invite reviewers who have potential competing interests with the authors. Further, in order to provide a broad and balanced assessment of the work, and ensure scientific rigor, please suggest diverse candidate reviewers who are located in different countries/ regions from the author group. Also consider other diversity attributes e.g. gender, race and ethnicity, career stage, etc. Finally, you should not include existing members of the journal's editorial team, of whom the journal are already aware.

Note: the editor decides whether or not to invite your suggested reviewers.

PREPARATION

Manuscripts must conform to the instructions given below:

General

Type the manuscript using 'Times New Roman' font, size 12 in double space throughout. Please arrange the manuscript as follows: Title page, Abstract, Introduction, Methods, Results, Discussion, and References. Number all pages consecutively, beginning with the title page. All figures and Tables must be referred to in the manuscript. Consult a recent issue of the Journal for details. Only the Title page should bear the names and addresses of the author(s). Editorials, perspective and review articles are generally by invitation. However if you are interested in writing a review/perspective, you can send an email to the editor with the topic and a short summary of contents to be included. The editor will convey his decision in 7-10 days' time.

Length of articles

Text of original articles should be between 2000 and 3500 words. The article should not ordinarily contain more than 3 tables, 2 figures and 25 references. Case Reports are accepted only if they can be converted into 'What is your diagnosis?' format (please consult a recent issue of the Journal). Briefly, the format consists of case report of about 500 words, a diagnostic image followed by the actual diagnosis/answer and discussion (250 words) and upto 5 references. Letters discussing or criticizing material published recently in the Journal, brief presentations of data, or those pertaining to issues of relevance to health policy, practice of medicine, or the like, are welcome. These should not exceed 500 words, 1 table and 5 references.

Queries

For questions about the editorial process (including the status of manuscripts under review) or for technical support on submissions, please visit our [Support Center](#).

Peer review

This journal operates a double anonymized review process. All contributions will be initially assessed by the editor for suitability for the journal. Papers deemed suitable are then typically sent to a minimum of two independent expert reviewers to assess the scientific quality of the paper. The Editor is responsible for the final decision regarding acceptance or rejection of articles. The Editor's decision is final. Editors are not involved in decisions about papers which they have written themselves or have been written by family members or colleagues or which relate to products or services in which the editor has an interest. Any such submission is subject to all of the journal's usual procedures, with peer review handled independently of the relevant editor and their research groups. [More information on types of peer review](#).

Double anonymized review

This journal uses double anonymized review, which means the identities of the authors are concealed from the reviewers, and vice versa. [More information](#) is available on our website. To facilitate this, please include the following separately:

Title page (with author details): This should include the title, authors' names, affiliations, acknowledgements and any Declaration of Interest statement, and a complete address for the corresponding author including an e-mail address.

Anonymized manuscript (no author details): The main body of the paper (including the references, figures, tables and any acknowledgements) should not include any identifying information, such as the authors' names or affiliations.

Use of word processing software

It is important that the file be saved in the native format of the word processor used. The text should be in single-column format. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. In particular, do not use the word processor's options to justify text or to hyphenate words. However, do use bold face, italics, subscripts, superscripts etc. When preparing tables, if you are using a table grid, use only one grid for each individual table and not a grid for each row. If no grid is used, use tabs, not spaces, to align columns. The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the [Guide to Publishing with Elsevier](#)). Note that source files of figures, tables and text graphics will be required whether or not you embed your figures in the text. See also the section on Electronic artwork.

To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your word processor.

Article structure

Subdivision - numbered sections

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Material and methods

Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized, and indicated by a reference. If quoting directly from a previously published method, use quotation marks and also cite the source. Any modifications to existing methods should also be described.

Theory/calculation

A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.

Results

Results should be clear and concise.

Discussion

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Conclusions

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

Appendices

If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Essential title page information

- **Title.** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
- **Author names and affiliations.** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. You can add your name between parentheses in your own script behind the English transliteration. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lowercase superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.
- **Corresponding author.** Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. This responsibility includes answering any future queries about Methodology and Materials. **Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.**
- **Present/permanent address.** If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Title page

In animal studies, the title should state the species; all other titles will refer to human studies. State names of authors (including first names), the departments and the institution where the work was done. Please do not add your academic qualifications, designation etc. State contribution of each author clearly. A short, running title, not exceeding 40 characters, should be provided. Please provide the name, postal address with PIN code, facsimile number and E-mail address of the author to whom communications and proofs are to be sent. Acknowledgements, if any, may be mentioned on this page.

Abstract

A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Keywords

Immediately after the abstract, provide a minimum of 3 keywords to maximum of 12 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Abbreviations

Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

Acknowledgements

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Formatting of funding sources

List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, it is recommended to include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Units

Follow internationally accepted rules and conventions: use the international system of units (SI). If other units are mentioned, please give their equivalent in SI.

Math formulae

Please submit math equations as editable text and not as images. Present simple formulae in line with normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

Footnotes

Footnotes should be used sparingly. Number them consecutively throughout the article. Many word processors can build footnotes into the text, and this feature may be used. Otherwise, please indicate the position of footnotes in the text and list the footnotes themselves separately at the end of the article. Do not include footnotes in the Reference list.

Artwork

Electronic artwork General points

- Make sure you use uniform lettering and sizing of your original artwork.
- Embed the used fonts if the application provides that option.
- Aim to use the following fonts in your illustrations: Arial, Courier, Times New Roman, Symbol, or use fonts that look similar.
- Number the illustrations according to their sequence in the text.
- Use a logical naming convention for your artwork files.
- Provide captions to illustrations separately.
- Size the illustrations close to the desired dimensions of the published version.
- Submit each illustration as a separate file.

- Ensure that color images are accessible to all, including those with impaired color vision.

A detailed [guide on electronic artwork](#) is available.

You are urged to visit this site; some excerpts from the detailed information are given here. *Formats*

If your electronic artwork is created in a Microsoft Office application (Word, PowerPoint, Excel) then please supply 'as is' in the native document format.

Regardless of the application used other than Microsoft Office, when your electronic artwork is finalized, please 'Save as' or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):

EPS (or PDF): Vector drawings, embed all used fonts.

TIFF (or JPEG): Color or grayscale photographs (halftones), keep to a minimum of 300 dpi.

TIFF (or JPEG): Bitmapped (pure black & white pixels) line drawings, keep to a minimum of 1000 dpi. TIFF (or JPEG): Combinations bitmapped line/half-tone (color or grayscale), keep to a minimum of 500 dpi.

Please do not:

- Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); these typically have a low number of pixels and limited set of colors;
- Supply files that are too low in resolution;
- Submit graphics that are disproportionately large for the content.

Color artwork

Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF) or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that these figures will appear in color online (e.g., ScienceDirect and other sites) in addition to color reproduction in print. [Further information on the preparation of electronic artwork.](#)

Figure captions

Ensure that each illustration has a caption. Supply captions separately, not attached to the figure. A caption should comprise a brief title (**not** on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Tables

Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

References

Number the references in the order in which they first appear in the text and identify the reference numbers in the text in superscript. References must be placed at the end of the manuscript. Please use recent references as much as possible. The responsibility for accuracy of references lies with the respective authors. The Journal is in agreement with the International Committee of Medical Journal Editors (<http://www.icmje.org>). The general arrangement, abbreviations of Journal names and punctuations followed are as per the Uniform Requirements for Manuscripts submitted to Biomedical Journals (<http://www.icmje.org>). Please pay attention to the style of references and punctuations as follows:

Journal article

List all authors when six or less as shown in the example below: Tallon D, Chard J, Dieppe P. Exploring the priorities of patients with osteoarthritis of the knee. *Arthritis Care and Res* 2000;13:312–9.

When there are seven or more authors, list only the first six and add et al.

Book or monograph

Following is an example: Cassidy JT. Juvenile rheumatoid arthritis. In: *Textbook of Rheumatology* 6th ed, Kelly et al (eds) Philadelphia Saunders 2000; pp. 1297–313.

Citation in text

Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Reference links

Increased discoverability of research and high quality peer review are ensured by online links to the sources cited. In order to allow us to create links to abstracting and indexing services, such

as Scopus, Crossref and PubMed, please ensure that data provided in the references are correct. Please note that incorrect surnames, journal/book titles, publication year and pagination may prevent link creation. When copying references, please be careful as they may already contain errors. Use of the DOI is highly encouraged.

A DOI is guaranteed never to change, so you can use it as a permanent link to any electronic article. An example of a citation using DOI for an article not yet in an issue is: VanDecar J.C., Russo R.M., James D.E., Ambeh W.B., Franke M. (2003). Aseismic continuation of the Lesser Antilles slab beneath northeastern Venezuela. *Journal of Geophysical Research*, <https://doi.org/10.1029/2001JB000884>. Please note the format of such citations should be in the same style as all other references in the paper.

Web references

As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

Data references

This journal encourages you to cite underlying or relevant datasets in your manuscript by citing them in your text and including a data reference in your Reference List. Data references should include the following elements: author name(s), dataset title, data repository, version (where available), year, and global persistent identifier. Add [dataset] immediately before the reference so we can properly identify it as a data reference. The [dataset] identifier will not appear in your published article.

Preprint references

Where a preprint has subsequently become available as a peer-reviewed publication, the formal publication should be used as the reference. If there are preprints that are central to your work or that cover crucial developments in the topic, but are not yet formally published, these may be referenced. Preprints should be clearly marked as such, for example by including the word preprint, or the name of the preprint server, as part of the reference. The preprint DOI should also be provided.

References in a special issue

Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Reference style

Text: Indicate references by (consecutive) superscript arabic numerals in the order in which they appear in the text. The numerals are to be used *outside* periods and commas, *inside* colons and semicolons. For further detail and examples you are referred to the [AMA Manual of Style](#), A Guide for Authors and Editors, 11th Edition.

List: Number the references in the list in the order in which they appear in the text.

Examples:

Reference to a journal publication:

1. Van der Geer J, Hanraads JAJ, Lupton RA. The art of writing a scientific article. *J Sci Commun*. 2010;163:51–59. <https://doi.org/10.1016/j.Sc.2010.00372> Reference to a journal publication with an article number:
2. Van der Geer J, Hanraads JAJ, Lupton RA. The art of writing a scientific article. *Heliyon*. 2018;19:e00205. <https://doi.org/10.1016/j.heliyon.2018.e00205> Reference to a book:
3. Strunk W Jr, White EB. *The Elements of Style*. 4th ed. New York, NY: Longman; 2000. Reference to a chapter in an edited book:
4. Mettam GR, Adams LB. How to prepare an electronic version of your article. In: Jones BS, SmithRZ, eds. *Introduction to the Electronic Age*. New York, NY: E-Publishing Inc; 2009:281–304.

Reference to a website:

5. Cancer Research UK. Cancer statistics reports for the UK. Accessed 13 March 2003. <http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/>; 2003. .

Reference to a dataset:

[dataset] 6. Oguro M, Imahiro S, Saito S, Nakashizuka T. Mortality data for Japanese oak wilt disease and surrounding forest compositions, Mendeley Data, v1; 2015. <https://doi.org/10.17632/xwj98nb39r.1>

Reference to software:

7. Coon E, Berndt M, Jan A, Svyatsky D, Atchley A, Kikinzon E, Harp D, Manzini G, Shelef E, Lipnikov K, Garimella R, Xu C, Moulton D, Karra S, Painter S, Jafarov E, Molins S. Advanced Terrestrial Simulator (ATS) v0.88 (Version 0.88). Zenodo; 2020, March 25. <https://doi.org/10.5281/zenodo.3727209>

Journal abbreviations source

Journal names should be abbreviated according to the [List of Title Word Abbreviations](#).

Video

Elsevier accepts video material and animation sequences to support and enhance your scientific research. Authors who have video or animation files that they wish to submit with their article are strongly encouraged to include links to these within the body of the article. This can be done in the same way as a figure or table by referring to the video or animation content and noting in the body text where it should be placed. All submitted files should be properly labeled so that they directly relate to the video file's content. In order to ensure that your video or animation material is directly usable, please provide the file in one of our recommended file formats with a preferred maximum size of 150 MB per file, 1 GB in total. Video and animation files supplied will be published online in the electronic version of your article in Elsevier Web products, including [ScienceDirect](#). Please supply 'stills' with your files: you can choose any frame from the video or animation or make a separate image. These will be used instead of standard icons and will personalize the link to your video data. For more detailed instructions please visit our [video instruction pages](#). Note: since video and animation cannot be embedded in the print version of the journal, please provide text for both the electronic and the print version for the portions of the article that refer to this content.

Research data

This journal encourages and enables you to share data that supports your research publication where appropriate, and enables you to interlink the data with your published articles. Research data refers to the results of observations or experimentation that validate research findings. To facilitate reproducibility and data reuse, this journal also encourages you to share your software, code, models, algorithms, protocols, methods and other useful materials related to the project.

Below are a number of ways in which you can associate data with your article or make a statement about the availability of your data when submitting your manuscript. If you are sharing data in one of these ways, you are encouraged to cite the data in your manuscript and reference list. Please refer to the "References" section for more information about data citation. For more information on depositing, sharing and using research data and other relevant research materials, visit the [research data](#) page.

Data linking

If you have made your research data available in a data repository, you can link your article directly to the dataset. Elsevier collaborates with a number of repositories to link articles on ScienceDirect with relevant repositories, giving readers access to underlying data that gives them a better understanding of the research described.

There are different ways to link your datasets to your article. When available, you can directly link your dataset to your article by providing the relevant information in the submission system. For more information, visit the [database linking page](#).

For [supported data repositories](#) a repository banner will automatically appear next to your published article on ScienceDirect.

In addition, you can link to relevant data or entities through identifiers within the text of your manuscript, using the following format: Database: xxxx (e.g., TAIR: AT1G01020; CCDC: 734053; PDB: 1XFN).

Data statement

To foster transparency, we encourage you to state the availability of your data in your submission. This may be a requirement of your funding body or institution. If your data is unavailable to access or unsuitable to post, you will have the opportunity to indicate why during the submission process, for example by stating that the research data is confidential. The statement will appear with your published article on ScienceDirect. For more information, visit the [Data Statement page](#).

Editorial process

All articles submitted to the Journal undergo initial review by the Editor/associate editor and articles that are outside the scope of Journal or are not in the journal format are excluded. Later each article is reviewed by at least two reviewers. The time to first decision is usually less than 6 weeks. As per the policy of the Journal, an Editor, who is either author of a manuscript or belongs to the same institution as any of the authors, is not assigned that manuscript and is not involved in decisionmaking regarding its publication.

Reviewers/Editorial Board members should decline the invitation to review a manuscript which is submitted by authors from their institution.

AFTER ACCEPTANCE

Online proof correction

To ensure a fast publication process of the article, we kindly ask authors to provide us with their proof corrections within two days. Corresponding authors will receive an e-mail with a link to our online proofing system, allowing annotation and correction of proofs online. The environment is similar to MS Word: in addition to editing text, you can also comment on figures/tables and answer questions from the Copy Editor. Web-based proofing provides a faster and less error-prone process by allowing you to directly type your corrections, eliminating the potential introduction of errors.

If preferred, you can still choose to annotate and upload your edits on the PDF version. All instructions for proofing will be given in the e-mail we send to authors, including alternative methods to the online version and PDF.

We will do everything possible to get your article published quickly and accurately. Please use this proof only for checking the typesetting, editing, completeness and correctness of the text,

tables and figures. Significant changes to the article as accepted for publication will only be considered at this stage with permission from the Editor. It is important to ensure that all corrections are sent back to us in one communication. Please check carefully before replying, as inclusion of any subsequent corrections cannot be guaranteed. Proofreading is solely your responsibility.

Offprints

The corresponding author, at no cost, will be provided with a personalized link providing 50 days free access to the final published version of the article on ScienceDirect. This link can also be used for sharing via email and social networks. For an extra charge, paper offprints can be ordered via the offprint order form which is sent once the article is accepted for publication.

AUTHOR INQUIRIES

Visit the [Elsevier Support Center](#) to find the answers you need. Here you will find everything from Frequently Asked Questions to ways to get in touch.

You can also [check the status of your submitted article](#) or find out [when your accepted article will be published](#).

© Copyright 2018 Elsevier | <https://www.elsevier.com>

Appendix F: Student's contribution to the research and writing of the "submissible" paper

Division of Orthopaedic Surgery
Faculty of Health Sciences, 4th Floor 12, Wits Medical School, 7 York Road, Parktown 2193
• Tel: +27 11 717 2100 • Fax: +27 11 717 2199

26/02/2023

Faculty of Health Sciences, University of the Witwatersrand

RE: NABILA GOGA'S CONTRIBUTION TO THE RESEARCH AND WRITING OF THE "SUBMISSIBLE" PAPER

To whom it may concern,

This letter serves to confirm that the co-authors of the "submissible" research paper have agreed to its use by Nabila Goga, student number 0503841V, as part of her MMed research report. Nabila Goga made a substantial contribution to conducting the research study and writing the manuscript.

Yours sincerely,


.....
Dr. J. Pietrzak
Primary Supervisor


.....
Nabila Goga
MMed Candidate

Short-term outcomes in obese patients undergoing anterior minimally invasive Total Hip Arthroplasty



UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Nabila Goga 0503841V

MMed (Orth)

Supervisors

Dr JRT Pietrzak

MBBCh (Wits), MMed (Orth) WITS, FC Orth (SA)

Dr JN Cakic

MD, PhD, FCS (Orth) SA, MMed (Orth) WITS

Prof SK Magobotha

MBChB, FCS (Orth) SA

Table of contents

List of Tables	iii
Nomenclature	iv
1. INTRODUCTION / BACKGROUND	1
2. STUDY AIM AND OBJECTIVES	10
3. METHODS	11
4. DATA ANALYSIS	14
5. ETHICS	15
6. TIMING	15
7. FUNDING	16
8. ANTICIPATED PROBLEMS	16
References	18

List of Tables

Table 6.1 Gantt Chart.....	13
Table 7.1 Funding.....	13

Nomenclature

ADL	Activities of Daily Living
AL	Anterolateral approach
AKI	Acute kidney Injury
AAHKS	American Association of Hip and Knee Surgeons
BMI	Body Mass Index
CA	Cardiac Arrhythmia
CK	Creatine Kinase
DAA	Direct Anterior Approach
DL	Direct Lateral Approach
DM	Diabetes Mellitus
HIV	Human Immunodeficiency Virus
HHS	Harris Hip Score
HOOS	Hip Disability and Osteoarthritis Outcome Scores
HS	Hip Society
LLD	Limb Length Discrepancy

MIS	Minimally Invasive Surgery
OECD	Organisation for Economic Co-operation and Development
PA	Posterior Approach
PROM	Patient Reported Outcome Measures
QALY	Quality of Life Years
QOL	Quality of Life
TFL	Tensor Fascia Lata
THA	Total Hip Arthroplasty
TJA	Total Joint Arthroplasty
USA	United States of America
UPAT	Universal Pain Assessment Tool
VAS	Visual Analogue Scale
WHO	World Health Organization

1. INTRODUCTION / BACKGROUND

1.1 Total Hip Arthroplasty

Total Hip Arthroplasty (THA) is one of the most successful interventions in the field of orthopaedic surgery (1,2). A 2007 article published in *The Lancet* labelled it ‘The operation of the century’ (1,2). Since Sir Charnley popularised the procedure in the latter part of the 20th century, the number of patients undergoing THA have continued to grow year on year with approximately one million THAs being performed annually worldwide and an average of 184 THA surgeries per 100 000 people in Organisation for Economic Cooperation and Development (OECD) countries (2–4).

The demand for THA surgery shows no signs of abating and current projections support a continuation of this trend for the foreseeable future with the annual number of procedures performed in the United States of America (USA) alone expected to increase by over one million from 400 000 to 1 429 000 by the year 2040 (5). The market for THA has expanded with widened of criteria for eligibility and increased demand from younger patients as technology and skills evolve (6,7).

The reason this procedure is held in such high esteem is due to the significant improvement in quality of life (QOL) for the majority of patients who undergo it (1,2,8). About ninety-four percent (93.9%) of patients who have undergone primary THA report being satisfied with the procedure (9–11). Primary THA has excellent outcomes with reported survivorship of up to 95% at 10 years and > 80% survivorship at 25 years (3). It has been shown to result in a significant increase in quality of life years (QALY) and from an economic perspective is a cost

effective surgical intervention (12,13). The majority of patients (78-96%) who undergo primary THA surgery are able to return to work within one year, however this number is lower in patients with more physically demanding roles (14,15).

1.2 The Direct Anterior Approach (DAA)

Despite the success and high usage of THA, there are still many areas of controversy. One of the hotly debated issues is that of the optimal surgical approach. Historically, the commonly used approaches were the anterolateral (AL), direct lateral (DL) and posterior approach (PA) however; this is rapidly changing with the growing interest in minimally invasive surgery (MIS) especially the direct anterior approach (DAA) (16).

The DAA has been described since the early days of arthroplasty however it has only become popularised over the last two decades (16,17). It is an MIS approach that uses intermuscular and internervous planes to access hip joint (17). Additional advantages are that it can be performed with the patient supine and it is amenable to the use of intraoperative fluoroscopy (17). As the DAA is a relatively novel and rapidly expanding focus within THA, there is a relative dearth of clinical information concerning long-term outcomes (18). The surgical approach plays a role in the incidence and type of complications (19,20). The DAA and PA have been noted to have superior outcomes than the AL and DL approaches with better Hip Disability and Osteoarthritis Outcome Scores (HOOS) for pain, activities of daily living (ADL), sports and QOL as well as lower rates of self-reported limping (21,22).

Currently there is no consensus on optimal surgical approach in terms of blood loss or need for perioperative blood transfusion (18,23–25). Radiographic outcomes have demonstrated no significant difference in implant position following surgery *via* DAA and PA groups however

cup anteversion tended to be greater in the following PA (24,26). Wang et al. conducted a meta-analysis of randomised control trials (RCT) comparing outcomes of the DAA and PA and found no significant differences in hospital stay, operative time, complications or Harris Hip Score (HHS) at 12 weeks or one year (23). A 2017 systemic review by Meermans et al. concluded that there is limited evidence for improved kinematics or better long-term outcomes when using the DAA for THA however, there was a need for high quality RCT comparing the approaches before any final conclusions could be made on the optimal approach (27). Awad et al. noted that the DAA resulted in a short-term functional benefit which equalized by six to eight weeks postoperatively along with a higher cumulative cost when compared to the PA (25).

Frequently cited benefits of the DAA include improved early outcomes; lower postoperative visual analogue scale scores (VAS) for pain and reduced use of postoperative analgesia, shorter time to discharge and better Harris Hip Scores (HHS) at two, four and six weeks postoperatively (17,18,23–26,28). The incision length is usually smaller (23,29). Many surgeons believe the DAA results in less muscle damage owing its intermuscular nature; a theory which is supported by a 2011 study by Bergin et al. that noted a significantly lower increase in Creatine Kinase (CK) levels in patients following DAA than PA (28,29). There is a lower dislocation risk following THA using the DAA and patients are frequently given less restrictive postoperative guidelines when compared to other approaches (24,28,30–32). Surgeons generally allow DAA patients to return to sports and a wider variety of activities earlier during the postoperative period than they would following other approaches (32). Patients are reported to have earlier restoration of gait kinematics in the early postoperative (three month) period with more patients able to walk, climb stairs and higher total HHS scores during early follow-ups (24,30). Sun et al. conducted a meta-analysis comparing outcomes of

the DAA and PA. They noted that the DAA group achieved better HHS scores initially but these equalised by the six month follow-up (24). In a matched retrospective review with a minimum two-year follow-up, Maldonado et al. showed similar patient reported outcome measures (PROM) when comparing the DAA and matched PA groups including comparable patient satisfaction and VAS scores however the QOL outcome scores were higher for the DAA cohort (34). Five year follow-up studies show comparable outcomes to the PA in terms of function, QOL and survivorship as well as patient satisfaction (11,30).

1.3 Attitudes and Trends around the DAA

There is still trepidation amongst many surgeons about using this approach (19,35). Surgeons who do not perform the DAA cite concerns that the DAA results in poorer outcomes, has no clinical benefit and expressed concern about the steep learning curve (35). In a survey of Hip Society (HS) members, 49.3% of respondents had used the DAA for THA however, 42.9% of the surgeons who had used it were no longer using it at the time of the survey (19). Only 22.5% of participants believed that the DAA had significant benefits over other approaches when considering the risks (19).

In a poll done at the 2018 meeting of the American Association of Hip and Knee Surgeons (AAKHS), the most common approach for routine THA was the PA (47%), followed closely by the DAA (40%). This showed a 28% increase in usage of the DAA in under a decade (36). In an email survey of members of the AAKHS the following year, it was noted that over 56% of respondents were comfortable performing the DAA (35). These surgeons overall had less years in practise than those who did not perform the DAA suggesting that the newer generation of surgeons are more likely to adopt this approach (35).

Surgeons report increased patient interest in the DAA: a survey of surgeons AAHKS revealed that the majority of participants felt that offering the DAA resulted in improved patient market share with 76.1% of surgeons who performed it reporting increases and 65.8% of surgeons who did not perform it reporting losses in their patient market share (35).

1.4 Concerns regarding the DAA

The general consensus amongst surgeons is that the DAA is a difficult technique with a steep learning curve and may not be suitable for inexperienced surgeons (24,27,30). Even for otherwise experienced surgeons, it is recommended that they have someone proficient in the approach assist and guide them during their initial surgeries to reduce the risk of surgeon-related complications.

There is a higher rate of certain complications noted in DAA patients namely surgical site infection, intraoperative fractures and postoperative lateral femoral cutaneous nerve (LFCN) neuropraxia (18,20,24,26). The higher rate of surgical site infection is thought to be due to the pannus overlying the surgical site (27). Operative time is typically longer in the DAA than the PA which is an independent risk factor for postoperative infection (11,17,24–26,37). Intraoperative fracture risk declines as the surgeon's experience grows and is thus a modifiable risk factor (27). LFCN neuropraxia has been reported in as much as 15 – 80% of patients undergoing THA, however the majority of these resolve without any long-term complications (27). The high incidence of LFCN neuropraxia is due to the nerve's significant anatomical variations and branching patterns with injuries to branches of the LFCN considered to be unavoidable in up to 42% of patients during the DAA due to the variations in its course (27,39,40). Increased pain may be caused by the rare complication of a postoperative neuroma (27).

There are certain patient factors that lead surgeons who preferentially use the DAA to use the PA instead. Specifically, revision cases (79.3%), complex anatomy (65%), and body habitus (53%) (35). Some institutions consider a high body mass index (BMI) to be a relative contraindication to the DAA (27).

1.5 Obesity and the DAA

Overweight or obesity are defined by the World Health Organisation (WHO) as abnormal or excessive fat accumulation that presents a risk to health (41). Obesity, which was first recognised as an epidemic in the USA, has become a global pandemic (42). Worldwide obesity has increased significantly over the last century and almost tripled since 1975 (41). In 2016, 39% of adults (more than 1.9 billion people) worldwide were overweight with over 650 million classified as obese (41).

BMI is calculated using an individual's weight in kilograms divided by the square of their height in metres, i.e. $BMI = \text{weight} / (\text{height})^2$ (41). A BMI of over 30 is classified as obese (41).

Obesity is a significant public health concern with a high prevalence across all population groups in South Africa. In a 2016 survey, it was noted that 41% of South African women were obese, 20% were classified as severely obese and a further 27% were classified as overweight. Only 30% of women had a BMI in the normal range with a further 3% classified as underweight (43). South African men fared better than their female counterparts with 59% classified as having a BMI within the normal range, 10% underweight, 20% overweight and 11% classified as obese. A further 3% were severely obese (43). In terms of demographics, South African white men were more likely to be overweight or obese (75%) with the prevalence much lower amongst black African males (27%). Women had a fair distribution across racial divides.

Women tended to have the highest prevalence in the age group 45 – 64 years (81 – 82%) while men aged 65 years or older were the age group most affected (54%). Severe obesity correlated with increased wealth among both men and women (43).

Obesity is linked to an earlier onset of osteoarthritis (44,45). This is due to a combination of biomechanical and physiological mechanisms, which are compromised, in the obese patient (45). Obese patients are likely to have altered gait patterns and increased vertical ground reaction forces (45). Articular cartilage is subjected to increased loading which can lead to tissue damage and earlier degenerative disease (45). Adipose tissue releases Adipokine, a protein that causes an increase in inflammation of the cartilage with resulting cartilage degradation (45). Obese patients have higher levels of inflammatory markers. This state of chronic inflammation is thought to contribute to the severity of the patients' symptoms including pain, functional limitation and disease progression (46).

The relative risk of undergoing THA increases with increasing BMI (45). Patients classified as morbidly obese are 8.5 times more likely to require a THA than non-obese patients (45). Obese individuals are more likely to require TJA at a younger age than their non-obese counterparts. Patients with class I obesity were on average two years younger, and class II and III obese patients between seven and nine years younger than non-obese patients at the time of THA (44,45).

Obesity is rarely found alone. It is associated with a cluster of comorbidities including Diabetes mellitus, dyslipidaemia, hypertension, coronary artery disease and obstructive sleep apnoea; all of which may contribute to the increased perioperative risk (45). Obesity is an independent risk factor for complications in TJA. Obese patients have an increased risk of combined complications, acute kidney injury (AKI), cardiac complications, hip dislocation, reintubation,

reoperation, superficial infection, wound complications and deep infection (11,44,47–53). The risk of these complications increase progressively with higher BMIs, specifically with BMI \geq 35, BMI \geq 45 or patient weight of \geq 100 kg (47,48,53). Obesity is also related to an increased risk of deep vein thrombosis (DVT) and pulmonary embolism (PE) (54). Obese patients have increased operative times, duration of admission and require more analgesia (51,52). They are more likely to require assistive devices two weeks postoperatively and step down facilities for rehabilitation on discharge (51). The overall incidence of wound infection or deep infection following THA is comparable between the DAA and PA however obesity, in particular morbid obesity, puts patients at a greater risk for superficial wound complications following DAA, often requiring further operative management (49,50). Obese patients undergoing a DAA have an 8.8 and 3.6 fold increase in major and wound complications respectively, compared to patients with a BMI $<$ 30.

Antoniadis et al. compared outcomes of THA *via* the DAA in non-obese and Class II Obese patients. Functional outcomes improved significantly with the HHS of both cohorts improving by a mean delta value of 45 from preoperative to postoperative. Radiologically, there were no significant differences between acetabular version, inclination, vertical centre of rotation or leg length however the non-obese cohort had a slightly medialized horizontal centre of rotation compared to the obese group (11). They noted a four-fold increase in the reoperation rate in the obese cohort. This was primarily due to wound complications such as wound infection and dehiscence. The higher complication and reoperation rates were comparable to the rates of the standard approach noted in the literature and were deemed by the authors to be acceptable suggesting that the DAA is an acceptable option for obese patients (11).

1.6 Anti-Fat bias

Implicit bias amongst health care providers has come under the spotlight in recent years with increased reportage of its detrimental effects on health care (55). In a study done on medical doctors to assess for weight bias it was noted that there were very strong implicit and explicit (self-reported) anti-fat attitudes (55). The strong explicit bias implies that participants may find it more socially acceptable to express negative attitude towards overweight people, which may result in overweight patients receiving suboptimal care (55). Considering the increased demand for THA, increasing usage of the DAA along with the growing prevalence of obesity, the aim of this study is to assess if there are differences in outcomes of obese and non-obese patients undergoing THA *via* the DAA and to assess whether the DAA is a viable option for obese patients.

2. STUDY AIM AND OBJECTIVES

Aim

- To compare short-term outcomes of obese and non-obese patients undergoing THA using the DAA.

Objectives

- The primary objective is to evaluate short-term outcomes in terms of clinical and functional outcomes; radiological parameters, intraoperative, early and late complications in obese and non-obese patients undergoing THA using the DAA.

- ***Clinical and functional outcomes:***

This includes preoperative and postoperative limb length discrepancy (LLD), HHS and pain scores.

- ***Radiological parameters:***

We will compare the range of preoperative radiological diagnosis as well as postoperative component positioning on standard radiographic images at a minimum of one-year.

- ***Intraoperative:***

Our study will evaluate any differences in surgical time, intraoperative blood loss, need for blood transfusion as well as intraoperative complications.

- ***Complications:***

Our study will assess early and late, surgical and medical complications. We will look at the postoperative time to discharge, review data recorded during follow-up appointments for other complications and will review the results of duplex doppler scans done three weeks postoperatively to record the incidence of early asymptomatic DVTs.

- The secondary objective of our study is to determine a change in patient-reported outcome measures, pain scores and satisfaction rates in obese and non-obese patients who have undergone DAA primary THA at a minimum of one-year follow-up.

3. METHODS

Study design

The study will be a retrospective chart analysis of patients who have undergone an elective primary THA using DAA. A single high-volume hip surgeon practising in a single theatre in a single private institution performed all cases. He performed a total of 416 elective THAs from the period of January 2017 to January 2020. We will retrospectively assess all patients who were followed-up for at least one year postoperatively.

Site of study

The study will be conducted at Life Fourways Hospital. This is a private institution, which provides a wide range of medical and surgical services as well as a spectrum of ancillary

services including physiotherapy, radiology and wound services. The primary surgeon is an experienced hip surgeon and is based at this institution.

Data Collection: Main variables and outcome measures

The following baseline demographic data were collected for all participants preoperatively on a uniform data collection form designed by the primary surgeon (see appendix section). Baseline preoperative data collected included age (years), gender, primary diagnosis, BMI and comorbidities. Preoperative pain scores were assessed using the Universal Pain Assessment Tool (UPAT). Patients were assessed for LLD in cm and PROMs using the HHS.

- The Body Mass Index (BMI) is calculated as mentioned in **Section 1.4**.
- The LLD is measured in cm as the difference between the leg length (measured from the ASIS to the medial malleolus of each leg) of the contralateral and ipsilateral legs.
- The HHS is a validated assessment tool developed to evaluate the results of hip surgery. It assesses various outcomes including pain, function, deformity and range of motion. It covers pain, function, deformity and range of motion. It has good to excellent retest and inter-rater reliability.
- The UPAT is combination tool comprising of the verbal numeric rating scale, the verbal descriptor scale and the Wong-Baker FACES® pain rating scale.

Intraoperative data collected included surgical time (minutes), estimated blood loss (ml), techniques and implants used, and intra-operative complications as well as fluoroscopy.

Postoperatively the need for blood transfusion was documented along with time to discharge (days) and the residual LLD.

At subsequent follow-ups of six-weeks, six-months and one-year, the following functional, clinical and radiographic data were collected:

- Functional outcomes were assessed using the HHS and pain was assessed using the UPAT.
- Clinical information assessed included complications, which were classified as early (< 4 weeks) *versus* late (> 4 weeks) as well as medical *versus* surgical. Medical complications were classified as being related to the patients' baseline \pm the physiological effect of the surgery. Surgical complications were considered as being directly related to the effects of the surgery. These included wound complications, infection, periprosthetic fractures, dislocation, psoas tendon impingement, subsidence of prosthesis, nerve injury and mechanical complications.
- Standard radiological imaging was done postoperatively and at the follow-ups. These images were assessed for acetabular inclination and version, femoral version, femoral subsidence and for the presence of any radiolucent lines surrounding the acetabular or femoral components. Radiolucent lines surrounding the acetabular cup were be classified according to the Charnley and DeLee classification system while similarly radiolucent lines surrounding the femoral were described using Greun's zones.

Moreover, patients were asked about their postoperative satisfaction according to a five level Likert-type scale that included the following options; significantly dissatisfied, dissatisfied, neutral, satisfied, significantly satisfied. The Likert-type scale was used to assess patient satisfaction, which is a commonly used tool for the assessment of participant attitude. Patients were subsequently classified as satisfied if they chose satisfied or significantly satisfied and

dissatisfied if they chose neutral, dissatisfied or significantly dissatisfied at one-year follow-up.

Patient Selection Criteria

Inclusion criteria:

- Patients over the age of 18 years who underwent an elective total hip arthroplasty *via* the DAA done by Dr JN Cakic.
- Patients who had consented for the collection of their data by the primary surgeon.

Exclusion criteria:

- Patients who did not complete the minimum of one-year follow-up schedule as described.
- Patients incapable of informed consent.
- Patients who underwent THA due to trauma.
- Patients who underwent bilateral simultaneous THA.
- Patients who underwent revision THA by the primary surgeon.

4. DATA ANALYSIS

The control and obese patient cohorts will be statistically compared based on a series of parameters. The means of these parameters will be compared using T-tests with statistical significance at $p < 0.05$. Confidence intervals will be calculated at 95%, thereby subsequently, used in conjunction with the p -values to determine clinical significance. Groups will be tested for linear model assumptions: normality and homogeneity of variances. In the event of violation of the linear model assumptions, the Wilcoxon rank-sum alternative will be used to

hypothesis test between the two cohorts (These tests can be used to demonstrate any changes in PROMS pre- and post-operatively within the same cohort). Implant survival will be plotted on a Kaplan-Meier curve to produce the empirical probability of implant survival over the study period. The statistical package to be used is the R version 4.0.4 (2021-02-15); University of Auckland, New Zealand.

5. ETHICS

All patients' data will be retrospectively collected from database that is kept securely by Dr JN Cakic. Dr Cakic has previously received ethical approval for the prospective collection of data for his hip patients. All the data are currently housed securely in a single server. All patients have consented for their data to be used for academic research purposes. All patients have been assigned a file number and names and other identifying data are kept separately from clinical information. The primary investigator has signed a non-disclosure agreement. The Human Research Ethics Committee has granted provisional approval for the study (Protocol no: **M210819**). We will await the clearance certificate before accessing the database.

6. TIMING

	July 2021	August 2021	September 2021	October 2021	November 2021	December 2021	January 2022
Protocol Development							
Protocol Submission							
Ethics Application							

Data collection							
Data Analysis							
Write up of Research Report							

7. FUNDING

Study will be self-funded (see Table below):

Item	Estimated Cost (ZAR)
Stationary	R400
Printing	R600
Laptop	Own
Transport/fuel	R200
Statistician	R500
Total	R1700

8. ANTICIPATED PROBLEMS

This is a retrospective chart analysis and therefore there may be some concerns with collecting all the data for all patients across all the subsets and time variables with absolute consistency and uniformity. Evaluation also demands that patients have been consistent in complying with

their follow-up appointments, thus some patients may be lost if they did not complete their scheduled follow-up appointments.

We have classified obese and non-obese patients as those with a BMI of < 30 and ≥ 30 respectively; however, we are aware that BMI is not considered the most accurate measure of obesity. Concerns noted are that it does not differentiate between muscle and fat, does not take into account the distribution of adiposity and or variations across populations or gender. We chose to use it due to the ease of use and because it is widely accepted and utilised (45).

References

1. Knight SR, Aujla R, Biswas SP. Total Hip Arthroplasty - over 100 years of operative history. *Orthopedic Reviews* [Internet]. 2011 Nov 7 [cited 2021 May 30];3(2):16. Available from: [/pmc/articles/PMC3257425/](#)
2. Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement [Internet]. *The Lancet*. Elsevier B.V.; 2007 [cited 2021 May 30];370:1508–19. Available from: <https://pubmed.ncbi.nlm.nih.gov/17964352/>
3. Pivec R, Johnson AJ, Mears SC, Mont MA. Hip arthroplasty. *The Lancet*. Elsevier B.V.; 2012:1768–77.
4. Health at a Glance 2019 [Internet]. OECD; 2019 [cited 2021 Jun 5]. (Health at a Glance). Available from: https://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-2019_4dd50c09-en
5. Singh JA, Yu S, Chen L, Cleveland JD. Rates of total joint replacement in the United States: Future projections to 2020-2040 using the national inpatient sample. *Journal of Rheumatology*. 2019;46(9):1134–40.
6. Rahm S, Hoch A, Tondelli T, Fuchs J, Zingg PO. Revision rate of THA in patients younger than 40 years depends on primary diagnosis – a retrospective analysis with a minimum follow-up of 10 years. *European Journal of Orthopaedic Surgery and Traumatology* [Internet]. 2021. Available from: <https://doi.org/10.1007/s00590-021-02881-w>

7. Kurtz SM, Lau E, Ong K, Zhao K, Kelly M, Bozic KJ. Future young patient demand for primary and revision joint replacement: National projections from 2010 to 2030. In: *Clinical Orthopaedics and Related Research*. Springer New York; 2009: 2606–12.
8. Garriga C, Murphy J, Leal J, Arden NK, Price AJ, Prieto-Alhambra D, et al. Assessment on patient outcomes of primary hip replacement: An interrupted time series analysis from the National Joint Registry of England and Wales'. *BMJ Open* [Internet]. 2019 Nov 1 [cited 2021 May 30];9(11). Available from: <https://pubmed.ncbi.nlm.nih.gov/31753882/>
9. Palme CK, Gooberman-Hill R, Blom AW, Whitehous MR, Moo AJ. Post-surgery and recovery experiences following one- And two-stage revision for prosthetic joint infection-A qualitative study of patients' experiences. *PLoS ONE* [Internet]. 2020 Aug 1 [cited 2021 May 30];15(8 August). Available from: <https://pubmed.ncbi.nlm.nih.gov/32745086/>
10. Lueck E, Schlaepfer TE, Schildberg FA, Randau TM, Hischebeth GTR, Jaenisch M, et al. The psychological burden of a two-stage exchange of infected total hip and knee arthroplasties [Internet]. *Journal of Health Psychology*. SAGE Publications Ltd; 2020 [cited 2021 May 31]. Available from: <https://pubmed.ncbi.nlm.nih.gov/32840382/>
11. Antoniadis A, Dimitriou D, Flury A, Wiedmer G, Hasler J, Helmy N. Is Direct Anterior Approach a Credible Option for Severely Obese Patients Undergoing Total Hip Arthroplasty? A Matched-Control, Retrospective, Clinical Study [Internet]. Available from: www.arthroplastyjournal.org
12. Kurtz SM, Lau EC, Ong KL, Adler EM, Kolisek FR, Manley MT. Hospital, Patient, and Clinical Factors Influence 30- and 90-Day Readmission After Primary Total Hip Arthroplasty. *Journal of Arthroplasty*. 2016 Oct 1;31(10):2130–8.

13. Aslan EÇ, Agirbas I. Rates, causes, and types of readmissions after total joint arthroplasty. *Turkish Journal of Physical Medicine and Rehabilitation*. 2020;66(1):31–9.
14. Malviya A, Wilson G, Kleim B, Kurtz SM, Deehan D. Factors influencing return to work after hip and knee replacement. *Occupational Medicine*. Oxford University Press; 2014: 64:402–409.
15. Cowie JG, Turnball GS, Ker AM, Breusch SJ. Return to work and sports after total hip replacement. *Archives of Orthopaedic and Trauma Surgery*. 2013;133(5):695–700.
16. Fontalis A, Epinette JA, Thaler M, Zagra L, Khanduja V, Haddad FS. Advances and innovations in total hip arthroplasty. Vol. 7, SICOT-J. EDP Sciences; 2021.
17. Petis S, Howard JL, Lanting BL, Vasarhelyi EM. Surgical approach in primary total hip arthroplasty: Anatomy, technique and clinical outcomes. *Canadian Journal of Surgery*. 2015 Apr 1;58(2):128–39.
18. Graves SC, Dropkin BM, Keeney BJ, Lurie JD, Tomek IM. Does surgical approach affect patient-reported function after primary THA? *Clinical Orthopaedics and Related Research*. 2016 Nov 30;474(4):971–81.
19. Aggarwal VK, Elbuluk A, Dundon J, Herrero C, Hernandez C, Vigdorichik JM, et al. Surgical approach significantly affects the complication rates associated with total hip arthroplasty. *Bone and Joint Journal*. 2019;101 B(6):646–51.
20. Amlie E, Havelin LI, Furnes O, Baste V, Nordsletten L, Hovik O, et al. Worse patient-reported outcome after lateral approach than after anterior and posterolateral approach in primary hip

arthroplasty A cross-sectional questionnaire study of 1,476 patients 1-3 years after surgery. *Acta Orthopaedica*. 2014 Sep 1;85(5):463–9.

21. Peters RM, van Beers LWAH, van Steenberg LN, Wolkenfelt J, Ettema HB, ten Have BLEF, et al. Similar Superior Patient-Reported Outcome Measures for Anterior and Posterolateral Approaches After Total Hip Arthroplasty: Postoperative Patient-Reported Outcome Measure Improvement After 3 months in 12,774 Primary Total Hip Arthroplasties Using the Anterior, Anterolateral, Straight Lateral, or Posterolateral Approach. *Journal of Arthroplasty*. 2018 Jun 1;33(6):1786–93.
22. Wang Z, Hou J zhao, Wu C hua, Zhou Y jiang, Gu X ming, Wang H hong, et al. A systematic review and meta-analysis of direct anterior approach versus posterior approach in total hip arthroplasty. Vol. 13, *Journal of Orthopaedic Surgery and Research*. BioMed Central Ltd.; 2018.
23. Sun X, Zhao X, Zhou L, Su Z. Direct anterior approach versus posterolateral approach in total hip arthroplasty: a meta-analysis of results on early post-operative period. Vol. 16, *Journal of Orthopaedic Surgery and Research*. BioMed Central Ltd; 2021.
24. Awad ME, Farley BJ, Mostafa G, Saleh KJ. Direct anterior approach has short-term functional benefit and higher resource requirements compared with the posterior approach in primary total hip arthroplasty : a meta-analysis of functional outcomes and cost. *The bone & joint journal*. 2021 Jun 1;103-B(6):1078–87.
25. Jia F, Guo B, Xu F, Hou Y, Tang X, Huang L. A comparison of clinical, radiographic and surgical outcomes of total hip arthroplasty between direct anterior and posterior approaches: a systematic review and meta-analysis. *HIP International*. 2019 Nov 1;29(6):584–96.

26. Meermans G, Konan S, Das R, Volpin A, Haddad FS. The direct anterior approach in total hip arthroplasty a systematic review of the literature. *Bone and Joint Journal. British Editorial Society of Bone and Joint Surgery.* 2017; Vol.99B, p. 732–40.
27. Galakatos GR. Direct Anterior Total Hip Arthroplasty. *Missouri Medicine.* 2018;115(6):537-541.
28. Bergin PF, Doppelt JD, Kephart CJ, Benke MT, Graeter JH, Holmes AS, et al. Comparison of minimally invasive direct anterior versus posterior total hip arthroplasty based on inflammation and muscle damage markers. *Journal of Bone and Joint Surgery - Series A.* 2011 Aug 3;93(15):1392–8.
29. Kyriakopoulos G, Poultsides L, Christofilopoulos P. Total hip arthroplasty through an anterior approach: The pros and cons. *EFORT Open Reviews.* 2018 Nov 1;3(11):574–83.
30. Yuasa T, Aoki K, Gomi M, Shiota K. Comparison of direct anterior approach and posterior approach total hip arthroplasty: More than 5-year follow-up. *Journal of Orthopaedics.* 2021 Mar 1;24:271–3.
31. Tsukada S, Wakui M. Lower Dislocation Rate Following Total Hip Arthroplasty via Direct Anterior Approach than via Posterior Approach: Five-Year-Average Follow-Up Results. *The Open Orthopaedics Journal.* 2015 May 27;9(1):157–62.
32. Thaler M, Khosravi I, Putzer D, Siebenrock KA, Zagra L. Return to Sports After Total Hip Arthroplasty: A Survey Among Members of the European Hip Society. *Journal of Arthroplasty.* 2020.

33. Maldonado DR, Kyin C, Walker-Santiago R, Rosinsky PJ, Shapira J, Lall AC, et al. Direct anterior approach versus posterior approach in primary total hip replacement: comparison of minimum 2-year outcomes. *HIP International*. 2021 Mar 1;31(2):166–73.
34. Patel NN, Shah JA, Erens GA. Current Trends in Clinical Practice for the Direct Anterior Approach Total Hip Arthroplasty. *Journal of Arthroplasty*. 2019 Sep 1;34(9):1987-1993.e3.
35. Woolson ST. A survey of Hip Society surgeons concerning the direct anterior approach total hip arthroplasty. 2020;102-B(7_Supple_B):57-61.
36. Abdel MP, Berry DJ. Current Practice Trends in Primary Hip and Knee Arthroplasties Among Members of the American Association of Hip and Knee Surgeons: A Long-Term Update. *Journal of Arthroplasty*. 2019 Jul 1;34(7):S24–7.
37. Pincus D, Jenkinson R, Paterson M, Leroux T, Ravi B. Association between Surgical Approach and Major Surgical Complications in Patients Undergoing Total Hip Arthroplasty. *JAMA - Journal of the American Medical Association*. 2020 Mar 17;323(11):1070–6.
38. Sugano M, Nakamura J, Hagiwara S, Suzuki T, Nakajima T, Orita S, et al. Anatomical course of the lateral femoral cutaneous nerve with special reference to the direct anterior approach to total hip arthroplasty. *Modern Rheumatology*. 2020 Jul 3;30(4):752–7.
39. Rudin D, Manestar M, Ullrich O, Erhardt J, Grob K. The anatomical course of the lateral femoral cutaneous nerve with special attention to the anterior approach to the hip joint. *Journal of Bone and Joint Surgery - American Volume*. 2016 Apr 6;98(7):561–7.
40. World Health Organization. Obesity and overweight [Internet]. 2021 Jun [cited 2021 Jul 7]. Available from: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>

41. Roth J, Qiang X, Marbán SL, Redelt H, Lowell BC. The obesity pandemic: where have we been and where are we going? Vol. 12 Suppl 2, Obesity research. 2004.
42. National Department of Health (NDoH) SSA (Stats SSAMRC (SAMRC), and I. South Africa Demographic and Health Survey 2016 [Internet]. Pretoria; 2019 [cited 2021 Jul 7]. Available from: <https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf>
43. Haynes J, Nam D, Barrack RL. Hip arthroplasty: Avoiding and managing problems obesity in total hip arthroplasty does it make a difference? Bone and Joint Journal. British Editorial Society of Bone and Joint Surgery. 2017:31–36.
44. Bryan D, Parvizi J, Austin M, Backe H, Valle C della, Kolessar DJ, et al. Obesity and total joint arthroplasty. A literature based review. Vol. 28, Journal of Arthroplasty. 2013;28: 714–21.
45. Messier SP. Obesity and Osteoarthritis: Disease Genesis and Nonpharmacologic Weight Management. Vol. 34, Rheumatic Disease Clinics of North America. 2008. 713–29.
46. Lübbecke A, Zingg M, Vu D, Miozzari HH, Christofilopoulos P, Uçkay I, et al. Body mass and weight thresholds for increased prosthetic joint infection rates after primary total joint arthroplasty. Acta Orthopaedica. 2016 Mar 3;87(2):132–8.
47. Ward DT, Metz LN, Horst PK, Kim HT, Kuo AC. Complications of Morbid Obesity in Total Joint Arthroplasty: Risk Stratification Based on BMI. Journal of Arthroplasty. 2015 Sep 1;30(9):42–6.

48. Watts CD, Houdek MT, Wagner ER, Sculco PK, Chalmers BP, Taunton MJ. High Risk of Wound Complications Following Direct Anterior Total Hip Arthroplasty in Obese Patients. *Journal of Arthroplasty*. 2015 Dec 1;30(12):2296–8.
49. Purcell RL, Parks NL, Cody JP, Hamilton WG. Comparison of Wound Complications and Deep Infections With Direct Anterior and Posterior Approaches in Obese Hip Arthroplasty Patients. *Journal of Arthroplasty*. 2018 Jan 1;33(1):220–3.
50. Russo MW, Macdonell JR, Paulus MC, Keller JM, Zawadsky MW. Increased Complications in Obese Patients Undergoing Direct Anterior Total Hip Arthroplasty. *Journal of Arthroplasty*. 2015 Aug 1;30(8):1384–7.
51. Liu W, Wahafu T, Cheng M, Cheng T, Zhang Y, Zhang X. The influence of obesity on primary total hip arthroplasty outcomes: A meta-analysis of prospective cohort studies. *Orthopaedics and Traumatology: Surgery and Research*. 2015 May 1;101(3):289–96.
52. Sayed-Noor AS, Mukka S, Mohaddes M, Kärrholm J, Rolfson O. Body mass index is associated with risk of reoperation and revision after primary total hip arthroplasty: a study of the Swedish Hip Arthroplasty Register including 83,146 patients. *Acta Orthopaedica*. 2019 May 4;90(3):220–5.
53. Klovaite J, Benn M, Nordestgaard BG. Obesity as a causal risk factor for deep venous thrombosis: A Mendelian randomization study. *Journal of Internal Medicine*. 2015 May 1;277(5):573–84.
54. Sabin JA, Marini M, Nosek BA. Implicit and Explicit Anti-Fat Bias among a Large Sample of Medical Doctors by BMI, Race/Ethnicity and Gender. *PLoS ONE*. 2012 Nov 7;7(11).