ARTHROPLASTY

# What is the current consensus among orthopaedic surgeons in South Africa regarding robotic-assisted surgery in total joint arthroplasty?

**Richard P Almeida,* Nkhodiseni Sikhauli, Lipalo Mokete, Allan Seiketto, Jurek Pietrzak**

Division of Orthopaedic Surgery, University of the Witwatersrand, Charlotte Maxeke Johannesburg Academic Hospital, Johannesburg, South Africa

**Corresponding author: rich.almeida11@gmail.com*

**Citation**: Almeida RP, Sikhauli N, Mokete L, Seiketto A, Pietrzak J. What is the current consensus among orthopaedic surgeons in South Africa regarding robotic-assisted surgery in total joint arthroplasty? SA Orthop J. 2026;25(1):23-32. http://dx.doi.org/10.17159/2309-8309/2026/v25n1a4

**Editor**: Prof. Michael Held, University of Cape Town, Cape Town, South Africa

**Received**: October 2024

**Accepted**: May 2025

**Published**: March 2026

**Copyright**: © 2026 Almeida RP. This is an open-access article distributed under the terms of the Creative Commons Attribution Licence, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

**Funding**: No funding was received for this study.

**Conflict of interest**: The authors declare they have no conflicts of interest that are directly or indirectly related to the research.

## Abstract

### Background

Total joint arthroplasty (TJA), including total knee arthroplasty (TKA) and total hip arthroplasty (THA), are successful orthopaedic procedures, with survivorship reported at 98% at ten years and 95% at 20 years. The development of robotic-assisted total joint arthroplasty (RA-TJA) is one example of the continual evolution in technology in an attempt to improve these numbers. The use of RA-TJA is increasing, with little known about the potential factors which may impact the decision of surgeons to integrate robotic-assisted technology into their clinical practice. The aim of this study is to assess the usage and opinions of orthopaedic surgeons in South Africa regarding RA-TJA.

### Methods

An anonymous online survey was distributed via email to all orthopaedic surgeons registered with the South African Orthopaedic Association (SAOA). Analysis was subsequently undertaken to establish factors which might influence opinions regarding RA-TJA.

### Results

In total, there were 155 responses, with 37% (n = 57) of respondents being fellowship-trained in arthroplasty, either nationally, internationally or both. Seventy-one per cent (n = 110) of respondents were in private practice only, 6% (n = 9) in state practice only, and 23% (n = 36) in both. Forty-four per cent (n = 68) of surgeons are using RA-TJA, with 8% (n = 13) using both RA-THA and RA-TKA, 1% (n = 2) using RA-THA only, and 34% (n = 53) using RA-TKA only. The most common reason for using RA-TJA was higher precision in reproducibility of the procedure, at 91% (n = 62). The most common reason for hesitation in using RA-TJA is cost, at 69% (n = 60). Forty-seven per cent (n = 73) of surgeons believe it takes 11 to 20 cases to become competent using RA-TJA. The formation of an RA-TJA special interest group was agreed to by 71% (n = 110) of respondents.

### Conclusion

The usage of RA-TJA in South Africa is higher than in other nations but it follows the same trend that there are more surgeons not using RA-TJA. Cost, lack of long-term data proving superiority, and the learning curve are the most common reported obstacles to RA-TJA, with improved precision a common reason for adopting RA-TJA. RA-TJA is a broad term, and further analysis of the type of systems currently in use and their possible perceived benefits will provide more information regarding the use of RA-TJA.

**Level of evidence**: 3

**Keywords**: robotic-assisted surgery, computer-assisted surgery, arthroplasty, total hip arthroplasty, total knee arthroplasty

## Introduction

The demand for total joint arthroplasty (TJA) is continuously rising. Primary total hip arthroplasty (THA) has been estimated to grow by 71% to 635 000 procedures annually, and total knee arthroplasty (TKA) is projected to increase by 85% to 1.26 million procedures annually in the USA alone by the year 2030.[1] While reported survivorship of TJA is at 98% at ten years and 95% at 20 years, the outcomes of these procedures, unfortunately, still remain imperfect.[2-4] The dissatisfaction rates for TKA range from 5–20%, and for THA from 7–11%.[5,6] It has been predicted that by the year 2040 the revision load will increase in both THA and TKA by 42% and 149%, respectively.[7] Subsequently, it is imperative that technology continues to evolve in the pursuit of the optimal outcomes and reduced complications in TJA. Although the current available results are mixed, the development of robotic-assisted total joint arthroplasty (RA-TJA) has been part of the technological innovations utilised in TJA in an effort to enhance surgical precision and improve outcomes.[8]

The clinical use of RA-TJA in orthopaedic surgery is still in the early stages but usage is growing for both TKA and THA.[9] RA-TJA has been utilised for just over two decades, with systems classified according to the level of independence as active, semi-active or passive.[10-12] RA-TJA utilises computer software to analyse anatomical information captured either in real time or via imaging prior to surgery and converting this information into a virtual patient-specific 3-D reconstruction of the joint.[12] This information is then utilised for surgical planning and accurate implant placement.

Using RA-TJA in the hope of improving outcomes is not without pitfalls. There have been limitations noted with the use of RA-TJA, including an increased learning curve.[12,13] The robotic devices are expensive to install, with separate hardware and software required for THA, TKA and unicompartmental knee arthroplasty (UKA).[12] Only certain implants are compatible with robotic technology, limiting options available to the surgeon.[12] Insertion of additional percutaneous pins are required, introducing another point of possible infection or iatrogenic fracture.[13] There are additional costs related to preoperative imaging (if required), increased operating times during the learning phase, and the various consumables required. The updating of computer software and servicing and maintenance of the robotic devices have also been noted to increase operating costs.[12] Image-guided RA-TJA requires preoperative CT scans that require extra time and radiation exposure.[12,13]

Interest in RA-TJA has grown among surgeons and patients although the long-term benefits and cost effectiveness remain debated.[9,14,15] The use of RA-TJA has increased significantly over the last decade, in the absence of evidence supporting superior long-term benefits and cost-effectiveness.[15,16] The increase in RA-TJA has been associated with notable differences between patient groups, insurances, hospital volume and types of surgeries.[9,16] Multiple studies have assessed the clinical and radiological outcomes, as well as the financial costs, with the use of RA-TJA; however, little is known about the potential factors which may impact the decision of surgeons to integrate RA-TJA into their individual clinical practices. The decision for surgeons to use RA-TJA is multifactorial.[9] To the authors' knowledge, no studies have assessed how these factors influence surgeons' opinions and choices regarding the use of robotic surgery in an upper-middle-income country (UMIC) such as South Africa.[17] The purpose of this study was to assess the opinions of South African orthopaedic surgeons regarding the use of RA-TJA.

## Methods

A voluntary, anonymous, self-administered online questionnaire that included a cover letter with an introduction to the research question was created by the senior author. A link to the questionnaire was distributed via the South African Orthopaedic Association (SAOA) to all members of the SAOA currently practising in South Africa. At the time of the first message there were 732 members. There were two subsequent follow-up messages reminding SAOA members of this survey sent at four weeks and eight weeks from the initial message. The link was left open for a total of 12 weeks. Access to the questionnaire was achieved only once digital consent was given by the respondent. Ethics was approved via the Human Research Ethics Committee (HREC) of the University of the Witwatersrand.

The questionnaire comprised two components: a demographic section, and a second segment evaluating the opinions and beliefs of the responding orthopaedic surgeon regarding RA-TJA. Demographic details included sex, area of health sector currently working in, number of years of experience in orthopaedic surgery, fellowship training, usage of RA-TJA in their practice, and geographical location. Questions from the second section seeking to evaluate the use of RA-TJA were based on similar previous studies.[9,18,19] The questions used in the survey can be found online in *Appendix A*.

A series of subjective questions relating to the perceptions and opinions regarding RA-TJA were assessed, with questions attached to a 3-point Likert scale or a 4-point forced-choice scale. A modified descriptive question based on Rogers' Diffusion of Innovation Theory was included, requiring the respondent to self-categorise themselves into an adopter of technology category.[9,20] These five categories included: enthusiast (I'll try anything new if it has a possibility if being better); visionary (I'm willing to test it out if there are a couple of good case series); early majority (I'll use it if enough people I trust use it); sceptic (Give me well-designed prospective randomised controlled trials before I consider it); and traditionalist (It's a fad).

Respondents were asked whether they use RA-TJA in their practice, and if the response was 'no' they were classified as 'RA-TJA non-users'. If the response was 'yes', they were classified as 'RA-TJA users'. Questions further assessed RA-TJA users on their usage. Comparisons were made between RA-TJA users and RA-TJA non-users' responses to questions assessing demographic details, level of training, area of practice, years of experience and subjective questions relating to perceptions and opinions regarding RA-TJA.

IBM SPSS Statistics 28 was used for the statistical analysis of the data. Descriptive statistics including frequencies and percentages were used to describe categorical variables. A Pearson's chi-squared test of independence was utilised on cross-tabulations to determine the association between two variables represented in the cross-tabulation. When conditions were not met, a Fisher's exact test was used. Spearman's correlation test was used to measure how the ordinal variables or rank orders were related, and Pearson's correlation coefficient was used as a measure of linear association. A p-value $< 0.05$ was considered statistically significant.

## Results

A total of 155 responses to this survey were received, with 96% (n = 149) of respondents being male.

Forty-eight per cent (n = 74) of respondents had been practising for more than 15 years. The respondents working exclusively in state comprised 6% (n = 9); 71% (n = 110) of respondents were working in private; and 23% (n = 36) were working in both state and private sectors. Sixty-three per cent (n = 98) of respondents were fellowship trained, with fellowship training further divided into national fellowships in 17% (n = 26) of respondents and international fellowships in 17% (n = 26) of respondents. Demographic profile, years in practice, area of practice and fellowship training can be found summarised in *Table I*.

### *Distribution of RA-TJA usage*

There were 56% (n = 87) of respondents who were RA-TJA non-users, while 44% (n = 68) of respondents currently utilised RA-TJA, i.e. RA-TJA users (*Table II*). There were 34% (n = 53) of RA-TJA users who utilised RA-TJA exclusively in TKA. When assessing the volume of RA-TJA among RA-TJA users, 28% (n = 19) were currently utilising RA-TJA in 81–100% of their annual practice (*Table III*).

### *Perceptions of all respondents regarding RA-TJA*

When assessing the motivation to use RA-TJA among all surgeons, the perception that 'using RA-TJA takes more time than conventional methods in TJA' was the most agreed-upon statement as answered by 72% (n = 112) of respondents. The most disagreed statement was 'using RA-TJA takes away autonomy from me as a surgeon' as answered by 67% (n = 104) of respondents, with uniform disagreement between RA-TJA users non-users at 94%

**Table I**: Demographics

| Demographics | | All respondents % (n) | RA-TJA non-users % (n) | RA-TJA users % (n) | p-value |
|---|---|---|---|---|---|
| **Total** | | (155) | 56 (87) | 44 (68) | |
| Sex | | | | | |
| | Male | 96 (149) | 97 (84) | 96 (65) | 1.000 |
| | Female | 4 (6) | 3 (3) | 4 (3) | 1.000 |
| Years in practice | | | | | |
| | 0–5 years | 20 (31) | 16 (14) | 25 (17) | 0.169 |
| | 6–10 years | 17 (26) | 12 (10) | **24 (16)** | 0.047 |
| | 11–15 years | 16 (24) | 15 (13) | 16 (11) | 0.883 |
| | > 15 years | 48 (74) | **58 (50)** | 35 (24) | 0.006 |
| Training | | | | | |
| | No fellowship | 63 (98) | **74 (64)** | 50 (34) | 0.003 |
| | National fellowship | 17 (26) | 13 (11) | 22 (15) | 0.120 |
| | International fellowship | 17 (26) | 13 (11) | 22 (15) | 0.120 |
| | International and national fellowship | 3 (5) | 1 (1) | 6 (4) | 0.169 |
| Area of practice | | | | | |
| | State | 6 (9) | 6 (5) | 6 (4) | 1.000 |
| | Private | 71 (110) | 76 (66) | 65 (44) | 0.129 |
| | Private and state | 23 (36) | 18 (16) | 29 (20) | 0.107 |
| Province currently working | | | | | |
| | Western Cape | 30 (47) | 22 (19) | **41 (28)** | 0.009 |
| | Southern Gauteng | 28 (44) | 31 (27) | 25 (17) | 0.408 |
| | Northern Gauteng | 16 (24) | 17 (15) | 13 (9) | 0.494 |
| | KwaZulu-Natal | 8 (13) | 10 (9) | 6 (4) | 0.482 |
| | Eastern Cape | 6 (9) | 9 (8) | 2 (1) | 0.078 |
| | Mpumalanga | 4 (6) | 4 (3) | 4 (3) | 1.000 |
| | Free State | 3 (5) | 2 (2) | 4 (3) | 0.654 |
| | Northern Cape | 3 (5) | 4 (3) | 3 (2) | 1.000 |
| | Limpopo | 1 (1) | (0) | 2 (1) | 0.439 |
| | North-West | 1 (1) | 1 (1) | (0) | 1.000 |
| Are you an industry consultant? | | | | | |
| | Yes | 4 (6) | 2 (2) | 6 (4) | 0.405 |
| | No | 96 (148) | 98 (85) | 93 (63) | 0.241 |
| | Did not answer | 1 (1) | (0) | 2 (1) | |

**Table II**: Summary of RA-TJA utilisation trends

| Usage of RA-TJA | n (%) |
|---|---|
| Not using RA-TJA | **87 (56)** |
| Yes, total knee arthroplasty only | 53 (34) |
| Yes, both total hip and total knee arthroplasty | 13 (8) |
| Yes, total hip arthroplasty only | 2 (1) |

**Table III**: The annual percentage of RA-TJA utilised in TJA by RA-TJA users in their current practice

| Annual TJA usage of RA-TJA % | Respondents utilising RA-TJA % (n = 68) |
|---|---|
| 0–20 | 25 (17) |
| 21–40 | 16 (11) |
| 41–60 | 19 (13) |
| 61–80 | 12 (8) |
| 81–100 | 28 (19) |

(n = 64) and 46% (n = 40), respectively (p < 0.001). The only statement to show uniform agreement between RA-TJA users and non-users was 'using RA-TJA takes more time than conventional methods in TJA', with 63% (n = 43) of RA-TJA users and 79% (n = 69) of RA-TJA non-users (p = 0.816) agreeing. In total, 87% (n = 135) of respondents agreed that a need exists for *formal* training in RA-TJA (*Table IV*).

With regard to self-categorising as 'adopters of technology', 37% (n = 57) of all respondents regarded themselves as 'enthusiasts (I'll try anything new if it has the possibility of being better)'. Of the RA-TJA non-users, the majority self-categorised themselves as 'sceptic (Give me well designed prospective randomised controlled trials before I consider it)' at 31% (n = 27), while the majority of RA-TJA users self-categorised as 'enthusiasts (I'll try anything new if it has the possibility of being better)' at 50% (n = 34) (*Table IV*). When asked how many cases it takes to become competent in RA-TJA, there was uniform agreement that it takes 11–20 cases, as reported by 47% (n = 32) of RA-TJA users and 47% (n = 41) RA-TJA non-users, (p = 0.869) (*Table V*).

**Table IV**: Perceptions of surgeons regarding RA-TJA

| Question regarding perception of RA-TJA | All respondents % (n = 155) | RA-TJA non-users % (n = 87) | RA-TJA users % (n = 68) | p-value |
|---|---|---|---|---|
| The majority of surgeons use RA-TJA in TJA for marketing purposes: | | | | |
| Agree | **47 (72)** | **60 (52)** | 29 (20) | < 0.001 |
| Neutral | 30 (47) | 33 (29) | 27 (18) | |
| Disagree | 23 (36) | 7 (6) | **44 (30)** | |
| Did not answer | (0) | (0) | (0) | |
| Using RA-TJA leads to superior long-term functional outcomes compared to conventional methods in TJA: | | | | |
| Agree | 24 (37) | 8 (7) | **44 (30)** | < 0.001 |
| Neutral | **39 (60)** | 39 (34) | 38 (26) | |
| Disagree | 36 (56) | **51 (44)** | 18 (12) | |
| Did not answer | 1 (2) | 2 (2) | (0) | |
| Using RA-TJA leads to fewer complications compared to conventional methods in TJA: | | | | |
| Agree | 21 (33) | 9 (8) | **37 (25)** | < 0.001 |
| Neutral | 37 (58) | 38 (33) | 37 (25) | |
| Disagree | **41 (64)** | **53 (46)** | 26 (18) | |
| Did not answer | (0) | (0) | (0) | |
| Using RA-TJA leads to less revisions compared to conventional methods in TJA: | | | | |
| Agree | 23 (35) | 9 (8) | 40 (27) | 0.092 |
| Neutral | **47 (72)** | **49 (43)** | **43 (29)** | |
| Disagree | 30 (47) | 41 (36) | 16 (11) | |
| Did not answer | 1 (1) | (0) | 2 (1) | |
| Using RA-TJA takes more time than conventional methods in TJA: | | | | |
| Agree | **72 (112)** | **79 (69)** | **63 (43)** | **0.816** |
| Neutral | 15 (23) | 14 (12) | 16 (11) | |
| Disagree | 12 (19) | 7 (6) | 19 (13) | |
| Did not answer | 1 (1) | (0) | 2 (1) | |
| Using RA-TJA takes away autonomy from me as a surgeon: | | | | |
| Agree | 8 (13) | 15 (13) | 0 (0) | < 0.001 |
| Neutral | 24 (37) | 38 (33) | 6 (4) | |
| Disagree | **67 (104)** | **46 (40)** | **94 (64)** | |
| Did not answer | 1 (1) | 1 (1) | (0) | |
| Those who use RA-TJA have to modify the preoperative plan: | | | | |
| Never | 12 (19) | 15 (13) | 9 (6) | < 0.001 |
| Rarely | 29 (45) | 17 (15) | **44 (30)** | |
| Sometimes | **52 (81)** | **59 (51)** | **44 (30)** | |
| Often | 3 (4) | 2 (2) | 3 (2) | |
| Did not answer | 4 (6) | 7 (6) | (0) | |
| Is there a need for training in RA-TJA? | | | | |
| Yes, in residency | **45 (70)** | 41 (36) | **50 (34)** | **0.511** |
| Yes, as part of a fellowship programme only | 42 (65) | **45 (39)** | 38 (26) | |
| No, courses provide adequate training | 9 (14) | 8 (7) | 10 (7) | |
| No, robotic-assisted surgery should not be part of your total joint practice | 3 (5) | 5 (4) | 2 (1) | |
| Did not answer | 1 (1) | 1 (1) | (0) | |
| How would you categorise yourself as an adopter of technology? | | | | |
| Enthusiast (I'll try anything new if it has a possibility if being better) | **37 (57)** | 26 (23) | **50 (34)** | **0.005** |
| Visionary (I'm willing to test it out if there are a couple of good case series) | 17 (26) | 15 (13) | 19 (13) | |
| Early majority (I'll use it if enough people I trust use it) | 17 (27) | 20 (17) | 15 (10) | |
| Sceptic (Give me well-designed prospective randomised controlled trials before I consider it) | 23 (36) | **31 (27)** | 13 (9) | |
| Traditionalist (It's a fad) | 5 (8) | 8 (7) | 2 (1) | |
| Did not answer | 1 (1) | (0) | 2 (1) | |

**Table V**: How many TJA cases does it take to become competent using RA-TJA?

| Number of joints | All respondents % (n = 155) | RA-TJA non-users % (n = 87) | RA-TJA users % (n = 68) | p-value |
|---|---|---|---|---|
| 0–10 | 12 (18) | 10 (9) | 13 (9) | |
| 11–20 | **47 (73)** | **47 (41)** | **47 (32)** | |
| 21–40 | 27 (42) | 28 (24) | 27 (18) | |
| 41–50 | 8 (13) | 8 (7) | 9 (6) | 0.869 |
| 51–100 | 3 (5) | 2 (2) | 4 (3) | |
| > 100 | 1 (2) | 2 (2) | 0 | |
| Did not answer | 1 (2) | 2 (2) | 0 | |

**Table VI**: Perceptions of surgeons currently not using RA-TJA

| Question | Number of respondents % (n = 87) |
|---|---|
| I am hesitant to use robotic-assisted surgery in my practice for TJA because: | |
| Loss of autonomy and control over the procedure | 9 (8) |
| Learning curve | 33 (29) |
| Radiation exposure to the patient | 3 (3) |
| Risk of complications | 13 (11) |
| Cost | **69 (60)** |
| Lack of data demonstrating superior outcomes | 53 (46) |
| I am considering using robotic-assisted surgery in TJA because: | |
| Superior long-term outcomes | 5 (4) |
| Marketing | 18 (16) |
| Administrative pressure | 5 (4) |
| Patient satisfaction | 6 (5) |
| Higher precision and reproducibility in procedures | **35 (30)** |
| Pressure to maintain appearance among peers/staff | 12 (10) |
| I am not considering using robot arm assistance in TJA | **48 (42)** |
| By not offering robotic-assisted TJA, are you losing potential patients to your colleagues that do perform robotic-assisted TJA? | |
| Too early to discern | **41 (36)** |
| Yes | 40 (34) |
| No | 18 (16) |
| Did not answer | 1 (1) |

### *Perceptions of surgeons not currently utilising RA-TJA*

RA-TJA non-users were asked why they hesitated to use RA-TJA, with 69% (n = 60) reporting 'cost', followed by 'lack of data demonstrating superior outcomes' at 53% (n = 46) as obstacles to using RA-TJA. When asked if they were considering using RA-TJA, 48% (n = 42) were not (*Table VI*).

### *Perceptions of surgeons currently utilising RA-TJA*

When asked what the main reason was for using RA-TJA in TJA, 91% (n = 62) of RA-TJA users answered 'higher precision and reproducibility in procedures'. Of those RA-TJA users who were hesitant to adopt RA-TJA, 27% (n = 18) answered that 'the learning curve' was the reason (*Table VII*).

### *The need for a special interest group in RA-TJA*

The majority of respondents (71%; n = 110) agreed to support the formation of a special interest group. Of those supporting a special interest group, 81% (n = 89) felt that it should be part of the South African Arthroplasty Society (SAAS) (*Table VIII*).

## Discussion

### *Total usage of RA-TJA*

This study showed that 44% of surgeons performing TJA in South Africa utilise RA-TJA in their practice. Having more surgeons not utilising RA-TJA than surgeons utilising RA-TJA seems to be in keeping with the current global trend, although multiple national joint registries are showing an increase in the usage of RA-TJA.[14,15] RA-TJA usage in this study is higher than what was reported in a cohort of American Association of Hip and Knee Surgeons (AAHKS) members, with 33.8% of respondents incorporating RA-TJA into their TJA practice.[9] This is similar to Luyckx et al. who reported that 27% of surgeons who are part of the European Knee Society (EKS) are performing RA-TKA.[19] Desai et al. reported on the perceptions and utilisations of RA-TJA among Indian orthopaedic surgeons, and found 24.2% used RA-TJA.[18] The elevated reported usage compared to other similar studies may be attributed to the difference in level of independence of the RA-TJA systems used by surgeons, whether they are active, semi-active, passive or navigational systems, which has not been recorded in this study.[10] When comparing types of systems used, Luyckx et al. found there was a difference reported between surgeons using RA-TKA and surgeons using technology-assisted TKA that included navigation, at 27% and 19% respectively, highlighting the importance of correct

**Table VII**: Perceptions of surgeons using RA-TJA regarding RA-TJA

| Question | Number of respondents % (n = 68) |
|---|---|
| The main reason I use robotic-arm assistance in TJA is: | |
| Higher precision and reproducibility in procedures | **91 (62)** |
| Pressure to maintain appearance among peers/staff | 3 (2) |
| Superior long-term outcomes | 3 (2) |
| Marketing administrative pressure | 2 (1) |
| Patient satisfaction | 2 (1) |
| Were you hesitant to adopt RA-TJA? | |
| Never, I adopted immediately | **44 (30)** |
| Yes, but I needed very little convincing | 17 (27) |
| Yes, I needed a lot of convincing and promise of support | 6 (9) |
| I was hesitant, but it was forced upon me or I had no option but to use it | 2 (1) |
| Did not answer | 2 (1) |
| I was hesitant to use robotic-assisted surgery in my practice for TJA because: | |
| I was not hesitant | 44 (30) |
| Loss of autonomy and control over the procedure | 3 (2) |
| Learning curve | **27 (18)** |
| Radiation exposure to the patient | 0 (0) |
| Risk of complications | 6 (4) |
| Cost/lack of data demonstrating superior outcomes | 21 (14) |
| As you are becoming more experienced with robotic-assisted TJA you are: | |
| More inclined to increase the percentage of robotic-assisted surgery you are performing | **52 (35)** |
| Inclined to perform **all** cases of TJA with robot-assistance | 32 (22) |
| Less inclined to increase the percentage of robotic-assisted surgery you are performing | 10 (7) |
| Inclined to limit/stop the use of robot-assistance for TJA | 3 (2) |
| Did not answer | 3 (2) |

**Table VIII**: The current support regarding the formation of RA-TJA special interest group

| Would you support formation of special interest group? | All respondents % (n = 155) | RA-TJA non-users % (n = 87) | RA-TJA users % (n = 68) |
|---|---|---|---|
| No | 28 (44) | 38 (33) | 16 (11) |
| Yes | **71 (110)** | **61 (53)** | **84 (57)** |
| Did not answer | 1 (1) | 1 (1) | - |
| If yes, how would you prefer the group be affiliated? | **All respondents % (n = 110)** | **Non-users % (n = 53)** | **Users % (n = 57)** |
| Yes, as part of the South African Arthroplasty Society | **81 (89)** | **85 (45)** | **77 (44)** |
| Yes, as part of South African Knee Society | 119 (12) | 9 (5) | 12 (7) |
| Yes, standalone society | 4 (4) | 2 (1) | 5 (3) |
| Other | 1 (1) | 0 | 2 (1) |
| Did not answer | 4 (4) | 4 (2) | 4 (2) |

terminology when assessing the use of the type of system used in RA-TJA.[19] Similarly, Desai et al. found a large difference between the types of systems used.[18] Another factor that may contribute to the differences noted between the studies are the differences in the healthcare systems where the studies are conducted. South Africa is an UMIC but has two distinct health systems working in tandem.[21] The private healthcare system is similar to health systems of high-income countries (HICs), such as those where members of the AAHKS and EKS practise, as opposed to the public funded healthcare system in South Africa, which is far more resource constrained.[21]

### *Usage trends*

There is evidence that there are differences regarding the utilisation trends of RA-TJA between patient groups, insurances, hospital volume and the joints operated on.[9,16] In this cohort of orthopaedic surgeons, far more respondents utilised RA-TJA for TKA compared to THA. This large discrepancy between use of RA-TJA was also found by Sherman et al., where 55.3% of surgeons using robotic technology used RA-TJA for TKA only compared to 1.6% using RA-TJA for THA only.[9] This difference may be partly explained by the large discrepancy noted between numbers of TKA and THA performed, with 370 000 THA and 680 150 TKA performed in the United States in 2014, and projected increases of 71.2% and

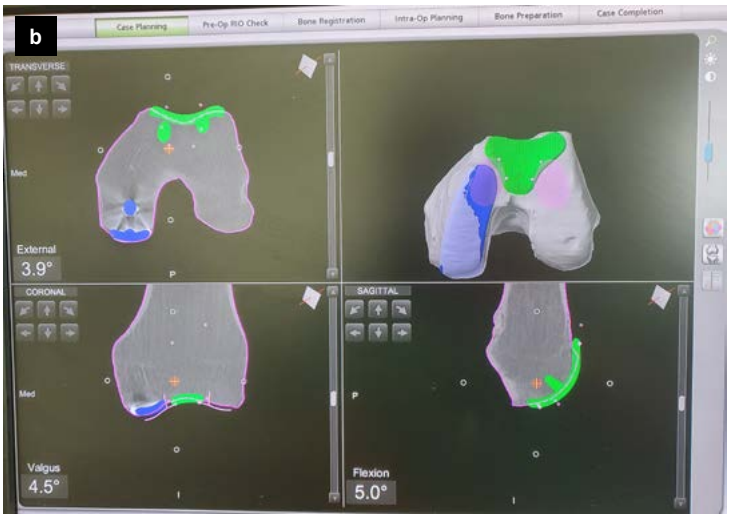
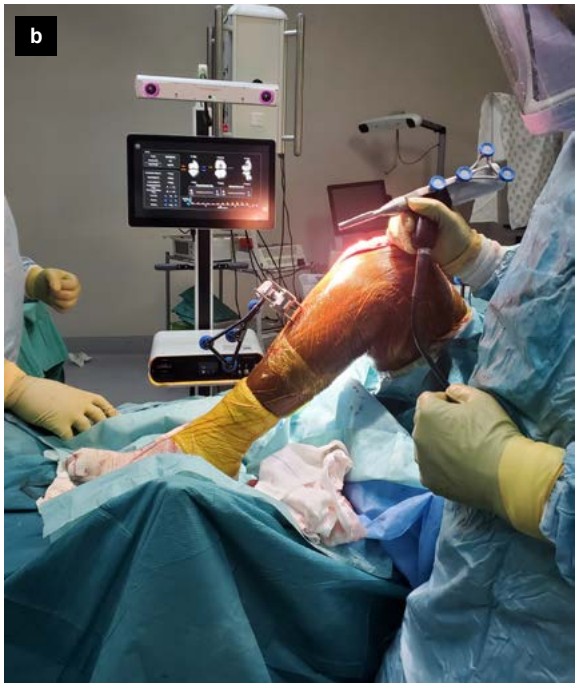



**Figure 1**. a) Example of MAKO robotic system in theatre; b) part of MAKO planning screen for patellofemoral joint replacement with medial unicompartmental knee replacement in situ

**Figure 2**. a) Example of ROSA robotic system; b) intraoperative use of ROSA robotic system during total hip arthroplasty through direct anterior approach with use of intraoperative fluoroscopy



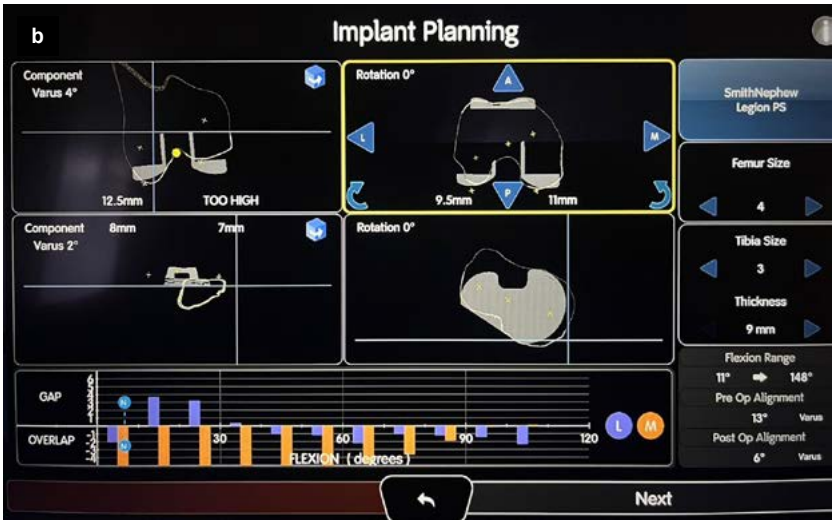




**Figure 3**. a) Intraoperative use of Smith & Nephew robotic system using burr for bone resection during TKA; b) initial implant planning screen

84.9% for THA and TKA, respectively.[1] However, with such a large difference between RA-TJA in THA and TKA, there are most likely other factors that are contributing such as cost, and the availability and exposure to robotic systems available for RA-THA; this may need further investigation to determine.

There was a geographical difference noted, with Western Cape and Southern Gauteng having the most orthopaedic surgeon respondents. Dell et al., reported on the quantity and provincial distribution of orthopaedic surgeons in South Africa, with Gauteng and Western Cape provinces comprising the majority of the orthopaedic surgery population at 39.8% and 25.6%, respectively.[17] When combining the results of Northern Gauteng and Southern Gauteng to complete the Gauteng province at 43.9%, the comparison of the results by Dell et al. are strikingly similar.[17]

Interestingly, it was only the Western Cape that reported more users of RA-TJA than non-users. The reason for one province adopting RA-TJA more than other provinces is difficult to explain but one possible explanation may be related to the composition of private and public sector resources. Dell et al. indicated that Western Cape had a higher orthopaedic surgeon density in the private sector of 11 per 100 000 population compared to Gauteng with 8.3 per 100 000 population.[17] Considering there are more resources in the private sector per the population compared to the public sector, and together with the higher orthopaedic surgeon density in the private sector, there is more opportunity to utilise an additional resource such as RA-TJA.[21] Future endeavours such as implementing a national joint registry in South Africa may provide more information regarding RA-TJA use in South Africa.

### *Reason for using RA-TJA*

In this cohort of orthopaedic surgeons, the majority of RA-TJA users reported adopting RA-TJA based on the perception of increased precision and reproducibility, although robust long-term clinical outcome data remains limited. Just over half of RA-TJA non-users reported that they would consider using RA-TJA. However, just over a third of respondents reported that the allure is due to perceived higher precision and reproducibility in robotic-assisted procedures. These results are comparable with the evaluation of a cohort of 727 AAHKS members where 73.1% agreed that improved precision was the predominant reason for RA-TJA usage. Luyckx et al. found that there was agreement among orthopaedic surgeons that RA-TKA had an impact on accuracy of bone cuts and implant positioning.[19] Similarly Desai et al. reported that two-thirds of surgeons believed RA-TJA improves implant positioning and alignment.[18] These perceptions influencing the use of RA-TJA find support in numerous publications that have reported higher precision of implant placement and better radiographic results with RA-TJA.[8,11,14,22-25] It has been found that there are significantly fewer radiographic outliers, similar operating times and shorter length of stay with RA-TKA performed by low-volume surgeons.[26] Despite the lack of superior long-term outcomes, the improved level of accuracy of implant position may contribute in low-volume arthroplasty surgeons in adopting this technology.[12] While preliminary studies suggest potential benefits of RA-TJA, the current evidence is limited by small sample sizes and short follow-up periods. Larger, well-designed prospective studies are needed to draw more definitive conclusions, including whether these outcomes are mirrored by low-volume surgeons.

### *Reason for not using RA-TJA*

More than two-thirds of South African orthopaedic surgeons cited additional costs as the reason for not utilising robotic assistance in TJA. This is in keeping with similar studies. Desai et al. found that 93.5% of Indian surgeons believed cost to be the biggest obstacle to using RA-TJA, and 78% of EKS members cited cost as the main deterrent to RA-TJA.[18,19] Prolonged operating time with RA-TJA was also reported as a limitation to use by AAHKS, although no consensus regarding time was reached by EKS members.[9,19]

The increased costs associated with RA-TJA may include capital acquisition, the use of robotic-specific disposables and annual operating expenditures, including service agreements.[9,27] The increased operating time associated with RA-TJA also contributes to increased costs. It has been suggested that the improved component precision may reduce complications and the need for revision surgery, thereby reducing the total cost of TJA.[27] Rajan et al. concluded that RA-TKA had higher capital equipment costs, but this was offset by lower revision rates and higher patient-reported outcomes making RA-TKA cost effective, especially in institutions performing more than 24 cases annually.[27] Maldonado et al. found that RA-THA was more cost effective than conventional THA but only looked at direct medical costs from a payer's perspective.[28] There are many variables that can be used when comparing the cost analysis between conventional- and RA-TJA, from 90-day global expenditures, length of stay, in-patient costs and 90-day episode of care costs.[27] Kirchner et al. compared conventional THA to RA-THA and found that both systems have a similar perioperative safety profile, and despite having a shorter length of stay (LOS), RA-THA still incurred a higher overall cost.[29] It has been suggested that the direct increased cost of RA-TJA may be offset by other advantages such as reducing and streamlining surgical trays, and improved workflow with potential for economies of scale.[30] With so many different variables included, it does make answering the question of over-all cost effectiveness difficult, with resultant mixed messages in available literature. As the volume of RA-TJA increases as predicted, it's crucial that future studies evaluating RA-TJA continue to acquire data to assess the overall cost effectiveness of RA-TJA.

Just over half of the respondents in this study agreed that their reluctance to support RA-TJA was due to the lack of long-term data supporting superior outcomes. The lack of evidence on superior long-term outcomes was the predominant deterrent to the use of RA-TJA cited by AAHKS members.[9] Patient-reported outcomes in TJA have been found to correlate with component fixation, component positioning, soft tissue balancing, leg alignment, and joint line maintenance.[11,13] Suboptimal implant positioning in TJA has been found to lead to poor functional recovery, reduced patient-reported outcomes and reduced implant survivorship.[12] The use of RA-TJA has increased precision of implant placement and improved inpatient functional rehabilitation and but it has not been found to match superior long-term clinical outcomes.[8,11,12,14]

The systematic review by Alrajeb et al. only included randomised control trials and found that, although RA-TKA resulted in superior implant placement, following both mechanical and anatomical alignment, there was no difference in functional outcomes and complications.[24] Similarly, Bensa et al. found RA-THA resulted in more accurate cup placement with restoration of native hip anatomy, but did not result in superior patient-reported clinical outcomes.[25] When interpreting the results of the many available studies evaluating RA-TJA, the heterogenicity of robotic systems included, as well as the various alignment principles used, should be noted.[23] Systematic review and meta-analysis by Zhang et al., which excluded the use of active robotic systems, demonstrated RA-TJA resulted in significantly better knee society scores and Western Ontario and McMaster Universities Osteoarthritis index (WOMAC) scores in the short- to mid-term follow-up compared to manual TKA.[23] Similarly, Ng et al. reported that that RA-THA achieved a significantly greater number of cases with correct component positioning in safe zones compared to manual THA, and was associated with enhanced functional outcomes when looking at studies excluding active robotic systems.[22] These studies

highlight the importance of standardising terminology used with the type of robotic systems, and how results can differ based on the inclusion and exclusion of certain robotic systems. As the predicted volume of RA-TJA increases, together with further development of the various robotic systems, data from future studies using standardised definitions regarding robotic systems (active, semi-active and passive) as well as alignment principles may differ to what is currently available.

### Proficiency of cases

Just under half of all respondents agreed it takes 11–20 cases to become competent in RA-TJA. There was agreement with this statement between both users and non-users of RA-TJA. This is in keeping with the literature that the learning curve ranges between six and 43 cases for RA-TJA, with the majority of AAHKS surgeons reporting at least 20 cases are required.[9,22] Although there are many factors affecting the learning curve with RA-TJA, the type of robotic system seems to play a role.[31] Learning curves for ROSA (Robotic Surgical Assistant) Knee System (Zimmer-Biomet, Warsaw, IN, USA) have been reported at 6–43 cases, MAKO Robotic Arm Interactive Orthopaedic System (Stryker, Kalamazoo, MI, USA) reported at 7–43 cases and NAVIO Surgical System (Smith & Nephew, Andover, TX, USA) reported at 7–29 cases[31] (*Figures 1–3*) It is interesting to note that the learning curve was the third most common reason for not using RA-TJA by non-users, and it was the most common reason for hesitancy reported by users of RA-TJA. The obstacle of the learning curve may be addressed by improving our current training in RA-TJA. More than 80% of respondents indicate that there is a need for training in the use of RA-TJA either at a registrar level or during fellowship. Orthopaedic trainees can be educated in RA-TJA with the possible benefits of real-time feedback without negatively impacting patient risk and surgical efficiency.[32] Increasing exposure, training and adequate supervision of RA-TJA during the perceived learning curve of 11–20 cases may alter perceptions of obstacles to RA-TJA usage. Once the learning curve is achieved, high volumes of RA-TJA do not appear to be needed as low-volume surgeons have positive outcomes with RA-TJA.[26] However, this was the experience of a single arthroplasty surgeon with 19 cases. Future higher-powered studies are required to further accurately evaluate surgeon volume and outcomes in RA-TJA.

### Users of RA-TJA

Almost one-third of RA-TJA users employ robotic assistance for 81–100% of their current TJA practice. Furthermore, just over half of RA-TJA users stated that they are more inclined to increase their current use of RA-TJA. The explanation of this current usage and the proposed increased usage of RA-TJA may be related to the learning curve. As a surgeon becomes more familiar with RA-TJA, efficiency is improved, which may also reduce the total cost by improving operating time. This is in keeping with EKS members suggesting improved efficiency would promote the use of RA-TJA.[19] The majority of RA-TJA users in this study believe that RA-TJA takes longer than conventional TJA. Considering more respondents are practising in the South African private sector where payments are received per procedure performed, decreasing the number of procedures performed in a day could significantly reduce income. It appears that in South Africa, the perception that RA-TJA is more time consuming is offset by the belief that RA-TJA results in improved outcomes, fewer complications and fewer revisions, even though the majority of current evidence does not support this belief.

In this cohort of surgeons, more users of RA-TJA disagreed than agreed with the statement that RA-TJA is utilised for marketing purposes. Marketing may play a role in the usage of RA-TJA, considering the majority of surgeons are working in private practice. Of the non-users of RA-TJA, 39% agreed and 41% felt it was too early to discern, that by not offering RA-TJA they were losing potential patients to colleagues performing RA-TJA. Patients' knowledge of RA-TJA is improving, however, and it has been reported that patients feel facilities that offer RA-TJA are better than facilities that do not.[15] The results of this study show that the motivations for usage of RA-TJA are indeed multifactorial. Marketing may play a role, and this may increase as more patients become aware of RA-TJA.

### Self-categorising willingness to adopt new technology

Rogers' Diffusion of Innovation Theory divides people into five categories based on their inclination to adopt a new technology.[20] Using this framework, respondents were asked to self-categorise themselves based on their feelings towards new technological innovations using modified statements from Rogers' Diffusion of Innovation Theory. These same statements were used in previous similar studies and allow surgeons to self-classify as to whether they see themselves as an enthusiast, visionary, early majority adopter, sceptic or traditionalist.[9,18,20] The majority of the respondents self-categorised themselves as enthusiasts. These results are similar to Desai et al., reporting 43.4% of surgeons self-categorising themselves as enthusiasts.[18] There was a difference noted between users of RA-TJA and non-users of RA-TJA, with just under a third of non-RA-TJA users self-categorising themselves as sceptics (requiring the need of well-designed prospective randomised controlled trials before considering adopting new technology), compared to half of RA-TJA users self-categorising themselves as enthusiasts (I'll try anything new if it has a possibility of being better). This difference may suggest that the use of RA-TJA is closely related to the surgeon's inclination of embracing technology, and why there is wide adoption of technology before substantial long-term data is acquired.

### Support of interest group

There seems to be support for a special interest group in RA-TJA, with more than two-thirds of respondents advocating for the creation of a special interest group. The majority of respondents felt that a special interest group under the South African Arthroplasty Society (SAAS) was the best option, with agreement between both RA-TJA users and non-users. Creating a special interest group may be key in improving awareness of RA-TJA, and assisting with future clinical studies evaluating RA-TJA in South Africa. As a UMIC, we should strive to avoid being left behind when it comes to global trends and utilising the available technology that may affect our surgical outcomes.

The study has some limitations. The survey was distributed only to surgeons who are currently part of the SAOA database, and therefore some surgeons practising TJA in South Africa may have been excluded. Also, not all registered orthopaedic surgeons are currently practising TJA and would not have responded to the questionnaire. We did not specifically ask whether respondents routinely perform total hip or knee arthroplasty in their daily practice. This could impact the generalisability of the results, as the opinions of non-arthroplasty surgeons may differ from those who regularly perform these procedures.

The classification of robotic systems was not included, and therefore there may be inclusion of purely navigation systems within RA-TJA usage, skewing results. Future studies may benefit by including the type of system used such as active, semi-active, passive and navigation systems.

The use of RA-TJA was not broken down according to THA, TKA and UKA. There may be some surgeons utilising robotic-assisted

surgery for UKA only that would be excluded from this study. Future studies would benefit from including UKA, as well as the alignment principles used in TKA. The recent evolution of knee alignment principles, specifically functional alignment, using gap-balancing software by RA-TJA systems may be the driving force behind the use of this technology in arthroplasty surgery of the knee.[14]

## Conclusion

The adoption of RA-TJA among South African orthopaedic surgeons reflects global trends, with cost and lack of long-term outcome data being the primary barriers to wider use. While early data suggests potential benefits in surgical precision, robust evidence supporting long-term clinical and cost effectiveness remains limited. Future studies should prioritise high-powered, prospective research to clarify the role of RA-TJA in improving patient outcomes and addressing cost effectiveness. RA-TJA is a broad term, and further studies would benefit from including the type of robotic systems in use.

### *Ethics statement*

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to commencement of the study, ethical approval was obtained from the University of the Witwatersrand's Human Research Ethics Committee (Wits HREC) (Medical) – clearance certificate number M230316. All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed written consent was obtained from all patients for being included in the study.

### *Declaration*

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

### *Author contributions*

RPA: data capture, data analysis, study design, manuscript preparation
NS: manuscript revision
LM: manuscript revision
AS: manuscript revision
JP: study conceptualisation, data analysis, study design, manuscript revision

### *ORCID*

Almeida RP https://orcid.org/0009-0004-4252-0036
Sikhauli N https://orcid.org/0000-0002-0862-8615
Mokete L https://orcid.org/0000-0001-9227-0515
Seiketto A https://orcid.org/0000-0002-5402-6500
Pietrzak J https://orcid.org/0000-0001-5694-0016

## References

1. Sloan M, Premkumar A, Sheth NP. Projected volume of primary total joint arthroplasty in the US, 2014 to 2030. J Bone Joint Surg Am. 2018;100(17):1455-60.
2. Booth RE, Sharkey PF, Parvizi J. Robotics in hip and knee arthroplasty: real innovation or marketing ruse. Vol. 34, J Arthroplasty. 2019;34:2197-98.
3. Pivec R, Johnson AJ, Mears SC, Mont MA. Hip arthroplasty. Lancet. 2012 Nov 17;380(9855):1768-77.
4. Jauregui JJ, Cherian JJ, Pierce TP, et al. Long-term survivorship and clinical outcomes following total knee arthroplasty. J Arthroplasty. 2015;30(12):2164-66.
5. Orr MN, Klika AK, Emara AK, et al. Dissatisfaction after total hip arthroplasty associated with preoperative patient-reported outcome phenotypes. J Arthroplasty. 2022 Jul 1;37(7):S498-509.
6. DeFrance MJ, Scuderi GR. Are 20% of patients actually dissatisfied following total knee arthroplasty? A systematic review of the literature. J Arthroplasty. 2023 Mar 1;38(3):594-99.
7. Shichman I, Askew N, Habibi A, et al. Projections and epidemiology of revision hip and knee arthroplasty in the United States to 2040–2060. Arthroplast Today. 2023 Jun 1;21.
8. Deckey DG, Rosenow CS, Verhey JT, et al. Robotic-assisted total knee arthroplasty improves accuracy and precision compared to conventional techniques. Bone Joint J. 2021;103(6):74-80.
9. Sherman WF, Wu VJ. Robotic surgery in total joint arthroplasty: a survey of the AAHKS membership to understand the utilization, motivations, and perceptions of total joint surgeons. J Arthroplasty. 2020 Dec 1;35(12):3474-3481.e2.
10. Jacofsky DJ, Allen M. Robotics in arthroplasty: a comprehensive review. J Arthroplasty. 2016 Oct 1;31(10):2353-63.
11. Karunaratne S, Duan M, Pappas E, et al. The effectiveness of robotic hip and knee arthroplasty on patient-reported outcomes: A systematic review and meta-analysis. Int Orthop. 2019 Jun 3;43(6):1283-95.
12. Kayani B, Haddad FS. Robotic total knee arthroplasty: where are we today? Bone Joint Res. 2019;8(10):438-42. https://doi.org/10.1302/2046-3758.810.BJR-2019-0175
13. Lonner JH, Fillingham YA. Pros and cons: a balanced view of robotics in knee arthroplasty. J Arthroplasty. 2018 Jul 1;33(7):2007-13.
14. Heinz T, Eidmann A, Anderson P, et al. Trends in computer-assisted surgery for total knee arthroplasty in Germany: an analysis based on the operative procedure classification system between 2010 to 2021. J Clin Med. 2023 Jan 1;12(2).
15. Pagani NR, Moverman MA, Puzzitiello RN, et al. Online crowdsourcing to explore public perceptions of robotic-assisted orthopedic surgery. J Arthroplasty. 2021 Jun 1;36(6):1887-94.e3.
16. Boylan M, Suchman K, Vigdorchik J, et al. Technology-assisted hip and knee arthroplasties: an analysis of utilization trends. J Arthroplasty. 2018 Apr 1;33(4):1019-23.
17. Dell AJ, Gray S, Fraser R, et al. Orthopaedic surgeon density in South Africa. World J Surg. 2018 Dec 1;42(12):3849-55.
18. Desai KB, Mulpur P, Jayakumar T, et al. Adoption of robotics in arthroplasty- a survey of perceptions, utilization and challenges with technology among Indian surgeons. J Orthop. 2023 Dec 1;46:51-57.
19. Luyckx T, Monk AP, Müller JH, et al. What are the perceived benefits and barriers to the use of robot-assisted total knee arthroplasty? A survey of members of the European Knee Society. Int Orthop. 2023 Feb 1;47(2):405-12.
20. Rogers E. Diffusion of Innovations. 5th ed. Simon and Schuster, Inc. 2003. 1-576 p.
21. Dell AJ, Kahn D, Klopper J. Surgical resources in South Africa: An analysis of the inequalities between the public and private sector. S Afr J Surg. 2018 Jun 1;56(2):16-20.
22. Ng N, Gaston P, Simpson PM, et al. Robotic arm-assisted versus manual total hip arthroplasty – a systematic review and meta-analysis. Bone Joint J. 2021;103-B(6):1009-20.
23. Zhang J, Ndou WS, Ng N, et al. Robotic arm-assisted total knee arthroplasty is associated with improved accuracy and patient reported outcomes: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2022 Aug 1;30(8):2677-95.
24. Alrajeb R, Zarti M, Shuia Z, et al. Robotic-assisted versus conventional total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. Eur J Orthop Surg Traumatol. 2024 Apr 1;34(3):1333-43.
25. Bensa A, Pagliazzi G, Miele A, et al. Robotic-assisted total hip arthroplasty provides greater implant placement accuracy and lower complication rates, but not superior clinical results compared to the conventional manual approach: a systematic review and meta-analysis. J Arthroplasty. 2025;40(7):1921-31.
26. Byrne C, Durst C, Rezzadeh K, et al. Robotic-assisted total knee arthroplasty reduces radiographic outliers for low-volume total knee arthroplasty surgeons. Arthroplast Today. 2024 Feb 1;25.
27. Rajan PV, Khlopas A, Klika A, et al. The cost-effectiveness of robotic-assisted versus manual total knee arthroplasty: a Markov model-based evaluation. J Am Acad Orthop Surg. 2022 Feb 15;30(4):168-76.
28. Maldonado DR, Go CC, Kyin C, et al. Robotic arm-assisted total hip arthroplasty is more cost-effective than manual total hip arthroplasty: a Markov model analysis. J Am Acad Orthop Surg. 2021 Feb 15;29(4):E168-77.
29. Kirchner GJ, Lieber AM, Haislup B, et al. The cost of robot-assisted total hip arthroplasty: comparing safety and hospital charges to conventional total hip arthroplasty. J Am Acad Orthop Surg. 2021 Jul 15;29(14):609-15.
30. Lonner JH, Goh GS. Moving beyond radiographic alignment: applying the Wald principles in the adoption of robotic total knee arthroplasty. Int Orthop. 2023;47:365-73.
31. Neira I, Llopis R, Cuadrado L, et al. Analysis of the initial learning curve for robotic-assisted total knee arthroplasty using the ROSA® Knee System. J Clin Med. 2024 Jun 1;13(11).
32. Deckey DG, Verhey JT, Rosenow CS, et al. Robotic-assisted total knee arthroplasty allows for trainee involvement and teaching without lengthening operative time. J Arthroplasty. 2022 Jun 1;37(6):S201-6.

***Appendix available online at:***
***https://saoj.org.za/index.php/saoj/article/view/897/785***