Infection prevention in shoulder arthroplasty: current practices among South African orthopaedic surgeons

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Abstract

Background

Periprosthetic joint infection (PJI) following shoulder arthroplasty is costly and difficult to treat. Effective perioperative infection prevention is thus of utmost importance. Recent years have seen advances in the scientific literature pertaining to infection prevention in shoulder arthroplasty, including an International Consensus Meeting (ICM). However, little is known about infection prevention practices in South Africa and to what extent they reflect the latest evidence. Therefore, the aim of this study was to investigate the current perioperative infection control practices for primary total shoulder arthroplasty among South African orthopaedic surgeons.

Methods

This cross-sectional study involved a survey conducted at the annual South African Shoulder and Elbow Surgeon Society Congress in 2023. The survey was developed based on the study aim and the existing literature. Surveys were distributed to delegates in paper-based form, and responses captured electronically for descriptive analysis.

Results

Fifty-two of 75 (69%) orthopaedic surgeon delegates completed the survey. Forty-one (79%) were in full-time private practice. Among preoperative measures surveyed, 30 of 47 (64%) respondents used chlorhexidine only as a preadmission skin preparation, 46 of 51 (90%) used cefazolin only as a preoperative antibiotic, and 28 of 51 (55%) used 0.5% chlorhexidine gluconate in 70% isopropyl alcohol as a pre-incision skin scrub. Among intraoperative measures, 51 of 52 (98%) used double gloving, 26 of 52 (50%) used iodine-impregnated adhesive drapes, 37 of 52 (71%) always used tranexamic acid (TXA), 42 of 52 (81%) always used antibiotic-impregnated cement, and 37 of 52 (71%) always redosed antibiotics for procedures > 2 hours. Postoperatively, 41 of 46 (89%) administered antibiotics for up to 24 hours.

Conclusion

There was a majority response for most of the items surveyed, indicating reasonable consensus in shoulder arthroplasty infection prevention practices. Most responses were generally in keeping with ICM recommendations, except routine use of TXA and antibiotic-impregnated cement. These measures were deemed by the ICM to have insufficient evidence. A minority of respondents indicated practices that show room for improvement in reducing periprosthetic joint infection risk.

Level of evidence: 3

Keywords: shoulder arthroplasty, periprosthetic joint infection, infection prevention, perioperative

Introduction

Widened indications for shoulder arthroplasty, along with ageing populations, have led to an exponential rise in shoulder arthroplasty surgeries over the last decade, especially those involving a reverse prosthesis.[1-3] Like all orthopaedic surgeries, shoulder arthroplasty carries a risk of complications, including infection.[2,4,5] The reported incidence of periprosthetic joint infection (PJI) following primary shoulder arthroplasty has varied from 0.08% to 5%, according to different diagnostic criteria and follow-up periods.[6] Although relatively rare, it is a devastating complication, involving revision operations, extended hospital stay, functional disability, high cost and an overall poor outcome for the patient.[2,7] Thus, precautions to minimise the risk of infection form a vital part of perioperative care.[7-9]

Historically, the evidence for infection prevention in shoulder arthroplasty has lagged behind that of hip and knee arthroplasty, with evidence from other joint replacement literature simply extrapolated to the shoulder.[8,10] However, this has changed in recent years.[11-13] A number of randomised controlled trials on infection prevention in shoulder PJI have now been conducted, allowing for

robust evidence syntheses such as systematic reviews and meta-analyses.[11-13] A further notable development has been the 2nd International Consensus Meeting (ICM) on Orthopedic Infections, held in Philadelphia, United States, in 2018.[14] Consensus was sought on infection prevention practices including perioperative antibiotics, intrawound antiseptics and the use of tranexamic acid (TXA).[10] To our knowledge, the proceedings of this meeting are currently the only international consensus recommendations specifically addressing PJI in shoulder arthroplasty.[10]

In South Africa, little is known about shoulder arthroplasty infection prevention practices and to what extent these reflect the latest international literature. It was envisaged that assessing current practices within our setting would provide insight into the level of professional agreement on this topic, as well as identify possible areas for improvement. Therefore, the aim of the study was to investigate current perioperative infection control practices for primary total shoulder arthroplasty among South African orthopaedic surgeons.

Methods

This cross-sectional study involved a survey conducted at the annual South African Shoulder and Elbow Surgeon Society (SASES) Congress, which was held in Cape Town in May 2023. To be eligible for the study, individuals were required to be orthopaedic surgeons currently practising shoulder arthroplasty in South Africa. While the exact number of orthopaedic surgeons practising shoulder surgery in South Africa is unclear, SASES delegates provided a large and accessible representation of this group.

Data collection and analysis

To our knowledge, there were no existing survey instruments which suited the purpose of the current study. Thus, a short survey was developed based on the study aim and the existing literature on the topic. In addition to items related to infection prevention, the survey included basic professional details to allow for a description of the respondents. Three shoulder surgeons reviewed the face and content validity of the survey, and suggested changes were incorporated.

The survey was distributed at the congress in paper-based form and was briefly introduced from the podium. All surveys were completed anonymously. Responses were captured into an Excel spreadsheet using drop-down menus to facilitate accurate data entry.

Categorical responses were reported as counts and percentages. Categories with very low response rates were pooled in certain cases. Analyses were conducted using jamovi version 1.6 (www.jamovi.org) and GraphPad Prism version 9.2.0 for Mac OS, GraphPad Software, San Diego, California USA, www.graphpad.com.

Results

The 2023 SASES Congress was attended by 75 orthopaedic surgeon delegates, of whom 52 completed the survey: a response rate of 69%. The characteristics of the respondents are shown in *Table I*. Certain participants elected not to respond to some of the survey questions, thus respondent numbers out of a possible 52 are specified per item throughout the results.

Preoperative measures

There were seven survey questions pertaining to preoperative measures for infection prevention. All questions elicited one majority response, with the size of the majority ranging from 55% to 90%. Prior to conducting a primary shoulder arthroplasty, 34 of 52 (65%) respondents said they would wait at least three months following an intra-articular steroid injection, with a further 17 of 52 (33%) indicating that they would wait at least one month. Responses to the remaining six questions are shown in *Figure 1*. Chlorhexidine only was the most common preadmission skin preparation, used by 30 of 47 respondents (64%). Eight respondents (17%) utilised benzoyl peroxide (BP) for preadmission skin preparation, including five who used both chlorhexidine and BP, two who used BP only and one who used chlorhexidine, BP and 60% isopropyl alcohol (e.g. Dermaprep®).

Intraoperative measures

There were seven questions related to intraoperative infection prevention measures. First, respondents were asked to select from a list all the measures they currently used, with responses shown in *Figure 2*. Double gloving, laminar flow, saline irrigation, changing blades and changing gloves were practised by the majority of respondents (≥ 69%), whereas measures such as a mask and sterile hood were less prevalent. When questioned specifically about the use of TXA, redosing of antibiotics for procedures longer than two hours and use of antibiotic-impregnated bone cement, ≥ 71% of respondents always used each of these measures (*Figure 3*).

Measures used before wound closure was the only survey item not to elicit one majority response. The largest proportion of respondents used povidone-iodine irrigation only (18 of 39; 46%) (*Figure 4a*). However, there was notable heterogeneity in the remaining responses, with 13 of 39 (33%) respondents using one alternate agent only (vancomycin powder, gentamicin-impregnated collagen sponges [Garacol®]), gentamicin powder, chlorhexidine gluconate or saline only), five of 39 (13%) respondents using two or more agents in combination, and two respondents indicating 'none' to measures used before wound closure. Methods of skin closure showed strong consensus with 44 of 51 (86%) using absorbable sutures only (*Figure 4b*). The final question of the section related to wound dressing and had a response rate of only 36 out of 52

Table I: Infection prevention survey respondent characteristics

	n (%)
Years practising shoulder arthroplasty (n = 52)	
< 5	10 (19)
5–9	6 (12)
10–19	23 (44)
≥ 20	13 (25)
Average number of shoulder arthroplasties per month (n = 52)	
< 4	27 (52)
5–8	20 (39)
≥ 9	5 (10)
Percentage reverse shoulder arthroplasty (n = 51)	
Percentage out of all arthroplasties performed, median [IQR]	90 [78-90]
Time in the private sector (n = 52)	
None	4 (8)
Part-time	7 (13)
Full-time	41 (79)
Most influence on arthroplasty infection control practices (n = 38)	
Courses/webinars/conferences	12 (32)
Scientific literature	12 (32)
Fellowship training	8 (21)
Other	6 (16)

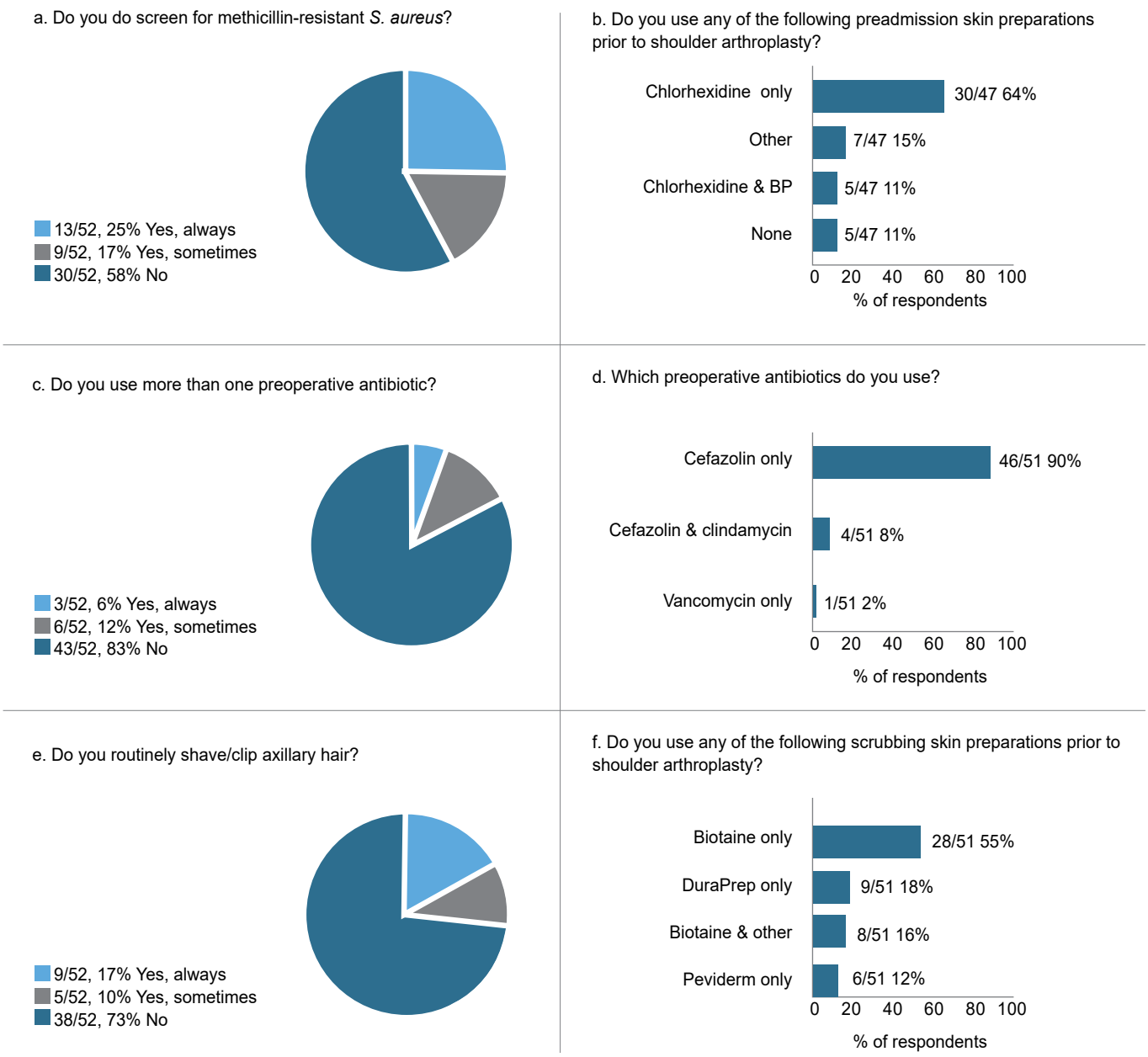

Figure 1. Preoperative infection prevention measures: a) screening for methicillin-resistant *S. aureus*; b) preadmission skin preparations; c) use of more than one preoperative antibiotic; d) choice of preoperative antibiotics; e) shaving axillary hair; f) preoperative skin scrub

BP: benzoyl peroxide; Biotaine = 0.5% chlorhexidine + 70% isopropyl alcohol; DuraPrep = iodine povacrylex (0.7% iodine) + 74% isopropyl alcohol; Peviderm = povidone-iodine scrub

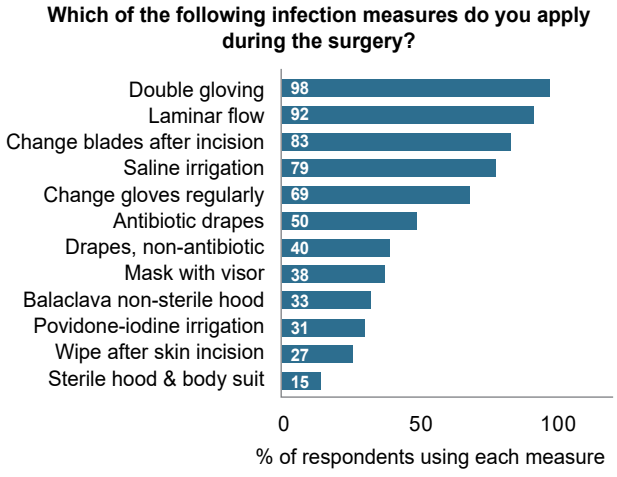

Figure 2. Infection prevention measures applied during surgery

participants. Of these, 12 (33%) used silver-impregnated dressings sometimes or always, three (10%) sometimes used vacuum dressings, and 21 (58%) reported using some other, conventional dressing only.

Postoperative measures

There were three questions related to postoperative infection measures. Only 27 of 52 participants responded to the question, 'If you use a postoperative drain, when do you normally remove it?'. Nineteen (70%) indicated that they removed the drain within 24 hours, seven of 27 (26%) removed the drain when less than a certain amount of fluid was draining, and one respondent indicated 'other' for determining when the drain was removed. Responses regarding the duration of postoperative antibiotics and wound inspection are shown in *Figure 5*. Both items showed a large majority response for continuing antibiotics for 24 hours and checking the wound at 10–14 days postoperatively. Of 49

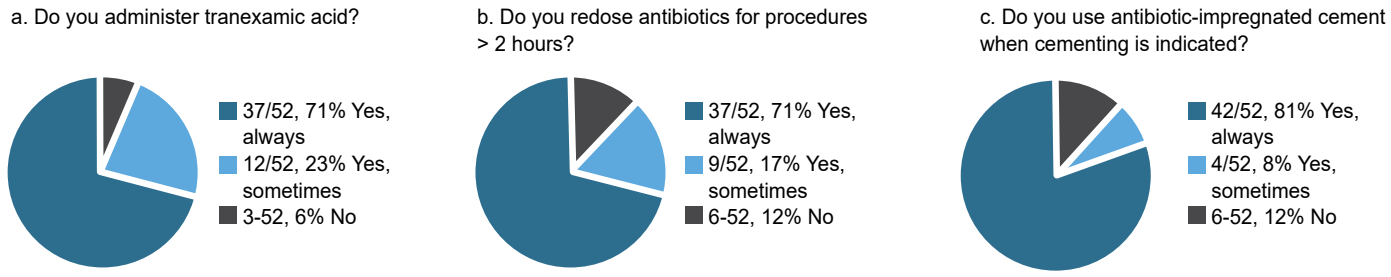

Figure 3. Intraoperative infection prevention measures a) use of tranexamic acid, b) redosing of antibiotics for procedures > 2 hours, c) use of antibiotic-impregnated cement when indicated

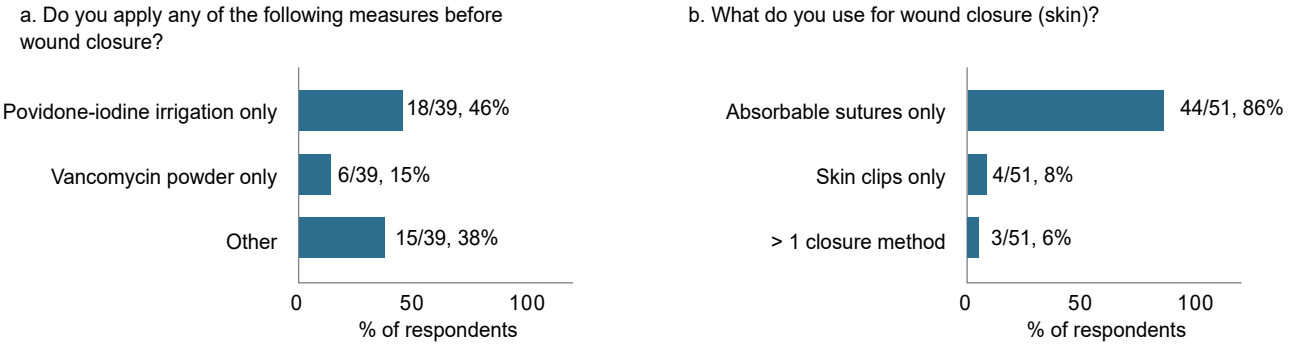

Figure 4. Intraoperative infection prevention measures: a) measures used before wound closure; b) method of wound closure

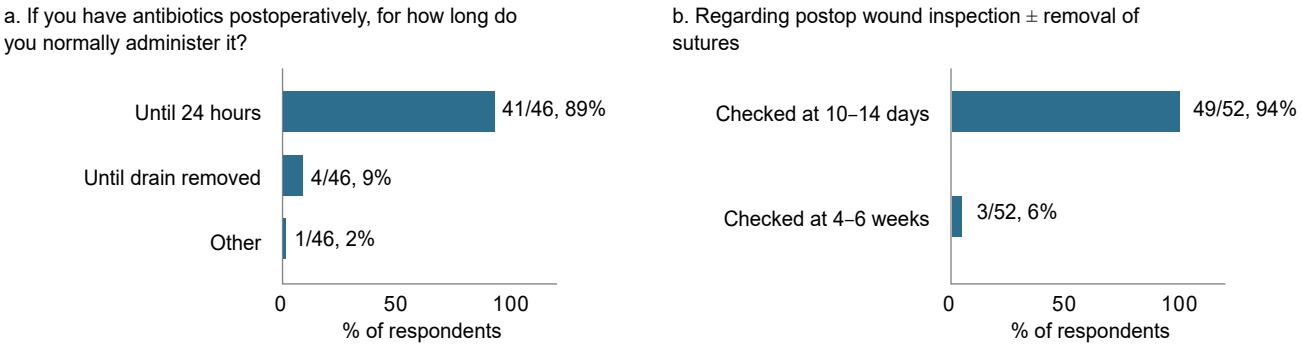

Figure 5. Postoperative infection prevention measures: a) duration of postoperative antibiotics; b) postoperative wound inspection

respondents with wound checking at 10–14 days, 44 performed the check personally and five asked a wound care nurse or general practitioner to perform the check.

Discussion

The first finding of the study was that there was a majority response (55–90%) for most of the items surveyed. This suggests reasonable consistency and professional agreement in shoulder PJI prevention approaches in our setting. At present, the only international best practice guidelines that specifically address PJI in shoulder arthroplasty are the proceedings of the ICM, which was held in 2018.[10] These guidelines are a valuable reference against which to compare the survey responses, although, in some cases, subsequent advances in the scientific literature raise uncertainty as to whether the guidelines still constitute best practice.

Preoperative measures

The second finding of the study was that the majority of respondents (55–90%) were in keeping with ICM recommendations regarding the use of chlorhexidine as a home-based skin preparation, cefazolin as a preoperative antibiotic, and 0.5% chlorhexidine gluconate + 70% isopropyl alcohol (e.g. Biotaine) as a pre-incision skin preparation.[10] There was no clear ICM recommendation regarding the timing of shoulder arthroplasty following steroid injections, MRSA screening or removal of axillary hair.[10] Each measure is discussed in approximately chronological order below.

Two-thirds of respondents (65%) indicated waiting at least three months following an intra-articular steroid injection before performing shoulder arthroplasty. The ICM noted that multiple injections or a short time period between a steroid injection and shoulder arthroplasty may increase the risk of PJI but did not provide a recommended waiting time.[10] To wait three months after an injection before considering surgery is in keeping with a recent meta-analysis.[15] This evidence synthesis found a strong trend towards increased risk of PJI when injections were given < 3 months prior to primary shoulder arthroplasty compared to no prior injections.[15] One in three respondents (33%) waited only one month following a steroid injection before performing shoulder arthroplasty. The available evidence suggests that this should be increased to at least three months to lower the risk of PJI.[15,16]

Most respondents (58%) indicated that they did not perform MRSA screening. While evidence specific to shoulder surgery is lacking, a meta-analysis involving knee and hip arthroplasty found

that colonisation with *Staphylococcus aureus* was associated with increased risk of surgical site infection.[17] The same analysis found that screening and decolonisation was associated with reduced risk of infection, and that there was no difference in risk reduction between screening and decolonisation versus universal decolonisation.[17] However, there is currently insufficient evidence from shoulder arthroplasty for a clear recommendation regarding MRSA screening and decolonisation.[9]

Approximately two-thirds of respondents (64%) prescribed a chlorhexidine product only as a home-based skin preparation, in keeping with the ICM recommendation of at least two applications of chlorhexidine gluconate showers or wipes to reduce the incidence of skin culture positivity.[10] Notably, a systematic review concluded that chlorhexidine is not effective in reducing the skin burden of *Cutibacterium acnes*,[18] likely due to poor ability to penetrate the sebaceous glands where *C. acnes* resides.

C. acnes has been found to be the most common causative agent in postoperative shoulder infection.[4] While strong evidence linking the skin burden of *C. acnes* to the incidence of PJI is still lacking, skin colonisation has been associated with contamination of the surgical field, and reducing the skin burden of *C. acnes* is thought to be important.[4,19,20] BP has shown promise in this regard with a systematic review concluding that topical BP is effective in reducing colonisation of *C. acnes* prior to shoulder surgery.[13] A randomised controlled trial found that topical BP (5%) or BP (5%) + 1% clindamycin were significantly more effective in reducing *C. acnes* skin and wound colonisation than a chlorhexidine product.[19] The ICM felt that there was insufficient evidence to endorse BP as standard practice for PJI infection.[14] However, subsequent studies increasingly support BP.[13,18,19] Use of BP was relatively low among survey respondents (17%); more widespread use in skin preparation protocols may help to reduce shoulder PJI risk in our setting. Of concern was a minority of respondents who indicated that they did not use any preadmission skin preparation. This constitutes a missed opportunity to likely reduce the risk of PJI at relatively low cost and risk.

There was strong agreement around preoperative antibiotic prophylaxis: 90% of respondents indicated using cefazolin only. This approach aligned with the ICM recommendation of weight-based cefazolin, in the absence of β-lactam allergy, administered within 30 minutes of incision.[10] Recent evidence for cefazolin includes a large observational study of 7 713 primary shoulder arthroplasties which found that cefazolin was associated with a significantly lower risk of PJI compared to alternatives such as vancomycin or clindamycin.[21] In the event of MRSA positivity, the ICM recommended the addition of vancomycin to cefazolin.[10]

Perioperatively, 55% of respondents used Biotaine (0.5% chlorhexidine gluconate + 70% isopropyl alcohol) only as a pre-incision skin preparation. This choice reflects the ICM recommendation,[10] which, in turn, is based on the level 1 evidence provided by Saltzman et al.[22] These authors randomised patients undergoing shoulder surgery to receive ChloraPrep (2% chlorhexidine gluconate + 70% isopropyl alcohol), DuraPrep (0.7% iodophor + 74% isopropyl alcohol), or povidone-iodine scrub and paint (0.75% iodine scrub + 1.0% iodine paint) as a skin preparation and performed skin cultures.[22] They found that ChloraPrep was more effective at reducing bacterial burden than DuraPrep or povidone-iodine, and that povidone-iodine was the least effective of the three products overall.[22] DuraPrep and a povidone-iodine product, Peviderm, were used by 18% and 12% of respondents, respectively. Although a link between skin preparation and the incidence of shoulder PJI has not been demonstrated, the available evidence suggests that chlorhexidine in alcohol may be the better option for infection prevention.[22]

Finally, 73% of respondents indicated that they did not routinely shave or clip axillary hair. A Cochrane review published in 2021 concluded that there was moderate-certainty evidence that shaving increased the risk of surgical site infections compared to clipping or to no hair removal in a variety of surgeries.[23] There appeared to be little difference in infection risk between clipping and no hair removal.[23] In one of the few shoulder-specific studies on this topic, clipping axillary hair was associated with increased bacteria before, but not after, skin preparation with ChloraPrep.[24] Thus the available evidence appears to support not removing axillary hair or, if necessary, doing so with clippers followed by antiseptic skin preparation.[23,24]

Intraoperative measures

The third finding of the study was that although a large majority of respondents used TXA (94%, always or sometimes) and antibiotic-impregnated cement (88%, always or sometimes) in primary shoulder arthroplasty, the ICM was reticent about these measures, stating that there was insufficient evidence to make a recommendation.[10] There was no majority response regarding the use of topical antibiotics before wound closure, although povidone-iodine irrigation was used by just under half of respondents (46%). The ICM did not make a recommendation regarding topical wound antiseptics during shoulder arthroplasty but noted that povidone-iodine lavage and vancomycin powder may have a role in patients considered at high risk of PJI, based on evidence from other orthopaedic surgeries.[10] The remaining intraoperative measures surveyed were not addressed by the ICM.

Double gloving was practised by most respondents (98%), although only two-thirds (69%) reported changing gloves during the surgery. A Cochrane review found that double gloving significantly reduced perforation of the inner gloves, and a systematic review found that changing gloves significantly reduces contamination rates.[25,26] It was recommended that gloves be changed after draping, before handling implants, in the event of visible perforation and, over and above the former reasons, at least once an hour.[26] For both double gloving and changing gloves, the benefit for infection prevention is implied through surrogate measures such as perforation and contamination; however, there is currently little evidence directly linking these practices to reduced incidence of shoulder PJI.[26] Lack of direct evidence is a common problem in shoulder arthroplasty infection prevention measures as the low incidence of shoulder PJI necessitates very large sample sizes to detect a between-group effect.

Other measures intended to reduce contamination intraoperatively include adhesive drapes.[27] Iodine-impregnated antimicrobial drapes (e.g. Ioban) and plain, non-antimicrobial drapes were used by 50% and 40% of respondents, respectively, suggesting that 90% of respondents used some form of drape. A systematic review investigated the use of adhesive drapes for infection prevention in orthopaedic surgery and found that drapes significantly reduced wound contamination.[27] Notably, limited evidence suggests that peel back of the drape during the procedure negates any potential infection prevention benefit.[27] Overall, the systematic review found insufficient evidence to form a conclusion regarding adhesive drapes and surgical site infections.[27]

As with the use of drapes, changing blades was very common, with 83% of respondents applying this measure. There is limited available evidence for changing blades to reduce infection risk, especially specifically relating to shoulder arthroplasty. Two studies found that *C. acnes* was cultured from the incision blade in 10–12% of patients undergoing shoulder arthroplasty, despite a rigorous infection prevention protocol.[28,29] While stronger evidence is required,[21] the available findings appear to support changing

blades after incision, particularly given that this is a relatively inexpensive precaution.[29]

TXA was widely utilised among respondents, with only 6% indicating that they did not use this agent. There is high-quality evidence that use of TXA reduces blood loss in shoulder arthroplasty.[30] However, a meta-analysis failed to show any reduction in postoperative infection in shoulder arthroplasty following the use of TXA.[31] Likewise, a multicentre cohort study of 9 276 patients, found a very similar safety profile between those who did and did not receive TXA when undergoing shoulder arthroplasty, and no difference in the probability of revision for deep infection within five years.[32] As noted by the ICM, there may be justification for use of TXA in patients at high risk for blood transfusion.[10] However, at present, there is a lack of evidence to support its routine use in primary shoulder arthroplasty,[31,32] as practised by 71% of the survey respondents.

Regarding intraoperative antibiotic prophylaxis, redosing of antibiotics for procedures greater > 2 hours and routine use of antibiotic-impregnated cement were practised by 71% and 81% of respondents, respectively. Redosing antibiotics is in keeping with the following recommendation from an international working group: additional antibiotics should be given for procedures exceeding two antibiotic half-lives (a time period of four hours for cefazolin) or procedures involving blood loss > 1.5 L.[33] Despite its popularity, direct evidence supporting the use of antibiotic-impregnated cement in primary shoulder arthroplasty is limited to a single retrospective study with a notable risk of confounding.[10,34] Further studies are available in the context of hip and knee arthroplasty.[33,35] However, recent critical analysis of this evidence concluded that further research is required to justify routine prophylactic use of antibiotic-impregnated cement, especially from a cost-effectiveness perspective.[36,37] This aligns with the ICM's conclusion that there is insufficient evidence to determine whether this measure should be used in shoulder arthroplasty.[10]

Finally, there was no predominant approach to the use of topical intrawound antibiotics prior to wound closure among survey respondents, with povidone-iodine lavage receiving the most responses (46%). The ICM noted that, based on evidence from other orthopaedic surgeries, there may be a role for povidone-iodine lavage and for vancomycin powder in patients deemed at high risk of PJI.[10] For example, a systematic review found that povidone-iodine lavage reduced the incidence of PJI in total hip or knee arthroplasty compared to saline.[38] Nevertheless, another review concluded that further clinical studies are needed to establish optimal irrigation protocols for shoulder arthroplasty, considering both effective antimicrobial action and low cytotoxicity.[39] Regarding the method of wound closure, 86% of respondents used absorbable sutures only. A meta-analysis which compared sutures of various types to staples following orthopaedic surgery found no difference in surgical site infection.[40] However, there appears to be little available evidence or expert consensus specific to shoulder arthroplasty to inform a preferred closure method.

Postoperative measures

The fourth finding of the study was that there was strong respondent consensus for continuing antibiotics until 24 hours postoperatively (89%), which was directly in keeping with the ICM recommendation.[10] In contrast, more recent publications argue against continuing antibiotics after surgery.[33,35] A meta-analysis found a significant reduction in the incidence of PJI when patients received a single dose versus extended antibiotic prophylaxis in hip and knee arthroplasty.[35] However, the authors expressed caution in generalising these findings to other clinical settings due to heterogeneity in antibiotic protocols, and the potential for bias in the observational studies included.[35] To our knowledge, single dose versus extended antibiotics have not been investigated in shoulder arthroplasty.

Regarding drains in shoulder arthroplasty, respondents were not asked whether they used a postoperative drain but rather, if they used one, when did they remove the drain. Most respondents (70%) indicated removing the drain within 24 hours postoperatively. The ICM found insufficient evidence to make a recommendation regarding postoperative drains.[10] However, the survey responses were in keeping with a study published in 1995, which found a notable increase in the frequency of drain tip contamination from 24 hours following hip or knee arthroplasty.[41] Regarding the use of drains in general, a randomised controlled trial found no difference in short-term perioperative outcomes with the use of a closed suction drain, and concluded that postoperative drains were unnecessary for shoulder arthroplasty in the presence of TXA.[42]

There are limitations to this study. Although the survey included a large proportion of South African shoulder arthroplasty surgeons, it was not a random sample, and the extent to which the findings can be generalised to the total population of South African shoulder arthroplasty surgeons is unclear. It is also acknowledged that surveys may be subject to certain types of bias such as recall bias, which may affect the responses provided. Finally, low response rates to questions on antibiotics before wound closure, the duration of antibiotics postoperatively and removal of postoperative drains limited interpretation of these findings.

Conclusion

This survey on infection prevention measures in primary shoulder arthroplasty found a majority response for most items, indicating reasonable consensus among the participating South African orthopaedic surgeons. The majority response was generally in keeping with ICM recommendations, with the exception of routine use of TXA and antibiotic-impregnated cement. These measures were very common among respondents but were deemed by the ICM to have insufficient evidence. A minority of respondents indicated practices that may have room for improvement in reducing PJI risk. Improvements include waiting three months instead of one month between an intra-articular steroid injection and shoulder arthroplasty, and using a chlorhexidine product instead of a povidone-iodine product for pre-incision skin preparation. In future, widespread engagement with the South African Orthopaedic Registry may allow research into the incidence of shoulder PJI in our setting – the true indicator of effective infection prevention.

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 following ethical review board: Health Research Ethics Committee of Stellenbosch University (reference number N23/03/018). 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. Participation in the study was voluntary and entirely anonymous. Completion of the survey was taken as consent to participate 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

RK: study conceptualisation, study design, data capture, first draft preparation
TNM: study conceptualisation, study design, data analysis, manuscript preparation
CA: study design, manuscript revision
JFdB: study design, manuscript revision

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