Original Article

Management of deep surgical site infections of the spine: a Canadian nationwide survey

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Background: Deep surgical site infections after spinal instrumentation represent a significant source of patient morbidity and poorer outcomes. Given lack of evidence or guidelines on the variety of procedural options in the management of deep spine surgical site infections, the purpose of this survey was to document and investigate the use of these techniques across Canada.

Methods: A 34-question survey evaluating surgical techniques for irrigation and debridement in postoperative thoracolumbar infection was distributed to Canadian adult spine surgeons. Results were analyzed qualitatively, and comparisons by specialty, years of training, and number of cases were completed using Fischer's exact tests. We defined consensus as >70% agreement.

Results: We received 53 responses (62% response rate) from a comprehensive sample of Canadian adult spine surgeons. There was a consensus to retain hardware (80%) and interbody implants (93%) in acute infection, to retain interbody implants in chronic/recurrent infection (71%), and application of topical antibiotics in recurrent infection (85%). There was consensus on the use of absorbable suture to close fascia in acute (83%) and chronic (87%) infection. Eighty-five percent of surgeons used nonabsorbable materials such as Nylon or staples for skin closure in chronic infection, however, there was no consensus in acute infection. Surgeons varied significantly in type, volume and pressure of fluids, adjuvant solvents, graft management, use of topical antibiotics acutely, and the use of negative pressure wound therapy. Partial hardware exchange was controversial. Additionally, specialty or surgeon experience had no impact on management strategy.

Conclusions: This survey demonstrates significant heterogeneity amongst Canadian adult spine surgeons regarding key steps in the surgical management of deep instrumented spine infection, concordant with scarce literature addressing these steps.

Keywords: Spinal infection; deep surgical site infection; irrigation and debridement

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Introduction

Deep surgical site infections occur after posterior thoracolumbar instrumentation of the spine at a rate of 2–20% (1-5). These are associated with significant patient morbidity, prolonged hospitalization (6), poorer long-term outcomes (7) and high costs to the healthcare system (8,9). Generally, the approach to treatment involves surgical irrigation and debridement with subsequent antimicrobial therapy (10). Failure to achieve eradication of infection after surgical debridement and antibiotic therapy has been reported in up to 24% of patients (11).

The irrigation and debridement procedure generally involve a meticulous, layer by layer removal of any devitalized tissue, with fluid irrigation of the surgical site (10). There are currently no best practice guidelines with more specific recommendations regarding the surgical details of this procedure in the literature. Furthermore, no consensus guidelines from any major spine surgical organization exist on the advised best practice management of this surgical complication.

The volume, type of solvent, irrigation pressure and management of bone graft have not been studied. Bone graft, especially allograft, may be considered a nidus for infection and risk factor for infection recurrence (12); however, if removed in full this increases the risk for pseudarthrosis and hardware related complications. While there are theoretical benefits to hardware exchange, some authors suggest higher rates of reoperation and death with removal of hardware at initial washout (13). Other investigations have advocated for complete removal and exchange of hardware at the time of initial washout (14-16). Closure techniques vary (17) and the use of drains (17) or vacuum assisted closure (14,15) has mixed recommendations.

Given the lack of research and consensus on the variety of procedural options involved in the management of deep surgical site infections, the purpose of this survey was to investigate the surgical techniques amongst complex adult spine surgeons across Canada. We present the following article in accordance with the SURGE reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-22-47/rc).

Methods

Survey development

A multi-stage development strategy was utilized to create our survey. Following a detailed review of the available literature on management options, a template was developed in keeping with previously published guidelines for academic survey development (18-20). Following this, a five-person focus group reviewed the template including two academic orthopaedic spine surgeons, one academic neurosurgeon and two spine surgery fellows. The focus group provided increased clarity, readability, and generalizability to the survey, while minimizing bias.

Ultimately, a 34-item questionnaire was developed by the authors with a 6-question demographic section (see *Table 1*) and 28-question practice preference section; divided into management of acute, and recurrent infection (see *Table 2*). The survey was administered via SurveyMonkey (https://www.surveymonkey.com/, Palo Alto, California). The survey link was delivered via three rounds of emails, delivered weekly over a three-week period to current practicing Canadian complex adult spine surgeons. Surgeons were identified at every Canadian centre providing spine surgery through departmental pages, and individual contacts at each site were queried to ensure that other respondents, potentially situated at satellite campuses, were not missed. A cover letter introducing the study to potential survey respondents was created by the study team and sent by the project Principal Investigator (C Oitment), to outline the study objective, explain passive consent via survey completion, emphasising the confidential and anonymized nature of the questionnaire, and providing an approximate time for survey completion. No incentives were provided for completion of the survey. Given that this was a questionnaire of expert clinicians with no appeal to patient specific information, Ethics Board approval was not required based on institutional guidelines.

The questionnaire was divided into two parts; acute and recurrent infection (see *Table 2*). Part I, "Acute Infection", provided the following prompt: "For the purposes of this questionnaire, assume an acute infection to refer to a clinically obvious infection of an instrumented thoracolumbar fusion, which occurs during the immediate post-operative period". We allowed respondents to determine the time period that defined an infection as acute. Part II, "Recurrent Infection", began with the following prompt: "For the purposes of this survey, consider recurrent infection to represent ongoing, clinically obvious infection after initial irrigation and debridement. The sample case would be a 2–3 level instrumented lumbar decompression and fusion which recurs after initial washout".

The survey began with an initial screening question

Table 1 Demographic information of included participants

Questions	Percentage [N]
Surgical training background	
Orthopedic surgery	71.4 [30]
Neurosurgery	28.6 [12]
Province of practice	
British Columbia	7.0 [3]
Alberta	9.3 [4]
Manitoba	0 [0]
Saskatchewan	0 [0]
Ontario	74.4 [32]
Quebec	4.7 [2]
Nova Scotia	2.3 [1]
Prince Edward Island (PEI)	0 [0]
Newfoundland	0 [0]
New Brunswick	2.3 [1]
Number of years in practice	
<5	20.9 [9]
5–9	14.0 [6]
10–19	32.2 [13]
≥20	34.9 [15]
Location of practice	
Academic	86.0 [37]
Community	14.0 [6]
Number of spine surgeries per year	
<200	33.3 [14]
200–299	50.0 [21]
300–399	14.3 [6]
≥400	2.4 [1]

asking whether the respondent would routinely manage an infection of the instrumented thoracolumbar spine. If the respondent indicated that they did not routinely manage this condition, the respondent was immediately disqualified, and no further responses were collected.

Respondents

Participants were selected from each academic institution as being surgeons mainly practicing in complex adult spine surgery. Responses were requested from surgeons practicing at every major academic institution in Canada, across all provinces. Surgeons practicing primarily in pediatric spine surgery were excluded. Neurosurgeons with primarily non-spine practices were also excluded.

Statistical analysis

Data were anonymized, and statistical analyses were conducted in the program R; version 4.1.0. Categorical data are summarized as counts and reported in *Table 1* and *Table 2*. Fischer's exact test accounted for the differences between categorical data. P values were two-tailed, with an *a priori* alpha value defined at 0.05 for statistical significance. Data was 94% complete with missing data imputed with multiple imputations using chained equations technique (R package mice). Imputed values used predictive mean matching using the first iteration with five imputations. The response rate was calculated by dividing the number of responses [53] by the number of invitations distributed [86]. Questions were optional (respondents were not required to answer all to proceed) and completion was only considered achieved when respondents answered all questions in the survey.

Consensus

The aim of this survey is to identify areas of consensus or discordance between surgeons in management strategies. Though 'consensus' is difficult to define, we *a priori* defined consensus liberally as >70% agreement between respondents.

Results

Eighty-six complex adult spine surgeons were contacted with first administration of the survey on January 15, 2022. Shortly following a second reminder email on January 27, a 61.6% response rate (53 responses) was achieved. Three of 53 respondents indicated that they were not comfortable managing infected posterior thoracolumbar instrumentation at which point the survey was terminated. These were counted as incomplete surveys. Survey completion rate was 77% with a 7-minute average time to completion. Demographic information regarding participants is included in *Table 1*. Most respondents (52.5%, 21/40) considered acute infections to be within a timeframe of 12 weeks, and

Table 2 Questions administered to participants regarding acute, as well as recurrent/ongoing infections with management options and responses

Questions	Acute thoracolumbar infections, percentage [N]	Ongoing or recurrent thoracolumbar infections, percentage [N]
At what point do you consider a post-operative thoracolumbar infection chronic, rather than acute?		–
>3 weeks	7.5 [3]	
>6 weeks	32.5 [13]	
>9 weeks	7.5 [3]	
>12 weeks	52.5 [21]	
What is your primary method of irrigation		–
Gravity/manual pouring	61.0 [25]	
Power/pulse lavage	26.8 [11]	
Manual bulb syringe	12.2 [5]	
Other	0.00 [0]	
What is the main solution used for irrigation?		
Normal saline	48.8 [20]	50.0 [20]
Bacitracin	39.0 [16]	37.5 [15]
Other	12.2 [5]	12.5 [5]
Do you routinely use other agents (check all that apply)		–
Proviodine	55.9 [19]	
Peroxide	52.9 [18]	
Chlorhexidine	5.9 [2]	
Bleach/Dakin solution	0.0 [0]	
Other	0.0 [0]	
How many litres of solution would you routinely utilize for irrigation?		
<3.1 L	26.8 [11]	27.5 [11]
3.1–6.0 L	43.9 [18]	32.5 [13]
6.1–9.0 L	24.4 [10]	30.0 [12]
>9.0 L	4.9 [2]	10.0 [4]
Do you remove posterolateral bone graft?		
Yes, allograft only	4.9 [2]	0.0 [0]
Yes, all bone graft	31.7 [13]	53.7 [22]
Retain all posterolateral graft	9.8 [4]	4.9 [2]
Only loose graft is removed	53.7 [22]	41.5 [17]
If yes, bone graft is removed, what is your subsequent management?		
Place new autograft at time of washout	10.3 [4]	7.9 [3]
Place new allograft at time of washout	7.7 [3]	5.3 [2]
Return for grafting once infection is cleared	10.3 [4]	15.8 [6]

Table 2 *(continued)*

Table 2 *(continued)*

Questions	Acute thoracolumbar infections, percentage [N]	Ongoing or recurrent thoracolumbar infections, percentage [N]
Return for grafting only if the patient becomes:	51.3 [20]	48.7 [19]
Symptomatic with pseudarthrosis or loose		
Hardware		
Do not place new graft in any circumstance	20.5 [8]	23.1 [9]
Assuming the hardware is stable (not loose) and in satisfactory position, how do you manage hardware?		
Retain all hardware	80.4 [33]	35.0 [14]
Exchange set screws/rods	14.6 [6]	17.5 [7]
Exchange all hardware	0.0 [0]	47.5 [19]
Other	5.0 [2]	0.0 [0]
In the past year, have you considered a partial hardware exchange (e.g., set screws and rods) for an acute infection?		–
Yes	41.5 [17]	
No	58.5 [24]	
If there is an interbody fusion, do you		
Retain cages/interbody graft	92.7 [38]	72.5 [29]
Remove and exchange cages/interbody graft	0.0 [0]	10.0 [4]
Remove cages/interbody graft all together	0.0 [0]	5.0 [2]
Other	7.3 [3]	12.5 [5]
Do you use topical antibiotics prior to closure?		
Topical glycopeptides (e.g., vancomycin powder)	58.5 [24]	65.0 [26]
Topical aminoglycoside (e.g., tobramycin powder or pellets)	2.4 [1]	15.0 [6]
No topical antibiotics	26.8 [11]	12.5 [5]
Other	12.2 [5]	7.5 [3]
What suture material do you use to close fascia?		
Braided absorbable (e.g., vicryl)	63.4 [26]	62.5 [25]
Braided nonabsorbable (e.g., Ticron)	2.4 [1]	2.5 [1]
Monofilament absorbable (e.g., monocryl)	19.5 [8]	25.0 [10]
Monofilament nonabsorbable (e.g., prolene, nylon)	14.6 [6]	10.0 [4]
What suture material do you use to close skin?		
Braided absorbable (e.g., vicryl)	2.4 [1]	2.5 [1]
Braided nonabsorbable (e.g., Silk)	0.0 [0]	0.0 [0]
Monofilament absorbable (e.g., monocryl)	12.2 [5]	12.5 [5]
Monofilament nonabsorbable (e.g., prolene, nylon)	51.2 [21]	60. [24]
Staples	34.1 [14]	25. [10]

Table 2 *(continued)*

Table 2 *(continued)*

Questions	Acute thoracolumbar infections, percentage [N]	Ongoing or recurrent thoracolumbar infections, percentage [N]
Do you routinely utilize an incisional vacuum dressing after irrigation and debridement?		–
Yes	39.0 [16]	
No	61.0 [25]	
How long do you routinely recommend antibiotics after the diagnosis of infection (with instrumentation)?		
<6 weeks	2.4 [1]	0.0 [0]
6 weeks	46.3 [19]	10.0 [4]
3 months	31.7 [13]	20.0 [8]
>3 months	4.9 [2]	40.0 [16]
Other time period (please specify)	14.6 [6]	22.5 [9]
Lifelong	N/A	7.5 [3]
If a patient has had a decompression only (no hardware), please indicate your recommended duration of antibiotics		–
<6 weeks	41.5 [17]	
6 weeks	53.7 [22]	
3 months	4.9 [2]	
>3 months	0.0 [0]	
Are there any circumstances in which a patient with an acute post-operative surgical site infection would be recommended life-long suppressive antibiotics?		–
Yes	46.3 [19]	
No	53.7 [22]	

32.5% (13/40) defined their cut-off at 6 weeks. Results are divided into details of the irrigation and debridement (type of fluids, volume of fluids, method of fluid administration), management of bone graft, management of hardware, topical antibiotics and closure and post-operative antibiotics. Complete individual questions and responses are available in *Table 2*.

Irrigation and debridement

The primary method of irrigation for acute infection was gravity/manual pouring of fluids for 61.0% (26/42) of participants, with 26.8% (11/42) utilizing power/pulse lavage and 12.2% (5/42) utilizing manual bulb syringe. For acute posterior thoracolumbar infections, the primary solution was normal saline in 49% (21/42) of participants with 39% (16/42) utilizing bacitracin solution. Most respondents utilized adjuncts such as proviodine (56%) or peroxide (53%), few used chlorhexidine (6%; 2/34), and 29.4% (10/32) of respondents indicated using no adjuncts other than their main irrigant. No respondents indicated using bleach or Dakin's solution. For recurrent/ongoing thoracolumbar infections, 51% (21/41) utilized normal saline primarily, 37% used bacitracin (13/41), and 13% preferred "alternative solutions" such as a vancomycin wash.

In terms of volume used, for acute thoracolumbar infections, 27% (11/42) utilized <3.1 L for washout, 44% (19/42) utilized 3.1–6.0 L, 24% (10/42) used 6.1–9.0 L and 4.9% (2/42) utilized >9.0 L. In the setting of recurrent/ongoing infection 28% (11/41) used <3.1 L, 32% (13/41) used 3.1–6.0 L, 32% (13/41) used 6.1–9.0 L, and 10% (4/41) of participants utilized >9.0 L.

Management of bone graft

For acute thoracolumbar infections, 5% (2/42) of

participants removed allograft only, 32% (14/42) removed all bone graft, 9.8% (4/42) retained all bone graft and 54% (22/42) removed only loose graft (whether allograft or autograft). If bone graft was removed, 10% (4/39) placed new autograft at the time of washout, 8% (3/39) replaced the graft with allograft, 10% (4/39) staged a fusion procedure when the infection was cleared, 51% (20/39) return for grafting only if the patient becomes symptomatic with pseudarthrosis or loose hardware, and 20% (8/39) do not place new graft under any circumstances.

In recurrent/ongoing infections no (0%) participants removed allograft only, 54% (22/41) removed all graft, 5% (2/41) retained all graft and 41% (17/42) removed only loose graft. In this case, 8% (3/39) place new autograft at the time of washout, 5% (2/39) use allograft, 15% (6/39) stage bone grafting, 49% (19/39) only return for bone graft if the patient becomes symptomatic, and 23% (9/39) do not place graft under any circumstances.

Management of hardware

Participants were instructed to assume that hardware was stable (not loose) and in satisfactory position and then questioned as to their management of the hardware in the settings of both acute and recurrent infection. For acute infections, 83% (34/41) indicated that they routinely retain all hardware, 15% (6/41) performed a partial hardware exchange (set screws/rods) and no respondents (0%) exchanged all hardware. A single respondent reported removing hardware acutely and returning to re-instrument once the infection is cleared. Forty-three percent (18/42) of respondents indicated that they had considered a partial hardware exchange for acute infections in the last year.

In recurrent infections, 34% (14/39) retain all hardware, 20% (8/39) perform partial hardware exchange, and 46% (19/39) exchange all hardware.

For interbody implants, respondents were asked to distinguish between stable and loose implants. Interbody implants were routinely retained by 95% (40/42) of respondents for acute infections, with 5% (2/42) only removing cages if loose. In recurrent/ongoing infection, 71% (29/41) retain cages, 10.0% (4/41) exchange cages, 5.0% (2/41) remove cages all together and 15% (6/41) remove loose cages.

Topical antibiotics and closure

For acute thoracolumbar infections, prior to closure, topical glycopeptides (e.g., vancomycin powder) were used by 59% (25/42) of respondents, one respondent (2%) used aminoglycosides (e.g., tobramycin powder/pellets), 33% (14/42) used no topical antibiotic and 5% (2/42) utilized other topical agents.

For ongoing/recurrent infection topical glycopeptides are used by 66% (27/41) of respondents, 17% (7/41) utilize aminoglycosides, 15% (6/41) utilize no topical antibiotics and one used topical Cefazolin.

In acute infection, fascia was closed with braided absorbable sutures (such as Vicryl) by 62% (26/42) of participants, 2% (1/42) used braided nonabsorbable (such as Ticron), 21% utilized an absorbable monofilament (9/42) and 14% (6/42) utilized a nonabsorbable monofilament suture. Skin was closed using nonabsorbable monofilament by the majority of respondents; 52% (22/42). Thirty-three percent (14/42) used staples, 12% (5/42) preferred absorbable monofilament, and 2% (1/42) used braided absorbable sutures.

Similarly, in recurrent/ongoing infections 61% (25/41) used braided absorbable suture, 2% (1/41) used nonabsorbable braided, 27% (11/41) used absorbable monofilament, and 10% (4/41) used nonabsorbable monofilament. For skin closure in recurrent infection, 61% (25/41) utilize nonabsorbable monofilament, 24% (10/41) use staples, 12% (5/41) utilize absorbable monofilament, and 2.5% (1/41) use absorbable braided suture.

Negative pressure vacuum assisted closure was utilized by 38% (16/42) of respondents for acute infection.

Analysis by specialty, years of training, and number of cases

Fischer's exact tests failed to identify any statistical differences between type of training (Orthopedic *vs.* Neurosurgery) and answer responses to any questions. These tests also failed to provide any statistical difference in years of training or number of cases performed yearly, in response to any of the questions on the survey.

Discussion

Deep spinal surgical site infections are a challenging complication of instrumented thoracolumbar spine surgery. Herein we present a relatively large survey of Canadian complex spine surgeons with a high response rate. There was a consensus to retain hardware (80%) and interbody implants (93%) in acute infection, to retain interbody implants in chronic/recurrent infection (71%),

and application of topical antibiotics in recurrent infection (85%). There was consensus on the use of absorbable suture to close fascia in acute (83%) and chronic (87%) infection. Eighty-five percent of surgeons used nonabsorbable materials such as Nylon or staples for skin closure in chronic infection, however, there was no consensus in acute infection. Aside from these points, there was significant heterogeneity in type, volume and pressure of fluids, adjuvant solvents, graft management, use of topical antibiotics acutely, and the use of negative pressure wound therapy. Partial hardware exchange was controversial.

Currently no level one evidence exists, and there are no published guidelines from major spine society organizations regarding surgical management of spinal infections. A recent systematic review by Lall *et al.* (21) on the management of surgical site infection after spinal instrumentation found that all published literature advocated for early surgical debridement and antibiotic therapy. They also found that hardware retention was generally successful in acute infection, whereas removal was necessary in delayed hardware infections with high rates of treatment failure with hardware retention. This is consistent with the answers from our respondents.

Hersh *et al.* (13) [2021] performed a systematic review of removal of instrumentation of post-operative spine infections. Five of 15 studies were found to document rates of instrumentation removal in early and late infection. Seventeen of 160 (11%) patients underwent instrumentation removal in early infections compared to 99/172 (58%) of patients with instrumentation removal in chronic infections (13). The author concluded that retention of hardware in early infections is preferred to maintain spinal stability. However, in late infection, removal of hardware is often necessary to eradicate colonized bacteria in the mature biofilm adherent to the hardware.

The decision to remove hardware can also be influenced by location of the infection and length of construct. Pull ter Gunne *et al.* (22) suggest that infections superficial to the fascia do not require hardware removal and in their series, 73% (35/48) of superficial surgical site infections were treated without surgical debridement. It should be noted that in practice differentiation of superficial and deep infections can be difficult and treating most infections as deep has been suggested (23). In addition, increasing length of the instrumented construct may be associated with lower rates of hardware exchange in the setting of infection (24), however, this survey was not designed to detect such differences.

Failure to eradicate infection in the setting of chronic infection with hardware retention range from 50% (25) to 100% (26). Our survey indicates that Canadian surgeons have higher rates of hardware exchange with recurrent/ongoing infection; however still 34% of respondents retain all hardware and 20% perform a partial hardware exchange (set screw/rod removal with retention of screws) for recurrent infection. To our knowledge, there is no evidence in the literature currently to support partial hardware exchange.

Interestingly, despite risks for non-union/pseudarthrosis and delayed hardware complications, few surgeons provide any graft substitute when removing graft at the time of surgical debridement. Most surgeons remove all graft at the initial debridement. In recurrent infection, most surgeons indicate they would either stage a procedure for fusion or return if the patient becomes symptomatic from nonunion.

With respect to preferred irrigation technique in the setting of a deep spinal infection, most surgeons utilize gravity/manual pouring of fluids over more aggressive pressure washing/pulse lavage, with normal saline being the preferred primary solution for both acute and chronic infections. Counter-intuitively, the strategy for clearing infection does not appear to rely on volume of fluid, nor antimicrobial fluid irrigation, as similar volume and type of fluid was utilized for both acute and recurrent infection. The responses that changed significantly between acute and recurrent infection management were removal of bone graft, and tendency toward hardware exchange, both of which were more frequent in chronic/recurrent infection.

We report on a comprehensive population of surgeons across the country with a diversity of experience and background. The Canadian healthcare system is unique in being a single-payer public system, so this may bias some respondents towards resource conservation. Despite this unique commonality, we still found little agreement in our data and believe our results to be generalizable to other populations and countries offering complex spine surgery. Our data analysis did not yield any significant differences in management strategy based on surgical background (orthopedic versus neurosurgery), years of training, or number of cases performed yearly. This reflects the fact that neither specialty nor experience can inform practice management in the absence of clinically relevant data. There is a need for future studies to clarify the rates of failed irrigation/debridement, quantify the morbidity and costs associated with deep surgical site infections as well as subsequent failed treatment. This study is limited by the complexity of clinical decision-making around infection

management, the case-specific factors of which are difficult to capture in a multiple-choice survey. Given survey anonymity, we are unable to comment on demographic differences of non-responders, which may be a potential source of bias. Even so, this survey demonstrates that this is a complex problem with variable management strategies predicted neither by surgeon background nor by patient factors. Given the heterogeneity of practice across Canadian surgeons, a consensus statement is needed to guide the treatment of surgical site infections. The areas of controversy in this questionnaire should be targeted for areas of future study, including type, volume and pressure of fluids, adjuvant solvents, management of graft, and use of topical antibiotics.

Conclusions

This survey is the first to investigate opinions regarding surgical management of instrumented spine surgical site infection across the entire body of Canadian adult spine surgeons. The results demonstrate scant agreement between surgeons in the management of deep surgical site infection following instrumented thoracolumbar fusion. We highlight the need for higher quality evidence and subsequently, guidelines for surgical management. We have identified eight main areas for future study including type, volume and pressure of fluids, adjuvant solvents, management of graft and hardware, utility of intrawound antibiotics, and closure techniques.

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Footnote

Reporting Checklist: The authors have completed the SURGE reporting checklist. Available at https://jss.amegroups.com/article/view/10.21037/jss-22-47/rc

Peer Review File: Available at https://jss.amegroups.com/article/view/10.21037/jss-22-47/prf

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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