Cohort Study

Predictors of failure after initial arthroscopic washout in septic arthritis of native knee joint- a retrospective analysis

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A B S T R A C T

Background: Acute septic arthritis of the knee is an orthopaedic emergency requiring prompt debridement and washout to reduce infection. However, more than one washout procedure may be required to eradicate infection. This study was performed to analyse the factors associated with the failure of a single arthroscopic washout.
Methods: This is a retrospective analysis of 78 patients with septic arthritis of the knee over 6 years from January 2015 from a single trauma centre. We analysed the variables like patient demographic factors, comorbidities, laboratory parameters and various operative and non-operative factors with regard to the outcome after a single arthroscopic washout. Statistical analysis using univariate and multivariate logistic regression analysis were performed to identify the variables associated.
Results: Out of the 78 patients who underwent arthroscopic washout for a diagnosis of septic arthritis, 31 patients (39.74%) had failure of a single arthroscopic washout, with six patients (7.69%) requiring two additional washouts and one patient (1.28%) requiring three additional washouts to eradicate infection. Statistical analysis identified high temperature at presentation (p value 0.084), BMI >45 (p value 0.025), high CRP (0.014), high neutrophil count (p value 0.113) and high creatinine (p value 0.111) as the predictors of failure of a single arthroscopic washout.
Conclusion: A high failure rate (39.74%) was seen with a single arthroscopic washout procedure. A high BMI, elevated CRP, higher temperature at presentation, elevated neutrophil count were identified as the predictors of failure of a single arthroscopic washout for septic arthritis of the knee in our study.

1. Introduction

Septic arthritis is the infection of the synovial fluid and joint surface affecting its structure and function significantly. Therefore, early diagnosis and prompt management are essential to avoid functional impairments and long-term consequences [1–3]. The incidence of septic arthritis has been reported to be around 1 to 10 cases per 100,000 population per year with a still higher rate seen after 50 years of age [1–4].

The evaluation of suspected septic arthritis includes clinical examination and analysis of laboratory findings.5 While the clinical features include raised local temperature, pain, effusion, redness, limitation of movements and function, the laboratory blood parameters include white

blood-cell (WBC) count, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and blood cultures [1]. Joint aspiration is useful to find out synovial-fluid cell count, crystals, Gram stain and cultures.

The management of septic arthritis not only relies on blood parameters, Gram stain and cell count, but also on the clinical findings [2]. The definitive management in proven or suspected cases includes surgical irrigation followed by antibiotics. An arthroscopically performed surgical debridement and irrigation combined with antibiotics has been the preferred method of washout by various authors and promising outcomes [3,5–10]. A successful washout not only relieves the symptoms but also reduces the infection. However, a single procedure may not always eradicate the infection, and more than one debridement and irrigation may be required [11]. The incidence of the requirement of

additional washouts has been noted to be 23%–48% according to various studies [2,5,12]. In all these studies, they have included multiple native joints. Since knee is the commonest affected joint [2], it is useful to analyse and predict the various patient factors, clinical and laboratory factors that contribute to persistent symptoms, and manage accordingly.

The present study aimed at analysing the failure rates of a single arthroscopic washout procedure for a clinical diagnosis of septic arthritis of the knee and to analyse the predictors of persistent symptoms of infection including patient comorbidities, social factors, laboratory parameters and various operative and non-operative factors.

2. Materials and methods

This study is a retrospective analysis of patients who underwent arthroscopic washout of the knee for a clinical diagnosis of septic arthritis of the knee. We included a cohort of patients operated between January 2015 and May 2021 from a single tertiary referral centre for trauma and orthopaedics. The data was collected from the hospital electronic database. An institutional review board approval was obtained before performing the analysis (registration number- CA 26421), and the work has been reported in line with the STROCSS criteria [13].

We included patients with age 18 or above and with the clinical diagnosis of native knee septic arthritis for whom at least one arthroscopic washout procedure was performed. There were 78 patients included, of which one patient had bilateral involvement. We excluded non-hematogenous causes for septic arthritis like trauma and knee surgeries. We also excluded open knee washout cases.

The patients who referred to the orthopaedic team from the emergency department, in-patient wards or general practitioners (GP) with clinical features suggestive of septic arthritis. They were assessed by the on-call orthopaedic team. After making a clinical diagnosis of septic arthritis, the knees were aspirated under aseptic precautions and samples were sent for culture, Gram stain and crystal analysis.

Those patients who had native knee joint infection confirmed by clinical and laboratory parameters underwent arthroscopic washout of knee as the index procedure. All the cases were operated by an orthopaedic consultant or a senior registrar. The number of arthroscopic portals and the volume of sterile saline used for washout were decided by the operating surgeon during the procedure. The irrigation (washout) was performed until the circulating saline had become clear in appearance.

Intraoperative synovial fluid samples were sent for culture, and then the patients were started on antibiotics as per microbiology advice. In the cases were vancomycin was given as per the culture sensitivity, their concentration was monitored, and optimal concentration was achieved in all those cases. Some of the patients were already started on antibiotics either by GP or by the responsible team when they were already in-patients. Intraoperative findings in terms of the nature of fluid washed out, synovial changes and cartilage damage were noted in the operative notes, and based on this Gächter scores were calculated for the analysis [8,9,14].

The parameters included for the analysis were patient demographics, comorbidities, synovial fluid characteristics, blood parameters, in-patient observations and various peri-operative parameters. Demographic data analysed included age, gender and body mass index (BMI), duration of symptoms, side of involvement and referral source. Observations included temperature (^{0}C) at presentation and National Early Warning Score (NEWS). Laboratory parameters included were hemoglobin concentration in grams (Hb), WBC count (x 10^9 cells/L), neutrophil count (x 10^9 cells/L), CRP (mg/dL), creatinine, urea, serum albumin level (g/L), an estimated glomerular filtration rate (eGFR) ≤ 90 ml/min/1.73 m^2, abnormal electrolyte values. The comorbidities analysed included history of intravenous drug usage (IVDU), diabetes, hypertension (HTN), pulmonary embolism (PE)/deep vein thrombosis (DVT), previous history of septic arthritis, inflammatory arthritis including gout, osteoarthritis (OA), cancer (CA)/immunosuppression,

chronic smoking, chronic alcoholism and cardiac dysfunction. The perioperative factors included were nature of the preoperative knee aspirate, Gachter score (≤ 2 versus ≥ 3) [14,15], positive gram stain, presence of numerous pus cells, presence of crystals in the aspirate, organisms cultured, additional foci of infection, administration of pre-operative antibiotics, number of arthroscopic portals made, volume of saline used for the washout, stage of osteoarthritis (OA) in the knee x-ray (grade ≤ 2 or ≥ 3) and American Society of Anesthesiologists (ASA) grade of the patient.

The patients were discharged once they had clinical improvement correlating with improvement in laboratory parameters. In those patients with unresolving signs of infection either by clinical or laboratory parameters, additional washouts were carried out until the infection was under control. After discharge, they were followed up either virtually or face to face to look for any signs of unresolved infection, based on both clinical and laboratory parameters. Any worsening of signs or symptoms warranted emergency review, and in-patient care if required. Those with recurrent infection were operated with washout again. The patients were discharged from clinical follow-up after a minimum period of three months.

2.1. Statistical analysis

Initially, the data was analysed with univariate analysis for statistical evaluation on the response variable of failure of a single arthroscopic washout namely successful infection control versus requirement of multiple washouts (binary response). A two-tailed Student-t test was used for continuous variables, two proportions test for binary discrete variables and Chi-Square test for a discrete variable with multiple categories (organism).

Further, those parameters with a p value less than 0.20 were considered for stepwise variable selection using binary logistic regression. This was performed to identify a subset of significant independent variables for failure of a single arthroscopic washout.

The continuous variables analysed were age, BMI, temperature, duration of symptoms, Hb, WBC count, neutrophil count, CRP, urea, creatinine and albumin. Moreover, categorical data with binary variables for analysis included gender, referral source, history of diabetes (DM), history of hypertension (HTN), history of pulmonary embolism or deep vein thrombosis (PE/DVT), history of septic arthritis, history of inflammatory arthritis including gout, history of smoking, history of chronic alcoholism, history of cancer (CA) or immunosuppression, history of heart disease, electrolytes, intravenous drug usage (IVDU), side operated, preoperative aspirate, gram stain, pus cells, presence of crystals in the aspirate, additional foci of infection, preoperative antibiotics and the number of portals used for arthroscopic washout. Although NEWS score, eGFR, number of comorbidities, Gächter score, volume of saline used, stage of OA in the knee x-ray and ASA grade were also analysed as binary variables, thresholds were assigned to detect a difference within these variables.

3. Results

3.1. Univariate analysis

As represented in Table 1, there were 78 patients out of which 47 patients had successful control of the septic arthritis on their first arthroscopic washout (index procedure). The remaining 31 patients who had the failed index procedure had subsequent washouts until they had resolution of infection. A 2-proportions test was performed between both the categories of patients and found that the proportion of patients with a single washout (only the index procedure) was significantly higher than that of patients with multiple washouts (p value 0.009).

Parameters like BMI (27.90 ± 6.22 compared with 30.18 ± 6.83, respectively), temperature at presentation (37.26 ± 0.79 compared with 37.57 ± 0.74, respectively), neutrophil count (9.65 ± 4.89 compared

Table 1

Summary of univariate analysis involving patient demographic factors, comorbidities and various operative factors.

Variable	Single arthroscopic washout	Failure of single arthroscopic washout	p value
Age (yr)[a]	63.50 ± 17.04	65.99 ± 14.90	0.509
Gender-Male[b]	33 (70.2%)	24 (77.4%)	0.473
Body Mass Index (BMI)[a¥]	27.90 ± 6.22	30.18 ± 6.83	0.133
Duration of symptoms (days)[a]	4.79 ± 4.91	4.84 ± 5.57	0.966
Side operated -Left[b,d]	17 (35.4%)	18 (58.1%)	0.044
Referral Source -AE or Clinic[b]	40 (85.1%)	26 (83.9%)	1.000
Temp (^{0}C)[a]	37.26 ± 0.79	37.57 ± 0.74	0.084
NEWS Score >4[b]	2 (95.7%)	1 (3.2%)	1.000
Hb (gms)[a]	63.40 ± 58.00	69.70 ± 59.30	0.641
WBC (x 10^9 cells/L)[a]	12.88 ± 7.02	13.97 ± 5.38	0.462
Neutrophils[a]	9.65 ± 4.89	11.51 ± 5.18	0.113
CRP[a]	199.80 ± 105.10	262.50 ± 110.80	0.014
Creatine[a]	78.60 ± 32.85	101.00 ± 71.50	0.111
Urea[a]	7.35 ± 4.11	9.08 ± 8.00	0.273
Albumin[a]	27.98 ± 7.04	26.65 ± 8.37	0.450
eGFR ≤ 90[b]	23 (48.9%)	17 (54.8%)	0.609
Abnormal Electrolytes[b]	12 (25.5%)	7 (22.6%)	0.764
Preop Aspirate-Purulent[b]	22 (46.8%)	19 (61.3%)	0.203
Gächter score- 3 or 4[b]	14 (29.8%)	12 (38.7%)	0.417
Positive Gram Stain[b]	3 (6.4%)	2 (6.5%)	1.000
Pus cells - Numerous[b]	38 (80.9%)	25 (80.6%)	0.982
Crystals -Yes[b]	8 (17.0%)	2 (6.5%)	0.300
Organism[c]	28 (59.6%)	13 (41.9%)	0.266
No Organism	11 (23.4%)	12 (38.7%)	
Staph aureus	8 (17.0%)	6 (19.4%)	
Others			
Presence of additional foci of infection[b]	18 (38.3%)	13 (41.9%)	0.749
Having taken preoperative antibiotics[b]	39 (83.0%)	26 (83.9%)	1.000
Having used 2 arthroscopic portals[b]	45 (95.7%)	30 (96.8%)	1.000
Volume of saline <6 L[b]	10 (21.3%)	9 (29.0%)	0.443
X-Ray - Grade3 or 4 OA[b]	23 (48.9%)	18 (58.1%)	0.426
ASA grade-3 or 4[b]	18 (38.3%)	15 (48.4%)	0.378
Comorbidities >3[b]	19 (40.4%)	10 (32.3%)	0.459
IVDU[b]	7 (14.9%)	2 (6.5%)	0.304
DM (Yes)[b]	10 (21.3%)	9 (29.0%)	0.443
HTN (Yes)[b]	15 (31.9%)	14 (45.2%)	0.238
PE/DVT (Yes)[b]	5 (10.6%)	3 (9.7%)	1.000
Prev history of septic arthritis[b]	3 (6.4%)	2 (6.5%)	1.000
Inflamm arthritis including gout[b]	13 (27.7%)	5 (16.1%)	0.214
OA[b]	8 (17.0%)	8 (25.8%)	0.359
CA/Immunosuppression[b]	9 (19.1%)	5 (16.1%)	0.730
Smoker (Yes)[b]	11 (23.9%)	6 (19.4%)	0.631
Alcoholic[b]	8 (17.0%)	3 (9.7%)	0.511
Cardiac/IHD/AF[b]	11 (23.4%)	11 (35.5%)	0.254

[a] Continuous variables: Values are given as the mean value and standard deviation for the variable.
[b] Binary variables: values given as number and percentage in parenthesis.
[c] Categorical variable: values given as number and percentage in parenthesis.
[d] One patient with both knees performed a single arthroscopic washout.

with 11.51 ± 5.18, respectively), CRP (199.80 ± 105.10 compared with 262.50 ± 110.80, respectively), creatinine (78.60 ± 32.85 compared with 101.00 ± 71.50, respectively) and left knee involvement (51.4%of infected left knee joints had multiple washouts, whereas 29.5% of infected right knees had multiple washouts) had a p value < 0.20, which were further analysed using multivariate logistic regression. Apart from the above variables, all the other variables did not correlate with the requirement of repeated washouts, as shown in Table 1 (p value > 0.20).

The CRP level appeared to be on the higher side for patients who required more than one arthroscopic washout, in a statistically significant manner (p value 0.014). Moreover, patients with left sided septic

arthritis had a statistically significant higher chance of failure of a single arthroscopic washout (p value 0.044).

Needle aspiration was performed on all the 78 patients (79 knee joints) preoperatively. The culture results did not show any organisms in half of the patients (38 patients). Among the culture positive patients, *Staphylococcus aureus* was the most common organism, infecting 24 of the patients (30.76%). The remaining cases were infected by various species of Streptococci, at 7.69% (6 patients), anaerobes, at 3.84% (3 patients), and by other organisms, at 8.4% (5 patients). Between the two groups considered for analysis (single washouts versus multiple washouts), there was no significant difference in the infection rates by any of these organisms, as shown in Table 1.

Thirty-one (39.7%) of the 78 patients (79 septic knees) had persistent infection following the index arthroscopic washout, requiring further washouts. Six cases (7.69%) required a total of two additional washouts and one case (1.2%) required three additional washouts. In one patient from the repeated washout group, open washout and synovectomy was performed as there was significant adhesion and therefore converted to open procedure as per the surgeon's discretion. In those patients who required an additional washout, the average duration between the index procedure and the first additional procedure was 3.96 days except in one patient who had a delayed second washout, at 90 days. In all these patients who required additional washouts, the culture results during the subsequent procedures either showed the same organism or showed none.

Regarding the follow-up of these patients, 62 of them (79.48%) were discharged from the followup clinic at three months after the final procedure, 8 of the patients (10.25%) were discharged between three and six months. Seven patients (8.97%) died within 3 months of the index procedure and one patient died after discharge from the clinic, at 5 months.

3.2. Multivariate analysis

A multivariate binary logistic regression model for failure of a single washout was created using the identified variables from univariate analysis as shown in Table 2.

The logistic regression model for failure of a single washout suggested that at least one variable is significantly affecting the failure of a single arthroscopic washout (p value 0.002). The Hosmer-Lemeshow goodness-of-fit test was performed to detect any departure from a good model fit, which did not indicate any departure from a good model fit (p value 0.194).

We identified two independent variables that were associated with failure of single arthroscopic washout: BMI (odds ratio [OR] 1.10; 95% confidence interval [CI] 1.01 to 1.21; p value 0.025), and left side involvement (odds ratio [OR] 3.80; 95% confidence interval [CI] 1.24 to 11.60; p value 0.019). Though, CRP is found to be insignificant with 95% confidence level, p value of 0.076 suggests that this could be a border line case which could be validated further upon augmenting with any additional data in future.

From the logistic regression model, the probability of multiple washouts was calculated, and a scatter plot for BMI is shown in Fig. 1. It is evident from the figure, that patients with BMI less than 25 are

Table 2

Summary of Multivariate Logistic Regression for failure of single arthroscopic washout.

Variable	Odds Ratio	95% Confidence Interval	p value
BMI	1.10	1.01–1.21	0.025[a]
Temp	1.79	0.88–3.62	0.106
Neutrophil count	1.04	0.93–1.16	0.475
CRP	1.00	1.00–1.01	0.076
Creatinine	1.01	1.00–1.02	0.150
Side-Left	3.80		0.019[a]

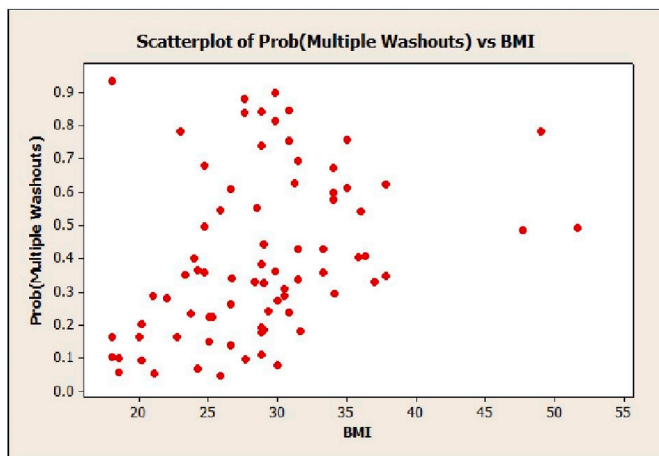[a] Statistically significant at 95% confidence level.

Fig. 1. Scatter plot showing correlation of probability of multiple washouts and BMI.

unlikely to have multiple washouts as their probability of multiple washouts are generally less than 0.5, whereas with patients having BMI more than 45 are very likely to have multiple washouts as the probability of multiple washouts is generally greater than 0.5. The patients with BMI between 25 and 40 were spread across single washouts and also for multiple washouts.

4. Discussion

The key components in the management of septic arthritis are to reduce the infective load by surgical washout and debridement and appropriate antibiotics. However, a single washout may be insufficient to control the infection, and therefore may require repeated washouts [2,11]. Our study aimed at analysing the variables associated with the failure of a single arthroscopic washout in septic arthritis of the knee. We analysed the demographic data, comorbidities, social factors and various operative and non-operative factors of 78 patients (79 knees) of septic arthritis in our study.

The preliminary analysis showed that 60.25% of the cases (47 out of 78 cases) were treated successfully with a single arthroscopic washout which is in agreement with the results of Hunter et al., who showed about 62% success rate in the first debridement and washout in their analysis. However, in their study, they included both open and arthroscopic procedures, and their study included hip, shoulder, elbow and ankle septic arthritis apart from the knee [2]. Abdel et al., in their retrospective analysis of 50 native shoulder septic arthritis showed that the first arthroscopic irrigation was successful in treating 68% of the infection [12]. Balabaud et al., in his retrospective analysis of 40 septic knee arthritis reported a failure rate of 37.5% which again agrees with our findings [5].

In our study, BMI was found to be correlating with the failure of a single arthroscopic washout, on performing a univariate analysis (p value 0.133). On performing a multivariate analysis, it was seen that people with a BMI >45 have a statistically significant chance of failure of a single arthroscopic washout, with a p value 0.025. For patients with BMI between 25 and 40, there was no statistically significant difference. The same has been represented in the scatter plot in Fig. 1. Hunter et al. analysed BMI in their study, and did not find any increase in the chance of failure of a single surgical debridement in septic arthritis of various joints [2].

Also, we found out that a high temperature at presentation (p value 0.084), raised CRP, high neutrophil count (p value 0.113) and high creatinine values (p value 0.111) were the variables predicting failure of a single arthroscopic washout of septic arthritis of the knee. Regarding temperature at presentation, Hunter et al., in his similar study on the risk

factors for failure of a single surgical debridement of septic arthritis, did not find any significant correlation [4]. Regarding CRP, a univariate analysis performed showed a statistical significance with a p value of 0.014. This was again in contrast to the findings of Hunter et al. who did not get any correlation with the CRP level in their study. Certain other authors have only proven the correlation of CRP with that of the initial infection [1], and not about the prediction of failure of initial washouts surgical management of septic arthritis. Regarding neutrophil count, no other studies as per our knowledge have shown to correlate with the increased requirement of repeated surgical debridement in septic arthritis. However, Hunter et al., pointed out that total WBC count positively correlated in a statistically significant manner with failure of a single surgical debridement (p value 0.007). The significance of high creatinine in predicting failure of a single washout procedure was not evaluated in any other studies in literature as per our knowledge.

Regarding the side of involvement in our study, left sided cases had a higher predilection towards failure of a single arthroscopic knee washout, with a p value of 0.044 (58.1% as against 35.4%) in the univariate analysis, and a p value of 0.019 while performing the logistic regression. However, we are unable to justify the importance of this finding or its clinical relevance.

Regarding the causative organisms, 50% of the cases in our study did not show any growth on culture. The samples included preoperative aspirates and intraoperative samples. This proportion is higher compared to other studies which reported non isolation of organisms in up to 40% of the instances [16,17]. In our study, *Staphylococcus aureus* accounted for the highest percentage of infection, affecting 31% of the cases. Furthermore, various species of Streptococci, *Escherichia coli* and anaerobes including *Bacteroides fragilis* affected 7.6%, 4% and 2% of the cases respectively; other rare organisms contributed to the remaining 5% cases. Similar to our study, *Staphylococcus aureus* was the most commonly isolated pathogen in previous studies, which reported a 37%–56% involvement in their patients [11,18–20]. Nonetheless, there was no statistically significant contribution by the presence or type of organism in the failure of a single arthroscopic washout in our study. This was in contrast to the findings of Aïm F et al., who demonstrated with a high positive predictive value that 93% of their patients with a negative initial bacterial culture obtained clearance from infection by a single arthroscopic washout, whereas, 35% of those with a positive initial culture sample required additional washouts [9].

Although age has been shown to be a risk factor for the occurrence of septic arthritis according to previous studies [21], our results do not show age as a statistically significant risk factor for the failure of a single arthroscopic washout in septic arthritis of the knee (p value 0.509). Another common risk factor associated with septic arthritis is diabetes. Hunter et al., in his study, showed that diabetes mellitus is a significant risk factor for the failure of a single surgical debridement of septic arthritis, with a p value 0.05 [2].

The severity stage of septic arthritis according to Gächter had been shown as a prognostic factor in earlier studies [8,9]. Gächter score has been recorded based on the nature of the synovial fluid and the intraoperative findings of the joints including synovial changes and cartilage damage [14]. According to Aïm F et al., 78% of the patients with Gächter stage 1 or 2 disease experienced full resolution infection compared to 67% in patients with stage 3 and 4 disease [9]. In our study, we found no correlation between the requirements of repeated arthroscopic washout with the Gächter scoring of the index procedure. However, in our study Gächter scoring was calculated retrospectively.

Intravenous drug usage (IVDU) has been an important predisposing factor for septic arthritis as per various studies [4,20,22–24]. However, none of them have evaluated their importance towards the risk of persistent infection requiring repeated washouts. In our study, we analysed the same but found no correlation between a history of IVDU and failure of a single arthroscopic washout for septic arthritis of the knee.

There were certain limitations in our study. Firstly, our study was retrospective in nature and evaluated by different clinicians at different

points of time which could have caused non-uniformity in the findings. Secondly, a high proportion of culture negative cases (50%) would have been contributed by prior antibiotics or due to inflammatory conditions. Finally, we have not taken into account the antibiotic duration and protocol which were given by the microbiology team, and hence were unable to evaluate their influence on the failure of a single arthroscopic washout. A prospective study would be helpful in developing a prognostic model in identifying factors which would lead to failure after the first arthroscopic washout, and help in developing a prognostic model regarding the same.

5. Conclusion

Our study showed a high failure rate (39%) of initial arthroscopic washout to eradicate infection in septic arthritis of the knee. A raised CRP, BMI >45, high temperature at presentation, high neutrophil count and high creatinine values were found to be the associated factors.

Ethical approval

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Author contributions

Niranj Ganeshan Radhamony - conceptualization, data curation, methodology, software, validation, writing- original draft.

Sriganesh Walkay - conceptualization, formal analysis, methodology, project administration, resources, supervision, validation, writing-review & editing.

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Consent

Yes, patient consent was obtained.

Provenance and peer review

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Declaration of competing interest

The authors do not have any conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi. org/10.1016/j.amsu.2022.103269.

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