JKFAS Journal of Korean Foot and Ankle Society
Original Article
pISSN 1738-3757 eISSN 2288-8551
J Korean Foot Ankle Soc 2024;28(4):157-164
https://doi.org/10.14193/jkfas.2024.28.4.157

당뇨발 환자에서 단일 절단 및 재수술 절단 사례의 병원체 검출 및 제거 비교 분석

권기연, 정희헌*, 이정우

연세대학교 원주의과대학 정형외과학교실, *연세대학교 원주의과대학 의학과

Comparative Analysis of Pathogen Detection and Eradication in Single vs. Revision Amputation Cases of Diabetic Foot Patients

Ki Youn Kwon, Hee Heon Jeong*, Jung Woo Lee

Department of Orthopedic Surgery, *Department of Medicine, Yonsei University Wonju College of Medicine, Wonju, Korea

Purpose: This study examined the differences in pathogen survival between single and revision amputations in diabetic foot infections. Current research lacks data on the postoperative pathogen profiles, particularly in cases involving repeated surgeries, making this study essential for targeted infection management.

Materials and Methods: The medical records of 168 diabetic foot ulcer patients treated at a single center, divided into single (n=113) and revision amputation groups (n=55) were analyzed retrospectively. Preoperative deep tissue samples and postoperative wound swab samples were collected to analyze the pathogens. The C-reactive protein (CRP) levels were measured as an inflammation marker. The pathogen diversity, frequency, and survival rate were compared. The 'survival rate' was defined as the frequency of postoperative persistence of pathogens relative to the preoperative detection frequency.

Results: Revision amputation cases showed a higher diversity (p=0.0029) and persistence of pathogens, with methicillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa*, and most other detected pathogens displaying higher survival rates. The CRP levels generally decreased postoperatively, but the variability was more pronounced in the revision group, suggesting that CRP may not consistently correlate with infection control in complex cases.

Conclusion: These findings revealed significant differences in the pathogen profiles between single and revision amputations, with revision cases facing more significant infection challenges because of the higher resistant pathogen persistence.

Key Words: Diabetic foot, Pathogen, Amputation, C-reactive protein

Received October 29, 2024 **Revised** November 24, 2024
Accepted November 27, 2024
Corresponding Author: Jung Woo Lee
Department of Orthopedic Surgery, Yonsei University Wonju College of Medicine, 20 Ilsan-ro, Wonju 26426, Korea
Tel: 82-33-741-0114, Fax: 82-33-741-0114, E-mail: berrybearlee@gmail.com
ORCID: https://orcid.org/0000-0003-2989-4952

Financial support: This research was financially supported by a grant from the Korea Health Technology R&D Project (grant number: HI23C0476) conducted by the Korea Health Industry Development Institute (KHIDI) and funded by the Ministry of Health and Welfare, Korea. It was also supported by the "Regional Innovation Cluster Development Program (R&D, grant number: P0025898, project number: 1415188707)" conducted by the Korea Institute for Advancement of Technology (KIAT) and funded by the Ministry of Trade, Industry and Energy, Korea.
Conflict of interest: None.

INTRODUCTION

Prevalence of diabetes mellitus is increasing rapidly in South Korea and is a major risk factor for lower extremity amputations. From 2003 to 2021, the incidence of lower extremity amputations in the general population more than doubled, with the contribution of diabetes mellitus to these amputations also increasing from 47% in 2003 to 70% in 2021. This indicates that a significant proportion of lower extremity amputations in South Korea is due to diabetic foot complications.[1)] Diabetic foot infection (DFI) stands as the primary and most catastrophic complication associated with diabetic foot conditions.[2)]

Research on Western populations consistently shows that Gram-positive aerobes, particularly *Staphylococcus aureus*, are the predominant causative organisms in DFI, with detection rates often around 20%~50%.[3-6)] Additionally, methicillin-resistant *Staphylococcus aureus* (MRSA) cases have been increasing, indicating a growing prevalence of resistant strains over time.[7)] In contrast, studies from the Middle East, Asia, and Africa report a higher isolation rate of Gram-negative rods, such as *Pseudomonas aeruginosa*, compared to Western populations.[8-11)] For instance, research in South India found *Pseudomonas* spp. as a significant pathogen, and a comprehensive study in Kuwait reported *Enterobacteriaceae* and *Pseudomonas* accounting for a combined prevalence of nearly 45%.[12-14)]

Similarly, South Korean studies have shown a predominance of Gram-positive aerobes, with S. aureus detected in up to 39.8% of cases, while Gram-negative aerobes, including *Pseudomonas* spp., are also commonly isolated.[15-17)] These regional patterns highlight the need for tailored infection control strategies based on local pathogen profiles.

Previous studies have mainly focused on identifying pathogens present before surgery, often overlooking the types of pathogens that can appear after the procedure. Additionally, there is a notable lack of research comparing the microbiological profiles of patients undergoing single versus revision amputations. Most existing studies in this area have focused more on analyzing patient histories and various clinical parameters rather than examining the specific bacteria involved.[18-20)] Given the increasing number of DFIs and the complications associated with them, including the need for repeated surgeries, there is a critical need for more comprehensive data. Therefore, the goal of our study is to analyze the differences in pathogen detection and eradication in DFI patients who undergo single versus revision amputations. This study hypothesizes that pathogen diversity and pathogen persistence will differ between single and revision amputation cases, which could provide insight into tailored infection management strategies for high-risk patients.

MATERIALS AND METHODS

We examined the medical records of 168 diabetic foot ulcer patients who received surgical treatment in the Orthopedic Surgery Department at Wonju Severance Christian Hospital from November 2020 to January 2023. A thorough medical history was compiled for each patient. The analysis covered participants' ages, sexes, identified pathogens, C-reactive protein (CRP) and surgical details, including the types of surgeries performed.

DFIs were diagnosed according to the criteria established by the International Working Group on the Diabetic Foot (IWGDF) 2019 update guideline, using the Site, Ischemia, Neuropathy, Bacterial infection, Area and Depth (SINBAD) classification system, supplemented by magnetic resonance imaging findings to enhance diagnostic accuracy. All patients were diagnosed and managed by a single surgeon to ensure consistency in clinical assessments.

We categorized 168 patients who underwent lower extremity amputation surgery due to diabetic foot ulcers into two groups: the single amputation group and the revisional amputation group. The single amputation group included cases with no prior surgeries on the affected area, while the revision amputation group consisted of cases where the infection worsened in the same anatomical location, necessitating a secondary surgery. In the single amputation group, there were 113 cases, whereas the revisional amputation group consisted of 55 patients who underwent a total of 132 cases (Fig. 1).

For bacterial culture, deep tissue samples were collected during preoperative and intraoperative periods, while swab samples were taken postoperatively. Deep tissue samples

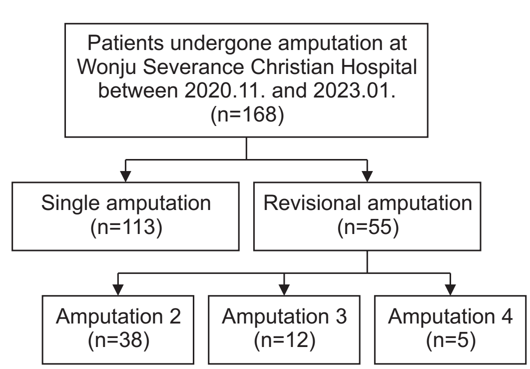

Figure 1. Flow diagram.

were obtained according to established protocols, which included tissue biopsies or bone specimens stored in aseptic tubes and sent immediately to the microbiology laboratory for culture.[21,22] For both groups, we analyzed the pathogens detected in the wound before surgery and those identified in the wound 3~5 days post-surgery. Swab samples were primarily used postoperatively and are acknowledged for being less reliable than tissue samples, particularly in identifying Gram-negative bacteria such as *Escherichia coli* and *Citrobacter*.[23)]

Due to the diversity of pathogens, it was impractical to present the full scientific names of all species in each table and graph. Therefore, we assigned codes to each pathogen based on its type to streamline the analysis and presentation. Specifically, Gram-positive bacteria were coded as "1," Gram-negative bacteria as "2," and fungal species as "3."

For postoperative pathogen survival analysis, we defined the 'survival rate' as the frequency of pathogens that persisted postoperatively divided by the frequency of pathogens identified preoperatively. This metric was used to assess the persistence of specific pathogens after surgical intervention, allowing for a comparative analysis between single and revision amputation groups.

The CRP levels were analyzed based on blood tests conducted around the same time as specimen collection. Following the approach used by Bravo-Molina et al.,[24)] which demonstrated that elevated CRP levels can predict the risk of major amputation, we collected and included CRP values in our analysis to evaluate their association with surgical outcomes.

All analyses were conducted using the R statistical software (version 4.1.0; R Foundation for Statistical Computing). Categorical variables are expressed as frequencies and percentages. The diversity and frequency of bacterial species identified before and after surgical procedures were evaluated using data aggregation and transformation techniques suitable for non-normally distributed variables. Statistical significance for differences in bacterial frequencies was assessed using the chi-squared test for categorical variables and the Mann-Whitney U-test for continuous variables related to bacterial counts. All statistical tests were two-sided, and significance was set at $p<0.05$.

This study protocol was approved by the Institutional Review Board of Yonsei University Wonju Severance Christian Hospital (Approval No: CR323082). All study procedures were performed in accordance with the ethical standards of the institutional and/or national research committee. Data were collected from patients who consented to participate, excluding those who expressed a clear intention to withdraw or whose data were insufficient.

Table 1. Patient Demographics

	Total	Single	Revision	p-value
No. of patient	168	113	55	
Age (yr)	67±13	65±14	69±10	0.048
Height (cm)	164.5±9.5	162.0±11.0	169.6±5.2	>0.05
Weight (kg)	63.6±12.6	61.2±12.7	68.5±12.4	0.022
Male/female ratio	4.25:1	3.70:1	5.88:1	>0.05
Male	136	89	47	
Female	32	24	8	

Values are presented as mean±standard deviation or number only.

RESULTS

The patient demographics, as summarized in Table 1, show the distribution and characteristics of participants in the single and revision amputation groups. Among the 168 patients with diabetic foot ulcers, a total of 34 different pathogens were identified and coded by type, as shown in Table 2.

Comparing the variety of pathogens detected in the wound samples of each patient prior to their first surgical procedure revealed a statistically significant difference between the two groups ($p=0.0029$). Patients in the single amputation group had an average of 1.45±0.58 different pathogens identified, whereas patients in the revision amputation group had an average of 1.93±1.07 different pathogens detected.

1. Preoperative pathogen detection and postoperative pathogen survival rates

In the single amputation group, which included 113 patients, preoperative pathogen detection frequencies are presented in Table 3. A total of 111 organisms (73.0%) were identified as Gram-positive, while 34 organisms (22.3%) were Gram-negative. Among the Gram-positive aerobes, *Enterococcus faecalis* was the most commonly isolated organism (13.2%), followed by *Streptococcus agalactiae* (10.5%), *Staph-*

Table 2. Identified Pathogens

Pathogen	Code
Gram-positive aerobes	
Staphylococcus	
MSSA	1-1s
MRSA	1-1r
Staphylococcus epidermidis	1-1b
Staphylococcus lugdunensis	1-1c
Staphylococcus haemolyticus	1-1d
Staphylococcus caprae	1-1e
Streptococcus	
Streptococcus oralis	1-2a
Streptococcus agalactiae	1-2b
Streptococcus dysgalactiae	1-2c
Streptococcus anginosus	1-2d
Streptococcus constellatus	1-2e
Enterococcus	
Enterococcus faecalis	1-3a
Enterococcus faecium	1-3b
Enterococcus avium	1-3c
Corynebacterium	
Corynebacterium striatum	1-4a
Corynebacterium jeikeium	1-4b
Microbacterium	
Microbacterium oxydans	1-5a
Dermabacter	
Dermabacter hominis	1-6a
Bacillus	1-7a
Gram-negative aerobes	
Serratia	
Serratia marcescens	2-1a
Serratia liquifaciens	2-1b
Pseudomonas	
Pseudomonas aeruginosa	2-2a
Pseudomonas monteilii	2-2b
Klebsiella	2-3a
Enterobacter	
Enterobacter cloacae	2-4a
E.coli	2-5a
Proteus	
Proteus mirabilis	2-6a
Proteus vulgaris	2-6b
Aeromonas	
Aeromonas hydrophila	2-7a
Acinetobacter	
Acinetobacter baumannii	2-8a
Morganella	
Morganella morganii	2-9a
Stenotrophomonas	
Stenotrophomonas maltophilia	2-10a
Burkholderia	
Burkholderia cenocepacia	2-11a
Fungal	
Candida albicans	3-1a

MSSA: methicillin-sensitive *Staphylococcus aureus*, MRSA: methicillin-resistant *Staphylococcus aureus*.

Table 3. Single Amputation Group Pathogen

Pathogen	Pre-op frequency	Survival rate (%)
Gram-positive aerobes	111 (73.0)	
Enterococcus faecalis	20 (13.2)	20
Streptococcus agalactiae	16 (10.5)	12.5
Staphylococcus epidermidis	15 (9.9)	20
MRSA	15 (9.9)	13.3
MSSA	10 (6.6)	10
Others	35 (23.0)	
Gram-negative aerobes	34 (22.4)	
Pseudomonas aeruginosa	13 (8.6)	23.1
Others	21 (13.8)	
Fungal		
Candida albicans	7 (4.6)	14.3
Total	152	

Values are presented as number (%).
MRSA: methicillin-resistant *Staphylococcus aureus*, MSSA: methicillin-sensitive *Staphylococcus aureus*.

ylococcus epidermidis (9.9%), MRSA (9.9%), and methicillin-sensitive *Staphylococcus aureus* (MSSA) (6.6%). For Gram-negative organisms, *P. aeruginosa* was the most frequently isolated (8.6%).

In terms of postoperative survival rates, among the Gram-positive organisms, *E. faecalis* and *S. epidermidis* both had a survival rate of 20.0%, followed by MRSA at 13.3%. For the Gram-negative organisms, *P. aeruginosa* showed a survival rate of 23.1% (Fig. 2).

In the revision amputation group, which included 55 patients, preoperative pathogen detection frequencies are presented in Table 4. Here, 225 organisms (57.0%) were identified as Gram-positive, and 155 organisms (39.2%) were Gram-negative. Among the Gram-positive aerobes, *S. epidermidis* was the most frequently detected organism (9.9%), followed by *E. faecalis* (9.1%), MSSA (8.4%), and MRSA (6.6%). Among the Gram-negative organisms, *Proteus mirabilis* was the most commonly isolated (9.9%), followed by *P. aeruginosa* (5.3%), *Morganella morganii* (4.1%), and *E. coli* (3.5%).

For postoperative survival rates in the revision group, MRSA showed the highest survival rate among the Gram-positive organisms at 38.5%, followed by *E. faecalis* at 33.3%, MSSA at 30.3%, and *S. epidermidis* at 28.2%. Among the Gram-negative organisms, *P. aeruginosa* had the highest survival rate at 23.8%, followed by *P. mirabilis* at 23.1%, and *E. coli* at 21.4% (Fig. 3).

The seven most frequently detected pathogens in both

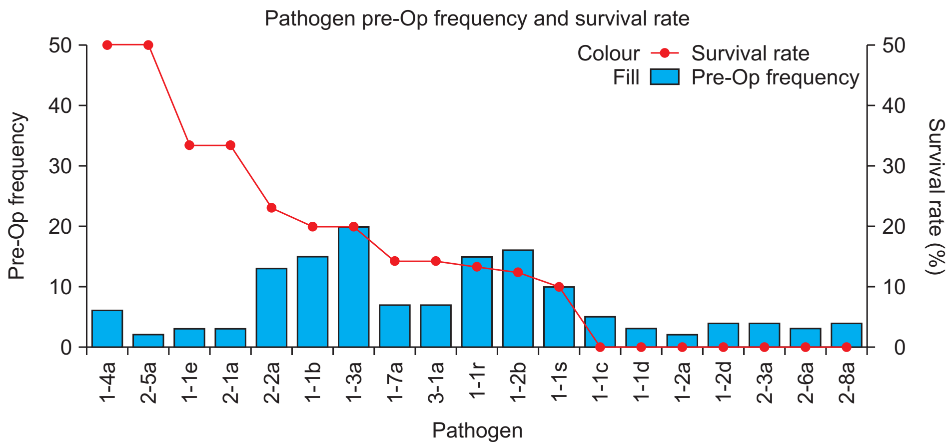

Figure 2. Detailed pathogen profiles: single amputation group.
Pre-Op: preoperative.

Table 4. Revision Amputation Group Pathogen

Pathogen	Pre-op frequency	Survival rate (%)
Gram-positive aerobes	225 (57.0)	
Staphylococcus epidermidis	39 (9.9)	28.2
Enterococcus faecalis	36 (9.1)	33.3
MSSA	33 (8.4)	30.3
MRSA	26 (6.6)	38.5
Streptococcus agalactiae	20 (5.1)	30
Corynebacterium striatum	16 (4.1)	31.3
Others	55 (13.9)	
Gram-negative aerobes	155 (39.2)	
Proteus mirabilis	39 (9.9)	23.1
Pseudomonas aeruginosa	21 (5.3)	23.8
Morganella morganii	16 (4.1)	12.5
Escherichia coli	14 (3.5)	21.4
Others	65 (16.5)	
Fungal		
Candida albicans	15 (3.8)	26.7
Total	395	

Values are presented as number (%).
MSSA: methicillin-sensitive *Staphylococcus aureus*, MRSA: methicillin-resistant *Staphylococcus aureus*.

groups—MRSA, MSSA, *S. epidermidis*, *E. faecalis*, *S. agalactiae*, *P. aeruginosa*, and *Candida albicans*—were analyzed to compare postoperative survival rates between the single and revision amputation groups. Although no statistically significant differences were observed in the survival rates for these pathogens between the two groups ($p>0.05$ for all pathogens), a trend toward higher survival rates in the revision group was noted.

2. Changes in CRP levels following the eradication of preoperative detected pathogens

In the single amputation group, postoperative CRP levels showed inconsistent changes following the eradication of preoperatively detected pathogens. Although CRP levels tended to decrease postoperatively in most cases, there was significant variation, and the changes were not uniform (Fig. 4).

In the revision amputation group, postoperative CRP levels generally decreased when preoperatively detected pathogens were eradicated. Despite some variability, most pathogens were associated with an average reduction in CRP levels following their removal (Fig. 5).

All detected pathogens were analyzed to assess postoperative CRP changes between the single and revision amputation groups. No statistically significant differences in CRP reduction were observed between the two groups for any specific pathogen ($p>0.05$ for all pathogens), though a trend toward higher CRP reduction was noted in the revision group.

DISCUSSION

Our study examined differences in pathogen detection and survival rates between single and revision amputation cases for DFIs, focusing on pathogen persistence post-amputation within a South Korean cohort. While prior research has largely focused on preoperative pathogen profiles,[4] this study provides unique insights into postoperative pathogen survival, particularly in revision surgeries where such data are limited.[18]

Factors influencing the observed differences include the complexity and chronicity of infections in revision cases, leading to greater microbial diversity and higher resistance, as evidenced by a higher average pathogen count per patient.[12,18] In contrast, single amputation cases showed re-

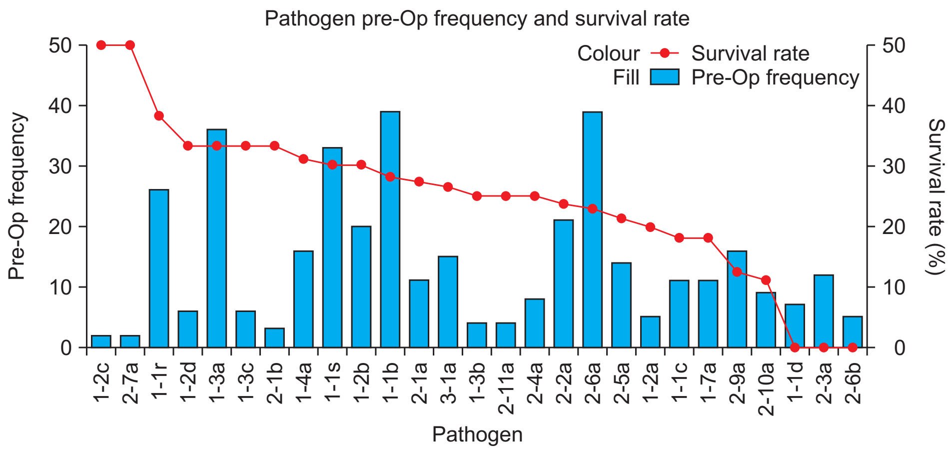

Figure 3. Detailed pathogen profiles: revision amputation group.
Pre-Op: preoperative.

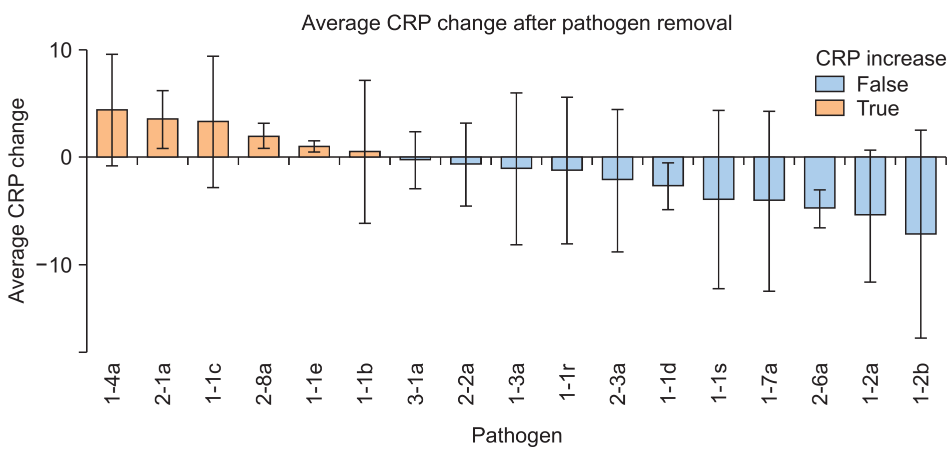

Figure 4. C-reactive protein (CRP) change after pathogen removal: single amputation group.

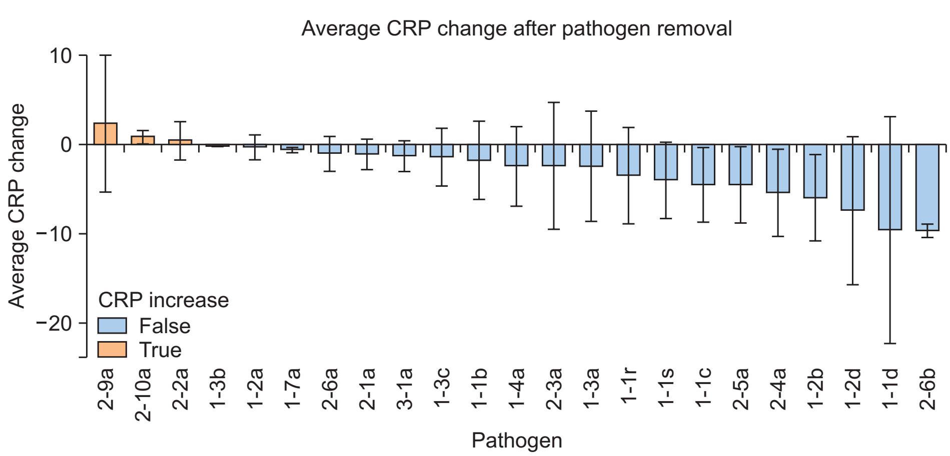

Figure 5. C-reactive protein (CRP) change after pathogen removal: revision amputation group.

duced pathogen diversity and survival, suggesting initial surgery may be more effective in early-stage infections.[18,20)]

Our findings highlight a higher frequency of pathogen diversity in revision amputation cases, with a notable prevalence of Gram-positive organisms, particularly *S. epidermidis, E. faecalis* and MRSA. This aligns with studies in Western populations reporting Gram-positive aerobes as primary DFI pathogens.[3,7,17,18)] However, our data uniquely show a higher survival rate of MRSA and other Gram-negative organisms such as *P. aeruginosa* in revision amputation cases, suggesting that repeated surgical interventions may favor the survival of more resistant or difficult-to-eradicate strains. This distribution is consistent with studies from Asia, where Gram-negative pathogens such as *P. aeruginosa* are frequently observed in DFI cases.[8-14] This is particularly significant as it implies the necessity for tailored antibiotic strategies and infection management protocols in revision cases to address these persistent pathogens effectively.[17,18]

Interestingly, our study also examined CRP levels as an inflammatory marker, following the method of Bravo-Molina et al.[24] While CRP levels generally decreased postoperatively, indicating infection control, the variability in CRP response was more pronounced in revision cases, suggesting that pathogen eradication does not uniformly correlate with inflammation reduction in these patients. This variability contrasts with previous studies that demonstrated a clear association between CRP reduction and infection resolution.[24] These results suggest that CRP might be less reliable as a sole marker of infection control in complex cases involving multiple surgical interventions.

Our study contributes to the current understanding by offering insights into pathogen behavior post-amputation and the differing infection risks associated with single versus repeated surgeries. This evidence underscores the importance of consistent pathogen surveillance and individualized postoperative care plans to manage persistent infections in diabetic patients requiring revision amputations. Future research should focus on refining diagnostic tools and developing targeted interventions for managing high-risk, recurrent infections in DFI patients.

This study has several limitations. First, due to limited sample sizes for some pathogens, p-values did not consistently demonstrate statistical significance, and our findings are therefore presented with an emphasis on observed trends rather than definitive statistical outcomes. Additionally, the postoperative wound swab method used to monitor pathogen persistence in closed wounds carries a risk of contamination, potentially affecting identification accuracy. Although specimens were carefully collected to minimize contamination, this method has limitations in reliably detecting certain pathogens. Furthermore, as a single-center, retrospective study, these findings may not be fully generalizable to other populations or healthcare settings. Finally, factors such as comorbidities and diabetes duration, which could affect infection complexity, were not specifically analyzed, limiting the assessment of their impact on outcomes. Future studies should consider these variables for a more comprehensive evaluation.

CONCLUSION

Our study reveals significant differences in pathogen detection and survival between single and revision amputation cases for DFIs. Revision amputation cases demonstrated greater pathogen diversity and persistence, notably with higher survival rates among resistant strains such as MRSA, Gram-negative organisms like *P. aeruginosa*, and *C. albicans*, highlighting the challenges of managing recurrent infections.

ORCID

Ki Youn Kwon, https://orcid.org/0000-0002-3678-1262
Hee Heon Jeong, https://orcid.org/0009-0002-5269-8634

REFERENCES

1. **Jeon JY, Kim N, Back JH, Lee N, Han SJ, Kim HJ, et al.** *1369-P: the natural trends in incidence of lower extremity amputations in South Korea, 2003-2021. Diabetes. 2023;72 Suppl:1369-P. doi: 10.2337/db23-1369-P.*
2. **Boulton AJ, Vileikyte L, Ragnarson-Tennvall G, Apelqvist J.** *The global burden of diabetic foot disease. Lancet. 2005;366:1719-24.*
3. **Mendes JJ, Marques-Costa A, Vilela C, Neves J, Candeias N, Cavaco-Silva P, et al.** *Clinical and bacteriological survey of diabetic foot infections in Lisbon. Diabetes Res Clin Pract. 2012;95:153-61. doi: 10.1016/j.diabres.2011.10.001.*
4. **Lipsky BA, Holroyd KJ, Zasloff M.** *Topical versus systemic antimicrobial therapy for treating mildly infected diabetic foot ulcers: a randomized, controlled, double-blinded, multicenter trial of pexiganan cream. Clin Infect Dis. 2008;47:1537-45. doi: 10.1086/593185.*
5. **Machado C, Teixeira S, Fonseca L, Abreu M, Carvalho A, Pereira MT, et al.** *Evolutionary trends in bacteria isolated from moderate and severe diabetic foot infections in a Portuguese tertiary center. Diabetes Metab Syndr. 2020;14:205-9. doi: 10.1016/j.dsx.2020.02.010.*
6. **Jneid J, Cassir N, Schuldiner S, Jourdan N, Sotto A, Lavigne JP, et al.** *Exploring the microbiota of diabetic foot infections with culturomics. Front Cell Infect Microbiol. 2018;8:282. doi: 10.3389/fcimb.2018.00282.*
7. **Dang CN, Prasad YD, Boulton AJ, Jude EB.** *Methicillin-resistant Staphylococcus aureus in the diabetic foot clinic: a worsening problem. Diabet Med. 2003;20:159-61. doi: 10.1046/j.1464-5491.2003.00860.x.*
8. **Citron DM, Goldstein EJ, Merriam CV, Lipsky BA, Abramson MA.** *Bacteriology of moderate-to-severe diabetic foot infections and in*

vitro activity of antimicrobial agents. J Clin Microbiol. 2007;45:2819-28. doi: 10.1128/JCM.00551-07.

9. **Ramakant P, Verma AK, Misra R, Prasad KN, Chand G, Mishra A, et al.** *Changing microbiological profile of pathogenic bacteria in diabetic foot infections: time for a rethink on which empirical therapy to choose? Diabetologia. 2011;54:58-64. doi: 10.1007/s00125-010-1893-7.*
10. **Shanmugam P, M J, Susan SL.** *The bacteriology of diabetic foot ulcers, with a special reference to multidrug resistant strains. J Clin Diagn Res. 2013;7:441-5. doi: 10.7860/JCDR/2013/5091.2794.*
11. **Uçkay I, Aragón-Sánchez J, Lew D, Lipsky BA.** *Diabetic foot infections: what have we learned in the last 30 years? Int J Infect Dis. 2015 ;40:81-91. doi: 10.1016/j.ijid.2015.09.023.*
12. **Shankar EM, Mohan V, Premalatha G, Srinivasan RS, Usha AR.** *Bacterial etiology of diabetic foot infections in South India. Eur J Intern Med. 2005;16:567-70. doi: 10.1016/j.ejim.2005.06.016.*
13. **Karmaker M, Sanyal SK, Sultana M, Hossain MA.** *Association of bacteria in diabetic and non-diabetic foot infection - an investigation in patients from Bangladesh. J Infect Public Health. 2016;9:267-77. doi: 10.1016/j.jiph.2015.10.011.*
14. **Al Benwan K, Al Mulla A, Rotimi VO.** *A study of the microbiology of diabetic foot infections in a teaching hospital in Kuwait. J Infect Public Health. 2012;5:1-8. doi: 10.1016/j.jiph.2011.07.004.*
15. **Son ST, Han SK, Lee TY, Namgoong S, Dhong ES.** *The microbiology of diabetic foot infections in Korea. J Wound Manag Res. 2017;13:8-12. doi: 10.22467/jwmr.2017.00108.*
16. **Kwon KT, Armstrong DG.** *Microbiology and antimicrobial therapy for diabetic foot infections. Infect Chemother. 2018;50:11-20. doi: 10.3947/ic.2018.50.1.11.*
17. **Lee JS, Son ST, Han SK.** *Risk factors of methicillin-resistant Staphylococcus aureus and Pseudomonas infection in diabetic foot ulcers in Korea. J Wound Manag Res. 2017;17:29-34. doi: 10.22467/jwmr.2017.00164.*
18. **Aragón-Sánchez J, Lázaro-Martínez JL, Molinés-Barroso R, García Álvarez Y, Quintana-Marrero Y, Hernández-Herrero MJ.** *Revision surgery for diabetic foot infections: giving another chance to the patient. Int J Low Extrem Wounds. 2013;12:146-51. doi: 10.1177/1534734613486155.*
19. **Aziz Z, Lin WK, Nather A, Huak CY.** *Predictive factors for lower extremity amputations in diabetic foot infections. Diabet Foot Ankle. 2011;2:7463. doi: 10.3402/dfa.v2i0.7463.*
20. **Uysal S, Arda B, Taşbakan MI, Çetinkalp Ş, Şimşir IY, Öztürk AM, et al.** *Risk factors for amputation in patients with diabetic foot infection: a prospective study. Int Wound J. 2017;14:1219-24. doi: 10.1111/iwj.12788.*
21. **Lipsky BA, Berendt AR, Cornia PB, Pile JC, Peters EJ, Armstrong DG, et al.**; *Infectious Diseases Society of America. 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. Clin Infect Dis. 2012;54:e132-73. doi: 10.1093/cid/cis346.*
22. **Lipsky BA, Aragón-Sánchez J, Diggle M, Embil J, Kono S, Lavery L, et al.**; *International Working Group on the Diabetic Foot. IWGDF guidance on the diagnosis and management of foot infections in persons with diabetes. Diabetes Metab Res Rev. 2016;32 Suppl:45-74. doi: 10.1002/dmrr.2699.*
23. **Huang Y, Cao Y, Zou M, Luo X, Jiang Y, Xue Y, et al.** *A comparison of tissue versus swab culturing of infected diabetic foot wounds. Int J Endocrinol. 2016;2016:8198714. doi: 10.1155/2016/8198714.*
24. **Bravo-Molina A, Linares-Palomino JP, Lozano-Alonso S, Asensio-García R, Ros-Díe E, Hernández-Quero J.** *Influence of wound scores and microbiology on the outcome of the diabetic foot syndrome. J Diabetes Complications. 2016;30:329-34. doi: 10.1016/j.jdiacomp.2015.11.001.*