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Microbial isolates and antibiotic sensitivity in patients hospitalized with odontogenic infections at a tertiary center over 10 years

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Abstract (J Korean Assoc Oral Maxillofac Surg 2023;49:198-207)

Objectives: This study investigated causative strains and their antibiotic sensitivity in patients who were hospitalized for maxillofacial odontogenic infections at a tertiary center in South Korea over the past 10 years with the aim of providing guidelines for the selection of appropriate empirical antibiotics.

Materials and Methods: Patients with head and neck fascial space abscesses due to odontogenic infections who underwent incision and drainage surgery with pus culture tests between 2013 and 2022 at the Department of Oral and Maxillofacial Surgery, Dankook University Hospital were included. The bacterial isolates and antibiotic sensitivity of each strain were analyzed for 2013-2022, 2013-2017, and 2018-2022. The affected fascial spaces were classified into primary, secondary, and deep neck spaces.

Results: In the 192 patients included in this study, 302 strains were detected. Viridans streptococcus had the highest frequency (51.7%), followed by *Prevotella* spp. (16.9%), *Staphylococcus* spp. (5.6%), and *Klebsiella pneumoniae* (4.6%). The identification rate of viridans streptococcus significantly increased from 41.8% in 2013-2017 to 60.9% in 2018-2022. Viridans streptococcus showed an antibiotic sensitivity of 80.5% to ampicillin; the sensitivity to penicillin antibiotics decreased over the study period. Antibiotic susceptibility was approximately 94% for third-generation cephalosporins. *K. pneumoniae*, which was identified at a high percentage in patients with deep neck space infection, showed increasing antibiotic resistance to most antibiotics over the study period.

Conclusion: Viridans streptococcus was identified in head and neck fascial space abscesses with the highest frequency. Empirical antibiotics should be effective against this strain; penicillin antibiotics are considered inappropriate. For effective treatment of deep neck space abscesses, bacterial culture and antibiotic sensitivity tests performed as soon as possible are essential.

Key words: Periapical abscess, Bacterial drug resistance, Microbiology, Viridans streptococci, *Klebsiella pneumoniae*

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I. Introduction

Odontogenic infection is the most common cause of fascial space abscesses in the head and neck region[1]. These abscesses mainly originate from pulpitis, periodontitis, or pericoronitis. Pulpitis with dental caries is the most frequent, followed by pericoronitis and periodontitis[2]. A well-localized abscess can be treated by eliminating the origin of the infection with incision and drainage. However, in cases of severe infection or compromised immunity, antibiotic therapy is required, and if not treated appropriately, lethal complications such as airway obstruction, necrotizing fasciitis, sepsis, and mediastinitis can occur[3].

Odontogenic fascial space abscesses are polymicrobial infections consisting of various aerobic, facultative anaerobic, and obligate anaerobic bacteria. The causative bacteria are mostly part of the normal flora in the oral cavity of the host[4-6]. *Streptococcus*, *Prevotella*, and *Staphylococcus* are the most frequently detected strains in odontogenic infection[7]. In the early stage of infection, aerobic *Streptococcus* spp. are dominant, but the percentages of anaerobic strains increase as the infection progresses to a chronic state[8].

In the treatment of fascial space abscesses, it is essential to test bacterial cultures to accurately identify the causative strains of infection and select a narrow range of antibiotics depending on the antibiotic sensitivity of the strain. Since

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these bacterial culture and antibiotic sensitivity tests take several days, empirical antibiotics should be used in the initial stage. The frequently used empirical antibiotics include penicillin, cephalosporin, and clindamycin. Because of the predominance of Gram-positive aerobic strains in odontogenic infections, beta-lactam antibiotics are mainly selected as empirical antibiotics for initial treatment[9].

For prophylaxis and the treatment of infections, dentists mostly prescribe broad-spectrum antibiotics. Even when sufficient treatment is possible through the elimination of the infection source, antibiotics are often also prescribed[10], which causes unnecessary exposure to a wide range of antibiotics as they are prescribed without bacterial culture and antibiotic sensitivity tests[11,12]. Accordingly, several studies reported that antibiotic resistance among causative strains of odontogenic infections has been increasing[13,14].

This study aimed to identify bacterial isolates and their antibiotic sensitivity in patients who were hospitalized for odontogenic fascial space abscesses between 2013 and 2022. Moreover, temporal changes over the past 10 years were identified to provide a reference for selecting the appropriate empirical antibiotics before receiving the results of bacterial culture tests.

II. Materials and Methods

This study included patients who were admitted to the Department of Oral and Maxillofacial Surgery, Dankook University Hospital between 2013 and 2022 for fascial space abscesses with odontogenic infection. Patients who underwent pus culture tests and antibiotic sensitivity tests following incision and drainage were included in this study. Patients with negative results and contaminated samples were excluded. If more than three different species were detected in the sample, the specimen was considered contaminated, and further culture tests were not conducted by our hospital's Department of Diagnostic Laboratory Medicine. In cases of mild abscesses in which no considerable amount of pus was accumulated or sampled due to preoperative antibiotic administration, the growth of bacteria may not be detected in the culture. Specimens were collected by the 'swabbing method' using a sterile culture swab in an aseptic surgical environment. The number of patients whose samples underwent culturing via the aspiration method in our clinic was small. Thus, to obtain sufficient data obtained under the same conditions for a period of 10 years, the swabbing method was chosen. A fascial space abscess was diagnosed through clinical and radiographic examinations, and the patient's dental history, panoramic view, periapical view, and enhanced computed tomography (CT) images were evaluated to confirm the dental origin of the infection.

To investigate changes in bacterial isolates and antibiotic sensitivity over the study period, the patients were divided into two groups based on their hospital visit dates: patients treated between 2013 and 2017 and those treated between 2018 and 2022. The identified strains and their antibiotic sensitivities were compared and analyzed between the groups, representing the past 5 years and the recent 5 years.

Fascial space with abscess formation was confirmed through enhanced CT imaging and classified into primary, secondary, and deep neck fascial space. Primary fascial spaces are spaces directly affected by odontogenic infection adjacent to the tooth apex or periodontal tissues, including canine, buccal, submental, sublingual, submandibular, and infratemporal spaces. Secondary fascial spaces, into which bacteria can spread from primary spaces, are located between masticatory muscles or in the loose connective tissue adjacent to the masticatory muscles. Finally, deep neck spaces, which include the lateral pharyngeal space and the retropharyngeal space, are spaces where infection can spread beyond the secondary spaces and cause complications such as upper airway obstruction or mediastinitis. We analyzed the differences in identified strains and their percentages among groups classified according to fascial space abscesses.

For statistical analysis, IBM SPSS Statistics (ver. 28; IBM) was used, and P-values <0.05 were considered significant. The t-test was used to compare the ratios of bacterial isolates and antibiotic sensitivities between the two groups (recent 5 years and the previous 5 years). One-way analysis of variance was used to compare the ratios of bacterial isolates among different fascial spaces.

This study was approved by the Institutional Review Board (IRB) of the Dankook University Dental Hospital (DKUDH IRB 2023-03-007). Because of the retrospective nature of the study, which did not use identifying personal information, the IRB waived the need to obtain written informed consent from the study participants.

III. Results

A total of 192 patients were included in this study from 2013 to 2022 and divided into two groups based on visit dates. In the patients treated between 2013-2017, the 79 patients comprised 40 males (50.6%) and 39 females (49.4%),

Table 1. Demographic information of the patients in the two study periods

	2013-2017			2018-2022			*P*-value
	Total	Male	Female	Total	Male	Female	
No. of patients	79 (100.0)	40 (50.6)	39 (49.4)	113 (100.0)	68 (60.2)	45 (39.8)	0.217
Mean age (yr)	57.5	49.7	65.5	58.0	53.2	65.2	0.207 (male), 0.924 (female)

Values are presented as number (%) or mean only.
P-values were calculated using the *t*-test.
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Table 2. Comparison of the distribution of the spaces involved in odontogenic infections in the study periods 2013-2017 and 2018-2022

	Total	2013-2017	2018-2022	*P*-value
Primary fascial space				
Submandibular space	22.7	27.4	19.9	0.095
Buccal space	9.1	9.6	8.9	0.117
Sublingual space	8.9	5.7	10.7	0.084
Submental space	8.4	8.9	8.1	0.719
Infratemproal space	6.1	6.4	5.9	>0.999
Canine space	1.6	1.9	1.5	0.391
Dentoalveolar space	1.4	1.9	1.1	0.391
Secondary fascial space				
Submasseteric space	14.7	14.0	15.1	0.778
Pterygomandibular space	13.1	11.5	14.0	0.373
Superficial & deep temporal space	5.6	5.1	5.9	0.030
Deep neck space				
Lateral pharyngeal space	6.5	5.7	7.0	0.012
Retropharyngeal space	1.9	1.9	1.8	>0.999

Values are presented as % only.
P-values were calculated using the *t*-test.
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whereas in the group treated 2018-2022, the 113 patients comprised 68 males (60.2%) and 45 females (39.8%). The sex distribution was not significantly different between the two groups. In the 2013-2017 group, the mean age of the male and female patients was 49.7 and 65.5 years, respectively, whereas in the 2018-2022 group, the mean age of male and female patients was 53.2 and 65.2 years, respectively, with no significant difference between the two groups.(Table 1) In the overall patient group, the most frequently affected fascial space was the submandibular space (22.7%), followed by the submasseteric space (14.7%), the pterygomandibular space (13.1%), the buccal space (9.1%), and the sublingual space (8.9%). There was no significant difference in involved fascial spaces between the two groups.(Table 2) Among the 192 patients, 65 patients (33.9%) had a single-space involvement, and 127 patients (66.1%) had more than two spaces involved.

A total of 302 strains were detected in pus cultures from the 192 patients, with a mean of 1.57 strains per patient.(Table 3) Aerobic strains comprised 73.8% of the 302 strains and anaerobic strains comprised 26.2%. Most strains (73.2%) were Gram-positive bacteria were 73.2%, while 26.8% were Gram-negative bacteria. The most frequently identified bacterial isolate was viridans streptococcus (51.7%), followed by *Prevotella* spp. (16.9%), *Staphylococcus* spp. (5.6%), *Klebsiella pneumoniae* (4.6%), and *Peptostreptococcus* spp. (4.6%).

In the comparison of bacteria in the 2013-2017 and 2018-2022 groups (Tables 3, 4), the frequency of Gram-positive aerobic bacteria significantly increased from 56.8% to 72.4%, whereas the frequency of Gram-negative anaerobic bacteria significantly decreased from 23.3% to 12.8%. Among the Gram-positive aerobic bacteria, the prevalence of viridans streptococci significantly increased from 41.8% to 60.9%; among the Gram-negative anaerobes, the prevalence of *Prevotella* spp. decreased from 22.6% to 11.5%. There was no significant difference between Gram-positive anaerobic and Gram-negative aerobic bacteria.

We next compared whether there was a difference in bacterial isolates in patients with primary, secondary, and deep neck space abscesses.(Tables 5, 6) The percentage of Gram-positive aerobic bacteria was significantly lower and the percentage of Gram-negative aerobic bacteria was significantly higher in patients with deep neck space abscesses than in those with primary or secondary space abscesses. In par-

Table 3. Microbiology results and temporal changes in bacterial isolates of patients with odontogenic infections

	Total		Year	
			2013-2017	2018-2022
	n	%	%	%
Gram (+)				
Aerobes				
Staphylococcus spp.	17	5.6	6.2	5.1
Streptococcus pyogenes (Group A)	1	0.3	0.0	0.6
Streptococcus agalactiae (Group B)	1	0.3	0.0	0.6
Streptococcus equisimilis (Group C)	2	0.7	0.7	0.6
Group D streptococcus	8	2.6	3.4	1.9
Viridans streptococcus	156	51.7	41.8	60.9
β-hemolytic streptococcus	2	0.7	0.7	0.6
Gemella morbillorum	4	1.3	2.7	0.0
Other Gram (+) aerobic cocci	1	0.3	0.7	0.0
Corynebacterium spp.	4	1.3	0.7	1.9
Anaerobes				
Peptostreptococcus spp.	14	4.6	6.8	2.6
Clostridium spp.	4	1.3	0.0	2.6
Other Gram (+) anaerobic cocci	4	1.3	2.7	0.0
Other Gram (+) anaerobic rods	3	1.0	0.7	1.3
Gram (–)				
Aerobes				
Klebsiella pneumoniae	14	4.6	3.4	5.8
Neisseria spp.	6	2.0	2.1	1.9
Eikenella corrodens	1	0.3	0.0	0.6
Candida albicans	5	1.7	3.4	0.0
Proteus mirabilis	1	0.3	0.7	0.0
Anaerobes				
Prevotella spp.	51	16.9	22.6	11.5
Fusobacterium mortiferum	1	0.3	0.0	0.6
Bacteroides fragilis	1	0.3	0.7	0.0
Citrobacter koseri	1	0.3	0.0	0.6

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Table 4. Comparison of bacterial isolates in odontogenic infections between 2013-2017 and 2018-2022

	2013-2017		2018-2022		*P*-value
	n	%	n	%	
Gram (+) aerobes	83	56.8	113	72.4	0.007*
Gram (+) anaerobes	15	10.3	10	6.4	0.199
Gram (–) aerobes	14	9.6	13	8.3	0.549
Gram (–) anaerobes	34	23.3	20	12.8	0.024*
Total	146	100	156	100	

*P<0.05.
P-values were calculated using the *t*-test.
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ticular, viridans streptococci had a lower percentage, and *K. pneumoniae* had a relatively higher percentage of deep neck space abscesses compared with primary or secondary space abscesses.

Table 7 shows the antibiotic sensitivity results of viridans streptococcus. Antibiotic sensitivity to penicillin G and ampicillin was 60.4% and 80.5%, respectively, and 93.5% and 95.5% to cefotaxime and ceftriaxone (third-generation cephalosporin drugs), respectively. Antibiotic resistance to erythromycin and clindamycin was 31.2% and 27.6%, respectively. The tested strains were 100.0%, 96.1%, and 99.4% sensitive to linezolid, levofloxacin, and vancomycin, respectively. In the analysis of response to tetracycline, 44.2% showed antibiotic sensitivity and 47.4% showed antibiotic resistance. The antibiotic sensitivity to penicillin G significantly decreased from 68.4% in 2013-2017 to 52.0% in 2018-2022. No significant differences for other antibiotics were found.(Table 8)

Table 9 shows the antibiotic sensitivity results for *K. pneumoniae*, which had an increased frequency in deep neck space abscesses. This strain showed 100.0% antibiotic resistance to ampicillin and 83.3% sensitivity to amoxicillin/clavulanic acid (CA). In response to cephalosporin drugs, it showed 22.2% resistance to the first-generation drug cefazolin, 5.6% resistance to the second-generation drug cefoxitin, 16.7% and

Table 5. Bacterial isolates from samples of patients with odontogenic infections according to involved fascial spaces

	Head & neck fascial space					
	Primary		Secondary		Deep neck	
	n	%	n	%	n	%
Gram (+)						
Aerobes						
Staphylococcus spp.	7	5.4	7	6.5	3	4.6
Streptococcus pyogenes (Group A)	0	0.0	0	0.0	1	1.5
Streptococcus agalactiae (Group B)	1	0.8	0	0.0	0	0.0
Streptococcus equisimilis (Group C)	2	1.6	0	0.0	0	0.0
Group D streptococcus	3	2.3	4	3.7	1	1.5
Viridans streptococcus	74	57.4	56	51.9	26	40.0
β-hemolytic streptococcus	1	0.8	1	0.9	0	0.0
Gemella morbillorum	1	0.8	3	2.8	0	0.0
Other Gram (+) aerobic cocci	0	0.0	1	0.9	0	0.0
Corynebacterium spp.	2	1.6	1	0.9	1	1.5
Anaerobes						
Peptostreptococcus spp.	5	3.9	5	4.6	4	6.2
Clostridium spp.	2	1.6	2	1.9	0	0.0
Other Gram (+) anaerobic cocci	1	0.8	2	1.9	1	1.5
Other Gram (+) anaerobic rods	1	0.8	1	0.9	1	1.5
Gram (–)						
Aerobes						
Klebsiella pneumoniae	4	3.1	3	2.8	7	10.8
Neisseria spp.	0	0.0	1	0.9	5	7.7
Eikenella corrodens	0	0.0	1	0.9	0	0.0
Candida albicans	3	2.3	1	0.9	1	1.5
Proteus mirabilis	0	0.0	0	0.0	1	1.5
Anaerobes						
Prevotella spp.	21	16.3	18	16.7	12	18.5
Fusobacterium mortiferum	0	0.0	1	0.9	0	0.0
Bacteroides fragilis	1	0.8	0	0.0	0	0.0
Citrobacter koseri	0	0.0	0	0.0	1	1.5

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Table 6. Comparison of bacterial isolates according to fascial spaces

	n	%	n	%	*P*-value
	Primary space (n=129)		Secondary space (n=108)		
Gram (+) aerobes	91	70.5	73	67.6	0.868
Gram (+) anaerobes	9	7.0	10	9.3	0.760
Gram (–) aerobes	7	5.4	6	5.6	0.739
Gram (–) anaerobes	22	17.1	19	17.6	0.842
	Primary space (n=129)		Deep neck space (n=65)		
Gram (+) aerobes	91	70.5	32	49.2	0.003*
Gram (+) anaerobes	9	7.0	6	9.2	0.622
Gram (–) aerobes	7	5.4	14	21.5	<0.001*
Gram (–) anaerobes	22	17.1	13	20.0	0.609
	Secondary space (n=108)		Deep neck space (n=65)		
Gram (+) aerobes	73	67.6	32	49.2	0.006*
Gram (+) anaerobes	10	9.3	6	9.2	0.463
Gram (–) aerobes	6	5.6	14	21.5	0.002*
Gram (–) anaerobes	19	17.6	13	20.0	0.747

*$P<0.05$.
P-values were calculated using one-way ANOVA.
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22.2% resistance to the third-generation drugs cefotaxime and ceftazidime, respectively, and 5.6% resistance to the fourth-generation drug cefepime. In response to piperacillin/tazobactam, the percentage of strains with antibiotic sensitivity was 88.9%. *K. pneumoniae* showed 100.0% sensitivity to all antibiotics except ampicillin in 2013-2017. In 2018-2022, the sensitivity rates decreased to 75.0% for amoxicillin/CA, 83.3% for piperacillin/tazobactam, 66.7% for cefazolin, 91.7% for cefoxitin, 66.7% for cefotaxime and ceftazidime, 91.7% for cefepime, 91.7% for amikacin, and 83.3% for ciprofloxacin.(Table 10)

Table 7. Antibiotic sensitivity of viridans streptococcus in 2013-2022

	No. of strains	%
Penicillin G		
R	6	3.9
I	55	35.7
S	93	60.4
Ampicillin		
R	7	4.5
I	23	14.9
S	124	80.5
Cefotaxime		
R	7	4.5
I	3	1.9
S	144	93.5
Ceftriaxone		
R	6	3.9
I	1	0.6
S	147	95.5
Levofloxacin		
R	4	2.6
I	2	1.3
S	148	96.1
Erythromycin		
R	48	31.2
I	1	0.6
S	105	68.2
Clindamycin		
R	41	27.6
I	4	2.6
S	109	70.8
Linezolid		
R	0	0.0
I	0	0.0
S	154	100.0
Vancomycin		
R	1	0.6
I	0	0.0
S	153	99.4
Tetracycline		
R	73	47.4
I	13	8.4
S	68	44.2

(R: resistant, I: intermediate, S: sensitive)

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Table 8. Comparison of antibiotic sensitivity of viridans streptococcus between 2013-2017 and 2018-2022

	2013-2017		2018-2022		*P*-value
	No. of strains	%	No. of strains	%	
Penicillin G					
R	3	3.8	3	4.0	>0.999
I	22	27.8	33	44.0	0.039*
S	54	68.4	39	52.0	0.043*
Ampicillin					
R	4	5.1	3	4.0	0.766
I	9	11.4	14	18.7	0.165
S	66	83.5	58	77.3	0.274
Cefotaxime					
R	4	5.1	3	4.0	0.766
I	2	2.5	1	1.3	0.380
S	73	92.4	71	94.7	0.453
Ceftriaxone					
R	3	3.8	3	4.0	>0.999
I	0	0.0	1	1.3	0.375
S	76	96.2	71	94.7	0.765
Levofloxacin					
R	4	5.1	0	0.0	0.051
I	1	1.3	1	1.3	>0.999
S	74	93.7	74	98.7	0.096
Erythromycin					
R	25	31.6	23	30.7	0.894
I	0	0.0	1	1.3	0.375
S	54	68.4	51	68.0	>0.999
Clindamycin					
R	23	29.1	18	24.0	0.484
I	2	2.5	2	2.7	>0.999
S	54	68.4	55	73.3	0.498
Linezolid					
R	0	0.0	0	0.0	>0.999
I	0	0.0	0	0.0	>0.999
S	79	100.0	75	100.0	>0.999
Vancomycin					
R	1	1.3	0	0.0	0.387
I	0	0.0	0	0.0	>0.999
S	78	98.7	75	100.0	0.387
Tetracycline					
R	37	46.8	36	48.0	0.902
I	6	7.6	7	9.3	0.824
S	36	45.6	32	42.7	0.709

(R: resistant, I: intermediate, S: sensitive)
$^{*}P<0.05$.
P-values were calculated using the *t*-test.

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IV. Discussion

The causes of odontogenic fascial space abscesses include periapical disease, periodontal disease, and pericoronitis. In the study by Dahlén[15], the *Streptococcus milleri* group was the most frequently identified strain in patients with odontogenic infection of dental pulp origin, and bacteria such as *Porphyromonas gingivalis*, *Bacteroides forsythus*, *Treponema denticola*, and *Peptostreptococcus micros* were commonly found in patients with infection of periodontal origin. In the current study, viridans streptococcus accounted for the largest proportion of all identified bacteria. Viridans streptococcus is a group of alpha-hemolytic *Streptococcus* strains, and the strains of the *S. milleri* group (*S. anginosus*, *S. constellatus*, and *S. intermedius*) all belong to the viridans streptococci. This suggests that periapical disease is a highly prevalent cause of fascial space abscesses, given the high frequency of viridans streptococcus infections and the fact that strains of the *S. milleri* group, which are commonly associated with odontogenic infections, belong to the viridans streptococci.

In this study, viridans streptococci showed a sensitivity of 60.4% and 80.5% to penicillin G and ampicillin, respectively, and approximately 94% to the third-generation cephalosporin. The strains showed a decreasing trend in sensitivity to penicillin G and ampicillin over the past 10 years but maintained an antibiotic sensitivity of 95% to cefotaxime and ceftriaxone, which are third-generation cephalosporins. Hirai et al.[16] reported that strains of the *S. milleri* group showed 100% sensitivity to second-, third-, and fourth-generation

Table 9. Antibiotic sensitivity of *Klebsiella pneumoniae* in 2013-2022

	No. of strains	%
Ampicillin		
R	18	100.0
I	0	0.0
S	0	0.0
Amoxicillin/CA		
R	1	5.6
I	2	11.1
S	15	83.3
Pip/tazobactam		
R	0	0.0
I	2	11.1
S	16	88.9
Cefazolin		
R	4	22.2
I	0	0.0
S	14	77.8
Cefoxitin		
R	1	5.6
I	0	0.0
S	17	94.4
Cefotaxime		
R	3	16.7
I	1	5.6
S	14	77.8
Ceftazidime		
R	4	22.2
I	0	0.0
S	14	77.8
Cefepime		
R	1	5.6
I	0	0.0
S	17	94.4
Aztreonam		
R	2	11.1
I	0	0.0
S	16	88.9
Ertapenem		
R	0	0.0
I	0	0.0
S	18	100.0
Imipenem		
R	0	0.0
I	0	0.0
S	18	100.0
Amikacin		
R	1	5.6
I	0	0.0
S	17	94.4
Gentamicin		
R	4	22.2
I	0	0.0
S	14	77.8
Ciprofloxacin		
R	2	11.1
I	0	0.0
S	16	88.9
Tigecycline		
R	0	0.0
I	1	5.6
S	17	94.4
Trimethoprim/sulfa		
R	1	5.6
I	0	0.0
S	17	94.4

(R: resistant, I: intermediate, S: sensitive, CA: clavulanic acid, Pip: piperacillin)

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Table 10. Comparison of antibiotic sensitivity of *Klebsiella pneumoniae* between 2013-2017 and 2018-2022

	2013-2017		2018-2022		*P*-value
	No. of strains	%	No. of strains	%	
Ampicillin					
R	6	100.0	12	100.0	>0.999
I	0	0.0	0	0.0	>0.999
S	0	0.0	0	0.0	>0.999
Amoxicillin/CA					
R	0	0.0	1	8.3	0.489
I	0	0.0	2	16.7	0.297
S	6	100.0	9	75.0	0.192
Pip/tazobactam					
R	0	0.0	0	0.0	>0.999
I	0	0.0	2	16.7	0.297
S	6	100.0	10	83.3	0.297
Cefazolin					
R	0	0.0	4	33.3	0.122
I	0	0.0	0	0.0	>0.999
S	6	100.0	8	66.7	0.122
Cefoxitin					
R	0	0.0	1	8.3	0.489
I	0	0.0	0	0.0	>0.999
S	6	100.0	11	91.7	0.489
Cefotaxime					
R	0	0.0	3	25.0	0.192
I	0	0.0	1	8.3	0.489
S	6	100.0	8	66.7	0.122
Ceftazidime					
R	0	0.0	4	33.3	0.122
I	0	0.0	0	0.0	>0.999
S	6	100.0	8	66.7	0.122
Cefepime					
R	0	0.0	1	8.3	0.489
I	0	0.0	0	0.0	>0.999
S	6	100.0	11	91.7	0.489
Aztreonam					
R	0	0.0	2	16.7	0.297
I	0	0.0	0	0.0	>0.999
S	6	100.0	10	83.3	0.297
Ertapenem					
R	0	0.0	0	0.0	>0.999
I	0	0.0	0	0.0	>0.999
S	6	100.0	12	100.0	>0.999
Imipenem					
R	0	0.0	0	0.0	>0.999
I	0	0.0	0	0.0	>0.999
S	6	100.0	12	100.0	>0.999
Amikacin					
R	0	0.0	1	8.3	0.489
I	0	0.0	0	0.0	>0.999
S	6	100.0	11	91.7	0.489
Gentamicin					
R	0	0.0	4	33.3	0.122
I	0	0.0	0	0.0	>0.999
S	6	100.0	8	66.7	0.122
Ciprofloxacin					
R	0	0.0	2	16.7	0.297
I	0	0.0	0	0.0	>0.999
S	6	100.0	10	83.3	0.297
Tigecycline					
R	0	0.0	0	0.0	>0.999
I	0	0.0	1	8.3	0.489
S	6	100.0	11	91.7	0.489
Trimethoprim/sulfa					
R	0	0.0	1	8.3	0.489
I	0	0.0	0	0.0	>0.999
S	6	100.0	11	91.7	0.489

(R: resistant, I: intermediate, S: sensitive, CA: clavulanic acid, Pip: piperacillin)

P-values were calculated using the *t*-test.

Gyu-Beom Kwon et al: Microbial isolates and antibiotic sensitivity in patients hospitalized with odontogenic infections at a tertiary center over 10 years. J Korean Assoc Oral Maxillofac Surg 2023 cephalosporins and 71% sensitivity to ampicillin. These results indicate that viridans streptococcus is more sensitive to third-generation cephalosporin antibiotics than to penicillin antibiotics. Considering that this strain is most common in patients with odontogenic infection and that the identification rate has significantly increased over the past 10 years, it is not appropriate to select penicillin antibiotics as an initial empirical antibiotic for patients with odontogenic fascial space abscesses.

Prevotella spp. accounted for 16.9% and *Staphylococcus* spp. for 5.6% of the identified strains in this study, which are similar results to those reported by Heim et al.[17] in 2021 on 206 patients with odontogenic infections. In some studies, Gram-negative bacilli, such as *Prevotella* spp., were found to be the dominant strains in odontogenic infections[18], which differs from our findings. We speculate this may be due to differences in sample collection methods. Needle aspiration is more advantageous for culturing anaerobic strains, and the swabbing method used in this study is more suitable for culturing aerobic strains because contact with air is inevitable during sample collection[19]. In comparing the bacteria identified in 2013-2017 and 2018-2022, the frequency of Gram-positive aerobic bacteria significantly increased from 56.8% to 72.4%, whereas the frequency of Gram-negative anaerobic bacteria significantly decreased from 23.3% to 12.8%. In recent care, if patients experience a toothache or facial swelling, it has become more common for them to visit a primary hospital or a local dental clinic early on to receive a prescription antibiotic before visiting a tertiary hospital[20]. Commonly prescribed drugs include oral antibiotics, such as Augmentin (amoxicillin and clavulanate potassium), clindamycin, and macrolides, which also cover infections by anaerobic bacteria[21]. Thus, the increasing frequency of broad-spectrum antibiotic use in primary hospitals before visiting a tertiary hospital may be related to the decrease in the proportion of Gram-negative and anaerobic strains in odontogenic infections.

In a study on deep neck abscesses conducted by Lee and Kanagalingam[22] in 2011, *Streptococcus* and anaerobic strains were the most frequently identified strains in cases of odontogenic infections, whereas *K. pneumoniae* was the predominant strain in upper respiratory infections. *Staphylococcus aureus* was most common in parotid gland infections[22]. Thus, there are differences in causative strains of odontogenic and non-odontogenic infections. In the study by Yun et al.[23] in 2021, viridans streptococcus was the most frequently identified strain (35.1%) in adult patients with deep neck space abscesses, followed by *K. pneumoniae* (13.7%). In contrast, the most frequently identified strain in pediatric patients with deep neck space abscesses was *Staphylococcus*, and *K. pneumoniae* was not identified in pediatric patients[23].

In the present study, the percentage of *K. pneumoniae* was significantly higher in the group of patients with deep neck space abscesses compared with the groups with primary or secondary spaces. This is the same result as reported by Chang et al.[24] in 2013, which showed that the rate of *K. pneumoniae* increased when the infection spread to secondary or deep neck spaces. *K. pneumoniae* is a Gram-negative facultative anaerobic bacterium, which is generally present on the mucosal surface of the oropharynx or gastrointestinal tract and shows high levels of toxicity and antibiotic resistance when it penetrates the mucosal barrier and causes infection. In previous studies, *K. pneumoniae* was highly associated with pneumonia in patients with alcohol use disorder or diabetes mellitus and immunocompromised patients[25,26]. In the current study, *K. pneumoniae* showed 100.0% resistance to ampicillin and 83.3% susceptibility to amoxicillin/CA, but the sensitivity had decreased compared with the prior 5-year period. For piperacillin/tazobactam, which is mainly used in patients with pneumonia or peritonitis, the antibiotic sensitivity of *K. pneumoniae* was 88.9%. *K. pneumoniae* showed a sensitivity of 77.8% to third-generation antibiotics cefotaxime and ceftazidime and a higher sensitivity to second-generation antibiotics cefoxitin of 94.4%. From the results of the present study, antibacterial agents such as piperacillin/tazobactam and imipenem, which are highly effective against *K. pneumoniae*, can be considered when patients are affected by deep neck space abscesses.

This study has several limitations. In this study, patients with head and neck fascial space abscesses due to odontogenic infections treated over the past 10 years were included, but patients who did not undergo appropriate bacterial culture and antibiotic sensitivity tests were excluded from the study; therefore, the sample of the target population was insufficient. Unlike strains with a high identification rate, *Staphylococcus*, *Peptostreptococcus*, and *Fusobacterium* spp. were present in a small number of samples, making it difficult to confirm changes over time. A future study with a larger number of participants may lead to significant results for more strains. A mean of 5 strains are found in most odontogenic infections, but in this study, a mean of 1.57 strains were detected per patient. We speculate this may be due to the fact that the collection of pus was carried out by the swabbing method, and this method is disadvantageous to the cultivation of anaerobic strains. In a study in which pus was collected using the aspiration method, a mean of 3.3 strains per patient was detected[27], which is two-fold higher than that of the current study. A study using the aspiration method may identify more diverse strains including anaerobic bacteria.

V. Conclusion

Viridans streptococcus was the most frequently detected strain in pus cultures from patients hospitalized for odontogenic fascial space abscesses. The frequency of viridans streptococcus increased in the last 10 years. Empirical antibiotics should comprise drugs with expected activity against viridans streptococcus. Viridans streptococcus showed an antibiotic sensitivity of 80.5% to ampicillin, but the sensitivity to penicillin antibiotics has been decreasing for the last 10 years. For third-generation cephalosporins such as cefotaxime or ceftriaxone, approximately 94% of sensitivity has been maintained over the past 10 years. In patients with deep neck space abscesses, viridans streptococcus accounted for the frequency, but the percentage of Gram-negative aerobic strains including *K. pneumoniae* significantly increased. The antibiotic resistance of *K. pneumoniae* to most antibiotics has increased over the past 10 years. Thus, it is important to perform bacterial culture and antibiotic sensitivity tests as soon as possible for effective treatment of deep neck space abscesses.

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Authors' Contributions

G.B.K. participated in data collection, performed the statistical analysis and wrote the manuscript. C.H.K. participated in the study design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

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Ethics Approval and Consent to Participate

This study was approved by the IRB of the Dankook University Dental Hospital (DKUDH IRB 2023-03-007). Because of the retrospective nature of the study, which did not use identifying personal information, the IRB waived the need to obtain written informed consent from the study participants.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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