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Predicting risk factors for complications in jaw cyst treatment: insights from a retrospective study

Yei-Jin Kang, Min-Keun Kim, Seong-Gon Kim, Young-Wook Park, Ji-Hyeon Oh

Department of Oral and Maxillofacial Surgery, College of Dentistry, Gangneung-Wonju National University, Gangneung, Korea

Abstract (J Korean Assoc Oral Maxillofac Surg 2025;51:33-40)

Objectives: Clinical situations that make it challenging to differentiate odontogenic cysts from non-odontogenic cysts and benign tumors of the jaw include cases with cystic conditions accompanied by secondary infection, impacted teeth, cortical thinning and expansion, or external root resorption. This study aimed to identify risk factors for complications in patients undergoing cyst enucleation of the jaw, propose a clinical model, and determine the necessary indications for preoperative root canal of adjacent teeth.

Materials and Methods: A review of surgical, pathological, and radiological reports, as well as medical records, was conducted. Pathological diagnosis, lesion size, history of preoperative endodontic treatment of the adjacent tooth, operator details, surgical procedures, age, gender, and complications (with severity) were analyzed.

Results: This study involved 77 patients (55 men, 22 women) and found 10 complications. Procedure type (cyst enucleation only, apicoectomy and bone graft, or bone graft only) and lesion size were significant risk factors. Preoperative root canal therapy and men gender also tended to positively correlate with complications, while age was not a factor.

Conclusion: Within the limitations of our study, additional procedures contributed to lower risk of complications with the exception of bone graft. A large cyst size was also associated with a higher risk of complications. It is important to consider the possibility of a second procedure and take thorough precautions to prevent infection when performing bone grafts. Patients should be informed of these risks in advance, scheduled for regular follow-up, and provided additional treatment when necessary.

Key words: Cysts, Dental pulp disease, Complications, Risk factors

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I. Introduction

Various types of cysts that involve root apexes can occur in the jaw. According to the literature, periapical cysts are the most frequent cyst followed by dentigerous cysts and nasopalatine duct cysts[1]. Clinical situations that make it challenging to differentiate odontogenic cysts from non-odontogenic cysts and benign tumors include cases with cystic conditions accompanied by secondary infection, impacted teeth, cortical thinning and expansion, and external root resorption[2,3].

Periapical cysts, also known as radicular cysts, are the most common type of jaw cyst, making up about half to two-thirds of all such lesions. On radiographs, continuity of lamina dura to the hyperostotic border is observed. These cysts typically develop from a periapical granuloma, which forms from the remnants of dead dental pulp. Chronic inflammation in this area initially triggers the cell rests of Malassez to proliferate, leading to the formation of the cyst[4].

Dentigerous cysts, which account for around one-sixth of dental cysts, are a fluid-filled expansion of the dental follicle and are attached to the tooth's crown at the junction between the enamel and cementum. Radiologically, they do not include the dental root[4].

Nasopalatine or incisive canal cysts originate from remnants of the nasopalatine ducts that were present during embryonic development. Cyst formation can be caused by local factors such as infection and trauma[4]. When differentiating them from periapical cysts, vitality testing of the teeth

Ji-Hyeon Oh
Department of Oral and Maxillofacial Surgery, College of Dentistry, Gangneung-Wonju National University, 7 Jukheon-gil, Gangneung 25457, Korea
TEL: +82-33-640-2761
E-mail: oms@gwnu.ac.kr
ORCID: https://orcid.org/0000-0002-6050-7175

involved teeth and continuity of the lamina dura on radiographs from different angles can be employed[3]. In differential diagnosis with dentigerous cyst, the relationship with the impacted mesiodens should be confirmed[3].

Infection is the most common postoperative complication of enucleation and curettage. An oroantral fistula is also a possible complication and may require a buccal advancement flap or a buccal fat pad advancement technique. A pathologic fracture may also occur in the mandible during the late postoperative period until sufficient bone regeneration has occurred[5].

Intraoperatively, if the lesion appears to be a benign tumor, enucleation and curettage may not be suitable and it could require resection instead[5]. If it is highly suspicious for benign tumor and an apicoectomy is planned, root canal therapy of the adjacent tooth could be necessary. For cysts affecting the apices of anterior teeth, electric pulp testing should be conducted, with nonvital teeth undergoing root canal therapy[6].

Interestingly, some studies indicate that even when a large cyst is associated with an erupted tooth, vitality can be preserved despite significant bone loss[6]. Infection in cysts may cause a temporary loss of vital response due to increased pressure, potentially leading to root resorption, pulpal ischemia, or necrosis[6]. In cases where a cyst impacts the apical region of a healthy tooth, blood flow to the pulp is maintained through the cyst capsule[6]. Removing the cyst lining can risk necrosis in adjacent teeth; thus, regular follow-up is crucial for monitoring the pulp vitality of teeth preserved without root canal therapy[6].

Previous studies about similar procedures have indicated that necrosis of adjacent teeth is extremely rare after maxillary sinus elevation (1/221)[7], and although pulp fibrosis is sometimes observed after posterior segmental osteotomy[8], it does not affect the prognosis of the teeth as many pulp tissues heal spontaneously, suggesting that root canal therapy should be postponed until absolutely necessary. Additionally, the nerves of adjacent teeth might regenerate post-surgery due to vascular endothelial growth factor and dental pulp stem cells[6].

Preoperative root canal therapy should be carefully considered by weighing the regenerative potential against the risk of complications, as tooth vitality will be lost. This study aims to identify risk factors for complications in patients undergoing cyst enucleation of the jaw, proposes a clinical model for predicting complications, and, based on this, identifies indications for preoperative root canal therapy of adjacent teeth.

II. Materials and Methods

1. Study design

This retrospective study was conducted with the approval of the Institutional Review Board (IRB) of Gangneung-Wonju National University Dental Hospital (GWNUDH-IRB2024-A006). The written informed consent was waived by the IRB due to the retrospective nature of the study. The study enrolled patients with cystic lesions of the jaw who underwent cyst enucleation at Gangneung-Wonju National University Dental Hospital between 2013 and 2023.(Fig. 1) Origin tooth has various environment such as infectious or developmental etiology and, what the worse, may not exist in non-odontogenic cyst. So, we focused on the effects of cyst enucleation on an adjacent tooth.(Fig. 2) Pathologic diagnosis of odontogenic keratocyst and unicystic ameloblastoma was excluded due to procedures involving peripheral ostectomy.

2. Data collection

A review of medical records was performed that included surgical, pathological, and radiological, reports. The inclusion criteria were (1) Patients with cystic lesions of the jaw who underwent cyst enucleation at Gangneung-Wonju National University Dental Hospital between 2013 and 2023, (2) Patients who were radiologically and pathologically diagnosed with either periapical cyst, dentigerous cyst, or nasopalatine duct cyst, (3) Patients who were followed postoperatively at least 6 months. Exclusion criteria were (1) Adjacent tooth apex with intact lamina dura (Fig. 2), (2) Previous root canal therapy on initial examination, (3) Adjacent tooth in question extracted during surgery, (4) Odontogenic keratocysts, (5) Unicystic ameloblastoma, or (6) Traumatic bone cyst. Electric pulp test (EPT) results, pathologic diagnosis, cyst size, preoperative root canal therapy, operator, surgical procedure, age, and gender were initial factors, and complications (with severity) were analyzed as outcome variables. For size measurement, maximum diameter was measured on computed tomography using INFINITT PACS 7.0 (INFINITT Healthcare).

3. Statistical analysis using SPSS

Data were analyzed using the statistical package IBM SPSS Statistics ver. 28.0 (IBM). Cross-tabulation analysis, Clavien–Dindo classification (Table 1) and chi-square test

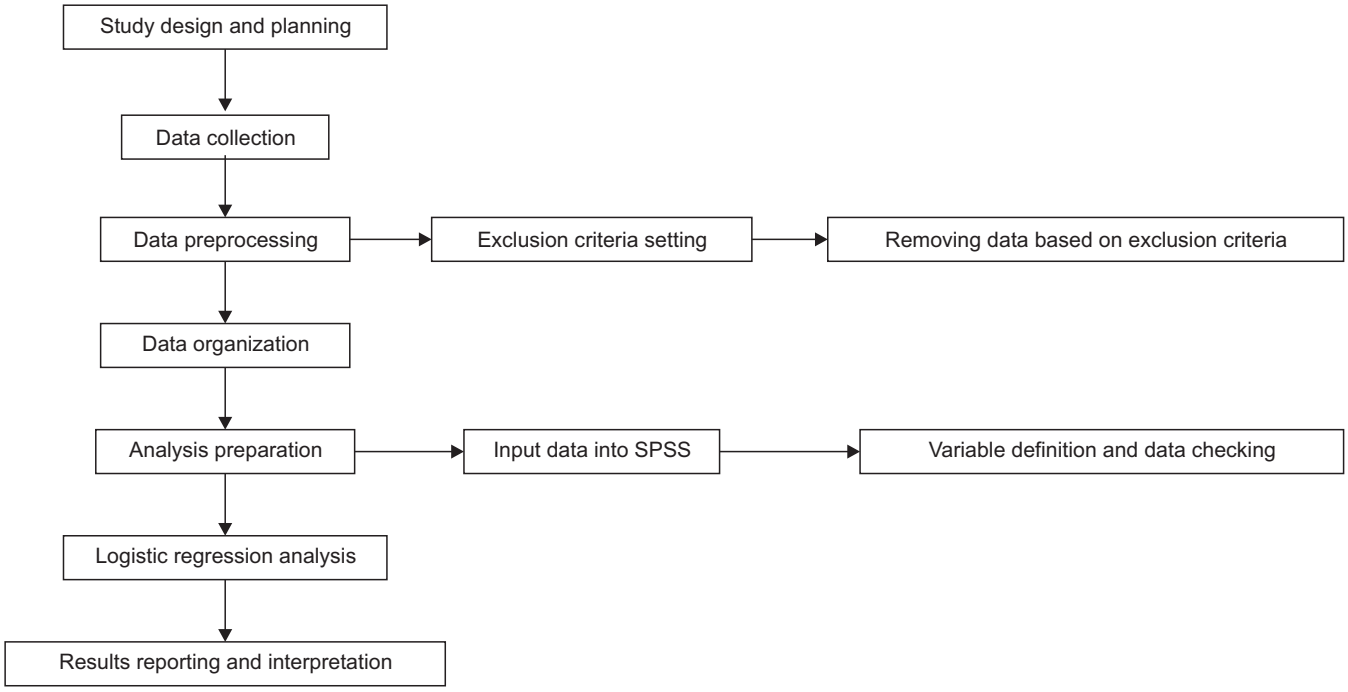

Fig. 1. Flow diagram of the study.
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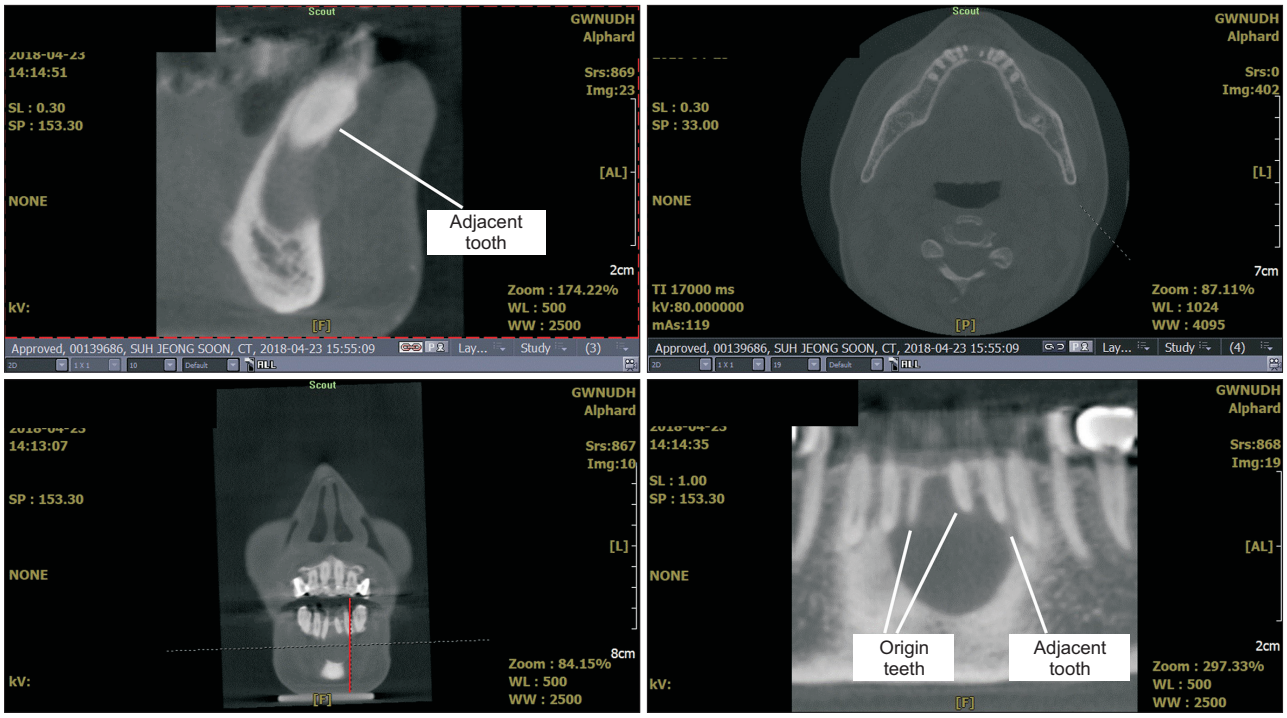

Fig. 2. Computed tomography image with the origin teeth and the adjacent tooth.
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(including Fisher's exact test, or linear by linear association) were used to check the variables. Univariable logistic regression was conducted for each variable to check significance. Multivariable logistic regression was carried out for significant variables. Selected variables were lesion size and procedure. The chi-square test was used for model coefficient total test (P<0.05). The Hosmer–Lemeshow test was used to check the goodness of fit and calibration for logistic regression

Table 1. Clavien–Dindo classification

Grade	Definition
Grade I	Any deviation from the normal postoperative course without the need for pharmacological treatment, or surgical, endoscopic, and radiological interventions Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgesics, diuretics and electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside
Grade II	Requiring pharmacological treatment with drugs other than such allowed for grade I complications Blood transfusions and total parenteral nutrition are also included
Grade III	Requiring surgical, endoscopic, or radiological intervention
Grade IIIa	Intervention not under general anesthesia
Grade IIIb	Intervention under general anesthesia
Grade IV	Life-threatening complications (including central nervous system complications) requiring IC/ICU management
Grade IVa	Single organ dysfunction (including dialysis)
Grade IVb	Multiorgan dysfunction
Grade V	Death of a patient

(IC: intermediate care, ICU: intensive care unit)

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Table 2. Statistical description and analysis of clinical features

	Patient discomfort		Complication severity (Clavien–Dindo)	Graft material	Total
	None	Reported			
Age (yr)					
≤40	15	2	I, II		17
>40	52	8	I, I, I, I, II, II, IIIa, IIIa		60
Gender					
Women	17	5	I, I, I, II, IIIa		22
Men	50	5	I, I, II, IIIa, IIIa		55
Pathology					
Abscess, granuloma	10	2	I, I		12
DC, NPC	41	5	I, II, IIIa, IIIa, IIIa		46
PAC	16	3	I, I, II		19
Size (mm)					
≤20	35	4	I, I, II, IIIa		39
>20	32	6	I, I, I, II, IIIa, IIIa		38
Procedure					
+A	17	0	-		17
+AB	2	2	I, I	Xeno, Xeno	4
+AE	3	0	-		3
+B	2	2	II, IIIa	Auto+xeno, Auto+xeno	4
+BE	6	1	IIIa	Auto tooth	7
C	9	4	I, I, II, IIIa		13
+E	28	1	I		29
Preoperative RCT					
Performed	29	4	I, I, IIIa, IIIa		33
Not performed	38	6	I, I, I, II, II, IIIa		44
Operator					
Resident	5	1	I		6
Staff	62	9	I, I, I, I, II, II, IIIa, IIIa, IIIa		71

(DC: dentigerous cyst, NPC: nasopalatine canal cyst, PAC: periapical cyst, +A: apicoectomy, +AB: apicoectomy; bone graft, +AE: apicoectomy; extraction, +B: bone graft, +BE: bone graft and extraction, C: cyst enucleation only, +E: extraction, -: not applicable, RCT: root canal therapy [of involved adjacent tooth])

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models (P>0.05). The level of significance was set at P<0.05.

4. Nomogram

Using Orange statistic software (Orange Data Mining 3.37.0; University of Ljubljana) logistic regression was conducted again after categorization, and a nomogram was formed. Each factor was presented according to its significance, translated as points, and summation of the points was calculated as the likelihood of complication.

III. Results

The study included 77 patients, 55 men and 22 women (men:women, 2.5:1), and resulted in 10 discomforts and complications.(Table 2) In this study, cases that did not undergo electric pulp testing existed, so this factor was excluded from analysis. There were no preoperative root canal therapy-related complications such as root fracture.

As complications, the following were observed: 5 cases of surgical site infection, 2 cases of reduced sensation in teeth or

skin, 1 case of tooth discoloration, 1 case of a secondary primary lesion at the same site, and 1 case of recurrence. There was 1 case of postoperative root canal therapy due to infection and 1 case of postoperative root canal therapy due to discoloration of the other tooth. Every complication was Clavien–Dindo Grade ≤IIIa[9]. On Fisher's exact test, there was no significant difference in complication rates in procedures using particulate bone material (*P*=0.084); however, this was at the borders of the confidence limit (*P*<0.1).(Table 3)

For analysis of the complication risk of each clinical variable, Fisher's exact test or linear by linear association was used. Cyst size (*P*=0.005, odds ratio [OR]=8.034) and procedure (*P*=0.011, OR=13.45) were significant variables.

On univariable logistic regression, the size and procedure (C: cyst enucleation only, +AB: with apicoectomy, bone graft, +B: with bone graft) were significantly associated with a higher risk of complications.(Table 4) The selected variables were tested after controlling for other variables using multivariable logistic regression. The chi-square test was used for model coefficient total test (*P*=0.002). The Hosmer–Lemeshow test was used to check the goodness of fit and calibration for logistic regression models (*P*=0.907).

Table 3. Analysis of bone graft material (Fisher's exact test)

	None	Reported	*P*-value
Particulate	10	5	0.084
Non-particulate	5	0	-

(-: not applicable)

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Table 4. Evaluation of each clinical variable (univariable logistic regression)

		P-value	Odds ratio
Pathologic diagnosis	PAC	0.585	0.650
Ref: periapical abscess, granuloma	NPC, DC	0.948	1.067
Size[1]		0.011	1.098
No preoperative RCT		0.658	1.563
Operator	Staff	0.781	0.726
Procedure	C[1]	0.033	12.444
Ref: +E	+A	0.999	0.000
	+AB[1]	0.020	28.000
	+AE	0.999	0.000
	+B[1]	0.020	28.000
	+BE	0.299	4.667
Age		0.958	1.001
Women gender ref: men		0.119	2.941

(PAC: periapical cyst, NPC: nasopalatine canal cyst, DC: dentigerous cyst, RCT: root canal therapy [of the involved adjacent tooth], +E: extraction, C: cyst enucleation only, +A: apicoectomy, +AB: apicoectomy; bone graft, +AE: apicoectomy; extraction, +B: bone graft, +BE: bone graft and extraction)

[1]Significant factor.

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On multicollinearity, tolerance was over 0.7 and the variance inflation factor was under 1.2. Larger size raised the risk of complication by 1.127 (*P*=0.047). Cyst enucleation only (C) raised complication risk by 17.716 compared to cyst enucleation with extraction (*P*=0.027). Cyst enucleation with apicoectomy and bone graft (+AB) increased complication risk by 33.939 compared to cyst enucleation with extraction (*P*=0.031). Cyst enucleation including bone graft (+B) elevated complication risk by 52.751 compared to cyst enucleation with extraction (*P*=0.009).(Table 5)

A nomogram for predicting complications was developed based on the logistic regression model. All variables were included after categorization.(Fig. 3) Procedure type was deemed to be the most critical factor. The blue points represent the fact that the bigger cyst size, treatment without extraction or apicoectomy, and treatment with bone graft has probability of discomfort by 48%.

IV. Discussion

We propose a clinical model for predicting complications in patients undergoing cyst enucleation of the jaw to facilitate decision-making in clinical situations where it is difficult to differentiate between odontogenic and non-odontogenic cyst and benign tumors.

Additional procedures such as apicoectomy, extraction, and preoperative root canal therapy lower the risk of complications, with the exception of bone graft. Previous studies suggested that particulate bone grafts may increase the risk of postoperative infection[10], which was consistent with our results. Some researchers have even argued that bone defects left after curettage may not need bone grafting for successful outcomes[11]. However, grafting large bone defects offers several structural and biological benefits that can accelerate healing and help restore normal function[12]. For future implant sites, the bone graft can be beneficial[11]. In large bone defects and sites prepared for future implants, achieving careful pri-

Table 5. Complication risk of each clinical variable (multivariable logistic regression)

		P-value	Odds ratio
Size[1]		0.047	1.127
Procedure	Cyst enucleation[1]	0.027	17.716
Ref: +E	+AB[1]	0.031	33.939
	+B[1]	0.009	52.751

(+E: extraction, +AB: apicoectomy; bone graft; +B: bone graft)

[1]Significant factor.

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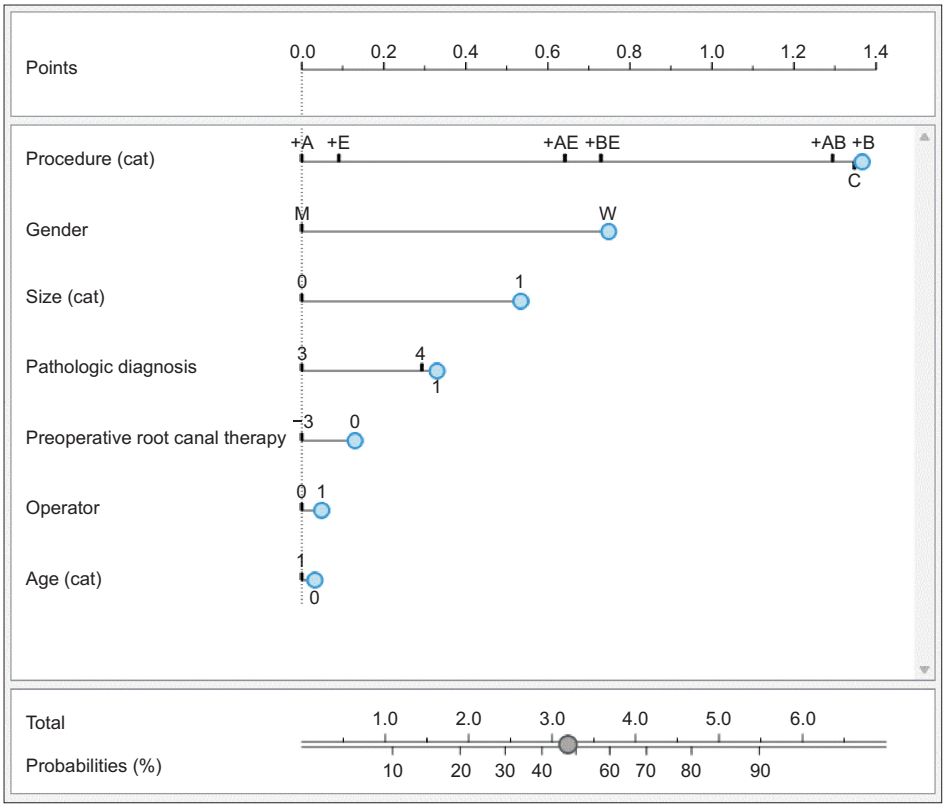

Fig. 3. A nomogram for predicting complication was developed based on a univariate logistic regression model. The procedure was deemed to be the most critical.
[Size] ≤20 mm: 0, >20 mm: 1
[Pathologic diagnosis] Periapical abscess, granuloma: 1; Periapical cyst: 4; Nasopalatine canal cyst, dentigerous cyst: 3
[Preoperative root canal therapy] Performed: 1, Unperformed: 0
[Operator] Resident: 0, Staff: 1
[Age] ≤40, >40
(+A: apicoectomy, +E: extraction, +AE: apicoectomy; extraction, +BE: bone graft and extraction, +AB: apicoectomy; bone graft, +B: bone graft, C: cyst enucleation only, M: men, W: women)
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mary closure of the grafted area is essential, with the use of a membrane whenever necessary.

Larger lesions result in more extensive bone defects. A previous study found that critical-size alveolar bone defects (≥20 mm) did not heal completely within one year[11]. The median percentage reduction in defect volume was 98% for the bone graft group compared to 73% for the control group (P=0.001), with evidence of soft tissue invagination in the control group[11]. This invagination can lead to trapping of food debris postoperatively. Proprioception and vitality, which help protect the wound during healing, combined with the inaccessibility of the surgical site, makes it very difficult for patients to clean the area conventionally[13]. Enucleating a large cyst can also increase the risk of damaging nerves connected to the dental pulp. In such cases, marsupialization is an option if tooth vitality might be compromised, although neoplastic changes in the cystic lining cannot be confirmed. Therefore, enucleation remains a viable option, with close postoperative follow-up being essential.

As another factor related to pathology, periapical abscesses and granulomas tend to carry the highest risk of complications. If left untreated, these periapical lesions can lead to severe complications due to the spread of infection. Potential complications include osteomyelitis, cellulitis, bacteremia, and the formation of a fistulous tract that opens into the oral cavity or skin. In severe cases, cavernous sinus thrombosis may also occur[14]. Surgical site infections caused by microorganisms are more frequent in cases involving acute abscesses and are predominantly due to anaerobic bacteria[15]. Secondary acute apical periodontitis is acute exacerbation of an existing chronic apical periodontitis lesion[16]. This condition can manifest as a secondary apical abscess when bacteria migrate from the root canal to infect the periapical tissue, although other local or systemic changes may also trigger acute inflammatory responses[17]. Surgical intervention may be a contributing factor to acute exacerbation in periapical granuloma. In contrast, periapical cysts show a lower incidence of complications, possibly due to their more chronic nature[16] and the potential protective role of host immunity.

There has been unpublished report that preoperative root canal treatment reduces postoperative complications. However, in this study, we did not observe that association due to the small sample size. Since postoperative EPT was positive even in some patients who had a negative EPT preoperatively, it may be possible to decide on root canal treatment for teeth adjacent to the cyst either preoperatively or postoperatively with EPT reevaluation after providing information on the risks and benefits to the patient. As another approach, EPT

results can serve as a reference for this decision especially in anterior teeth. In this study, a treatment plan based on EPT showed a lower incidence of complications. Additionally, preoperative radiographic diagnosis may indicate the need for preoperative root canal treatment and apicoectomy if invasive lesions are suspected.

Age was not a factor influencing complications. Considering wound healing delay in elderly patents, this might be due to fast growth patterns of cysts in younger patients[18]. Women gender tended to be related to higher risk. In postmenopausal women, decreased immunity and healing ability[19] may have an effect, or the patient's deppression could be a factor. Staff have a tendency of a risk factor unexpectedly. In addition to larger lesions, other factors such as procedure complexity, unplanned procedures (which carry higher surgical risks), patient expectations, and the involvement of more perioperative staff could affect outcomes[20], and long-term follow-up may also have influenced the observed incidence.

This study has several limitations. First, the sample size of patients was small as involved adjacent tooth was needed adequate for inclusion criteria. Furthermore, since this was a single-center study, the findings may not be widely applicable, highlighting the need for multicenter studies to confirm these results across different populations and settings. Second, as a retrospective study, our research is subject to inherent biases and limitations in data collection and analysis. Future research should focus on prospective studies to provide more reliable data and a better understanding of the factors influencing complications.

V. Conclusion

Within the limitations of our study, additional procedures reduced the risk of complications resulting from jaw cyst enucleation, except for bone grafts. Large cyst size was associated with a higher risk of complications. It is important to consider the possibility of a second procedure and take thorough precautions to prevent infections when performing bone grafts. Patients should be informed of these risks in advance, scheduled for regular follow-up, and provided additional treatment when necessary.

ORCID

Yei-Jin Kang, *https://orcid.org/0000-0002-6984-5234*
Min-Keun Kim, *https://orcid.org/0000-0002-5481-841*X
Seong-Gon Kim, *https://orcid.org/0000-0001-5088-2732*
Young-Wook Park, *https://orcid.org/0000-0001-5881-7257*
Ji-Hyeon Oh, *https://orcid.org/0000-0002-6050-7175*

Authors' Contributions

The study design, data collection, and analysis were conducted by Y.J.K. M.K.K. supported with data collection. Analyzing data was instructed by J.H.O., Y.W.P., and S.G.K. The initial version of the article was authored by Y.J.K. and J.H.O. performed the critical review. All the authors read and approved the final version of the manuscript.

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Ethics Approval and Consent to Participate

This retrospective study was conducted with the approval of the Institutional Review Board (IRB) of Gangneung-Wonju National University Dental Hospital (GWNUDH-IRB2024-A006). The written informed consent was waived by the IRB due to the retrospective nature of the study.

Conflict of Interest

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

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