



Three-dimensional analysis of decompression efficacy and influencing factors in the maxillofacial cystic lesions: a retrospective study

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Abstract (J Korean Assoc Oral Maxillofac Surg 2024;50:197-205)

Objectives: To evaluate the effectiveness of decompression and various parameters that may affect volume change in cystic lesions.

Patients and Methods: This retrospective study included patients who visited the Department of Oral and Maxillofacial Surgery at Ewha Womans University Medical Center between 2012 and 2022 for decompression of cystic lesions of the jaw. To measure volume changes, pre- and post-decompression cone-beam computed tomography was performed and reconstructed in three dimensions using Mimics 25.0 software (Materialise NV). A comparative analysis was performed based on sex, age, initial cyst volume, location, degree of cortical layer expansion, and pathologic diagnosis using the Mann-Whitney U and Kruskal-Wallis tests.

Results: In all 20 cases, the duration of decompression was 7.84 ± 3.35 months, and all patients successfully completed the decompression period without any complications. Significant differences were observed in the reduction rate and shrinkage speed based on the degree of cortical layer expansion. However, only the shrinkage speed (not the reduction rate) showed a significant difference with respect to the initial cyst volume. Significant differences were not observed based on sex, age, location, or pathologic diagnosis.

Conclusion: Although the present study involved a small number of cases, the effectiveness of decompression was confirmed. In particular, 3D analysis overcame the shortcomings of previous studies of decompression and allowed earlier resection. Further studies with more patients are required to provide a rationale for these results and identify factors that influence decompression.

Key words: Decompression, Odontogenic cysts, Cone-beam computed tomography

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I. Introduction

An odontogenic cyst is a connective tissue-lined space filled with soft or hard substances. The osmotic pressure inside a cyst is higher than in the surrounding area, allowing the entry of foreign tissue and resulting in increased fluid in the cavity and destruction of surrounding bone tissue. These cysts are common within the jaw and are usually slow-growing, asymptomatic, and sometimes remain undetected until they are very large. In such cases, invasion of important

anatomical structures such as the inferior alveolar nerve and maxillary sinus, tooth displacement, root resorption, nerve damage, and jaw bone fracture may occur^{1,2}.

Various treatments have been used for managing these cysts, ranging from decompression only to marsupialization, enucleation, and resection or a combination of decompression and enucleation^{3,4}. In developing a treatment plan for a cyst, features such as patient age, anatomical location of the lesion, lesion size, and histological diagnosis should be considered to obtain a better prognosis. Although invasive surgery (such as enucleation and resection) is usually considered the treatment of choice for cyst removal, conservative treatment should be considered if serious complications such as facial deformities, jaw bone fractures, tooth damage, or nerve damage are anticipated following surgery^{4,9}.

Decompression is a common conservative procedure in which the surgeon creates a window between the cyst and external environment, reducing the pressure of the cystic fluid in the cavity to stimulate growth of the osteoblasts¹⁰

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and induce bone deposition toward the cystic wall^{10,11}. If these methods result in a reduction in lesion size to not affect important anatomical structures such as the teeth or nerves, additional surgery may be performed to excise the remaining cyst^{2,12}.

Although the efficacy of decompression has been reported in several previous studies, the factors affecting cyst volume reduction and the rate of shrinkage remain controversial. The reduction in the size of the bone defects following decompression is commonly evaluated using panoramic radiographic imaging^{13,14}. Thus, information on the three-dimensional (3D) relationship between cystic lesions and major anatomical structures is limited^{15,16}, limiting determination of their exact size. These limitations hinder the ability to identify factors influencing cyst size changes after decompression and plan subsequent treatment strategies.

Thus, assuming that 3D assessment of volumetric changes in cystic lesions before and after decompression surgery could provide a more accurate evaluation of the efficacy of decompression surgery and help identify factors that may influence volume changes, cone-beam computed tomography (CBCT) was used to evaluate the effectiveness of decompression and analyze parameters that may affect the volume change in cystic lesions.

II. Patients and Methods

1. Study design and sample

This retrospective study followed the ethical standards of the Declaration of Helsinki and was approved by the Institutional Review Boards of Ewha Womans University Medical Center, Ewha Womans University Mokdong Hospital (No. 2022-09-003), and Ewha Womans University Seoul Hospital (No. 2022-09-010-002). Informed consent was obtained.

Patients who visited the Department of Oral and Maxillofacial Surgery at Ewha Womans University Mokdong Hospital or Ewha Womans University Seoul Hospital between 2012 and 2022 and who underwent decompression for cystic lesions of the jaw were selected. Twenty-six patients met the inclusion criteria (20 at Ewha Womans University Mokdong Hospital and six at Ewha Womans University Seoul Hospital).

The inclusion criteria were the following: histopathological diagnosis of odontogenic cysts, decompression based on the treatment plan, CBCT performed at least once for preoperative and postoperative comparisons, and at least 6 months of

follow-up. The following patients were excluded: patients who did not follow-up after decompression, had missing CT data, were illiterate, did not understand the decompression procedure or did not provide consent, were unable to perform self-cleaning, were pregnant, or had local infection or systemic diseases such as osteoporosis that could affect bone metabolism.

2. Surgical procedures for decompression

All patients underwent a standardized protocol as described below. Patients underwent CBCT imaging between 2012 and 2022 prior to the surgery at Ewha Womans University Mokdong Hospital using the CT scanner DINNOVA 3 (HDX Corp.) at a measurement value of 90 kVp (voltage), quality standard of 10 mA (tube current), and field of view (FOV) of 20×19 cm and between 2019 and 2022 at Ewha Womans University Seoul Hospital using the CT scanner Osstem T1 (Osstem Implant Co., Ltd.) at a measurement value of 95 kVp (voltage), quality standard of 6 mA (tube current), and FOV of 15×9 cm.

An incision was made under local anesthesia (2% lidocaine with 1:100,000 epinephrine; Yuhan Corp.) to perform decompression. A handpiece with a burr was used to create an opening to access the cyst, and a portion of the cystic membrane tissue was dissected and biopsied for histological confirmation. A disposable suction catheter (PVC; Medi-Force) was cut to the required length and diameter (12-16 Fr) based on the size of the lesion, inserted into the cyst, sutured to the oral mucosa using 4-0 Ethilon (Ethicon) to maintain patency, and irrigated with normal saline several times. In cases where suturing to prevent catheter dislodgement was difficult, acrylic resin was used to fabricate an obturator that could be worn by the patient as shown in Fig. 1. If an impacted third molar or some other tooth was present that could be extracted without complications, the tooth was extracted. Postoperatively, 250 mg amoxicillin and 385 mg ibuprofen were prescribed for 7 days, and the patient used a 0.2% chlorhexidine mouthwash daily. The patient was instructed to return to the clinic every week for 1 month after the procedure and to self-rinse with saline 2-3 times daily. Thereafter, the patient was followed up monthly, and if the catheter became contaminated or had fallen out, it was immediately replaced with a new catheter. CBCT was performed every 2 months to determine the timing of resection based on the size of the lesion and its relationship with the surrounding structures.(Fig. 2) Enucleation was performed when the cystic

tic boundaries were sufficiently clear to minimize damage to the surrounding structures.

3. Data collection

The duration of decompression was calculated as the date of CBCT at the first visit to the department to that of the last CBCT performed before resection. To measure the total volume of each patient's cystic lesion, the Digital Imaging and

Communications in Medicine files were entered into Mimics 25.0 software (Materialise NV). The cross-sectional boundary of the cystic lesion was used to delineate the lesion area using the difference in Hounsfield units in the CBCT images in all directions where the cyst was observed. After establishing the cross-sectional boundary of the lesion, the cyst was reconstructed three-dimensionally to measure its volume. (Fig. 3) The area marked as the cyst was reviewed and corrected along all axes of the CBCT image. The volume change fol-

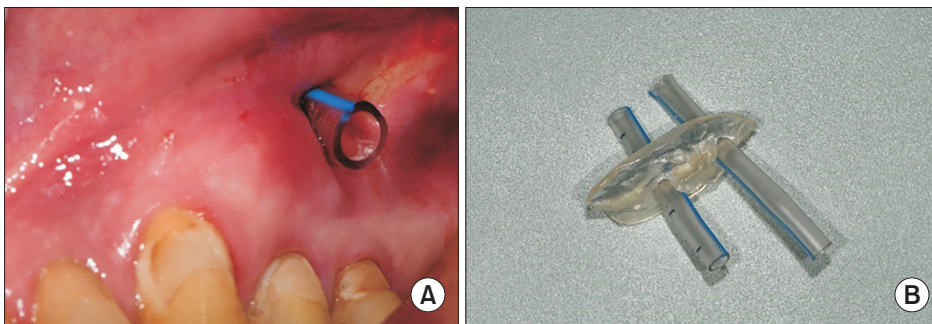


Fig. 1. A case involving catheter placement for decompression. A. Intraoral view after catheter placement for decompression. B. Obturator produced with acrylic resin and a catheter.
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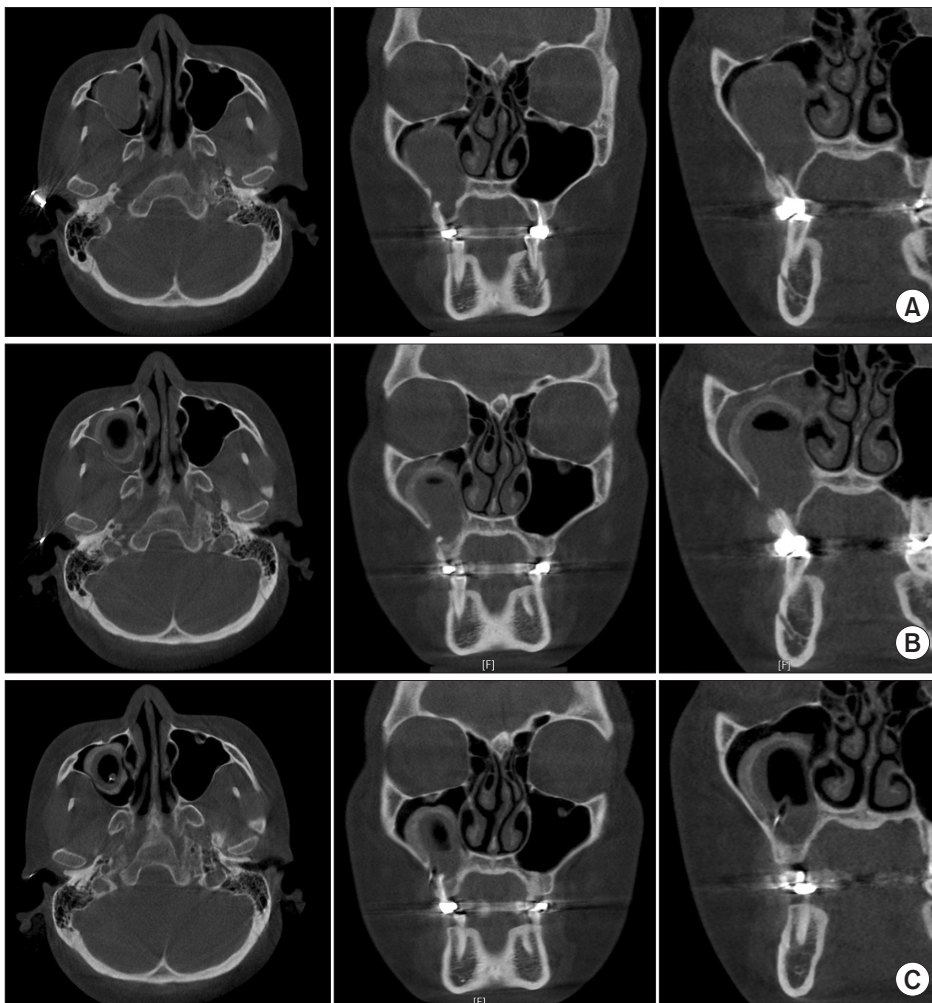


Fig. 2. Coronal and sagittal cone-beam computed tomography performed at follow-up after decompression; cystic lesion size decreased over the course of approximately 11 months. A. At initial diagnosis. B. Five months after decompression. C. Eleven months after decompression.
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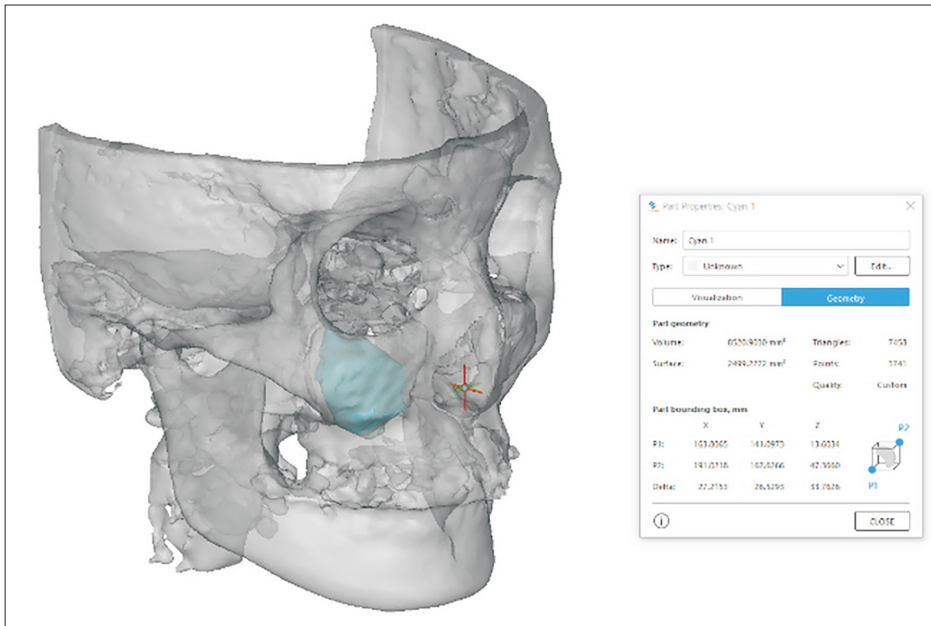


Fig. 3. Cystic lesion analysis in cone-beam computed tomography images. Three-dimensional reconstruction for volume measurement.

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lowing decompression was visually verified using the same method. In the mandible, the cyst was near the anatomical structures, such as the inferior alveolar nerve, and separation of the nerve and cyst lesion was confirmed during decompression and follow-up. To minimize error, a single clinician (SML) performed the procedure.

4. Parameters considered for evaluating the factors affecting decompression

To determine the factors influencing the effectiveness of decompression, a comparative analysis was performed based on patient sex and age, initial cyst volume, lesion location, degree of cortical layer expansion, and pathologic diagnosis. The criteria for these factors were based on previous studies: age was set at 30 years based on a study by Ihan Hren et al.¹⁷, and the initial volume of the cyst was set at 10,000 mm³ based on a study by Anavi et al.¹⁸. In addition, based on existing studies, the criteria were set and compared, and the reduction rate and shrinkage speed of the cysts were calculated¹⁹. Cases were categorized as severe when the degree of cortical layer expansion extended >1.5-fold buccolingually compared with the opposite normal site, and cases extending <1.5-fold were classified as mild¹⁹. To minimize bias, two reviewers independently assessed the data during the data collection and analysis process, and any ambiguous cases were resolved through discussion.

5. Statistical analysis

Data were analyzed using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp.). The Mann-Whitney U and Kruskal-Wallis tests were used for statistical analyses. Statistical significance was set at $P < 0.05$.

III. Results

Among the 26 patients who underwent decompression, six were not included in the study due to failure to attend follow-up appointments at the scheduled times, catheter dislodgement preventing tracking, or missing CBCT images. In all 20 cases (17 at Ewha Womans University Mokdong Hospital and three at Ewha Womans University Seoul Hospital), the duration of decompression was 7.84 ± 3.35 months, and all patients successfully completed the decompression period without any complications such as infection or edema. Furthermore, enucleation was safely performed, and no patients complained of signs of nerve damage. Demographic information regarding the participants is presented in Table 1, and pathological information about the odontogenic cyst is shown in Supplementary Table 1.

Table 2 shows the volume reduction rate and shrinkage speed of 20 odontogenic cysts based on the clinical and radiologic parameters. Significant differences were observed in the cyst volume reduction rate and shrinkage speed based on the degree of cortical layer expansion. Analysis of the degree of cortical layer expansion revealed a reduction rate of

62.0% in 12 mild cases and of 74.0% in eight severe cases, with a *P*-value of 0.045. In addition, the shrinkage speed was 557.1 mm³/month in mild cases and 1045.8 mm³/month in severe cases, with a *P*-value of 0.025. However, only shrinkage speed showed a significant difference with respect to the

initial cyst volume. For this volume, 16 of 20 patients had a reduction rate of 69.6% when the volume was <10,000 mm³ and of 67.6% when ≥10,000 mm³ (*P*=0.925). The shrinkage speed was 637.1 mm³/month when the volume was <10,000 mm³ and 1,703.2 mm³/month when ≥10,000 mm³ (*P*=0.038). Significant differences were not observed based on sex, age, location, or pathologic diagnosis.

Table 1. Patient information

| Variable | Total (n=20) |
|--|--------------|
| Sex | |
| Male | 8 |
| Female | 12 |
| Age (yr) | |
| ≤30 | 11 |
| >30 | 9 |
| Initial cyst volume (mm ³) | |
| <10,000 | 16 |
| ≥10,000 | 4 |
| Location | |
| Maxilla | 7 |
| Mandible | 13 |
| Degree of cortical layer expansion | |
| Mild | 8 |
| Severe | 12 |
| Pathologic diagnosis | |
| Dentigerous cyst | 11 |
| Radicular cyst | 7 |
| OKC | 2 |

(OKC: odontogenic keratocyst)

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IV. Discussion

In this retrospective study, the volume changes in maxillofacial cysts following decompression were analyzed using CBCT, and the effectiveness of decompression for the treatment of cysts was evaluated by assessing the influence of patients' sex and age, initial cyst volume, lesion location, degree of cortical layer expansion, and pathological diagnosis. Because volume reduction after decompression occurs in three dimensions, measuring the volume or reduction rate of a lesion using two-dimensional panoramic images is not accurate. Thus, 3D analysis using CT is useful for more accurate assessment of cyst volume or involvement of adjacent structures because the boundaries of the lesion are accurately shown^{20,21}. However, conventional CT is expensive and involves high radiation exposure, hindering additional scans during follow-up. In contrast, CBCT is useful due to its low cost and low exposure and has recently become a key diagnostic tool in dentistry, providing 3D images of the

Table 2. Rate of reduction in cyst volume and shrinkage speed based on parameters

| Parameter | Reduction rate | | | Shrinkage speed | | |
|--|----------------|-------------------------------|-----------------|-----------------|-------------------------------|-----------------|
| | Mean±SD | Mann-Whitney U test/ χ^2 | <i>P</i> -value | Mean±SD | Mann-Whitney U test/ χ^2 | <i>P</i> -value |
| Sex | | | | | | |
| Male | 66.2±11.1 | 35 | 0.316 | 697.8±619.7 | 38 | 0.440 |
| Female | 71.2±13.5 | | | 952.0±812.0 | | |
| Age (yr) | | | | | | |
| ≤30 | 69.9±14.6 | 48 | 0.909 | 739.9±460.1 | 47 | 0.939 |
| >30 | 68.2±10.4 | | | 1,015.9±1038.7 | | |
| Initial cyst volume (mm ³) | | | | | | |
| <10,000 | 69.6±12.8 | 31 | 0.925 | 637.1±448.9 | 10 | 0.038* |
| ≥10,000 | 67.6±13.1 | | | 1,703.2±1,094.5 | | |
| Location | | | | | | |
| Maxilla | 70.3±14.4 | 38 | 0.552 | 1,207.6±1,028.2 | 32 | 0.285 |
| Mandible | 68.5±12.1 | | | 657.9±459.7 | | |
| Degree of cortical layer expansion | | | | | | |
| Mild | 62.0±11.4 | 22 | 0.045* | 557.1±559.5 | 19 | 0.025* |
| Severe | 74.0±11.3 | | | 1,045.8±788.4 | | |
| Pathologic diagnosis | | | | | | |
| DC | 70.3±13.0 | 0.609 ¹ | 0.738 | 867.0±658.4 | 0.354 ¹ | 0.838 |
| RC | 67.4±15.1 | | | 593.3±339.4 | | |
| OKC | 66.0±0.66 | | | 519.4±99.9 | | |

(DC: dentigerous cyst, RC: radicular cyst, OKC: odontogenic keratocyst, SD: standard deviation)

¹Kruskal-Wallis test.

**P*<0.05.

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maxillofacial area²². Although differences may exist between multidetector CT (MDCT) and CBCT²³, recent studies have suggested that these differences are not significant. Furthermore, studies have been performed in which CBCT was used for decompression in the maxillofacial area²⁴.

Those previous results were the basis for the present study, although two different CBCT systems were used. After Mimics software was used to adjust for the three cases impacted by the different systems, the results were not significantly different; therefore, those three cases were included in the analysis.

In the present study, sex and age were not correlated with volume loss. Lizio et al.³, Gao et al.²⁵, and Kubota et al.²⁶ found no correlation between age and volume reduction, while Park et al.², Anavi et al.¹⁸, and Song et al.²⁷ did report such a correlation.

Song et al.²⁷ reported that the volume reduction rate was associated with the original size of the cystic lesion before decompression, and other studies reported that volume reduction increased with cyst size^{19,28}. However, Anavi et al.¹⁸ reported a significantly higher rate of reduction for smaller cysts than for larger cysts. In the present study, significant correlation was not observed in the rate of reduction; however, the shrinkage speed was significantly higher for larger cystic lesions ($P<0.05$).

Regarding the location of the cyst in the jaw, the mean volume reduction rates were 70.3% and 68.5%, with mean shrinkage speeds of 1,207.6 mm³/month and 657.9 mm³/month in the maxilla and mandible, respectively. Although the maxilla showed a higher reduction rate and faster shrinkage speed, the difference was not statistically significant. The higher rate of volume reduction and shrinkage speed in the maxilla may occur because most cysts in that area are associated with the maxillary sinus, which contains air. However, the mandible is a large, hard, U-shaped bone that can hinder volume reduction compared with the maxilla.

In the present study, several factors that may influence cyst volume changes were evaluated, and a significant difference was found in the degree of cortical layer expansion ($P<0.05$). However, in previous studies, significant differences were not observed in the rate of cyst volume reduction with the degree of cortical layer expansion^{19,27}.

In several studies, volumetric changes following pathologic diagnosis and decompression have been evaluated^{27,29}. Gao et al.²⁵ reported that decompression was more effective for radicular cysts (RCs) than for odontogenic keratocysts (OKCs) or unicystic ameloblastomas. Similar results were obtained

by Kubota et al.²⁶, who reported faster shrinkage speed after decompression in RCs than in OKCs or dentigerous cysts (DCs). In contrast, Kim et al.³⁰ reported greater shrinkage in DCs than in OKCs or RCs after decompression. However, Anavi et al.¹⁸ reported a few significant intergroup differences in shrinkage speed among RCs, DCs, and OKCs. In the present study, intergroup differences in the rate of reduction and shrinkage speed were not observed ($P>0.05$).

The factors influencing decompression remain controversial due to variations in conditions and analytical methods across studies. Notably, the results of the present study differed from previous studies due to the relatively small sample size; however, the effectiveness of decompression was confirmed. For large odontogenic cysts in the oral and maxillofacial regions, decompression can minimize damage to the adjacent structures and reduce the amount of bone grafting required, decreasing the treatment cost and risk of graft failure^{14,31,32}. The ability of decompression to reduce the extent or difficulty in performing the surgery, especially in children and older adult patients, leads to more favorable treatment outcomes compared with conventional resection³³. Complications have been reported more frequently when immediate excision is performed without decompression or marsupialization of extensive jaw cysts. In the literature, the prevalence of permanent sensory disturbances ranges from 2.0%-18.0%, temporary sensory disturbance from 8.0%-35.0%, and incomplete ossification from 12.0%-40.0%^{18,34-36}. Although the need for additional surgery following sufficient reduction of the cyst volume after decompression is a disadvantage, the resulting histological changes are conducive for resection, as shown in Fig. 4 for the present study. The epithelial lining was confirmed to be thicker and easier to enucleate after decompression⁷. Marker et al.⁶ reported that histologic changes facilitated enucleation in 23 OKC cases. However, response to decompression can vary by case, and regular follow-up is essential.

The disadvantages of decompression include a long treatment duration, discomfort, and varying results that greatly depend on patient cooperation^{37,38}. Regarding the decompression period, Enislidis et al.³⁹ reported an average shrinkage of 81% in 446 days, Lizio et al.³ reported an average reduction of 49.86% in 5.7 months, and Song et al.²⁷ reported a 48.28% reduction in volume in six months. Marker et al.⁶ recommended 12 months of decompression for odontogenic cysts, and Anavi et al.¹⁸ recommended 33 months for the maxilla and 22 months for the mandible. Park et al.⁴⁰ calculated the half-life of an odontogenic cyst to be 270 days. In the pres-

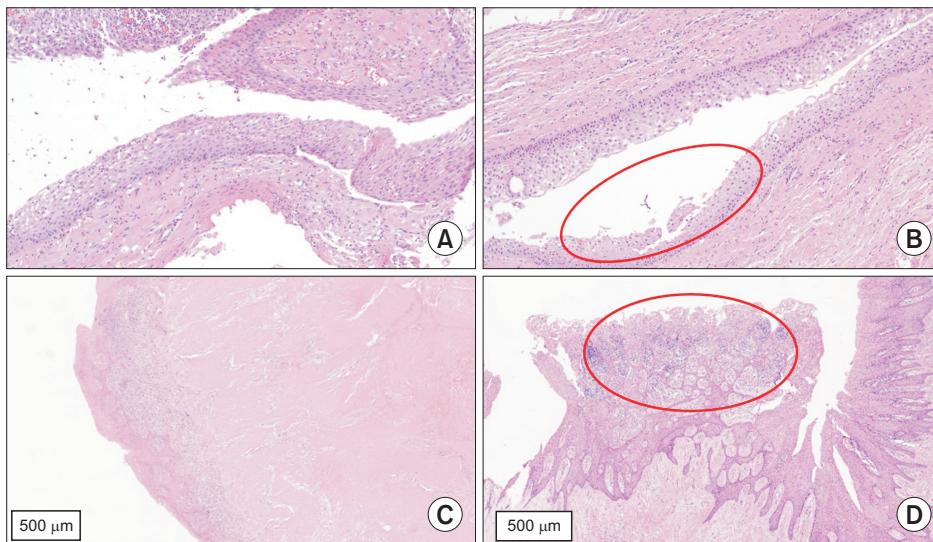


Fig. 4. Histopathologic changes due to decompression. A. Before decompression of an odontogenic keratocyst (H&E staining, $\times 200$). B. After decompression with resection (H&E staining, $\times 100$). C. Before decompression (H&E staining, $\times 40$) of a dentigerous cyst. D. After decompression with resection (H&E staining, $\times 40$).

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ent study, the duration of decompression was determined by observing the changes in the lesion. Furthermore, the enucleation was completed without any unusual complications. Compared with the duration of decompression in several previous studies, a short period of decompression was performed in the present study, and the rate of decompression was fast until 3-6 months after the procedure and then gradually slowed. (Supplementary Fig. 1) This finding is consistent with that of Tomomatsu et al.⁴¹, who showed a significant difference in the first 3-4.5 months and recommended enucleation be performed at 4.5 months. Although the duration of decompression varies widely by case, the ideal duration of decompression should be considered until the time when resection can be performed without damaging important anatomical structures^{2,29}. The performance of 3D analysis is expected to allow enucleation at an earlier time than in previous cases, somewhat compensating for the shortcomings of decompression. However, the present study had several limitations. The number of cases was relatively small, and there were only a few cases for each pathological diagnosis. In addition, even with appropriate software, standardizing the Hounsfield units obtained from CBCT is difficult compared with those of MDCT, and the results may vary by CBCT machine. This may introduce bias in the statistical analysis of volume changes and the efficacy of decompression. Furthermore, the study was limited to Korean patients, which may introduce regional and racial biases.

V. Conclusion

In the present study, 20 cases were analyzed to measure

volume change during decompression of odontogenic cysts. Although the present study involved a small number of cases, the effectiveness of decompression was confirmed. In particular, 3D analysis overcame the shortcomings of previous studies of decompression and allowed earlier resection. Further studies with more patients are required to provide a rationale for these results and identify factors that influence decompression.

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Authors' Contributions

H.Y.K. and S.M.L. obtained the data and wrote the manuscript. J.H.P. and S.J.K. reviewed and revised the manuscript. All authors read and approved the final manuscript.

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Ethics Approval and Consent to Participate

This retrospective study followed the ethical standards of the Declaration of Helsinki and was approved by the Institutional Review Boards of Ewha Womans University Medical

Center, Ewha Womans University Mokdong Hospital (No. 2022-09-003), and Ewha Womans University Seoul Hospital (No. 2022-09-010-002). Informed consent was obtained.

Supplementary Materials

Supplementary data is available at <http://www.jkaoms.org>.

Conflict of Interest

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

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