Computed tomographic evaluation of cystic volume changes of the jaws after decompression

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Computed tomographic evaluation of cystic volume changes of the jaws after decompression

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The Doctoral Dissertation
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The Graduate School
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June 2012

감사의 글

이 논문이 완성되기까지 많은 관심과 격려로 늘 변함없이 따뜻하게 지도해주신 박창서 지도 교수님께 깊은 감사의 마음을 올립니다. 아울러 논문의 완성을 위해서 세심한 조언을 아끼지 않으신 김기덕 교수님, , ,
김형준 교수님께도 진심으로 감사드립니다.

어려운 일이 있을 때마다 늘 자기 일처럼 도와주고 친형처럼 모든 생활의 본보기를 보여주며 다정하게 대해 주신 박혁 선생님과 옆에서 궂은 일을 묵묵히 도와준 김희준, .

힘든 업무 중에도 밝은 표정으로 격려해주고 힘이 되어준 구강악안면방사선과 가족들에게도 감사드립니다.

지금의 제가 있기까지 걱정어린 마음으로 항상 기도해주시고 모든 걸 희생하시며 물심양면으로 큰 힘이 되어 주신 부모님께 그동안 받은 사랑에 대한 송구함과 감사함을 이 글을 빌어 전해드립니다. 아울러 친아들처럼 항상 따뜻하게 대해 주시고 사랑을 베풀어 주신 장인어른, .

마지막으로 온갖 역경에도 묵묵히 참아내며 내게 용기를 주고 희망을 잃지 않도록 항상 함께 해 주어서 앞으로는 내가 지켜주고 싶은 사랑하는 아내 송희정과 항상 웃는 얼굴로 삶의 기쁨을 주는 하나밖에 없는 사랑스러운 딸 다은이와 이 모든 걸 가능하게 해 주신 하느님께 이 글을 바칩니다.

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Computed tomographic evaluation of cystic volume changes of the jaws after decompression

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The treatment for cystic lesions can be determined depending on the size, location, patients' age, perforation of cortical layer and proximity to vital structures. If the cysts are large or containing vital structures, conservative treatment such as decompression or marsupialization should be considered for preservation of oral tissues and avoidance of surgical damage to important anatomical structures. Decompression and marsupialization are very similar surgical procedures aimed to decrease the cystic size by reducing pressure of the cystic fluid and inducing bony apposition to the cystic walls. There has been many studies on the effects of marsupialization or decompression for cystic lesions of the jaw using panoramic radiographies. The disadvantages of plain radiographic examination are that it is impossible to objectively evaluate the degree of bony healing parallel to cystic wall and interval changes in size of cystic lesions. The aim of this study is to evaluate the effectiveness of decompression according to reduction parameters by measuring the cystic volume changes using computed tomography(CT).

We had chosen the patients who underwent decompression for a cystic lesion of the jaw at the Department of Oral and Maxillofacial Surgery of Yonsei university dental hospital from 2006 to 2010. All the patients had been examined by CT before and after decompression at intervals 6 months. We had measured the volume cystic lesions by threshold method and evaluated the volumetric changes after decompression according to various parameters.

The average reduction rates (RR) of 29 cystic cases was 56%. There was statistically significant difference in RR by age and initial volume. The group with younger age and large initial volume showed higher RR. There was no statistically significant difference in reduction rates by sex, location, expansion of cortical layer, radiographic finding and pathologic diagnosis.

In conclusion, decompression is more effective in younger patients, larger initial lesions. Computed tomography is an efficient method in evaluating the bony healing within the cyst cavity by measuring the changes of cystic volume after decompression. However, due to its high economic cost and radiation dose, an additional comparative study using another reasonable diagnostic radiographic tool should be considered.

Key words : decompression, cyst, computed tomography, volume, reduction rate

Computed tomographic evaluation of cystic volume changes of the jaws after decompression

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I INTRODUCTION

Various odontogenic and non-odontogenic cysts can occur in the jaw. The treatment for cystic lesions can be determined depending on the size, location, patients' age, perforation of cortical layer and proximity to vital structures, such as teeth, inferior alveolar canal, pterygomaxillary fossa and maxillary sinus.[1-5] If the cysts are large or containing vital structures, conservative treatment such as decompression or marsupialization should be considered for preservation of oral tissues and avoidance of surgical damage to important anatomical structures.[1,2,6-15] There can be some various complications of immediate enucleation of large cysts. For example, paresthesia can be caused by the situation when the lesion contains an important structures such as

mandibular canal or pterygomaxillary fossa and unnecessary extraction is also happened when it is with the teeth. Moreover, oral tissue can be damaged by enucleation because cortical layer became thinner and even perforated when cyst wall is adjacent to it and fracture can occur during operation. Especially for young patients, there can be a problem in esthetic aspects and an additional graft can be necessary for better healing of the defect.[12] For these reasons, conservative treatment like enucleation after marsupialization or decompression are recently being recommended when the cyst is large.[9-12,16,17,27] Although many surgeons preferred enucleation of odontogenic keratocyst(OKC) because of its aggressive growth pattern and high reccurrent rate in the past,[10,12,14,28-34] conservative treatment is now more recommended because there is no significant difference of the treatment modalities in the patients with OKC between enucleation and conservative treatment in many long-term follow up studies.[2,8-12,14,17,31,35-38]

Decompression and marsupialization are very similar surgical procedures aimed to decrease the cystic size by reducing pressure of the cystic fluid and inducing bony apposition to the cystic walls.[6,8-10,12,16,17] The main difference between the two lies in using surgical rigid drain to prevent mucosal closure.[11,13] The drainage tube for decompression facilitates the irrigation of the cavity and helps avoid food impaction and microorganism accumulation in the area, which could lead to secondary infection.[11]

The decrease in size of bony defect or the changes in bony healing patterns after surgical procedure can only be assessed by radiographic examinations.[18-21] There has been many studies on the effects of marsupialization or decompression for cystic lesions of the jaw using

panoramic radiographs.[1,2,6,7,12] Panoramic radiographs can be easily applied due to its lower costs and lower radiographic exposure dose.[18] The disadvantages of plain radiographic examination are that it is impossible to objectively evaluate the degree of bony healing parallel to cystic walls.[18,22-25] Another shortcomings is that the informations about three-dimensional relationships between cystic lesions and vital structures cannot be obtained.[1,26,39] Also, correction is needed in order to accurately evaluate the changes of cyst after decompression because the magnification rate or the distortion of the object are not constant in panoramic radiographs.[12,19] On the contrary, it is possible to accurately assess the changes in cystic size and bony healing patterns through 3-dimensional evaluation using computed tomography(CT). However, the studies rarely have used CT in evaluating the changes in cysts after decompression.

The aim of this study is to evaluate the effectiveness of decompression according to reduction parameters that can influence the outcome of decompression by measuring the cystic volume changes using CT.

Ⅱ MATERIALS & METHODS

1. Materials

We had chosen the patients who underwent decompression for a cystic lesion of the jaw at the Department of Oral and Maxillofacial Surgery of Yonsei University dental hospital from 2006 to 2010. Among them, only the patients who had been examined by CT before and after 6 months decompression were included in this study.

2. Methods

A. Taking computed tomography

CT was performed with HiSpeed Advantage®(GE Medical System, Milwaukee, U.S.A.) which was being hold by the Department of Oral and Maxillofacial Radiology of Yonsei University dental hospital. The axial images were scanned under the condition that the patients' occlusal plane was perpendicular to the floor in order to reproduce the same location. The scanning parameters were 3 mm slice thickness, 200 mAs, 120 kVp, and 15 cm field of view.

B. Decompression procedures

After bony window was created at the buccal area of cystic center under local anesthesia, the rubber tube was inserted and fixed with sutures so as to maintain patency and constantly drain cystic fluid (Fig. 1). The patients and their guardians were instructed to self-irrigate with sterile saline. Usually the patients revisited every 1 month to check for occurrence of inflammation on

the surgical area and falling out or loosening of tube.

Fig. 2A. Bone window formation

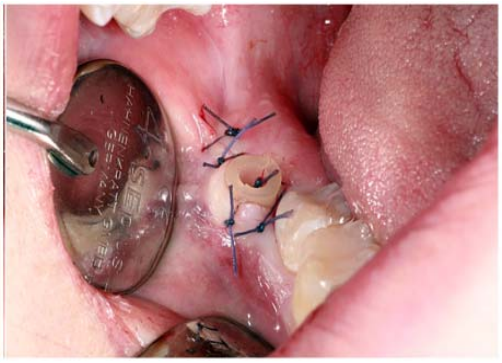

Fig. 1B. Rubber tube insertion

C. Volume measurements for cystic lesion by manual segmentation and threshold method

(A) Open the CT images which we want to measure using Ondemand3D® (Cybermed, Seoul, Korea) program.

(B) Draw cystic lesion area at each axial image (Fig. 2)

(C) Segment the selected area using 3D tool (Fig. 3).

(D) Set up the value of Hounsfield unit ranges from -1000 to 100 (Fig. 4)

(E) Measure the volume of area applied to Hounsfield unit ranges (Fig. 5).

(F) Calculate of the entire volume of the cystic lesion by sum up all the every axial images' volume.

(G) Measure the volume of the cystic lesion on the CT images taken 6 months after by same method.

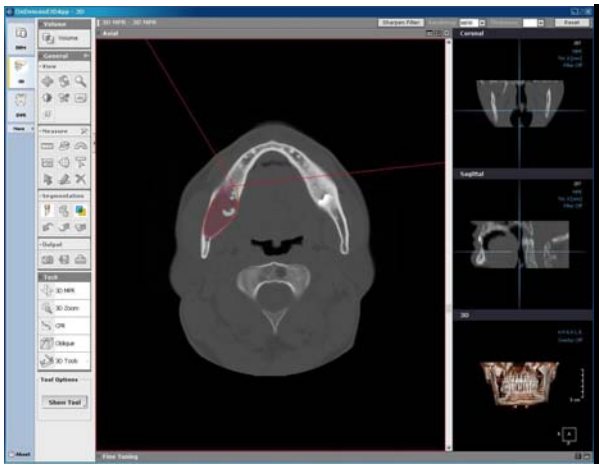

Fig. 2. Drawing the cyst lesion area

Fig. 3. Segmentation of lesion

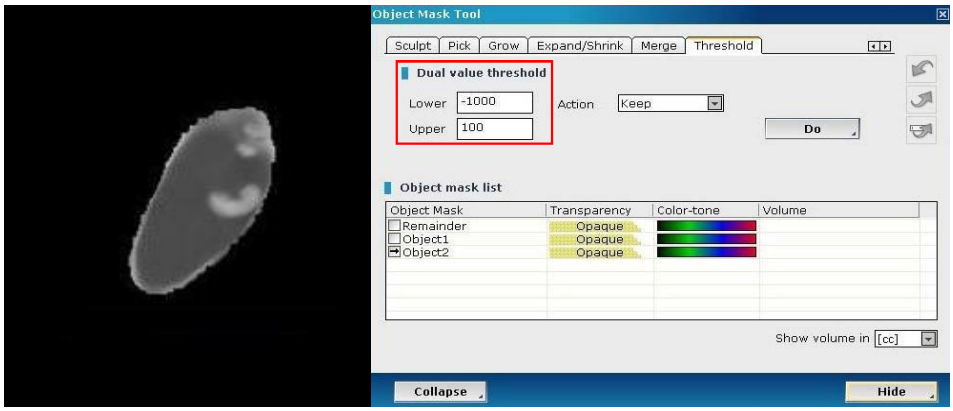

Fig. 4. Setting up the value of Hounsfield unit ranges from -1000 to 100

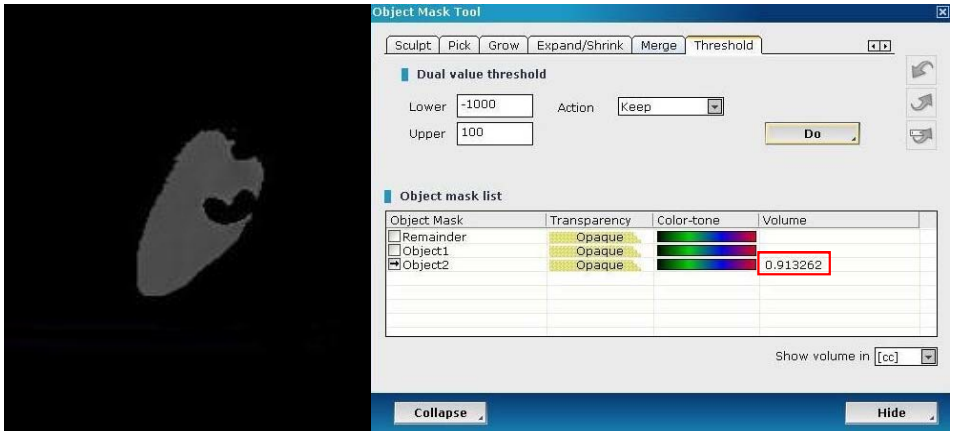

Fig. 5. Measurement the volume of area applied to the HU ranges

D. Determination of parameters that can influence the effect of decompression

(A) Sex : male, female

(B) Age : under 30 years old, over 30 years old

(C) Histologic diagnosis

(D) Initial cystic volume before decompression

: under 10cc, over 10cc

(E) Location of lesion : maxilla, mandible

(F) Degree of cortical layer expansion : mild, severe

(G) Radiographic appearance : unilocular, multilocular

Age has been categorized on the basis of age 30, according to the study results of Ihan Hren N et al.[19] As the previous studies were based on panoramic radiographs, there were no papers considering the initial cystic volume and degree of expansion of cortical layer. Based on the study by Anavi et al[6] where the size of the initial lesion was categorized on the basis of 10 cm^3 we determined 10 cc as initial cystic volume criteria. Considering degree of expansion of cortical layer, cystic lesion of the mandible that have expanded buccolingually over 1.5 times the opposite normal mandible have been classified as severe, and otherwise as mild. In cases where the cystic lesions occurred in the maxilla, involving the maxillary sinus, cystic lesions that involve over 1/2 the maxillary sinus have been classified as severe, and otherwise as mild.

E. Statistical analysis

The data set was analyzed using the Statistical Package for Social Science, ver 20.0 (SPSS, Chicago, IL) and Mann-Whitney U test was used for statistical analysis. The results were considered significant at $P<0.05$.

Ⅲ RESULTS

1. Distribution of study sample according to parameters

The study sample consisted of 29 patients, 21 (72.4%) males and 8 (27.6%) females (ratio 2.63:1), of average age 35.9 years (range 10-70 years) (Fig. 6). The pathologic diagnoses of 29 cysts were as follows: 11 odontogenic keratocyst (OKC), 9 dentigerous cyst (DC), 3 radicular cyst (RC), 3 unicystic ameloblstoma (UA), 2 nasopalatine canal cyst (NPC), and 1 post-operative maxillary cyst (POMC) (Fig. 7). Of the 29 patients, there were 10 patients with initial cystic volume over 10cc, and 19 patients with initial cystic volume under 10 cc before decompression. According to the location of the lesion, there were 8 patients with cystic lesions on maxilla and 21 patients with cystic lesions on mandible. Based on the degree of cortical layer expansion, there were 13 patients with mild expansion and 16 patients with severe expansion. According to the radiographic findings, there were 17 patients with unilocular cysts and 12 patients with multilocular cysts (Fig. 8).

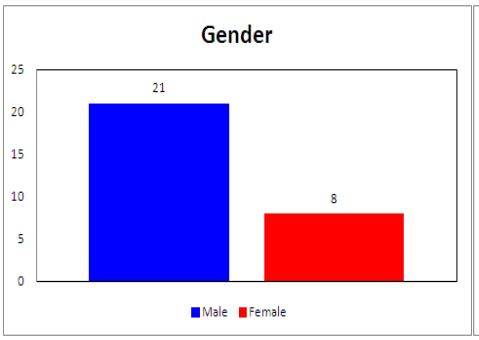

Fig 6A. Sex distribution of 29 cysts

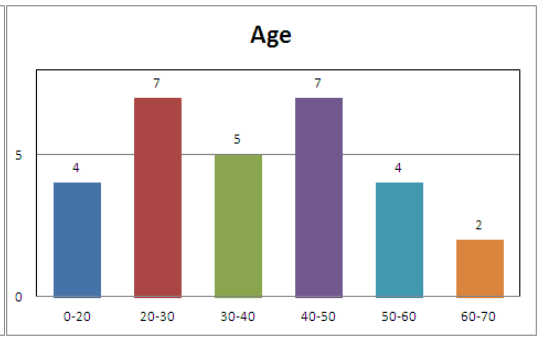

Fig. 6B. Age distribution of 29 cysts

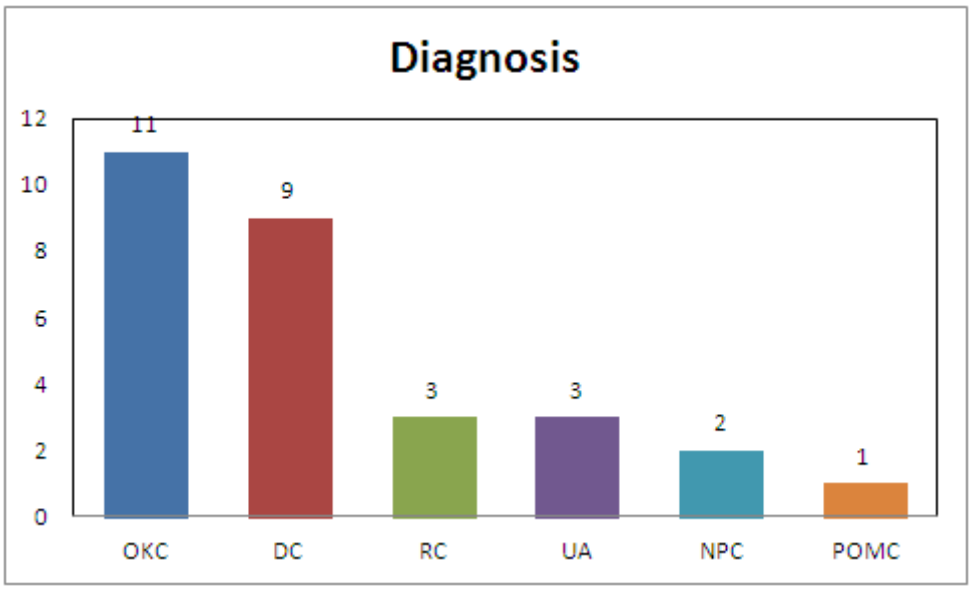

Fig. 7. Pathologic diagnosis distribution of 29 cysts

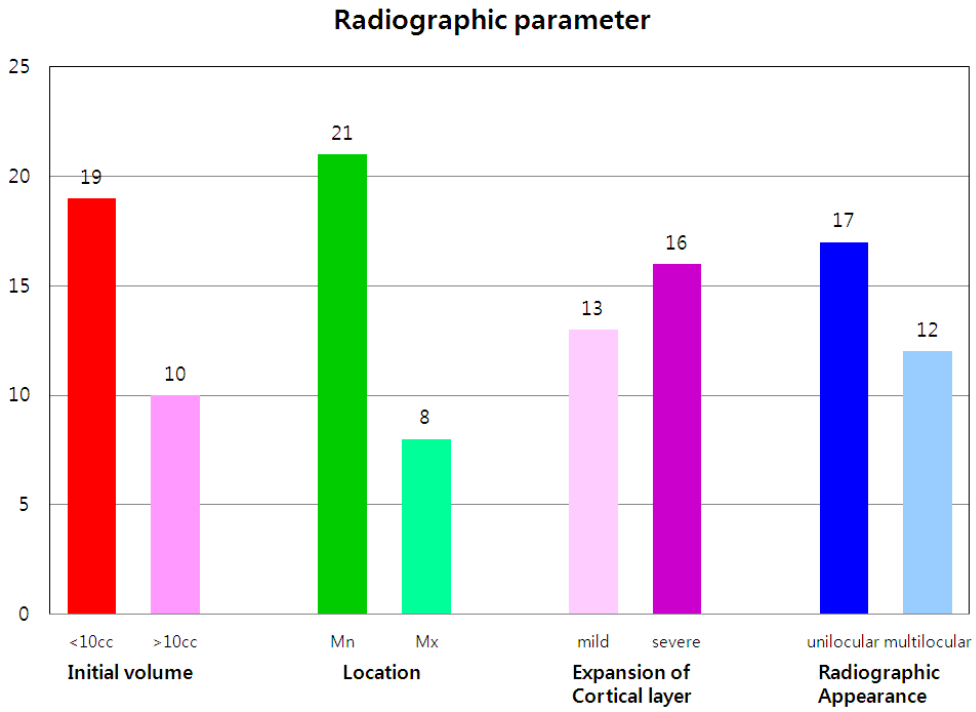

Fig. 8. Distribution according to radiographic parameters

2. Volumetric measurement and reduction rates (RR) of cystic lesions in the jaw

Table 1 shows the volumetric measurement values and reduction rates of cystic lesions in the jaw. The RR is as follows :

$$RR\ (\%) = \frac{\text{Before dec. - 6 month after dec.}}{\text{Before dec.}} \times 100$$

Table 1. Volumetric measurements (cc) and reduction rate (%) of cystic lesion in the jaw using CT images.

Case	Before decompression (cc)	6 month after decompression (cc)	RR (%)
1	6.29	4.03	35.93
2	11.80	6.82	42.20
3	4.37	1.94	55.61
4	51.47	11.28	78.08
5	40.26	9.34	76.80
6	27.11	9.20	66.06
7	9.54	3.75	60.69
8	22.27	3.90	82.49
9	2.18	2.29	-5.05
10	8.79	4.26	51.54
11	9.85	4.08	58.58
12	16.67	8.66	48.05
13	7.07	2.63	62.80
14	6.63	2.69	59.43
15	5.59	2.48	55.64
16	3.89	2.28	41.39
17	7.06	1.85	73.80
18	2.39	0.48	79.92
19	2.18	1.87	14.22
20	26.44	11.09	58.06
21	3.49	1.53	56.16
22	3.93	1.82	53.69
23	3.34	1.18	64.67
24	38.07	15.28	59.86
25	6.61	4.18	36.76
26	40.07	4.48	88.82
27	8.37	4.39	47.55
28	17.03	7.10	58.31
29	9.95	3.84	61.41
Mean	13.89±13.56	4.78±3.61	55.98±19.56

RR : Reduction rate

The RR showed the positive values in all the cases except for case #9. Fig. 9 shows the RR classified by Nakamura et al[12] and Anavi et al.[6] The grades for the effect of decompression using RR suggested by Nakamura et al[12] and Anavi et al[6] are as follows: good, RR great than 80%; moderately, RR greater than 50% but less than 80%; and poor RR less than 50%. There were 2 patients (6.9%) with good outcomes, 19 patients (65.5%) with moderate outcomes, 8 patients (27.6%) with poor outcomes and 21 patients (75.4%) with outcomes beyond moderate.

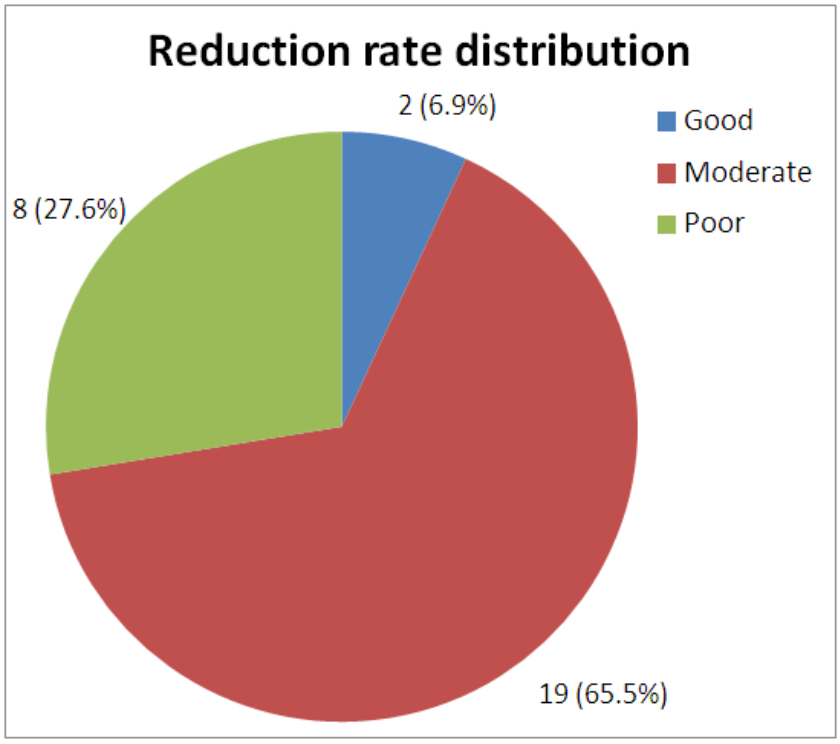

Fig. 9. Reduction rate distribution

Fig. 10 demonstrates axial images of the patients showing the highest and the lowest RR and the smallest remaining cyst volume.

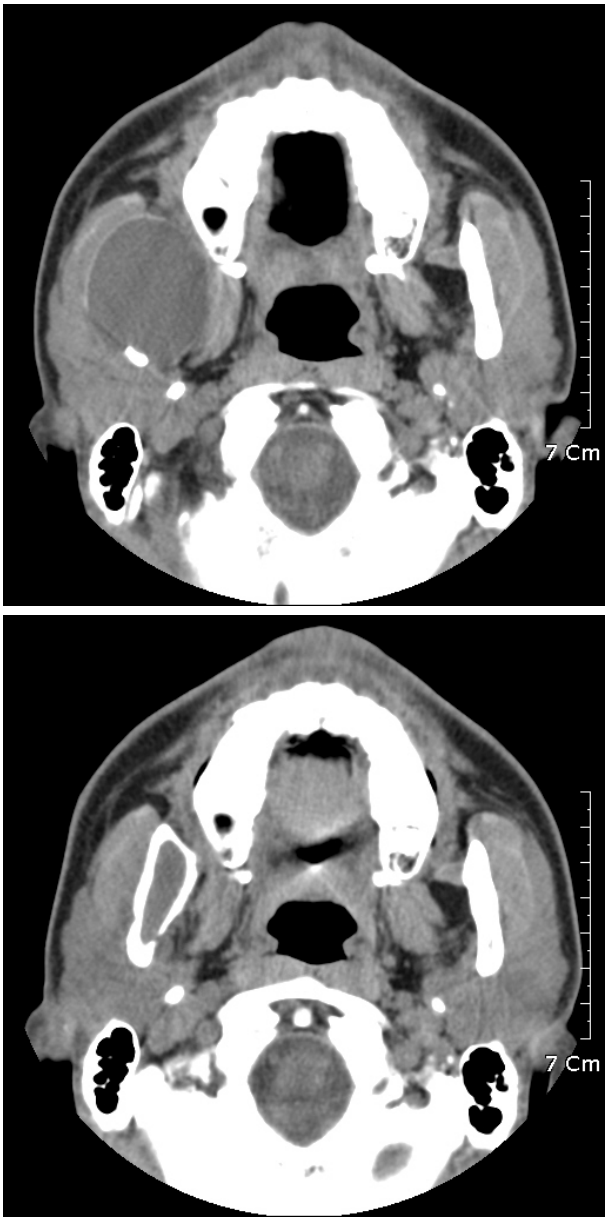

Fig. 10A. The case showing the highest reduction rate

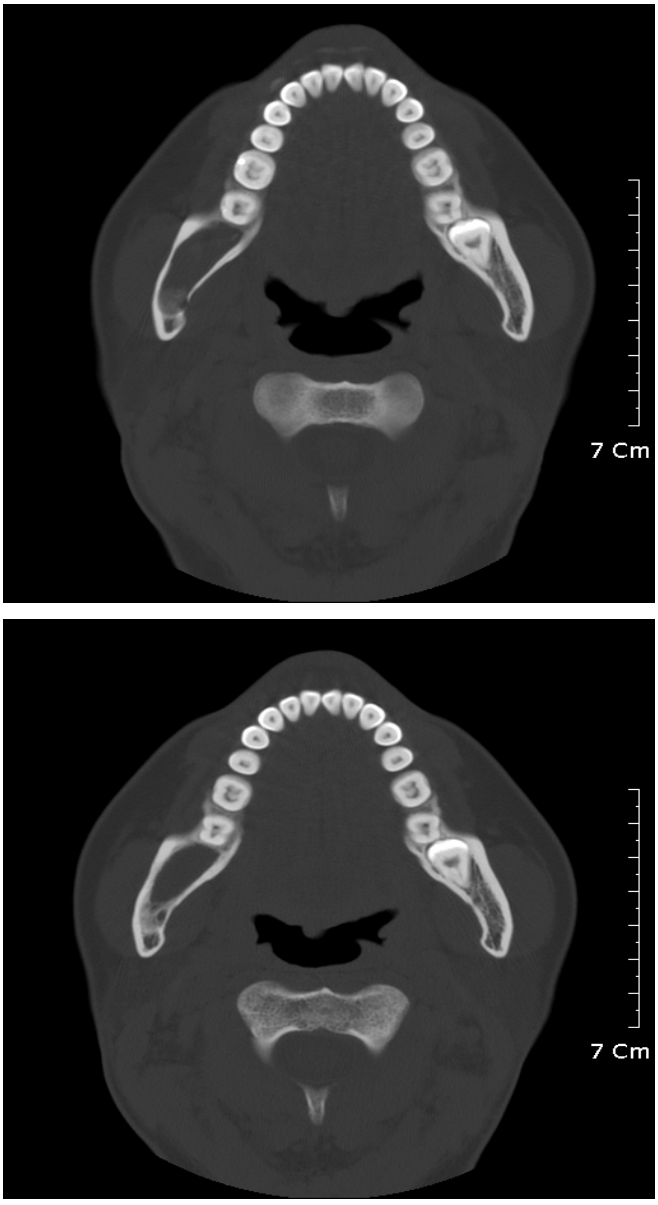

Fig. 10B. The case showing the lowest reduction rate

Fig. 10C. The case showing
the smalliest remaining cyst volume

3. Reduction rate of 29 cysts in the jaw by the parameters

Table 2 shows RR of 29 cysts in the jaw according to the clinical and radiographic parameters. There was statistically significant difference in RR by age and initial volume. On the other hand there was no statistically significant difference in RR by sex, location, expansion of cortical layer, radiographic appearance and pathologic diagnosis.

Table 2. Reduction rate of 29 cysts in the jaw according to the parameters

Parameter	RR	P value
Sex		
Male	58.61±17.21	0.306
Female	49.18±25.13	
Age		
<30 years	65.46±15.36	0.031*
>30 years	50.23±20.48	
Initial volume(cc)		
<10	50.79±20.71	0.048*
>10	65.93±15.59	
Location		
Mandible	52.12±21.85	0.051
Maxilla	66.23±12.27	
Expansion of cortical layer		
Mild	49.85±23.49	0.254
Prominent	61.02±16.35	
Radiolographic appearance		
Unilocular	58.22±17.94	0.565
Multilocular	52.88±23.78	
Pathologic diagnosis		
OKC	54.84±25.63	
DC	69.03±15.94	
RC	58.13±6.72	0.849
UA	61,78±26.17	
NPC	60.12±2.58	
POMC	47.59	

RR : reduction rate

* : statistically significant in the mean RR (p<0.05)

Ⅳ DISCUSSION

There have not yet been a study that have radiographically evaluated the volume change in cysts of the jaw after decompression. Zbao et al. have clinically assessed the cystic volume change after decompression by measuring the volume of saline that can be injected into the cystic cavity. In their study, the average initial volume of the 25 cysts was 32.76cc, which is higher than 13.89cc, the average volume measured in this study. The initial volumes in the two studies could have been different, but the discrepancy may be due to diffusion of the saline into the cancellous bone surrounding the cyst cavity.

There have not yet been any studies that have used CT in measuring the volume of cysts of the jaw, but there are many studies about measuring the volume of lesions in other parts of the body.[42-44] Rothe et al[42] introduced 4 methods in volume measurement using CT, and reported that manual segmentation and seed point method are the most accurate of all. In this study, threshold method was applied after manual segmentation in order to minimize the error in measurement.

In this study, the factors that can influence the outcome of decompression are as follows: sex, age, pathologic diagnosis, initial volume, location, expansion of cortcial layer, and radiographic appearance. When each factors have been statistically evaluated on their effect on decompression, all but age and initial volume did not show statistically significant differences. Patients under age 30 showed average 65.46% RR, and patients over age 30 showed average 50.23% RR. These results coincide with the study outcome of Ihan Hren N et al.[19] in which age 30-33 is the turning point of deterioration of

bony healing. Nakamura et al.[12] also stated in their study the effect of marsupialization decreases along the increase in age. In the study by Anavi et al.[6] where the effect of decompression was assessed by using panoramic radiograph, the patients were categorized on the basis of age 18. Their study also concluded that the group with younger age showed more favorable results. This study considered 18 as the age of termination of growth and explained that this difference was induced by the osteogenic activity.

This study concludes that the initial size of the lesion influences the effect of decompression statistically. In the study by Anavi et al[6], the size of the initial lesion was categorized on the basis of 10 cm^2 and concluded that the initial size of the lesion does not affect the outcome of decompression since there was no statistically significant difference. In their study, the changes in buccolingual dimension were not taken into account since it was based on panoramic radiograph. Also, the variety of changes in the size of the lesion could not be taken into account since the size of the lesion was calculated by multiplying the maximum vertical and horizontal dimensions. Also, errors could have occurred during the correction of magnification rate and the distortion of the object. Since this study evaluated the changes qualitatively and 3-dimensionally, the results are considered more accurate.

The other factors such as sex, pathologic diagnosis, location, expansion of cortical layer and radiographic appearance did not show statistically significant differences, but the location showed *p*-value of 0.051 which is slightly higher than the statistically approval rate ($p<0.05$). When comparing the average RR, maxilla showed 66.23% and mandible showed 52.12%, resulting that the outcome of decompression is more favorable in the maxilla. However, in the

study by Anavi et al.[6] the RR of maxilla and mandible did not show significant difference, showing 0.10 and 0.11 respectively. The more favorable RR in the maxilla shown in this study is due to the fact that most of the cyst that have developed in the maxilla involved maxillary sinus which contains a lot of air space, hence the recovery rate after decompression was advantageous compared to the mandible made of compact bone. There would have been difficulties in assessing the bony healing in the maxillary sinus area using panoramic radiographs. In the study by Nakamura et al,[12] the size of the lesion was measured by digitally scanning the panoramic radiograph and calculating the pixels in the area. However, the differences according to location could not be compared in this study since only 2 out of 28 cysts occurred in the maxilla

In this study, there were no statistically significant difference between unilocular and multilocular cysts, but in the study by Nakamura et al,[12] the unilocular cysts showed better outcomes after decompression. These differences need further study.

The difference according to the expansion rate of the cortical layer cannot be assessed by using panoramic radiographs, and only can be evaluated clinically or cross-sectionally. In this study, 3-dimensional evaluation was available and there were no statistically significant difference according to the rate of expansion of cortical layer. However the average RR were higher in severe expansion than in the mild cases.

Histologic diagnosis did not influence the effect of decompression and this was also proven in the study by Anavi et al.[6] In several studies, decompression of OKC showed more favorable results than in other type of

cysts,[12,13,40] however, in this study there were no statistically significant difference. This indicates that although some surgeons choose active enucleation as treatment for OKC due to its aggressive character and recurrence rate, OKC can also be effectively treated by decompression like other general cysts.

The grades for the effect of decompression using reduction rate(RR) suggested by Nakamura et al[12] and Anavi et al[6] are as follows: good, RR great than 80%; moderately, RR greater than 50% but less than 80%; and poor RR less than 50%. In this study, there were 2 patients (6.9%) with good outcomes, 18 patients (65.5%) with moderate, 9 patients (27.6%) with poor which were lower than the studies by Nakamura et al[12] and Anavi et al.[6] However, in these two studies, the duration of decompression were 23.5 months and 9.1 months for Nakamura et al[12] and Anavi et al[6] respectively, which were both longer than 6 months taken in this study. Therefore when comparing the RR according to the decompression duration suggested by Anavi et al,[6] this study showed similar research outcomes.

The outcome of decompression depends largely on the patient cooperation unlike other treatments.[2,7,8,11,41] In case #9 of this study, the volume of the lesion increased after decompression due to loosening of the drainage tube. In this patient, the cystic size was eventually reduced through constant decompression maintenance supervision.

The disadvantage of decompression is that the treatment period takes very long.[8] Therefore, selecting the optimal time for enucleation after decompression is important. According to this study, some cysts had diminished in size over 6 months, and could perform enucleation immediately. However, in previous

studies, decompression period could have been unnecessarily longer since the evaluation of bony healing were carried out by panoramic radiographs. Therefore, selecting the optimal time for enucleation could be aided by using CT to evaluate the changes in cystic size and bony healing. However, CT can be an overburden to be used in follow ups due to its high cost and high dose of exposure. The use of cone beam computed tomography (CBCT), which could be taken with lower cost and lower dose of exposure, could decrease the decompression period because it could more accurately and 3-dimensionally evaluate the changes than the panoramic radiographs. And considering high radiation only, multidetector computed tomography with low-dose scanning protocol is available. Clinically, when enucleation could be performed even before 6 months, tomography is recommended when needed.

In this study, a total of 29 cases were used to evaluate the factors that influence the outcome of decompression. However the sample size was too small in order to assess the effect of the factors, and this may be due to the fact that only patients who have taken the identical CT were taken into account for the research. Including the patients that have taken additional CBCT on follow ups for long-term evaluation could help in accurately evaluating the effect of various factors that influence the outcome of decompression and suggest a guideline for optimal timing of enucleation.

Ⅴ CONCLUSION

The conclusions of this study are as follows.

1. The average reduction rates of 29 cystic cases was 56%.

2. There was statistically significant difference in reduction rates by age and initial volume. The group with younger age and large initial volume showed higher reduction rates.

3. There was no statistically significant difference in reduction rates by sex, location, expansion of cortical layer, radiographic finding and pathologic diagnosis. But cysts involving more maxillary sinus showed higher reduction rates than those in mandible.

In conclusion, decompression is more effective in younger patients, larger initial lesions. Computed tomography is an efficient method in evaluating the bony healing within the cyst cavity by measuring the changes of cystic volume after decompression. However, due to its high economic cost and radiation dose, an additional comparative study using another reasonable diagnostic radiographic tool should be considered.

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국문요약

전산화단층영상을 이용한 악골에 발생한 낭의 감압술 후 부피 변화에 대한 평가

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( )

낭성 병소의 치료방법은 병소의 크기, , 피질골층의 천공 여부, . 낭이 크거나 주요 구조물이 포함되어 있다면 구강조직의 보존이나 수술시 주요 구조물의 손상을 피하기 위해서 감압술이나 조대술같은 보존적 치료 방법을 고려해야 한다. 감압술과 조대술은 낭의 내압을 줄이고 낭벽을 따라 골침착을 유도하는 것을 목적으로 하는 유사한 치료 방법이다. 파노라마 영상을 이용하여 악골에 발생하는 낭에 대한 감압술이나 조대술의 효과를 평가한 연구는 많았다. 그러나 일반 방사선영상은 낭벽을 따라 일어나는 골성 치유 정도와 낭의 크기 변화를 객관적으로 평가할 수 없는 단점이 있다. 이에 본 연구에서는 전산화단층영상을 이용하여 감압술 후 악골에 발생한 낭의 부피 변화를 계측하고 부피 변화의 감소율과 관련된 변수들이 감압술의 효과에 미치는 영향을 평가해 보고자 한다.

2006 2010 ¦까지 연세대학교 치과대학병원 구강악안면외과에서 악골의 낭성 병소에 감압술을 시행받은 환자들을 연구대상으로 하였다. 모든 환자들은 감압술 전과 감압술 후 6 ¦월에 전산화단층촬영을 시행하였다. 역치를 이용한 방법으로 낭성 병소의 부피를 계측하였고 다양한 변수에 따라 감압술 후 나타나는 부피 변화를 평가하였다.

29 56% . 환자의 나이와 초기 병소의 부피에 따라 감압술 후 나타나는 부피 변화는 통계학적으로 유의성 있는 차이가 있었다. 나이가 어릴수록 초기 병소의 부피가 클수록 높은 부피 감소율을 보였다. , , 피질골층의 팽창 정도, , 진단명에 대해서는 통계학적으로 유의성 있는 차이가 없었다.

결론적으로 환자의 나이가 어릴수록 초기 낭성 병소의 크기가 클수록 감압술에 의한 부피 감소 효과는 좋다. 전산화단층촬영은 감압술 후 낭성 병소의 부피 변화 계측을 통해 낭 내부의 골성 치유 정도를 평가할 수 있는 유용한 검사이다. 그러나 고비용과 높은 방사선 노출량 때문에 다른 합리적인 진단 영상을 이용한 부가적인 연구가 필요하다고 생각된다.

핵심되는 말 : , , , , 감소율