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Original Article

Evaluation of postoperative changes in the course of mandibular canals impacted by cystic lesions

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ABSTRACT

Background: This study aims to determine the positional alterations in the course of mandibular canal, which were caused by the common cystic lesions in the posterior mandible. Also, the effects of treatment methods on bone formation were evaluated.
Methods: We designed a retrospective cohort study with patients which were treated due to cystic lesions in the maxillofacial region between the years 2012–2018. Forty eight subjects were included and grouped regarding histopathologic diagnoses (radicular dentigerous and odontogenic keratocyst) and treatment methods (enucleation and marsupialization). The mean (range) of patients' age was 31.25 (18–66) years, and there were 32 male and 16 female individuals. The displacement of mandibular canals was verified on preoperative cone-beam computed tomographic images. The measurements of displacement and bone formation were performed on panoramic radiographs. In the statistical analysis of the data, descriptive statistics, parametric independent sample t-test, non-parametric Kruskal Wallis test, and one-way analysis of variance test were utilized.
Results: All the evaluated mandibular canals were replaced by a mean(SD) of 5.46(2.59) mm after the lesions eliminated, which was significant in the marsupialization group ($p = 0.002$). The bone formation was significantly higher in the enucleation group ($p = 0.003$). The multiple regression analyses revealed that the treatment methods significantly influenced the replacement of mandibular canal ($p < 0.001$) and the bone formation ($p = 0.026$).
Conclusion: In cases where there is an adequate distance between the lesion and the mandibular canal, the enucleation technique was found to be superior in terms of bone formation and the amount of bone height obtained.

1. Introduction

Odontogenic cysts are pathological cavities that are partially or wholly surrounded by epithelium, which are caused by inflammatory or developmental causes [1]. The most common types in the oral cavity are periapical cysts, dentigerous cysts, and odontogenic keratocysts [2]. Although it is more common in males (male:female ratio; 1.6:1), most cases are seen between the fourth and sixth decades of life [1].

Odontogenic cysts tend to increase with the flow of surrounding tissue fluid into the inner walls due to high intracapsular osmotic pressure. Hence, the odontogenic cysts expand in time and cause displacement or destruction of adjacent structures [3,4].

The primary objective in the treatment of the odontogenic cysts is the complete removal of cysts without remnants to prevent relapses. However, there are controversies about the treatment of choice in the literature [5]. The first proposed method is the decompression-marsupialization and this method aims to reduce the cyst volume/size by stimulating appositional bone regeneration [6,7]. The advantages of marsupialization are that adjacent anatomical structures can be preserved, and postoperative morbidity rates can be reduced [5]. However, marsupialization should be followed by a second intervention, enucleation, to annihilate the remnant lesion. The other proposed method is the primary enucleation, in which the cystic lesion is removed entirely

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[8,9]. The remaining cavity from the enucleated lesion is expected to be repaired by spontaneous bone regeneration from the adjacent bone walls or formed blood clot [10,11]. However, there are not many studies examining the changes in the positions of adjacent vital structures after the complete removal of cysts [12,13].

This retrospective study aims to determine the positional alterations of the mandibular canal (MC) after the surgical treatments of odontogenic keratocysts, dentigerous and radicular cysts by comparing measurements on preoperative and postoperative radiographs. In terms of postoperative bone formation in the cyst cavities, we also try to elucidate which treatment method is superior by comparing the grayscale values on the radiographs. A study hypothesis was formed stating that 'with marsupialization, the affected MC will replace superiorly more than with enucleation postoperatively, whereas the postoperative bone formation in cyst cavities will not differ significantly with the technique performed.

2. Material and methods

2.1. Study design

In this retrospective cohort study, we reviewed the data obtained from individuals who had referred to the our department for treatment of cystic lesions between years 2012 and 2018. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. This study was approved by the Clinical Research Ethical Committee of Faculty of Medicine, Tokat Gaziosmanpasa University, with registration number 19-KAEK-198. The preoperative cone-beam computed tomographic (CBCT) and panoramic radiographs of 2344 patients were examined to detect the displacement of MC due to cystic lesions. The study's exclusion criteria were; histopathological malignant lesions, patients below the age of 18, lack of either pre- or postoperative radiologic data, discontinuation of treatment or follow-up sessions, follow-up period shorter than 12 months, apparent anatomic variations of MC, interventions using bone substitute materials or autologous materials, cystic lesions; located in regions other than the posterior mandible, were not associated with MC, recurrent lesions or were not diagnosed with histopathological examination and lesions treated with techniques aside from marsupialization and enucleation. The patients had been followed-up with panoramic radiographs, and radiographs that were taken less than 12 months were also excluded.

The subjects were divided into three groups according to histopathological diagnoses: radicular cyst (RC), dentigerous cyst

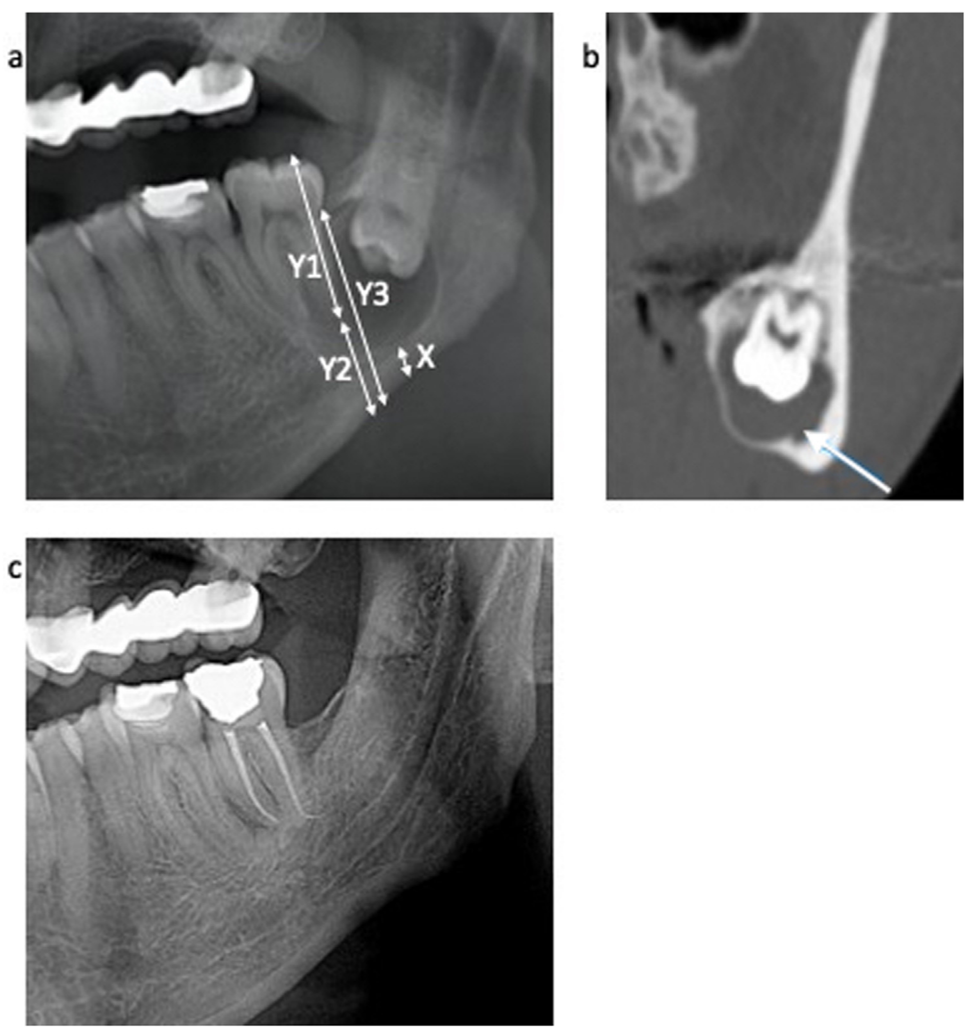

Fig. 1. Panoramic and CT images of an included case. (a) Panoramic radiographic view indicating the height of mandibular canal (X), the reference lengths (Y1: the distance between the tip of the cusp and the apex of the reference tooth adjacent to the lesion, Y2: the distance between the apex of reference tooth and mandibular lower border, and Y3: the distance between the distal cementoenamel junction of the reference tooth and mandibular lower border) preoperatively. (b) The displaced mandibular canal on CT view. (c) Panoramic radiographic view indicating the relocation of mandibular canal postoperatively.

(DC), and odontogenic keratocyst (OK) groups and into two groups according to treatment methods: marsupialization (MA) and enucleation (EN) groups.

2.2. Evaluation of radiographic images

The preoperative CBCT of each subject was analyzed to assess the site and dimensions of the cystic lesion, position of MC, the proximity of the lesion to the MC, cystic invasion, and displacement of MC.

All subjects had preoperative and postoperative panoramic radiographs. These radiographs were taken in standard positions with the same diagnostic equipment (Veraviewepocs 2D, J. Morita Mfg. Corp., Kyoto, Japan) and the same value set (65 kV, 5 mA, 15 s). Each individual's pre- and postoperative panoramic radiographs were assessed to determine the positional variance of MC on MetaPacs Viewer (Metasoft PACS system, Metasoft Computing Services Ind. Trade. Co. Ltd., Eskisehir, Turkey). Four different reference lengths were used on each assessment to standardize the measurement and comparison methods between radiographs [14]. The first length was the height of MC (X), which was the distance between the mandibular lower border and the lower cortex of MC. The second length (Y1) was the distance between the tip of the cusp and the apex of the reference tooth adjacent to the lesion. The third length (Y2) was the distance between the apex of reference tooth and mandibular lower border (measured as the extent of Y1). The fourth length (Y3) was the distance between the distal cementoenamel junction of the reference tooth and mandibular lower border (Fig. 1). All lengths were measured in parallel with each other. All measured data were calculated according to the actual size at a magnification of 130%. Preoperative and postoperative reference length measurements were compared statistically to verify measurement accuracy. The preoperative and postoperative X values were compared in regard of treatment methods to assess positional alterations within the MC's. Also, the mean differences between preoperative and postoperative X values were compared according to the histopathological diagnoses to evaluate the amount of repositioning within MC.

The panoramic radiographs were digitalized and analyzed on Adobe Photoshop CC 2018 (Version 19.0, Adobe Inc., California, USA) to assess the bone formation by evaluating the mean grayscale values. The preoperative radiographs' parameters were standardized and recorded to apply for subsequent postoperative radiographs for each patient. The preoperative radiographs were taken as guides, and a section of the cystic lesions was marked using Magnetic Lasso Tool. The marked sections were superposed on postoperative radiographs. The mean grayscale values of the chosen sections were measured by Histogram Tool and recorded (Fig. 2). The mean differences in grayscale values were compared according to treatment methods, and higher values were interpreted as higher bone healing capacity.

2.3. Statistical analysis

The normal distribution and homogeneity of variance of the study data were evaluated whether they were homogeneous. In the analysis, preoperative and postoperative X, Y1, Y2, Y3 lengths, and the differences of these values between pre- and postoperative intervals were used.

Normal distribution was observed in pre- and postoperative X and grayscale values. Hence, these values were analyzed with the independent sample t-test. However, the pre- and postoperative Y1, Y2, and Y3 values were abnormally distributed, and the significance of differences was assessed using the Kruskal–Wallis test.

The histopathological diagnoses and the mean differences between preoperative and postoperative X lengths were compared by one-way analyses of variance test (ANOVA) to identify the between-group differences, and post-hoc analyses were performed by Bonferroni correction.

The multiple linear regression analysis was performed to determine the variables that have a significant effect on the positional variations of MC and the grayscale value differences. The patient's gender, age, histopathological diagnoses, location of the lesion, and treatment modalities (marsupialization or enucleation) were defined as the independent variables.

All statistical analyses were made with IBM SPSS Statistics for Windows (version 25, IBM Corp, Armonk, NY, ABD). Probabilities less than 0.05 were interpreted as significant.

3. Results

The study population consisted of 48 patients (48 lesions). Their mean (range) age was 31.25 (18–66) years, and out of 48 patients, 32 were male, and 16 were female. The treatment groups consisted of 25 patients in the EN group and 23 patients in the MA group. In terms of histopathological diagnoses out of 48 lesions, 29 dentigerous cysts, 11 were odontogenic keratocysts, and eight were

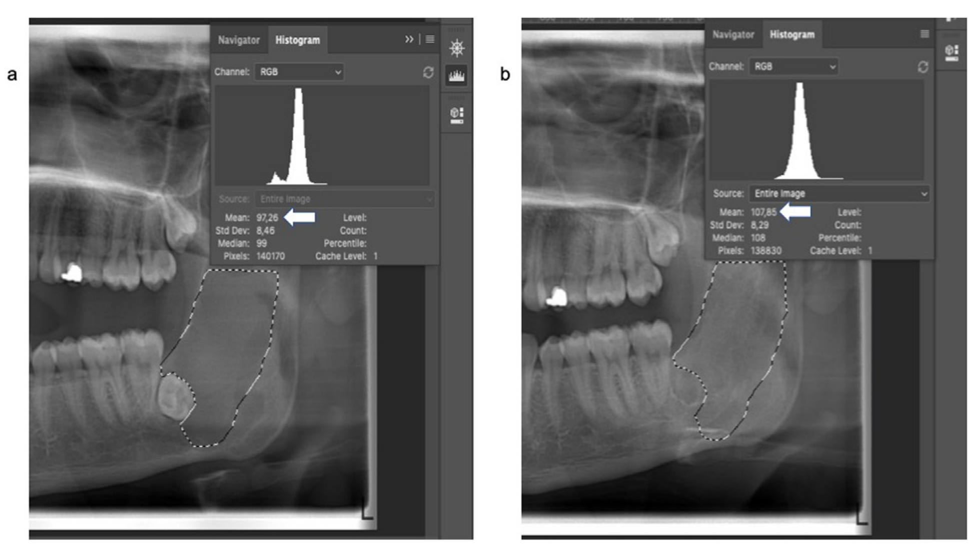

Fig. 2. Comparison of preoperative (a) and postoperative (b) mean grayscale values on panoramic radiographs.

Table 1
Demographic variables of included cases.

Variables		n(%)	Total
Histopathological diagnosis	Dentigerous cyst	29 (60.40%)	48
	Radicular cyst	8 (16.70%)	
	Odontogenic keratocyst	11 (22.90%)	
Gender	Male	32 (66.70%)	48
	Female	16 (33.30%)	
Location	Left side	24 (50%)	48
	Right side	24 (50%)	
Treatment method	Enucleation	25 (52.10%)	48
	Marsupialization	23 (47.90%)	

dentigerous cysts. The mean radiographic follow-up periods were 26 (15–46) months (Table 1).

The differences between pre- and postoperative measurements of reference lengths (Y1, Y2, and Y3) were not significant (p = 0.599, p = 0.985, p = 0.489).

The compensation rates of MC height (T1-T0; X value) regarding treatment methods and the histopathological diagnoses were analyzed as the primary outcome variables. The determination of treatment methods' impact on new bone formation during the follow-up period by comparing grayscale values was the secondary outcome variable.

The movement of MC in superior direction during the follow-up period was significantly different between treatment methods. In the MA group, MC replaced more superiorly than in the EN group (p = 0.003). However, there was no significant difference between the histopathological diagnostic groups in terms of the replacement of the mandibular canal (p = 0.384).

Also, the analysis of grayscale values revealed significant differences between treatment groups. However, in contrast with the height of MC values, in the EN group, more new bone formation observed than in the MA group (p = 0.002). (Tables 2 and 3).

The results of multiple regression analysis indicated that independent variables (gender, age, location, and histopathological diagnoses of lesions) had no significant impact on postoperative positional changes of MC and bone formation. However, these two dependent variables were effected significantly by one independent variable: treatment method (For positional changes of MC *Adjusted* R^2 = 0.192; F = 3.239, p = 0.0007, for bone formation *Adjusted* R^2 = 0.154 F = 2.710 p = 0.026) (Table 4).

4. Discussion

The most common diagnosed cystic lesions in the mandibular molar site are radicular, dentigerous, and odontogenic keratocysts [2]. Also, it has been shown that as the size of these lesions increases, the MC displaces downward [15]. Likewise, in our study, we observed that when the pressure of lesions ceased, the MCs replaced superiorly. However, the multiple regression analyses revealed that any other factor than treatment methods did not significantly affect the replacement.

The primary goal of any treatment is to eliminate the cystic lesions, as well as prevent recurrence and minimize morbidity [16]. Enucleation is the first option for the surgical treatment of cystic lesions that are relatively small in size or not adjacent to the vital structures. However, the enucleation of large cystic lesions carries risks such as pathologic fracture and high incidence of recurrence. Nevertheless, decompression, combined with marsupialization, are frequently used as another minimally invasive method in the treatment of large cystic lesions [17]. In addition to decreasing the morbidity rates in the treatment of large cysts with marsupialization, significant positional changes were also obtained on the adjacent MC according to the outcomes of our study. Therefore, the gradual decrease of the pathologic pressure on the MC with marsupialization may be considered effective on MC's superior replacement. However, in the enucleation group, significantly higher grayscale values were observed in terms of postoperative bone formation as well as upward replacement of the MC.

The impact of cystic lesions located on the posterior mandible were investigated in several previous studies [15,18–21]. Zerrin et al. [19] reported that 33% of dentigerous cysts cause displacement of the MC. Also, Farman et al. [18] stated that the size of the cyst and the position of the related tooth determine the impacts on the MC and large radicular cysts frequently displace the MC downward by the pathologic pressure.

Odontogenic keratocysts have a growth pattern in the anteroposterior direction [21]. Abdi et al. [20] reported that 53.8% of odontogenic keratocysts cause buccal and 46.2% cause lingual displacement of the MC. Furthermore, Farman et al. [18] reported that odontogenic keratocysts may induce minor downward displacement of the MC. Our results revealed that the histopathological diagnoses do not influence the positional alterations of MC. However, further studies evaluating the relevance between the positional changes of MC and the lesion types with larger sample sizes may reveal significant differences among odontogenic cystic lesions.

There were insignificant differences between reference lengths (Y1, Y2, Y3) measurements on pre- and postoperative radiographs, which indicates that the distortion of vertical measurements is negligible. Nevertheless, further studies that include routine CBCT follow-up design should be conducted.

Table 2
The differences between postoperative changes in the height of mandibular canal, reference measurements and grayscale values regarding treatment methods; mean (SD).

Groups		X	Y1	Y2	Y3	Grayscale value
Group EN (enucleation) (n = 25)						
	T0	27.54 (16.08)	84.93 (14.21)	140.24 (31.40)	119.50 (27.36)	102.78 (36.50)
	T1	32.36 (15.88)	85.28 (13.92)	140.21 (32.05)	119.70 (27.93)	121.23 (37.80)
	T1-T0	4.41 (1.92)	0.35 (3.25)	−0.03 (3.80)	0.20 (2.91)	19.65 (10.99)
Group MA (marsupialization) (n = 23)						
	T0	25.21 (11.84)	88.73 (8.32)	142.80 (27.78)	122.17 (20.03)	85.35 (31.20)
	T1	31.47 (12.81)	89.33 (7.48)	143.91 (26.86)	123.59 (18.44)	97.42 (30.83)
	T1–T0	6.60 (2.77)	0.60 (1.31)	1.10 (2.25)	1.42 (2.78)	11.64 (5.26)
Total (n = 48)						
	T0	26.43 (14.11)	86.75 (11.80)	141.47 (29.43)	120.78 (23.91)	94.43 (34.85)
	T1	31.93 (14.34)	87.22 (11.37)	141.98 (29.42)	121.56 (23.69)	109.82 (36.32)
	T1–T0	5.46 (2.59)	0.46 (2.50)	0.51 (3.17)	0.79 (2.89)	15.81 (9.54)
p Value	0.002[a]	0.599[b]	0.985[b]	0.489[b]	0.003[a]	

T0: preoperative value; T1: postoperative value; T1–T0: postoperative difference.
[a] Indicates the values were analyzed with independent sample t-test.
[b] Indicates the values were analyzed with Kruskal–Wallis test.

Table 3
The differences between postoperative changes in the height of mandibular canal (X values) among three lesion groups: mean (SD) and mean (SE) values.

Groups	Mean differences (SD)	Intergroup differences (SE) (*p* value)
Group DC (dentigerous cyst) (n = 29)	5.68 (2.78)	−0.03 (0.10) (1.000[a])
Group OK (odontogenic keratocyst) (n = 11)	5.71 (1.78)	1.42 (1.20) (0.726[b])
Group RC (radicular cyst) (n = 8)	4.29 (2.75)	−1.39 (1.03) (0.554[c])
p Value	0.384*	

SD, standard deviation SE, standard error. Comparison between groups were analyzed by ANOVA and Bonferroni Correction.
* p Value obtained by ANOVA analysis.
a Dentigerous cyst-odontogenic keratocyst.
b Odontogenic keratocyst-radicular cyst.
c Radicular cyst-dentigerous cyst.

Table 4
The multiple regression analyses to examine the effects of independent variables that influence the positional changes of the mandibular canals and the postoperative changes in the grayscale values (n = 48).

Independent variables/positional changes	B	SE	β	t Value	p Value
Age (years)	0.00	0.03	0.01	0.10	0.914
Gender	1.54	0.77	0.28	1.98	0.054
Histopathological diagnosis	−0.55	0.42	−0.18	−1.29	0.202
Treatment method	2.77	0.75	0.54	3.66	0.0007 *
Location of lesion	0.40	0.73	0.08	0.55	0.582
Independent variables/grayscale values					
Age (years)	−0.07	0.12	−0.09	−0.60	0.551
Gender	0.79	2.93	0.04	0.27	0.788
Histopathological diagnosis	−2.14	1.61	−0.18	−1.32	0.192
Treatment method	−6.59	2.85	−0.34	−2.31	0.026*
Location	3.91	2.77	0.20	1.41	0.165

R= 0.278; Adjusted R= 0.192; F = 3.239 (p = 0.0007). R= 0.244; Adjusted R= 0.154 F = 2.710 (p = 0.026). = unstandardized coefficients; SE = standard error of coefficients; β = standardized coefficients.
* Indicates significant p values < 0.05.

A limitation of our study is the evaluation method of bone formation. However, a standard evaluation method for bone formation is not described in the literature [5]. We evaluated the postoperative bone formation on defect sites by the technique described by Yelamali and Saikrishna [22]. Our evaluation revealed significant differences between treatment methods, but the lesion's defect size is a vital influencing factor on consolidation. Previous studies have mentioned that in the bony defects more extensive than the critical size, spontaneous complete bony regeneration cannot be observed [23,24]. Therefore, the discrepancies of defect size between the treatment groups may have influenced the secondary outcome of our study. For further research, we will focus on prospective studies evaluating the correlation between defect size and postoperative bone formation in cystic lesions.

In conclusion, within the limitations of our study, we observed that the MC tends to replace upward after cessation of pathologic pressure. Although this replacement was significantly higher with the marsupialization technique, the bone formation obtained with the enucleation technique was more significant. We, therefore recommend that applying the enucleation technique for the treatment of cystic lesions detected at a precise distance to vital anatomic structures has the advantage of single-stage surgery and provides better bone formation at defect sites.

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Informed consent

Informed consent was obtained from all participants.

Conflict of interest

The authors declare that they have no conflict of interest.

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