Original Article

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Factors affecting odontogenic keratocyst recurrence: a retrospective chart review

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Objectives: The aim of this study was to assess the association between the sociodemographic, clinical, radiological, and surgical characteristics and odontogenic keratocyst (OKC) recurrence and evaluate the recurrence rate.

Materials and Methods: A retrospective chart review of patients diagnosed and treated for OKC from 2001–2018 was performed using the hospital records. We reviewed the medical records of 129 patients to extract their sociodemographic, clinical features, radiological features, surgical treatment and its characteristics, follow-up period, and re-occurrence information. The parametric numerical variables (age) are described as mean and standard deviation, whereas the categorical variables are presented as frequency and percentage. The association between the socio-demographic, clinical, radiological, and surgical factors and OKC recurrence was assessed using logistic regression. The Nelson-Aalen estimator of survival function in the survival analysis was used to estimate the cumulative hazard of OKC recurrence with time. A *p-value* <0.05 was considered significant.

Results: Eighty-one patients who were diagnosed and treated for OKC were included in this study after meeting the inclusion criteria. Fifty percent of them were females. The mean age of the patients at diagnosis and treatment for OKC was 28.6 ± 12.6 years old. Among the risk factors, root resorption was significantly associated with OKC recurrence (p=0.004). Removal of teeth associated with root resorption demonstrated a significantly lower risk of recurrence (p=0.031). No other variable had a significant relationship with OKC recurrence. After a 2-year (24 months) follow-up, the recurrence was found in 14 cases with a cumulative probability of 27.5%.

Conclusions: Root resorption due to OKC is significantly associated with an increased recurrence rate. The removal of teeth associated with root resorption resulted in a significantly lower recurrence rate. However, other demographic, clinical, radiological, and surgical factors did not demonstrate significant differences in their OKC recurrence.

Keywords: *odontogenic keratocyst, recurrence, Thailand*

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Introduction

Odontogenic keratocysts (OKCs) are benign cysts of odontogenic origin that account for ~10% of all odontogenic cysts [1]. OKCs originate from the dental lamina and have a cystic area filled with desquamated keratin and a parakeratinized squamous epithelium lining [2]. Furthermore, the epithelium may exhibit basal layer budding into the underlying connective tissue, resulting in the production of detached microcysts known as daughter cysts [3]. OKCs have a wide age distribution, with a peak in occurrence in the third decade of life and a male predilection. OKCs

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present asymptomatically and develop in tooth-bearing areas, the mandible being more commonly involved than the maxilla. In the mandibular region, the most common location is at the angle or ramus, whereas, in the maxillary region, the most common sites are the anterior and third molar areas. OKCs can develop as single or multiple lesions within a jaw. The lesion is seen radiologically as unilocular or multilocular areas of radiolucency with well-defined borders [4].

OKCs are characterized by locally aggressive behavior and a high tendency to recur following treatment, particularly when associated with syndromes [5]. Previous studies have found factors linked to recurrence, such as cortical bone perforation, tooth involvement within the cyst lumen, and the presence of large and daughter cysts. In addition, a thin cystic epithelium remnant left after surgery also acts as a potential cause for recurrence. Many conservative and aggressive treatments have been recommended throughout the years to reduce the high rate of recurrence; however, none of them has been acknowledged as the standard treatment [6, 7]. Several surgical approaches, such as enucleation or marsupialization, peripheral ostectomy, chemical curettage with Carnoy's solution, cryotherapy, electrocautery, or en bloc or marginal resection, are used as possible options for OKC treatment [8]. The reported recurrence rates range from 5–62% [9]; this disparity may be attributed to the nature of the lesion and the type of treatment performed. Multiple retrospective investigations concerning the association of the clinicopathological or radiological, or surgical aspects of OKC with the recurrence have been conducted [10, 11]. However, globally, the results of these studies are inconclusive. This may be due to a low number of studies, a limited number of patients examined, and a cumbersome treatment approach. Therefore, we designed this research to investigate the association of several factors of OKC with recurrence in a Thai population that could add more supportive information to the global OKC data.

The aim of this study was to assess the association between risk factors, such as demographic, clinical, radiologic, and surgical factors, and OKC recurrence and determine the recurrence rate.

Materials and Methods

Study Design

A retrospective chart review was conducted in the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Mahidol University. Records of the patients diagnosed with OKC from 2001–2018 were extracted. We obtained ethical approval from the Institutional Review Board (protocol No 2020/DT072) of the Faculty of Dentistry/ Faculty of Pharmacy, Mahidol University, before conducting this study.

Data Extraction:

We extracted the sociodemographic, clinical features, radiological features, surgical treatment and its characteristics, follow-up period, and recurrence data. The socio-demographic data comprised age (in years) and sex (male/female).

Clinical features at the time of presentation comprising the ASA physical status, presence or absence of symptoms, such as swelling, pain, fluid discharge, paresthesia, and infection. Location at the maxilla or mandible, cystic content after biopsy, i.e., clear fluid, curd-like, or pus, and positive or negative tooth vitality determined using the Electric Pulp Test (EPT) were recorded.

Radiological features at the time of presentation consisting of the radiologic appearance as unilocular or multilocular radiolucency, and presence or absence

of cortical bone perforation, association with an unerupted or impacted tooth, tooth root, and root resorption on an orthopanoramic radiograph.

Surgical factors comprised the treatments as a conservative approach, either done by marsupialization or enucleation or marsupialization followed by enucleation, adjuvant therapy when enucleation or marsupialization followed by enucleation was performed involving Carnoy's solution application or peripheral ostectomy, and lesion resection involving at least 5 mm beyond the lesion border. Other surgical characteristics comprised preservation or extraction of the tooth that had a root associated with the lesion, root resorption, and the clinical experience of the operating surgeon. The teeth or the tooth root involved in the lesion were preserved by performing endodontic treatment followed by apical root resection during the surgery. The follow-up period for the clinical examination was every 3 months, and the radiological examination was every 6 months after treatment to identify a recurrence. Initially, the radiological follow-up was an orthopanoramic examination, while CBCT was considered only when there was a suspicion of lesion recurrence. There were 12 different surgeons with more than 10 years'experience and 5 other surgeons who had less than 10 years' experience in surgically treating OKC. However, the decision-making of the surgical plans and patient care was based on the hospital protocol using a team approach.

Recurrence criteria was based on the presence of a radiographic or CBCT image suggesting a new lesion within the boundaries of the original lesion and confirmed by a histopathological diagnosis of OKC.

Inclusion and exclusion criteria

We included patients with a confirmed diagnosis of OKC using histopathological and radiographical records, availability of pre-and post-operative radiographic examinations, surgical treatment of the lesion, and at least 1 year of follow-up. The patients who did not receive the final treatment procedure in the hospital were lost to follow-up, inconsistently attended follow-up appointments, where missing data of all the clinical or radiological or surgical factors and those associated with nevoid basal cell carcinoma syndrome were excluded from the study.

Statistical Analysis

Statistical analysis was performed using SPSS Statistics® for windows, version 21.0 (IBM, Armonk, NY, USA). We determined numeric variables as mean and standard deviation, whereas frequency and percentage were used for categorical variables. The association between the demographic, clinical, radiologic, and surgical factors and lesion recurrence was assessed using logistic regression. The Nelson-Aalen estimator of survival function in the survival analysis was used to estimate the cumulative hazard of OKC recurrence with time. The log-rank test was used to compare the mean recurrence time between the categorical variables (Supplementary table; Table 1). A *p-value* <0.05 was considered significant.

Results

We reviewed 129 patients diagnosed and treated for OKC, of which 81 patients met the eligibility criteria. The patients' demographic, clinical, radiological, and surgical characteristics included in the analysis are presented in Table 1. Of the patients included in this study, 41(50.6%) were male. The patients' ages ranged from 9–60 years old, with a mean age of 28.6±12.6 years old.

Table 1 Demographic, clinical, radiological, and surgical characteristics of the OKC patients

Characteristics (n = 81)	Overall, n (%)
Age (in years), Mean±SD	28.6±12.6
<21 years	28 (34.56)
21 - 30 years	22 (27.16)
>30 years	31 (38.27)
Sex	
Male	41 (50.6)
Female	40 (49.4)
Clinical Characteristics	
Health status (ASA)	
Class I	70 (86.4)
Class > I	11 (13.6)
Symptoms	
Asymptomatic	17 (21.2)
Symptomatic	63 (78.8)
Swelling	
No	38 (47.5)
Yes	42 (52.5)
Pain	
No	44 (55.0)
Yes	36 (45.0)
Discharge	
No	59 (73.8)
Yes	21 (26.2)
Paresthesia	
No	78 (97.5)
Yes	2 (2.5)
Location	
Maxilla	25 (30.9)
Mandible	56 (69.1)
Infection	
No	64 (79.0)
Yes	17 (21.0)
Cystic content	
Clear fluid	7 (9.2)

Table 1 Demographic, clinical, radiological, and surgical characteristics of the OKC patients (Continued)

Characteristics (n = 81)	Overall, n (%)
Curd	52 (68.4)
Pus	17 (22.4)
EPT	
Positive	35 (61.4)
Negative	22 (38.6)
Radiological Characteristics	
Bone perforation	
No	16 (21.1)
Yes	60 (78.9)
Radiographic features	
Unilocular radiolucency	60 (75.0)
Multilocular radiolucency	20 (25.0)
With unerupted tooth	
No	30 (37.0)
Yes	51 (63.0)
Involved tooth root	
No	4 (4.9)
Yes	77 (95.1)
Root resorption	
No	55 (71.4)
Yes	22 (28.6)
Surgical Factors	
Surgeon experiences	
> 10 years	60 (74.1)
< 10 years	21 (25.9)
Treatment	
Conservative	47 (58.0)
Adjuvant	30 (37.0)
Resection	4 (5.0)
Extraction of tooth involved with root	
Preservation	51 (66.2)
Extraction	26 (33.8)
Extraction of root resorption tooth	
Preservation	14 (63.6)
Extraction	8 (36.4)

Seventy cases (86.4%) were categorized in ASA class I, while the remaining 11 cases (13.6%) were above ASA class-I. Seventeen cases (21%) presented asymptomatically, and the remaining 63 cases (78.8%) were symptomatic. In the observed cases, 42 cases (52.5%) had swelling, 36 cases (45.0%) had experienced pain on presentation, and 21 cases (26.2%) had discharge or fluid leakage from their lesion. Only 2 cases (2.5%) had paresthesia. The lesions were most frequently located in the mandible (56 cases; 69.1%), while the other 25 cases (30.9%) were located in the maxilla. The most common location was in the posterior mandible accounting for 46 cases (56.8%), followed by the posterior maxilla at 17 cases (21%). Infection was found in 17 cases (21%). The cystic content appeared as curd-like in 52 cases (68.4%), pus in 17 cases (22.4%), and clear fluid in 7 cases (9.2%). Twenty-two cases (38.6%) had vital-associated teeth.

Sixty cases (78.9%) demonstrated cortical bone perforation. The most common radiographic appearance was unilocular radiolucency, accounting for 60 cases (75.0%), while the remaining 20 cases (25.0%) had a multilocular radiolucency. An unerupted or Impacted tooth within the lesion was found in 51 cases (63.0%). Seventy-seven cases (95.1%) had involved adjacent tooth roots, and 22 cases (28.6%) exhibited root resorption.

Forty-seven cases (58.0%) were treated using conservative treatment (marsupialization, enucleation, or marsupialization followed by enucleation), 30 cases (37.0%) by enucleation or marsupialization followed by enucleation with adjuvant therapy (Carnoy's solution or peripheral ostectomy), and 4 cases (5.0%) received surgical resection. Twenty-six cases (33.8%) out of 77 cases underwent the removal of a tooth that had a root associated with the lesion. Only 8 cases (36.4%) out of 22 cases had extraction of teeth that were associated with root resorption. When accounting for the clinical experience of the surgeon that operated on the cases, 60 of the selected cases (74.1%) were treated by surgeons with more than 10 years of experience, while 21 cases (25.9%) were treated by surgeons with less than 10 years of experience.

Table 2 presents the factors associated with OKC recurrence. Root resorption was significantly associated with the recurrence (*p-value*=0.004). The odds of recurrence was 4.90-fold (95%CI:1.58,15.08) higher among patients with root resorption compared with patients without root resorption. Removal of teeth associated with root resorption had a significantly lower risk of recurrence (*p-value*=0.031). No other variable had a significant relationship with OKC recurrence after treatment. The recurrence of OKC was found in 18 cases (22.2%), and the remaining 63 cases were censored. Figure 1 presents the hazard function of OKC recurrence. After a 1-year (12 months) follow-up, OKC recurrence was found in 5 cases with cumulative probabilities of 6.9%, and after a 2-year (24 months) follow-up, OKC recurrence was found in a cumulative 14 cases with a cumulative probability of 27.5%.

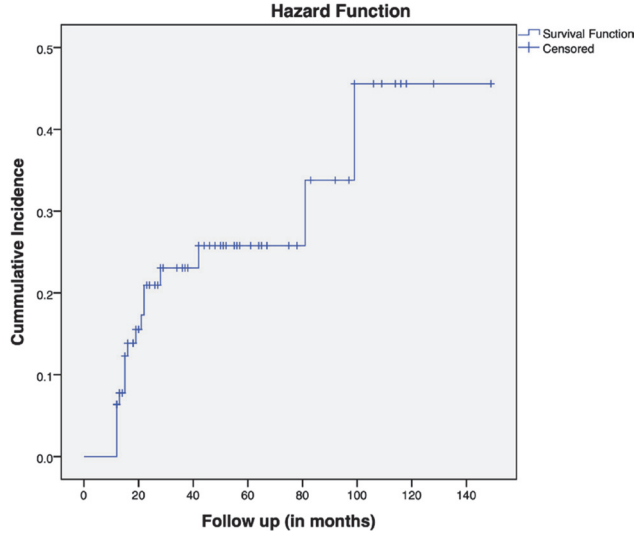

Figure 1 Cumulative incidence of OKC reoccurrence

Table 2 Factors associated with OKC recurrence

Characteristics (n= 81)	Recurrence in the first year			p-value
	Positive, n(%)	Negative, n(%)	Crude Odds ratio [95% CI]	
Age (in years), Mean±SD	29.8±13.4	24.2±7.9	0.96 (0.92, 1.00)	0.102
Sex				
Female	10 (25.0)	30 (75.0)	1	
Male	8 (19.5)	33 (80.5)	1.38 (0.48, 3.94)	0.553
Clinical Characteristics				
Health status (ASA)				
Class I	18 (25.7)	52 (74.3)	1	
Class > I	0	11 (100.0)	-	NA
Symptoms				
Asymptomatic	13 (76.5)	4 (23.5)	1	
Symptomatic	14 (22.2)	49 (77.8)	0.91 (0.26, 3.23)	0.884
Swelling				
No	8 (21.1)	30 (78.9)	1	
Yes	10 (23.8)	32 (76.2)	1.17 (0.41,3.37)	0.768
Pain				
No	9 (20.5)	35 (79.5)	1	
Yes	9 (25.0)	27 (75.0)	1.30 (0.45,3.71)	0.629
Discharge				
No	13 (22.0)	46 (78.0)	1	
Yes	5 (23.8)	16 (76.2)	1.11 (0.34, 3.60)	0.867
Paresthesia				
No	17 (21.8)	61 (78.2)	1	
Yes	1 (50.0)	1 (50.0)	3.59 (0.21, 60.41)	0.402
Location				
Maxilla	7 (28.0)	18 (72.0)	1	
Mandible	11 (19.6)	45 (80.4)	0.63(0.21, 1.88)	0.405
Infection				
No	12 (18.7)	52 (81.3)	1	
Yes	6 (35.3)	11 (64.7)	2.36(0.72, 7.66)	0.152
Cystic content				
Clear fluid	0	7 (100.0)	-	
Curd	10 (19.2)	42 (80.8)	0.44(0.13, 1.46)	0.180
Pus	6 (35.3)	11 (64.7)	1	

Table 2 Factors associated with OKC recurrence (Continued)

Characteristics (n= 81)	Recurrence in the first year			p-value
	Positive, n(%)	Negative, n(%)	Crude Odds ratio [95% CI]	
EPT *				
Positive	10 (28.6)	25 (71.4)	1	0.626
Negative	5 (22.7)	17 (77.3)	0.74(0.21, 2.54)	
Radiological Characteristics				
Bone perforation				
No	4 (25.0)	12 (75.0)	1	
Yes	13 (21.7)	47 (78.3)	0.83(0.23, 3.01)	0.776
Radiographic features				
Unilocular radiolucency	13 (21.7)	47 (78.3)	1	
Multilocular radiolucency	5 (25.0)	15 (75.0)	1.21(0.37,3.94)	0.757
With unerupted tooth				
No	8 (26.7)	22 (73.3)	1	
Yes	10 (19.6)	41 (80.4)	0.67(0.23,1.94)	0.462
Involved tooth root				
No	0	4 (100)	1	NA
Yes	18 (23.4)	59 (76.6)	-	
Root resorption				
No	8 (14.5)	47 (85.5)	1	
Yes	10 (45.5)	12 (54.5)	4.90 (1.58, 15.08)	0.004*
Surgical Factors				
Surgeon experiences				
> 10 years	15 (25.0)	45 (75.0)	1	
< 10 years	3 (14.3)	18 (85.7)	0.73 (0.56,2.35)	0.376
Treatment				
Conservative	14 (29.8)	33 (70.2)	1	
Adjuvant	4 (13.3)	26 (86.7)	0.36 (0.11,1.23)	0.104
Resection	0	4 (100)	-	NA
Extraction of tooth involved with root				
Preservation	15 (29.4)	36 (70.6)	1	
Extraction	3 (11.5)	23 (88.5)	0.31 (0.08, 1.20)	0.082
Extraction of root resorption tooth				
Preservation	9 (64.3)	5 (35.7)	1	
Extraction	1 (12.5)	7 (87.5)	0.08 (0.01, 0.083)	0.031*

CI: Confidence Interval

NA- Not available

Discussion

This retrospective chart review assessed various demographic, clinical, radiologic, and surgical factors that might affect OKC recurrence. The factors significantly associated with recurrence were root resorption and removal of a tooth associated with root resorption.

Odontogenic keratocysts can be found in all ages, however, they are most commonly diagnosed in individuals 11–30 years old [12, 13]. Similarly, the present study found that most cases occurred in patients under 30 years old. Several studies have found a higher male predilection, while other studies found an equal distribution between males and females [12, 13]. A similar sex distribution was observed in the current study. However, in contrast to our study, a retrospective study by Tiranon *et al.* in 2020 [14] and a review by Chirapathomsakul *et al.* in 2006 [15], both conducted in Thailand, reported an increased predilection for OKC in females. The ASA classification of most of the patients with OKC in this study was class I. Although few studies have investigated the ASA classification of patients with OKC, Kinard and colleagues found that the distribution of ASA classification of patients with OKC was 57.4% in class I, 32.7% in class II, 9.0% in class III, and 0.9% in class IV [16].

Most of the patients with OKC present clinically with swelling, which may be accompanied by pain, fluid discharge from the lesion, or paresthesia. The symptomatic presentation of the patients with OKC in the present study is consistent with findings from other studies [15, 17]. However, there are also studies where most of the patients were asymptomatic and the lesion was discovered coincidentally during radiographic examination [18, 19]. The most common location of OKC found in the present study was at the posterior mandible, accounting for 56.8% of the selected cases, which is consistent with most epidemiologic studies where more than 50% of the lesions were found in the same location [12, 14, 18, 20]. Approximately 25% of the patients included in this study had an infection, which could be due to the asymptomatic presentation of the lesions or chronic inflammatory process that led the patient to delay receiving prompt treatment. The cystic content can consist of a curd-like material, clear fluid, or pus [17], however, the most frequent OKC cystic content is curd-like [15], which supports the current study's findings. It is prudent retain a vital tooth however, in some instances, the root may be associated with the vicinity of the lesion. In this case, the removal of a vital tooth might be beneficial to prevent the recurrence without leaving a remnant of the cystic lesion.

Perforation of the cortical plate was found in 60% of the evaluated cases, similar to the findings from other studies, such as 65.5% of cases in Kinard *et al.* in 2013 [21], 50.8% by Chirapathomsakul *et al.* in 2006 [15], and 66.3% by Berge *et al.* in 2016 [17]. Although buccal cortical plate perforation was seen more in the maxilla than the mandible [17], the present study was unable to assess this factor. The radiographic features in this study revealed 75% cases with a unilocular radiolucency and 25% cases with a multilocular radiolucency. These findings were in line with Titinchi *et al.* [22], Chirapthomsakul *et al.* [15], and Boffano *et al.* [18] in which a unilocular radiolucency was observed in 71.0%, 71.6%, and 83.5% of cases respectively. Furthermore, Fidele *et al.* in 2019 [10] found lesions that appeared as a multilocular radiolucency had a 58.4% recurrence rate, while those with a unilocular radiolucency had a lower recurrence rate of 41.50% which was significantly different. However, in our study, the data analysis found no significant correlation between the radiographic features and OKC recurrence. According to Chrcanovic and Gomez in 2017 [4], unilocular radiolucent lesions were 0.67-fold more likely to recur compared with multilocular

radiolucent lesions (RR 0.67, p=0.007). The association of the lesion with an impacted or embedded tooth was 63% of the included cases. This percentage was higher compared with Titinchi *et al.* in 2012 [22], Kinard *et al.* in 2013 [21], Chow in 1998 [23], and Chirapathomsakul *et al.* in 2006 [15] that reported 52.4%, 51.6%, 52.8%, and 31.3% associations, respectively. This study also found that 95.1% of the lesions had root involvement. This percentage was higher than in other studies i.e., 22–33% of OKC with root involvement [15, 24-26]. 28.6% of the lesions with root involvement caused root resorption, which was relatively uncommon in other studies [15, 19, 24, 26]. A significant association was found between lesions with root resorption and an increased recurrence rate. 45.5% patients (ten out of 22 cases) with root resorption reported OKC recurrence, while lesions with no root resorption (eight out of 55 cases) had 14.5% recurrence. However, the cases with root resorption in this study might not be enough to establish the appropriate relationship with a high level of evidence between OKC recurrence and root resorption. This should be investigated in future studies.

The results of this study revealed that 47 patients were treated with conservative methods, 37 patients were treated with enucleation and adjuvant treatment, and 4 patients were treated with resection. OKC recurrence was the highest in cases treated with a conservative approach (29.8%), followed by enucleation with adjuvant treatment (13.3%), and no recurrence was found in the patients who received resection as a treatment. There was no significant difference between the treatment modalities and recurrence. In contrast, Kinard *et al.* (2019) [16] revealed a significant difference between the treatment modality and recurrence. In their study, a recurrence rate of 29.8% for lesions treated by marsupialization with enucleation, 14.6% for enucleation, and 16.7% for enucleation with peripheral ostectomy was found. Similarly, a review conducted in 2017 by Chrcanovic and Gomez [4] from the data of 94 studies, consisting of 6,427 OKC lesions, revealed a recurrence rate of 28.7% after marsupialization with or without enucleation, 18.6% after enucleation with peripheral ostectomy, 5.3% after enucleation with Carnoy's solution, 20.9% after enucleation and cryotherapy, and 2.2% after resection. However, Tiranon and colleagues in 2020 [14] found a recurrence rate of 18.2% following enucleation with Carnoy's solution and with or without prior marsupialization, 16.7% following marsupialization and enucleation with peripheral ostectomy or bone curettage, and no recurrence following resection or enucleation with peripheral ostectomy or bone curettage.

The removal of teeth with roots involved with the lesion was done in 26 out of 77 patients. There was less lesion recurrence (11.5%) in the tooth removal group compared with the patients with tooth preservation (29.4%). However, there was no significant difference in lesion recurrence between the groups. The result of this study conflict with those in Fidele *et al.* (2019) that recommended the removal of teeth associated with the lesion [10]. There was an 87.5% recurrence when the teeth were maintained, however, it was only 12.5% when the teeth were removed, which was significantly different. Furthermore, Chirapathomsakul and colleagues in 2006 [15] concluded that the preserving the associated teeth promotes lesion recurrence by preventing the complete enucleation of the lesion. To the best of our knowledge, there are no studies that investigated the association between the OKC recurrence rate and preserving the teeth in lesions with root resorption. Notably, a significance association was found between the two variables in this study. Despite the recommendations made by multiple studies to extract the teeth with root resorption during the surgical removal of the lesion, the surgeon may have

chosen to preserve some of the teeth in certain patients at their request or making a decision based on the experience of the surgeon. Thus, the findings of this study support the removal of teeth with root resorption from the lesion to prevent recurrence.

In this study, the overall OKC recurrence rate was 22.2%, which is similar to other studies including a study by the WHO in 2017 (25%) [12], Chrcanovic and Gomez in 2017 (21.1%) [4], and Kinard *et al.* in 2019 (19%) [16]. Further follow-up and investigation in the present study also found 6.9% and 27.5% cumulative probabilities to recur after a 1-year and 2-year follow-up, respectively. There was also 11.1% of recurrence within the first 5 years, and no recurrence after 10 years of follow-up. Multiple studies also revealed similar results, where most recurrences occurred within the first 5 years after treatment, therefore, it is recommended that there should be at least 5 years of follow-up after the treatment is completed [10, 14-16].

The present study has several limitations. Initially, the data collection was done from the hospital records by a single investigator which may have created information bias. In addition, the retrospective design of the research might produce low evidence data compared with the prospective nature of a clinical study. There was no active follow-up of patients in the records and there was a large amount of censored data that made it difficult to calculate the median recurrence time [27]. Furthermore, there was a loss of cases during the follow up that could have affected the recurrence rates with a lower number of patients in the follow-up periods. Therefore, the recurrence rate of this study has to be carefully considered when discussing it in future reports.

Conclusion

This retrospective study reports several risk factors for the recurrence of odontogenic keratocysts with long-term follow-up. Root resorption due to OKC demonstrated a significant association with the increased recurrence rate. Furthermore, the removal of teeth associated with root resorption resulted in a significantly lower recurrence rate. In contrast, other demographic, clinical, radiological, and surgical factors did not demonstrate significant differences in OKC recurrence. The overall recurrence rate of OKC was 22.2% and based on the results of this study it is recommended that at least a 5-year follow-up period is required after OKC treatment.

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Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Mahidol University, Thailand.

Conflict of Interest

None

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Supplementary Table Log-rank test comparing the mean time of OKC recurrence

Variables	Mean survival time (in months)	Log rank Chi square value	*p-value*
Gender			
Male	113.4 (90.4, 135.5)	0.000	0.996
Female	98.9 (83.4, 114.3)		
Health Status			
Class I	56.9 (47.4, 66.4)	6.20	0.013*
Class > I	35.5 (21.2, 49.9)		
Symptoms			
Asymptomatic	83.5 (64.2, 102.8)	0.030	0.862
Symptomatic	109.9 (91.9, 127.9)		
Swelling			
No	93.5 (79.7, 107.3)	0.070	0.792
Yes	103.3 (79.9, 126.7)		
Pain			
No	112.5 (91.0, 113.9)	0.292	0.589
Yes	85.9 (69.4, 102.4)		
Discharge			
No	98.2 (84.2, 112.2)	0.055	0.815
Yes	112.5 (84.6, 140.3)		
Paresthesia			
No	112 (96.4, 127.9)	0.843	0.359
Yes	24 (21.2, 26.8)		
Location			
Maxilla	90.5 (67.4, 113.5)	1.023	0.312
Mandible	113.4 (94.1, 132.7)		
Infection			
No	116.9 (100.2, 133.5)	3.398	0.065
Yes	60.6 (38.1, 83.2)		
EPT			
Positive	89.2 (70.4, 108.1)	0.015	0.903
Negative	115.9 (90.5, 141.3)		

Supplementary Table Log-rank test comparing the mean time of OKC recurrence (Continued)

Variables	Mean survival time (in months)	Log rank Chi square value	*p-value*
Bone perforation			
No	90.0 (67.9, 111.9)	0.004	0.947
Yes	109.6 (90.6, 128.7)		
Radiographic features			
Unilocular radiolucency	100.9(87.9, 113.8)	0.290	0.590
Multilocular radiolucency	100.4(64.8, 135.9)		
With unerupted tooth			
No	107.5(83.5, 131.5)	0.219	0.640
Yes	99.9(84.1, 115.8)		
Root resorption			
No	109.9(98.3, 121.5)	7.005	**0.008***
Yes	82.4(54.1, 110.7)		
Treatment			
Conservative	101.4(81.2, 121.6)	1.11	0.292
Adjuvant	108.2(90.4, 125.9)		

1. Mean reoccurrence time in Class I patient was significantly higher compared with higher than class I patient ($p<0.05$).
2. Mean duration of reoccurrence time in patients with no root resorption was longer compared with patients with root resorption ($p<0.05$).