A Retrospective Review of Treatment of the Odontogenic Keratocyst

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Purpose: The purpose of this study was to evaluate different surgical treatment methods for odontogenic keratocysts and the outcome of those treatments over a 25-year period.

Patients and Methods: A retrospective review was performed of 40 patient charts treated at the University of Iowa Hospitals and Clinics (Iowa City, IA) from 1977 to 2002 with the diagnosis of odontogenic keratocyst. Demographic data were collected along with lesion location, symptoms present at initial presentation, surgical treatment rendered, length of follow-up, and incidence of recurrence.

Results: Surgical treatments included enucleation, enucleation with Carnoy's solution, peripheral ostectomy, peripheral ostectomy with Carnoy's solution, and en bloc resection. Recurrence was found in 9 to 40 patients. Seven of 9 recurrences (78%) occurred in 5 years or less, with 2 (22%) occurring more than 5 years after initial treatment. Patients treated with enucleation had a recurrence rate of 54.5% (6 of 11 patients). One of 2 patients treated with enucleation and Carnoy's solution had a recurrence. Those treated with peripheral ostectomy had a recurrence rate of 18.2% (2 of 11). Peripheral ostectomy with Carnoy's solution had no recurrences (0/13).

Conclusion: Treatment of an odontogenic keratocyst with peripheral ostectomy, with or without the use of Carnoy's solution, had a significantly lower rate of recurrence. Treatment with enucleation, with or without the use of Carnoy's solution was associated with a significantly higher recurrence rate.

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The odontogenic keratocyst (OKC) is an epithelial developmental cyst of the jaws.[1] This lesion is commonly found in the maxilla and mandible, and can become quite large because of its potential for significant expansion, extension into adjacent tissues, and rapid growth.[2,3]

The treatment of the OKC remains controversial. Treatments are generally classified as conservative or aggressive. Conservative treatment generally includes simple enucleation, with or without curettage, using spoon curettes or marsupialization. Aggressive treatment generally includes peripheral ostectomy, chemical curettage with Carnoy's solution, and resection. Some surgeons believe the cyst can be properly treated with enucleation if the lesion is removed intact.[4,5] However, complete removal of the OKC can be difficult because of the thin friable epithelial lining, limited surgical access, skill and experience of the surgeon, cortical perforation, and the desire to preserve adjacent vital structures. The goals of treatment should involve eliminating the potential for recurrence while also minimizing the surgical morbidity. There is no consensus on adequate or appropriate treatment of this lesion.

Recurrence has been reported more than 10 years following the initial treatment. Recurrence of odontogenic keratocysts has been attributed to several mechanisms. Woolgar et al[6] described 3 different theories. The first involves incomplete removal of the original cyst lining. The second involves growth of a new OKC from small satellite cysts or odontogenic epithelial rests left behind by the surgical treatment. The third involves the development of an unrelated OKC in an adjacent region of the jaws that is interpreted as a recurrence. Marx and Stern[1] believe that the 2 most common reasons for recurrence are incomplete cyst removal and new primary cyst formation.

The literature reports that most recurrences will appear within the first 5 to 7 years,[6-12] but there are numerous reports of recurrences at much longer time intervals. A study by Crowley et al[7] reports that 25% of recurrences were found 9 or more years after the

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initial treatment; 1 case recurred 41 years after the initial treatment. These reports of recurrences many years after initial treatment substantiate the need for the long-term follow-up advocated by Williams and Hellstein[13] and Brannon.[8]

The purpose of this study was to evaluate the demographic, clinical, surgical, and recall aspects of care for 40 patients with OKCs treated between 1977 and 2002 at the University of Iowa Hospitals and Clinics. This study analyzed the age, gender, and race of the patients, location of the lesion, surgical treatment provided, recurrence rate, and overall follow-up.

Patients and Methods

A retrospective chart review was performed on 374 cases of potential odontogenic keratocysts. Criteria for inclusion included patients treated surgically at the University of Iowa for single OKCs meeting the histologic criteria as outlined by Pindborg and Hansen[14] and Browne.[15]

Exclusion criteria included: 1) patients treated elsewhere with no surgical treatment provided at the University of Iowa; 2) patients with the diagnosis of orthokeratinizing odontogenic cyst or odontogenic keratocyst-orthokeratinized variant meeting the criteria established by Wright[16]; 3) patients with a diagnosis of basal cell nevus syndrome; and 4) patients with less than 12 months of follow-up.

Forty patients met the inclusion criteria. The charts of these 40 patients were reviewed and the available information was documented on a chart review form. Recorded demographics included gender, race, and age at diagnosis. The method of initial diagnosis was recorded in 2 categories. The first category included OKCs identified incidentally by routine examination or radiograph. The second category included OKCs identified by presenting symptoms such as pain, swelling, or drainage.

The OKCs were recorded by location in the maxilla or mandible and were further subdivided into the following groups: 1) maxillary incisor and canine; 2) maxillary premolar; 3) maxillary molar and tuberosity; 4) mandibular incisor and canine; 5) mandibular premolar; 6) mandibular molar; 7) mandibular angle and ramus; 8) mandibular coronoid process; and 9) mandibular condyle. A large cyst might be included in multiple groups.

The treatment provided for each OKC was also recorded as determined by review of the operative report. Simple enucleation was defined as enucleation with or without the use of curettes. Peripheral ostectomy was defined as peripheral bone that was reduced with a powered hand-piece after enucleation of the lesion. Carnoy's solution was used as an adjuvant treatment to enucleation or peripheral ostectomy and documented in combination with these 2 treatments. Patients were placed in the resection group if the operative report verified an en-bloc removal of the cyst and a margin of adjacent normal tissue. Patients who underwent supraperiosteal soft tissue resection in regions of cortical perforation were classified as to the treatment given to the cystic bony cavity.

The length of follow-up was recorded as the total number of months between the time of treatment and the most recent recorded follow-up. The radiographic methods used for follow-up were also recorded. Patients were classified as lost to follow-up if they were currently not scheduled for a follow-up appointment at this institution and a follow-up appointment was past due. If the chart documented the patients were undergoing follow-up locally, they were contacted by telephone to verify the follow-up appointments and investigate recurrences.

A recurrence was noted if an OKC, originally treated at the University of Iowa, reappeared in the same location. Time to recurrence was recorded from the date of original treatment to the date of the biopsy verifying recurrence. The radiographic method used to identify recurrences was recorded.

Information was also recorded regarding presenting symptoms at the time of recurrence (symptomatic or asymptomatic). The treatment provided for the recurrence was obtained from the operative report and classified in the same groups listed for treatment of the primary cysts.

Statistical analysis was used to search for associations between multiple variables. Candidate variables included age, gender, presenting symptoms, location, treatment, recurrence, symptoms on recurrence, and total follow-up. SAS software (SAS Institute Inc, Cary, NC) was used to conduct data analyses. The hypothesis testing for the assessment of association in contingency tables for bivariate analyses were performed by chi-square test, or the Fisher's exact test if the sample sizes were too small. Wilcoxon rank-sum test was computed for comparison of age, months until lost to follow-up, follow-up months, and other continuing explanatory variables for each condition of outcome variables (recurrence, lost to follow-up, gender).

Results

The 40 patients ranged from age 11 to 81 years (mean, 40.7 years). There were 25 males (62.5%) and 15 females (37.5%) (ratio 1.7:1). Caucasians accounted for 97.5% of the patients. Twenty-three patients (57.5%) presented with symptoms (swelling, pain, drainage, and infection), whereas the remaining

Table 1. OKC DEMOGRAPHIC INFORMATION

	No. of Patients (N = 40)	% of Patients
Gender		
Male	25	62.5
Female	15	37.5
Age range (yrs)	11–81	
Race		
Caucasian	39	97.5
Asian	1	2.5
Presentation on identification		
Symptomatic	23	57.5
Asymptomatic/routine exam	17	42.5

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17 (42.5%) were diagnosed incidentally at the time of routine examination (Table 1).

Eleven lesions (27.5%) were maxillary; 29 (72.5%) were mandibular (ratio 1:2.6). The most frequently involved regions were the mandibular molar, angle, and ramus (45%). The maxillary molar and tuberosity region was the next most common location (22.5%). The majority (82.5%) of the OKC's were located posterior to the canines (Table 2).

Enucleation was used to treat 27.5% (11/40) of the cases. Enucleation and Carnoy's solution were used together to treat 5% (2/40). Peripheral ostectomy was used to treat 27.5% (11/40). Peripheral ostectomy in combination with the use of Carnoy's solution accounted for 32.5% (13/40). Resection was used to treat the remaining 7.5% (3/40) (Fig 1).

Follow-up ranged from 13 to 288 months (mean, 63.7 months). The review found 16 of the 40 patients (40%) were still in active follow-up. Figure 2 shows

Table 2. LOCATION RESULTS

	No. of Patients (N = 40)	% of Patients
Location		
Maxilla	11	27.5
Mandible	29	72.5
Specific location (one cyst may have multiple locations)		
Maxillary incisor and canine	2	5
Maxillary premolar	1	2.5
Maxillary molar and tuberosity	9	22.5
Mandibular incisor and canine	5	12.5
Mandibular premolar	5	12.5
Mandibular molar	18	45
Mandibular angle and ramus	18	45
Mandibular coronoid	7	17.5
Mandibular condyle	2	5

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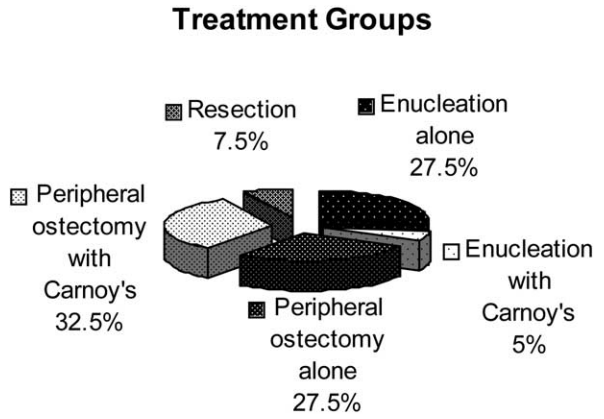

FIGURE 1. Treatment groups: 32.5% of all patients underwent peripheral ostectomy with Carnoy's solution, while 27.5% underwent peripheral ostectomy and enucleation without the use of Carnoy's solution.

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the length of time patients were in active recall before becoming lost to follow-up.

Recurrence was found in 9 of the 40 patients (22.5%). The mean number of months until recurrence was 49.1 (range, 3 to 106 months). Seven cysts (78%) recurred in 5 years or less; 2 (22%) recurred after more than 5 years. No presenting symptoms were found in 8 (89%) of the recurrences.

Enucleation had the highest recurrence rate at 54.5% (6/11). Two patients were treated with enucleation and Carnoy's solution; 1 of these had a recurrence. Peripheral ostectomy had a recurrence rate of 18.2% (2/11). Peripheral ostectomy combined with Carnoy's solution had no recurrences (0/13). Resection was only performed 3 times with no associated recurrences (Table 3).

Statistical analysis using the Fisher's exact test found significant associations ($P = .0045$) between recurrence and the type of treatment provided. Patients who had recurrences were significantly more likely to have been treated with enucleation (54.5%) than patients who were treated with peripheral os-

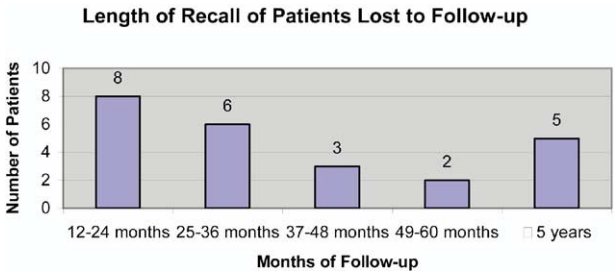

FIGURE 2. Length of recall of patients lost to follow-up. A total of 24 of 40 patients were lost to follow-up.

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Table 3. RECURRENCE

	No. of Recurrences/ Treatments	% Recurrences/ Treatments
Recurrence by treatment		
Enucleation	6/11	54.5
Peripheral ostectomy	2/11	18.2
Peripheral ostectomy and Carnoy's solution	0/13	0
Enucleation and Carnoy's solution	1/2	50
Resection	0/3	0
Recurrence by individual treatment		
Peripheral ostectomy	2/24	8.3
Carnoy's solution	1/15	6.7
Enucleation	7/13	53.8
Resection	0/3	0

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tectomy alone (18.2%) or with a combination of peripheral ostectomy and Carnoy's solution (0%).

The Fisher's exact test found a significant association ($P = .0175$) between recurrence and patients who had peripheral ostectomy as all or part of the treatment. Twenty-four patients were treated with peripheral ostectomy. Two of those 24 (8.3%) had recurrence. Sixteen patients had a treatment other than peripheral ostectomy. Seven of those 16 patients (43.8%) had a recurrence.

The Fisher's exact test found no significant association ($P = .117$) between recurrence and the use of Carnoy's solution.

There was no difference between the treatment groups described and the amount of follow-up they received.

Wilcoxon test found a significant difference ($P = .0026$) between the length of follow-up and recurrence. Patients with recurrence had a median follow-up of 142 months, compared with 37 months in those without recurrence.

Discussion

The mean age of 41.7 years in this study is similar to the mean ages of 41 years reported by Ahlfors et al[17] and 37 years by Brannon.[8] The exclusion of patients with nevoid basal cell carcinoma syndrome likely increased the mean age and possibly blunted the incidence peak typically reported in the second and third decades.

This study confirmed the male predominance reported for OKCs. Our findings are similar to those of previous studies, which generally show a distribution of approximately 60% males and 40% females.[7,8,17]

Patients in the study group were 98% caucasian. This study reflects the patient population with respect to race in Iowa.

Investigators have reported 50% to 67% of OKCs to be sympotomatic at the time of diagnosis.[7,8,18] This study confirms those findings. Improved or more frequent imaging could hopefully identify smaller lesions that are more easily treated. Presumably, symptomatic OKCs are larger, more destructive, and more difficult to treat.

Because of the lack of adequate radiographic documentation in this retrospective study, it was not possible to include data regarding removal or maintenance of teeth in direct contact with the lesion. We recognize this to be a shortcoming of this study.

Lesion location in our series confirms that the most common sites for the OKC are the posterior mandible, followed by the maxillary molar and tuberosity region.

The overall rate of recurrence was 22.5%. The patient population treated at this institution often travel a significant distance to receive care and for that reason a number of patients return to a local dentist or surgeon for follow-up after surgical intervention. Patients with less than 12 months of follow-up were excluded from this study. The elimination of this group from the study did elevate the rate of recurrence as the sample size was decreased.

Many questions remain as to the most appropriate treatment for the odontogenic keratocyst. This institution does not include chloroform as an ingredient of Carnoy's solution because of a hospital policy banning its use. The formulation used consisted of 95% ethanol (9 cc), glacial acetic acid (3 cc), and ferric chloride (1 g). In this study, treatment with Carnoy's solution did not show a significant association with recurrence. A larger sample size, or a larger group of patients treated with enucleation and Carnoy's solution together, for comparison to enucleation alone could better demonstrate the association between Carnoy's solution and recurrence, if such an association exists. Voorsmit et al[19] reported a decreased recurrence rate following treatment with enucleation and Carnoy's solution (2.5%) compared with enucleation alone (13.5%), but made no comment on the statistical validity or length of follow-up of the 2 groups.

Patients with recurrences had significantly longer follow-up (median, 142 months) than those without recurrence (median, 37 months). This raises the question of whether the recurrence was identified because of the longer follow-up. To better address this question, the nonparametric Wilcoxon rank-sum test was used to compare the distribution of months until first recurrence for patients who did have a recurrence ($n = 9$) and total follow-up months for patients

who did not have recurrence (n = 31). These data provided no evidence of a significant difference between these 2 groups (P = .7354). There was no significant difference in the mean time to recurrence for patients with recurrence and the mean follow-up for patients without recurrence.

This study found that treatment of an OKC with peripheral ostectomy was associated with a significantly decreased rate of recurrence, while treatment with enucleation was associated with a significantly increased rate of recurrence.

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