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Original

Keratocystic odontogenic tumor: a retrospective study of 183 cases

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Abstract: In 2005, the WHO Working Group considered odontogenic keratocyst (OKC) to be a tumor and recommended the term keratocystic odontogenic tumor (KCOT), separating the lesion from the orthokeratinizing variant, which is now considered an odontogenic cyst. We analyzed the clinicopathological features of KCOTs encountered over a period of 28 years at Meikai University Hospital. The diagnosis was confirmed by reevaluation of hematoxylin and eosin-stained slides on the basis of the 2005 WHO Classification. Clinical history was also taken into consideration. A total of 183 KCOTs were found, and the two genders were affected almost evenly (51.3% male; 48.7% female; male to female ratio 1.05 to 1). Patient age at the time of diagnosis ranged from 6 to 78 years, with a peak in the third decade of life (mean age: 32.8 years). The mandible was the site of occurrence of 70.5% of tumors; 16.4% occurred in the maxilla and 13.1% in both. Association with the nevoid basal cell carcinoma syndrome (NBCCS) was found in 6.0% of all tumors, and recurrence was found in 13.1% of patients. We found that tumors that initially appeared in the maxilla alone had a higher recurrence rate than those that first appeared in the mandible alone. Pathological examination of KCOT is important to avoid misdiagnosis and provide appropriate treatment and follow-up. (J. Oral Sci. 50, 205-212, 2008)

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Introduction

The diagnostic metamorphosis of odontogenic keratocyst into a recognized cystic neoplasm, keratocystic odontogenic tumor, occurred after observation of its biological behavior and modern investigations revealed chromosomal and genetic abnormalities consistent with neoplasic progression (1). The first description of odontogenic keratocyst (OKC) was published in 1956 by Philipsen (2-4); the lesion attracted interest because of its specific histopathological features. In 1963 Pindborg and Hansen suggested the histological criteria for describing the essential features of OKC (2), and investigators started to discuss the differences between the common parakeratinized type and the rarer orthokeratinized type (4). Clinically, the parakeratinizing lesions are characterized by aggressive growth and a tendency to recur after surgical treatment. They show increased mitotic activity in the cystic epithelium, together with a potential for budding of the basal layer and the presence of daughter cysts in the cystic wall. In addition, they show an association with nevoid basal cell carcinoma syndrome (NBCCS). Accordingly, the parakeratinizing variant of OKC is now regarded as a cystic neoplasm (1,5). The discovery of chromosomal abnormalities and genetic alterations, such as mutation of the PTCH gene, appeared to confirm this concept. Consequently, in 2005, the WHO Working Group considered the OKC parakeratinizing variant to be a cystic neoplasm and recommended the more descriptive term “keratocystic

odontogenic tumor" (KCOT). Now, cystic jaw lesions that are lined by orthokeratinizing epithelium do not form part of the spectrum of KCOT (6). All these findings have led to extensive research on KCOT, which today remains a subject of controversy.

We retrospectively investigated 183 KCOTs in Japanese patients diagnosed at the Division of Pathology, Department of Diagnostic and Therapeutic Sciences, Meikai University School of Dentistry, over a period of 28 years. We focused on patient gender and age, tumor location, recurrence rate, and association with NBCCS.

Materials and Methods

The present study was approved by the ethics committee of Meikai University School of Dentistry (A-0313), Saitama, Japan. A retrospective review was performed; tumors diagnosed between 1978 and 2006 in our department were overviewed and 183 cases of KCOT were selected. The diagnosis was confirmed by reevaluation of hematoxylin and eosin-stained slides, using the diagnostic criteria outlined in the 2005 WHO Classification of Head and Neck Tumors (6). Criteria for exclusion included cystic jaw lesions that were lined by orthokeratinizing epithelium (11 tumors) and tumors that had been earlier diagnosed as OKC but did not fulfill the 2005 WHO criteria for KCOT (9 tumors). The data included patient gender and age, tumor location, tumor recurrence, histopathological findings, and association with NBCCS. For patients who showed recurrence, each biopsy was entered into the database as a separate record. For patients with NBCCS who exhibited recurrence of KCOT, the age of the patient at the time of the initial diagnosis was taken as a reference point.

Results

Distribution of gender and age

During a 28-year period, a total of 183 tumors recorded at the Division of Pathology, Department of Diagnostic and Therapeutic Sciences, Meikai University School of Dentistry, were reevaluated and confirmed to be KCOT. Ninety-four (51.3%) occurred in males and 89 (48.7%) in females; the male to female ratio was 1.05:1 (Table 1). Patients ranged in age at the time of diagnosis from 6 to 78 years, with a mean age of 32.8 years. KCOTs had a peak of occurrence in the third decade of life, followed by the second decade of life. The ages of two males and one female were not available.

Distribution of tumor location

The overall mandibular to maxillary ratio of tumor occurrence was 4.3:1 (Table 2). One hundred and twenty-nine tumors (70.5%) occurred in the mandible: in the molar area in 41.0% of all tumors, the mandibular molar to ramus area in 7.8%, the incisor area in 4.3%, and the premolar area in 4.3%. Thirty tumors (16.4%) occurred in the maxilla: the molar area was involved in 5.0% of all tumors, the incisor area in 2.1%, and the premolar area in 0.5%. The remaining KCOTs (13.1%) were multiple.

Association with NBCCS

Eleven tumors (6.0%) were confirmed to be associated with NBCCS; all of them were multiple KCOTs (Table 3). Four tumors (36.4%) occurred in males and 7 (63.6%) in females; the male to female ratio was 1:1.75. Patients whose tumors were associated with NBCCS ranged in age from 8 to 43 years at the time of initial diagnosis (mean 19.5 years). Three of them had recurrences. Notably, 13 patients (4 male and 9 female) exhibited multiple KCOTs but had no signs or symptoms of NBCCS. The 24 patients

Table 1 Distribution of age and gender

Age	Male	(%)	Female	(%)	Total	(%)
0- 9	1	(0.5)	2	(1.0)	3	(1.7)
10-19	23	(12.6)	22	(12.0)	45	(24.6)
20-29	26	(14.2)	27	(14.8)	53	(28.9)
30-39	13	(7.1)	11	(6.0)	24	(13.1)
40-49	8	(4.3)	8	(4.2)	16	(8.8)
50-59	10	(5.4)	7	(4.0)	17	(9.2)
60-69	7	(3.9)	8	(4.2)	15	(8.2)
70-79	4	(2.2)	3	(1.6)	7	(3.8)
NAS	2	(1.0)	1	(0.5)	3	(1.7)
Total	94	(51.3)	89	(48.7)	183*	(100)

Mean age: 32.8 years. *: 11 tumors were confirmed to be associated with NBCCS (mean age: 19.5 years).

whose tumors were multiple KCOTs had a mean age of 25.9 years.

Histopathological findings

Of the KCOTs studied, 171 (93.4%) showed pure parakeratinization (Fig. 1), and 12 (6.6%) mixed parakeratinization and orthokeratinization (Fig. 2). All multiple KCOTs showed parakeratinization only. Koilocytosis was found in 17.8% of all tumors; one or more daughter cysts was found in the capsular connective tissue in 6.1% (Figs.

Table 2 Distribution of tumor location

Location	Total	(%)
Mandibular incisor	8	(4.3)
Mandibular premolar	8	(4.3)
Mandibular molar	75	(41.0)
Mandibular molar to ramus	14	(7.8)
Mandibular extent location	24	(13.1)
Maxillary incisor	4	(2.1)
Maxillary premolar	1	(0.5)
Maxillary molar	9	(5.0)
Maxillary extent location	16	(8.8)
Multiple location*	24	(13.1)
Total	183	(100)

*: 11 tumors were confirmed to be associated with NBCCS. Mandibular to maxillary ratio: 4.3:1.

Table 3 Distribution of age and gender of multiple tumors

Age	Male	Female	Total	(%)
0- 9	1	0	1	(4.1)
10-19	4	7	11	(45.9)
20-29	2	6	8	(33.4)
30-39	0	1	1	(4.1)
40-49	1	0	1	(4.1)
50-59	0	0	0	(0.0)
60-69	0	2	2	(8.4)
70-79	0	0	0	(0.0)
Total (%)	8 (16.6)	16 (37.5)	24*	(100)

Mean age: 25.9 years. *: 11 tumors were confirmed to be associated with NBCCS (mean age: 19.5 years).

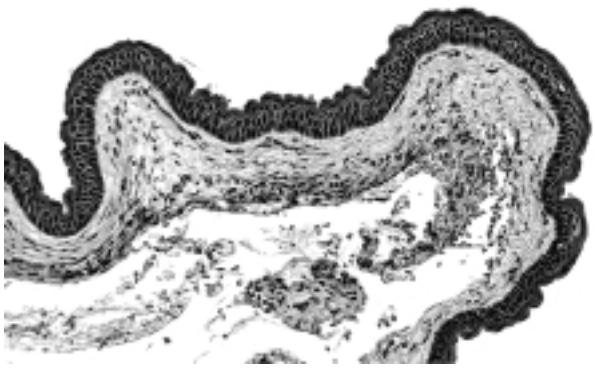

Fig. 1 Prominent palisade basal cell layer with dark-staining nuclei and a corrugated surface with parakeratinization (H-E staining, original magnification ×4).

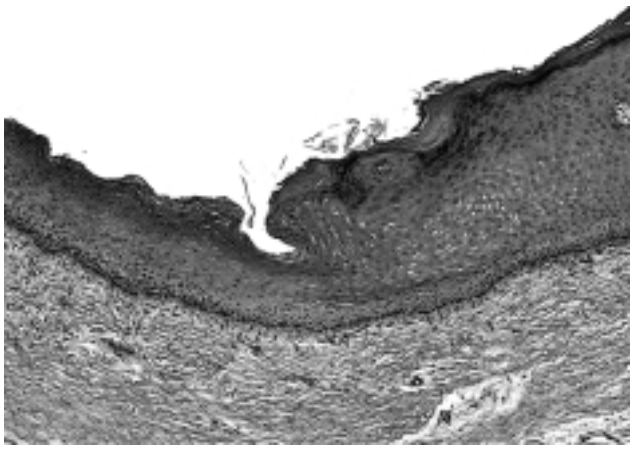

Fig. 2 Mixed parakeratin and orthokeratin in the lining epithelium (H-E staining, original magnification ×10).

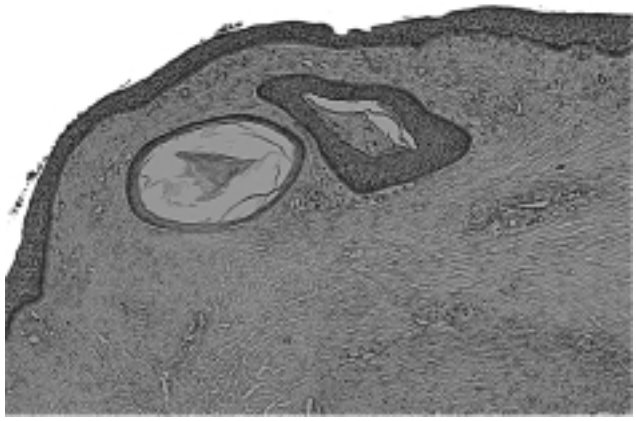

Fig. 3 Prominent daughter cysts containing keratin whorls (H-E staining, original magnification ×4).

3, 4b), epithelial islands in 5.0%, and epithelial budding of the basal layer in 1.6% (Figs. 4a, 4b). In addition, two tumors had hyaline bodies and two had dystrophic calcification in the epithelial islands (Figs. 5a, 5b). In 40 (21.8%) KCOTs, the lesions were associated with the presence of an impacted tooth (Table 4).

Clinicopathological findings of KCOT

Recurrence was found in 13.1% of patients. All of the recurrent tumors were parakeratinized, and in 5 of the patients the tumor recurred more than once: the 24 patients with recurrences had a total of 56 recurrent tumors. Sixteen of the patients with recurrences (66.6%) were female and only 8 (33.4%) were male. Of the 5 patients whose tumors recurred more than once, the tumors of three were associated with NBCCS. Time to recurrence ranged from 1 to 23 years. Patients with recurrences ranged in age from 6 to 67 years (mean 26.1 years) (Table 5). KCOTs

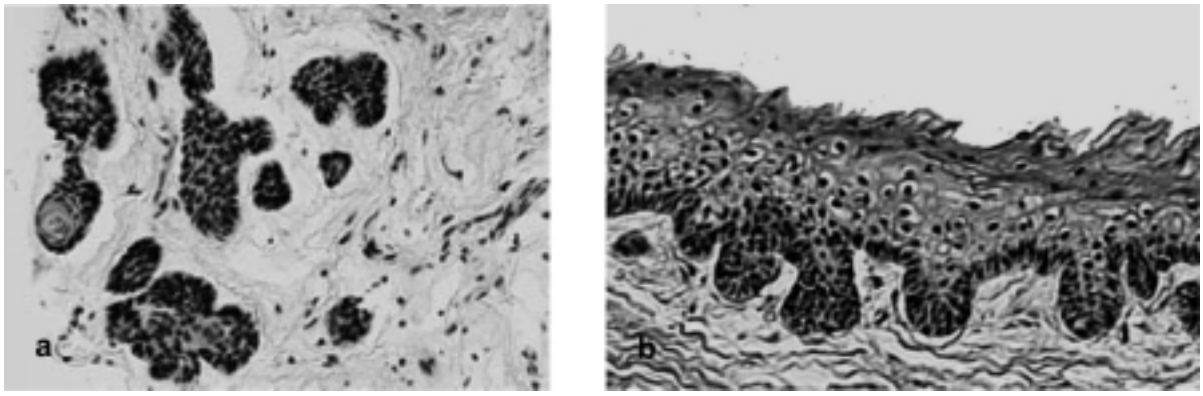

Fig. 4 Numerous well-delimited islands of odontogenic epithelium are present in the tumor capsule (a) (H-E staining, original magnification ×4), budding of the tumor epithelium, with koilocytosis. Halo formation to various degrees (b) (H-E staining, original magnification ×10).

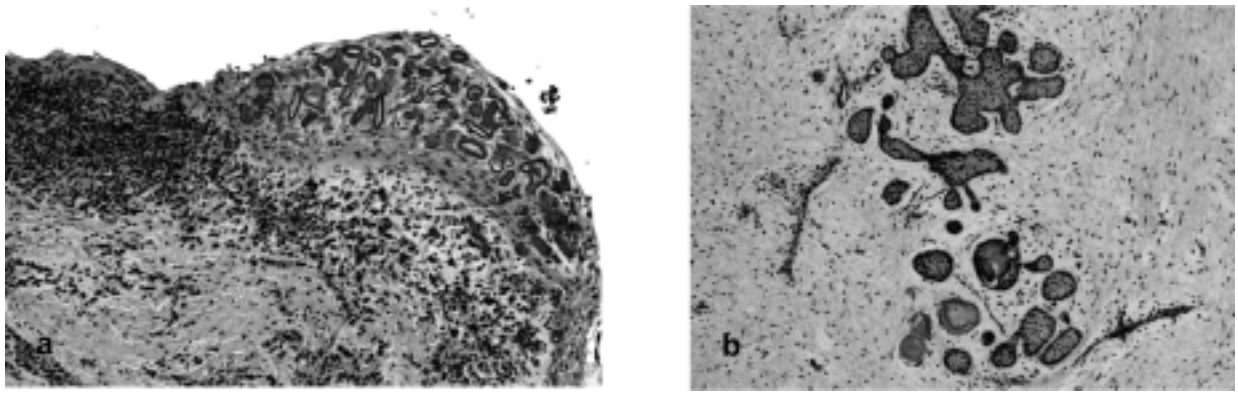

Fig. 5 Presence of hyaline bodies and inflammatory changes that have destroyed parts of the features of the lining epithelium (a), dystrophic calcification in the epithelial islands (b) (H-E staining, original magnification ×4).

in the maxilla alone showed a higher recurrence rate (34.2%; 13 out of 38 tumors) than those in the mandible alone (28.9%; 40 out of 138 tumors). In three of the patients the tumor had occurred, and then recurred, in both the mandible and maxilla. Among the recurrent tumors 16.6% had one or more daughter cysts, 11.1% had epithelial islands, and 5.5% showed epithelial budding of the basal layer. In 13 (23.2%) of the recurrent KCOTs, the lesions were associated with the presence of an impacted tooth.

Discussion

A male predominance has been reported for KCOT in previous studies, the general distribution being 60% male and 40% female (4,6-9). By contrast, Chirapathomsakul et al. found in a Thai population that females were affected slightly more often than males (male to female ratio: 1:1.2) (10). Also, Maurette et al. found a male to female ratio of 1:2.1 in a series of 30 Brazilian cases (3). We found that both genders were affected almost evenly; there appeared to be no predilection for males or females. These results are in concordance with those of Stoelinga (11) in the Netherlands, but his series was smaller (75 tumors) than ours. The age distribution in our series was in agreement with those in other reports, with a peak incidence in the third decade of life, followed by the second decade (4,6,7); however, Kakarantza-Angelopoulou and Nicolatou (8) found a major peak of frequency in the fifth and sixth decades of life in Greek patients. A bimodal distribution has also been found in other series (12,13). The mean age of patients with multiple KCOTs, with or without NBCCS, was lower than in those with single KCOTs - a result similar to those reported previously (6).

The mandible is involved more frequently than the maxilla: the percentage of KCOTs occurring in the mandible ranges from 65% to 83% (6). In our series the mandible was affected in 70.5% of tumors, and the most common site for both the parakeratinized and mixed types was the mandibular molar area. The posterior regions of the mandible and maxilla were the most commonly affected parts of these respective bones, the findings being in close agreement with those of other reports (7-11,14).

NBCCS was established as an entity by Gorlin and Goltz in 1960, and has a low incidence (around 1 per 56,000 people) (15). Recent genetic studies relate this syndrome to a gene-level disturbance of chromosome 9 (9q22.3-q31) (6,15). Multiple KCOTs occur in a high proportion of patients with NBCCS and are the most consistent and common manifestation of the syndrome, occurring in 65% to 100% of NBCCS patients (16), many of them young females (9). A diagnosis of NBCCS was associated with 6.0% of all tumors, a percentage similar to those in other reports, which range between 1.4% and 8.2% (4, 7-9).

Valid comparison between studies in the available literature is difficult: some studies were conducted before the 1992 WHO classification of odontogenic tumors, and

Table 4 Distribution of tumor location associated with the presence of an impacted tooth

Location	Total	(%)
Mandibular incisor	1	(2.5)
Mandibular molar	18	(45.0)
Mandibular molar to ramus	3	(7.5)
Mandibular extent location	2	(5.0)
Maxillary incisor	1	(2.5)
Maxillary molar	3	(7.5)
Maxillary extent location	3	(7.5)
Multiple location*	9	(22.5)
Total	40	(100)

*: 3 tumors were confirmed to be associated with NBCCS.

Table 5 Distribution of age and gender of the patients with recurrent tumors

Age	Male			Female			Total	(%)
	Sporadical KCOT	NBCCS	Total	Sporadical KCOT	NBCCS	Total		
0- 9	0	1	1	0	1	1	2	(8.4)
10-19	3	0	3	4	2	6	9	(37.6)
20-29	2	1	3	3	1	4	7	(29.1)
30-39	1	0	1	3	0	3	4	(16.7)
40-49	0	0	0	0	0	0	0	(0.0)
50-59	0	0	0	1	0	1	1	(4.1)
60-69	0	0	0	1	0	1	1	(4.1)
70-79	0	0	0	0	0	0	0	(0.0)
Total*	6	2	8	12	4	16	24	(100)

*: The 24 patients with recurrences had a total of 56 recurrent tumors. Mean age: 26.1 years.

only a few studies have been conducted in accordance with the 2005 WHO classification (5,17). Therefore, various criteria have been used to diagnose parakeratinized and mixed-type lesions. Despite this, parakeratinizing lesions have accounted for the majority of KCOTs in series conducted in different countries, such as Singapore (4), Greece (8), the USA (7,18) and Sweden (14). On the other hand, Lam and Chan (8) found a higher proportion of mixed-type tumors (12.3%) in Chinese patients compared to western series (8,7,14,18). In our series, 94.0% of KCOTs were parakeratinized, and 6.0% showed mixed parakeratinization and orthokeratinization.

With the coining of the new term KCOT, the lesion is now a step closer to a differential diagnosis from ameloblastoma. A characteristic regular parakeratinized stratified squamous epithelium and a well-defined basal layer are among the important features distinguishing KCOT from other jaw cysts (6). Nevertheless, the basal layer often shows a palisade pattern; in two of the tumors in our series, the diagnosis of OKC was changed to "ameloblastoma, unicystic type", because they showed characteristics of a stellate reticulum. Pathologists should be aware of such features when making a differential diagnosis. In addition, the presence of mitotic figures in the epithelial layer, as well as epithelial islands, daughter cysts, hyaline bodies, epithelial budding of the basal layer, and dystrophic calcification, has been reported within OKC and KCOT (5,6,8,13,22). We were able to identify such characteristics in our tumors from patients with sporadic KCOT and with NBCCS-associated KCOT.

In addition, we found that 17.1% of tumors showed koilocytosis. Since koilocytosis is a feature generally associated with infection with human papillomavirus (HPV) (19,20), a papillomavirus etiology for KCOT can be considered. However, to our knowledge, there has been only one report of HPV associated with OKC (21). Ahlfors et al. mentioned that the above features simply reflect the wide morphologic variations that can be expressed by the epithelium (13). Woolgar et al. have suggested that there is an increased proliferative capacity of the odontogenic epithelium in NBCCS patients (22).

Some KCOT linings may have the characteristics of epithelial dysplasia (6). Tumors with such characteristics could possess the potential to evolve into ameloblastoma or squamous cell carcinoma, and although rare, this has been reported (6,18). Moreover, the term "primary intraosseous squamous cell carcinoma derived from keratocystic odontogenic tumor" is now included in the 2005 WHO classification (6). Similarly to other series, in our study none of the 183 tumors showed evidence of malignancy (7,9,14).

Perhaps of importance in the management of KCOT is its tendency to recur, rather than showing a risk of malignant transformation (9). Different histological features of KCOT are reportedly related to recurrence rate, and although only daughter cyst formation has been significantly associated with high recurrence rates, this association has not been unanimously accepted (23). Ahlfors et al., in their series, stated that none of the histological features of the lesions could be used to predict recurrence (13).

The incidence of daughter cysts is reported to range between 7% (24) and 30.1% (23). Here, the incidence of daughter cysts was lower than reported previously (6.0% of all tumors). Reports of hyaline bodies and dystrophic calcifications within OKC and KCOT are scarce, the incidence ranging from 7% (9) to 32% (22) and from 10% (9) to 21% (22), respectively. We found a lower incidence than reported previously (9,22).

Recurrence rates have ranged from as low as 0% (24) to as high as 62% (2,4,24). Most reports point out that recurrence will appear within 5 to 7 years (9,13,14,25). In contrast, Crowley et al. found that 25% of their tumors recurred 9 or more years after initial treatment (7). Our 13.1% recurrence rate agrees with previous findings (9,13,14,25), although in one of our patients the tumor recurred 23 years after the first operation. A total of 20.8% of the 24 patients with recurrent KCOT had multiple recurrences. In this series most of the recurrences occurred in females, and although some authors consider that gender could play an important role in the recurrence rate (13,25), others consider gender not to be a significant determinant of recurrence (5,18,23).

In our series, 37.5% of recurrent tumors appeared within the third decade of life, followed by 30.4% in the second decade. This trend was similar to that found by Forssell et al. (26), who reported a higher recurrence rate in young patients, perhaps because younger patients often receive more conservative treatment that older patients (26). According to some researchers, the site of involvement could significantly affect the recurrence rate (24,25); we found that tumors initially arising in the maxillary bone had a higher recurrence rate than those arising in the mandible.

Over time, the OKC parakeratinizing variant has become a recognized cystic neoplasm. It has been difficult to perform comparative analyses in different populations around the world, because there are differences in the criteria used for diagnosis. Pathological examination of KCOT is important in order to separate this lesion from odontogenic cyst. To provide appropriate treatment it is essential to avoid misdiagnosis. The recurrence observed in KCOT may not necessarily be the result of surgical

management; instead, it is probably a reflection of the nature of the lesion itself. Therefore, long follow-up periods are suggested for this tumor.

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