The Management of Aggressive Cysts of the Jaws

Paul J. W. Stoelinga

Published online: 11 March 2012

© Association of Oral and Maxillofacial Surgeons of India 2012

Abstract There are essentially six types of aggressive cysts of the jaws that require special attention, so as to avoid recurrence, or even worse, widespread disease. They include, botryoid cysts, cysts in which carcinoma's arise, glandular odontogenic cysts, calcifying cystic odontogenic tumour, previously called calcifying odontogenic cyst and unicystic ameloblastoma and keratocystic odontogenic tumor, previously called odontogenic keratocysts. The estimated incidence of these cysts, based on some review studies has been discussed. The main issue, however, when treating a cyst of the jaws is; how sure can one be that the lesion is benign or potentially aggressive? In order to answer this question it is important to know how these cysts commonly present. The clinical presentation, frequency of occurrence and suggested modes of treatment has been addressed.

Keywords Aggressive odontogenic cysts · Keratocyst · Glandular odontogenic cyst

Introduction

There are essentially six types of aggressive cysts of the jaws that require special attention, so as to avoid recurrence, or even worse, widespread disease. They include, more or less in the reversed order of the frequency with which they occur; botryoid cysts, cysts in which carcinoma's arise, glandular odontogenic cysts (GOC),

calcifying cystic odontogenic tumour (CCOT), previously called calcifying odontogenic cyst and unicystic ameloblastoma and keratocystic odontogenic tumor (KCOT), previously called odontogenic keratocysts. The estimated incidence of these cysts, based on some review studies, is depicted in Tables 1 and 2. The main issue, however, when treating a cyst of the jaws is; how sure can one be that the lesion is benign or potentially aggressive? In order to answer this question it is important to know how these cysts commonly present. For this reason each of the above mentioned lesions will be addressed.

Botryoid Cyst

This is a relatively new entity in that a proper description was published by Weathers and Waldron [2] but case series appeared only in the 1990's and later. It is an extremely rare condition that may appear at all ages but usually in individuals of over fifty years and it may present as a lateral periodontal cyst but most often in a multilocular fashion. Some authors consider it to be a multicystic variant of the lateral periodontal cyst [3]. It also often appears in the body of the mandible as a multilocular radiolucency (Fig. 1). When growing into considerable size, they may give rise to swelling and other signs and symptoms, such as paraesthesia and pain [4]. These authors presented a review of 60 cases reported until 2005. The differential diagnosis should include ameloblastoma or some other lesions such as, among others, central giant cell granuloma or even myxoma. These cases warrant an incisional biopsy to ascertain a proper diagnosis.

These cysts are prone to recur, particularly the large cysts, when just enucleated (Ramer and Valauri) [4] and, according to Gurol et al. [5], the recurrence rate amounts to approximately 30%.

P. J. W. Stoelinga (✉)
Department of Oral and Maxillofacial Surgery, Radboud
University Nijmegen Medical Center and University
of Maastricht, Nijmegen, The Netherlands
e-mail: p.stoelinga@hetnet.nl

Table 1 Incidence of aggressive cysts

Keratocystic odontogenic tumour between 7 and 10%
Unicystic ameloblastoma approximately 0.7%
Calcifying odontogenic cyst approximately 0.6%
Glandular odontogenic cyst approximately 0.3% [1]
Carcinoma developing in the wall of a cyst approximately 0.2%
Botryoid odontogenic cyst less than 0.1%

Table 2 Incidence of carcinoma in od. cysts

Stoelinga [7]	1–486
Frankl et al. [8]	4–1300
Kreidler [9]	1–758
Stoelinga and Bronkhorst [10]	1–677

Cysts in Which Carcinoma Arises

The incidence of carcinoma developing in the wall of an ordinary odontogenic cyst is extremely low. There are not many series of cysts reported from which an impression can be gained. To the best of my knowledge there are only four studies that provide some information but the numbers of these series are too small to draw firm conclusions. Yet, based on these studies an incidence of about two per thousand could be ascertained. There are, however, plenty of case reports that describe carcinoma's in ordinary cysts and KCOT's and many of them came as a surprise (Fig. 2). In other words there were no signs or symptoms that indicated a malignant transformation. A review of 116 cases reported in the literature up till 2010, is presented by Bodner et al. [6]. There appears to be a predilection for men in the fifth and sixth decade. Pain and swelling were

the main symptoms with which the patients presented. In 60% of cases it concerned radicular or residual cysts, whilst in 40% follicular cysts or KCOT's. From this study it can not be concluded that malignant transformation is more prevalent in KCOT's, since no differentiation was made between follicular cyst and KCOT.

Glandular Odontogenic Cyst (COC)

This rare cyst may also occur at all ages with a slight predilection for males. They present commonly as lateral periodontal cysts both as a multilocular and unilocular lesion, almost evenly divided, according to Kaplan et al. [11], (Fig. 3). They are mostly rather small with a predilection for the anterior site of the mandible. In a review of 111 cases, as reported in the English literature, Kaplan et al. reported a 30% recurrence rate [11]. The particulars of the histological features have been well described by Fowler et al. [12]. Incisional biopsies, however, may be non-specific since the characteristic histology may be focal and thus, missed in the specimen examined.

Calcifying Cystic Odontogenic Tumour (CCOT)

The particulars of this cyst were first described by Gorlin et al. [13], soon followed by several case reports. Praetorius et al. postulated that this lesion actually exists of two separate entities, a cyst and a neoplasma [14]. They do appear, however, as unicystic lesions and therefore, are mentioned in this review. This is also a rare lesion that may present itself at all ages but there seems to be a peak

Fig. 1 Botryoid (multilocular) cyst in the body of the mandible of a 70 year old woman, which grew in less than 5 years, as ascertained by a radiograph taken 5 years previously

Fig. 2 **A** Residual cyst in the left canine area of the maxilla. **B** Cyst wall (HE $\times 25$) and **C** magnification (HE $\times 60$), showing polymorphia, atypia and mitosis throughout the whole wall of the cyst, diagnosed as carcinoma in situ. Basal layer still in tact

incidence for the second decade. Both jaws may be involved without any predilection but in both jaws they occur most often in the anterior region. There are several case reports showing double tumours, i.e., other odontogenic tumours associated with the CCOT [3]. These cysts tend to give rise to swelling which is often the reason why patients seek treatment. The cyst will be easily diagnosed when seeing the radiographs since calcified material is commonly present (Fig. 4). These cysts may recur after enucleation but most often do not.

Unicystic Ameloblastoma

Unicystic ameloblastoma presents as a cystic lesion in both the maxilla and mandible. The mandible, however, is much more often affected than the maxilla. Stoelinga and Bronkhorst [10] found in a series of 677 cysts that almost one percent of all cysts were unicystic ameloblastomas but three percent of all cysts of the mandible. The majority of

these cysts are found in the third molar area or ascending ramus of the mandible. They commonly present in the second and third decade, equally divided between males and females [15]. Unicystic ameloblastoma, as a rule, goes along with buccal and lingual expansion with tooth displacement (Fig. 5).

Unicystic ameloblastomas can be divided in three subgroups according to Ackermann et al. [16]. In type 1, the ameloblastic changes in the cyst are confined to the epithelial layer as described by Vickers and Gorlin [17]. In type 2, the tumor grows into the lumen of the cyst (intraluminal) In type 3, however, the tumor grows in the connective tissue wall and may reach the periphery of wall and, thus, come into contact with the bone. This classification has serious implications for the clinician, since types 1 and 2 can be treated conservatively such as KCOT's (see later). Type 3, however, should be treated like a solid or multicystic ameloblastoma with marginal or segmental resections, if indeed the tumour has come into contact with the bone.

Fig. 3 A, B Glandular odontogenic cyst appearing as a multilocular cyst in a lateral periodontal fashion between canine and lateral incisor. C Epithelial plaque with abundant goblet cells (HE $\times 25$)

Fig. 4 A Calcifying odontogenic cyst causing swelling. B Radio-opaque material represents calcified material in the cyst. C Fragment of cyst wall (He $\times 40$) shows cyst lining with hyperchromatic,

columnar basal cells in a palisading arrangement. Gost cells and eosinophilic masses are also present. From Stoelinga and Bronkhorst [10] with permission

Fig. 5 (A, B, C, D) 18-year-old girl with unicystic ameloblastoma presenting as a swelling in the left angle of the mandible. Note displacement of teeth and of the mandibular canal. Histology (HE $\times 40$) shows typical features of early ameloblastic changes in the epithelial lining, including columnar cells in the basal layer with

nuclei polarized away from the basal membrane and vacuolization in the basal cells. There is an indication of a budding off phenomenon with the typical hyalinization below the basal membrane. Close up from an ameloblastic island with the same features as described surrounded by hyalinized tissue

Keratocystic Odontogenic Tumor (KCOT) or Odontogenic Keratocyst

The odontogenic keratocyst or keratocystic odontogenic tumor, as it is called today [18], is by far the most frequently seen potentially aggressive cystic lesion. Since its original description by Philipsen in 1956 [19], it has received a lot of attention and many case series have been reported, almost all of a retrospective nature. This cyst will also most often appear in the third molar region of the mandible with extension into the ascending ramus, similar to unicystic ameloblastoma. In the maxilla, they also occur most often in the posterior area. The same age predilection is also notable, although KCOT's may present at later ages as well. Some studies show a second peak in the fifth decade. The major difference with unicystic ameloblastoma is the fact that keratocysts will hardly cause expansion of the jaw and seem to hollow out the jaw (Fig. 6). They do tend to cause perforations of mainly the lingual cortical plates and, thus, may come into contact with the lingual soft tissues. Only when they become infected or grow into an extremely big size, do they present with swelling. They do not tend to displace teeth or cause root resorption. Despite the fact that they mostly occur in the mandibular angle area, they are also seen in the dentate areas of the maxilla and mandible alike and may present themselves as unsuspecting looking ordinary odontogenic cysts. This is true for all types of odontogenic cysts but particularly for cysts that are diagnosed as lateral periodontal, because some 20% of those turn out to be KCOT (Fig. 7).

Treatment Strategy

All unilocular cysts in the dentate area, both in the maxilla and mandible, ought to be enucleated and always submitted for histo-pathologic examination in order to rule out any of

the aforementioned lesions. There is no reason to do incisional biopsies for these cysts because the treatment, i.e., careful complete enucleation, will be sufficient for all ordinary odontogenic cysts, apart from those that might show malignant degeneration. There also might be a remote possibility that a solid or multicystic ameloblastoma presents as an unicystic lesion, in which case additional measures are necessary. In case of a GOC, KCOT or unicystic ameloblastoma (Ackerman type 1 and 2) [16] it might also be enough, but long-term and careful follow-up will be necessary because the chances of recurrences are in the order of 30–40%, for all of these lesions. One could also consider to treat these patients with Carnoy's solution, at a second procedure, as an additional measure to reduce the chances of recurrence. This entails some risk since it may cause some damage to the periodontium of neighbouring teeth.

When a multilocular cystic lesion is seen, an incisional biopsy is warranted because other lesions may be encountered, such as ameloblastoma, central giant cell granuloma or myxoma. When, however, one of the above mentioned cystic lesions is involved, treatment with Carnoy's solution may be advisable as an additional measure. In case of a botryoid cyst, a marginal or even segmental resection might be indicated, depending on the age of the patient and other patient related factors.

All cysts in the angle of the mandible with extension into the ascending ramus, or completely located in the ramus, should be treated as potentially aggressive cysts, notably keratocyst or unicystic ameloblastoma. This is true for all unicystic cysts and certainly for cysts with a somewhat scalloped margin. In a retrospective study on 486 cysts of the jaws, Stoelinga [20] did not see any ordinary cyst of the lower third molar area extending into the ascending ramus. The remote possibility exists, however, that a follicular cyst may extend into the ascending ramus. Only when it is multilocular or multilobular, with deep lobes, may an incisional biopsy be considered or

Fig. 6 **A** multilocular KCOT in the left mandible not giving rise to any expansion. **B** Unicystic KCOT in right mandible which caused the lingual plate to be resorbed

Fig. 7 Lateral periodontal cyst which turned out to be a KCOT

when a solid tumor is suspected. When no infection has occurred, an aspiration may be carried out to assess the protein content and/or have a cytological examination done. A protein count of less than 4 gram per 100 ml will be indicative for keratocysts (Toller) [21]. An incisional biopsy tends “to spoil the broth” in that after the incision, infection will most certainly occur. The time span between the biopsy and the definitive surgery will allow for an inflammatory infiltrate to develop throughout the wall of the cyst, which will change the epithelial characteristics of the keratocyst (Fig. 8). That will make the final diagnosis almost impossible. On top of that, the biopsies may not be representative simply because of local inflammatory infiltrates in case of KCOT, or because of the absence of neoplasma in the part of the wall where the biopsy is taken (Fig. 8). Unicystic ameloblastomas often have local areas of tumor and not always throughout the whole wall. The early delineation of histo-pathological features of ameloblastoma in the wall of cysts is well described by Vickers and Gorlin [17]. Such diagnosis, however, requires expertise of an oral pathologist, which is probably not always available.

Fig. 8 Typical features of KCOT on the *right side* that are completely vanished on the *left* by the obvious inflammatory infiltrate. A biopsy taken from the *left site* would have provided the wrong diagnosis

The preferred treatment for both KCOT and unicystic ameloblastoma, Ackerman type 1 and 2 in the mandible, is complete enucleation and treatment of the bony defect with Carnoy's solution. In case of a suspected keratocyst, one should define the area where the cyst is attached to the overlying mucosa. This is always at the anterior site of the ascending ramus and in case of a maxillary cyst at the top of the tuberosity. For this purpose a fine needle may be used to identify the perforation present. This area should be widely circumcised after which the lingual and buccal bony wall should be identified and exposed by stripping the mucoperiosteum (Figs. 9, 10). The opening in the anterior aspect of the ascending ramus should then be enlarged, after which the cyst may be enucleated, preferably in one piece and attached to the overlying mucosa. The whole specimen should consist of the overlying mucosa to which the cyst is still attached. This would enable the histopathologist to cut the specimen tangentially so as to examine the area between the mucosa and the cyst wall for epithelial islands or even microcysts (Fig. 11). The bony wall is subsequently treated with Carnoy's solution, for which a small gauze is soaked in the solution and picked up by a Kocher clamp with which the defect is wiped out [22, 23]. This needs to be done several times so as to assure that the whole bony wall is treated. Areas where the cyst has made contact with the soft tissues, usually on the lingual site in case of KCOT, need special attention. Electro-cauterisation may be used in these areas to eliminate possible remnants of the cyst wall that tends to tear in those areas. Care should be taken not to damage the lingual nerve. When the inferior alveolar nerve is exposed in the bony defect, it may be lifted out its canal before the Carnoy's is applied. The bone will turn blackish after this treatment and should be washed out with saline before a pack is used to fill the defect. This pack should be soaked in Whitehead's varnish or impregnated with iodine-vaseline or any other ointment that can be used for this purpose. This pack

Fig. 9 Schematic design of incisions for a cyst in the mandible extending into the ascending ramus. *Note* the incisions around the area of the mucosa, attached to the cyst. From Stoelinga [22] with permission

Fig. 10 **A** Unicystic KCOT in left third molar area with scalloped margin. **B** Cyst removed with overlying mucosa attached. **C** Note enlarged ventral opening with exposure of buccal rim. No expansion of the mandible. From Stoelinga [22] with permission

can be left in place for a week and then replaced by a new pack. This should be repeated until the defect is completely epithelialised, which commonly takes about 3 weeks, depending on the size of the defect. Alternatively, the defect may be treated using cryotherapy, as recommended by Pogrel [24] and Schmidt and Pogrel [25]. Both treatments do two things. First, it reduces the chances of recurrences caused by remnants of the epithelial lining that may have been left behind. The often very thin membrane of this cyst easily tears which, in turn, frequently results in piecemeal enucleation of the cyst. Second, the resection of the overlying mucosa eliminates newly developing cysts from epithelial islands or microcysts that are found in about 50% of the cases [26–28]. The results of the treatment according to the protocol described were described in a prospective study [27]. Of the 49 KCOT's treated in a 25 year period, in which this protocol was followed, only three recurrences were seen. The recurrences showed again epithelial islands in the attached mucosa overlying the recurrent cysts in two cases. The remaining six recurrences happened in the 33 cases of small cysts in the dentate area where no suspicion had arisen. Comparisons with other studies are notoriously difficult because of their retrospective character and the variable follow-up periods. In general, however, the results reported stand out when reading these studies. The additional value of Carnoy's solution was confirmed by a study of Gosau et al. [28] and the systematic review of Blanas et al. [29], although they did not take into account the role of the excised attached mucosa. In this context, it is noteworthy to mention the results of a Cochrane study [30]. "In two large reviews comparing enucleation alone versus enucleation and adjunctive treatment with Carnoy's solution an overall benefit of the use of Carnoy became apparent, although not all the reviewed studies were consistent in this respect".

These authors, unfortunately, did also not take into account the excision of the overlying mucosa.

As mentioned before this treatment may also be applied to the unicystic ameloblastoma and will probably be just as effective for the Ackerman 1&2 type but less so for the type 3, when the tumour has reached the periphery of the connective tissue wall. Lau and Samman [31], however, in a systemic review, reported that this regime produced better results when compared with enucleation alone, whilst it was less damaging for the patient when compared to resections of the jaw bones. They did not differentiate between the three Ackermann types.

As mentioned before the remote possibility exists that an ordinary follicular cyst extends into the ascending ramus. The described treatment could then be considered overkill, but no damage will have been done, whereas the reversed would be worse. A KCOT or unicystic ameloblastoma, that is just enucleated, would require a second intervention for reasons mentioned.

Discussion

An algorithm on the surgical management of cystic lesions of the jaws is presented elsewhere [32]. It visualizes the strategy as outlined above. These decision trees are based on the clinical presentation of the cyst, i.e., unilocular, multilobular or multilocular, possible buccal and/or lingual expansion and location. They are meant to assist in the planning of treatment. One has to keep in mind, however, that much depends on proper diagnosis and not all will have the benefit of expertise of pathologists with a special interest in oral pathology. When the clinical picture gives rise to suspicion, one may consider a second opinion when the diagnosis does not fit the clinical diagnosis.

Fig. 11 **A** Original KCOT in left mandibular ascending ramus with small recurrence after 5 years, growing into considerable size 1 year later. **B** Recurrent cyst removed with attached mucosa. **C** Mucosa

with cyst attached; cyst in right lower corner. **D** higher magnification showing numerous epithelial islands in the mucosa attached to the cyst

The data on recurrences of the less frequently encountered aggressive cysts i.e., CCOT, GOC and botryoid cyst need to be viewed with some reservation since they are based on small series of various authors. A multicentre study with a strict protocol would be the only means to arrive at reliable results, provided the study is carried over a long period of time. This country, with its vast population, might be ideal to do just that.

Cysts in which carcinoma's arise are usually accidental findings. These lesions need to be treated as primary carcinoma's, including resection of the diseased bone. If necessary including dissection of the neck lymph nodes of the affected side.

The described protocol for unicystic ameloblastoma and KCOT, occurring in the mandible, provides acceptable results, although recurrences might still occur. This is particularly true

for the small keratocysts in the dentate areas that were only enucleated [27]. Carnoy's solution for cysts in the maxilla should be used very selectively, since the delicate bony walls around the sinus may become necrotic. Application in the alveolar process, however, does not give rise to problems.

This review would not be complete without mentioning some alternative methods as described in the recent literature. The suggested liquid nitrogen cryotherapy as described by Pogrel [24], Schmidt and Pogrel [25] certainly will take care of possible remnants of the cyst lining left behind in the bony defect. The main disadvantage is, however, that it weakens the bone with resulting fractures. Pogrel [33], therefore recommends immediate bone grafting so as to prevent this calamity.

Marsupialisation, so as to let the defect become smaller, because of decompression and allow the defect to be re-

epithelialised by metaplasia, was suggested by Brondum and Jensen [34]. They revealed excellent results without any recurrence, but Mendes et al. [35], in reviewing the pertinent literature, showed variable results ranging from 100 to 0 percent recurrences. This is in line with the results of Pogrel [36] who also initially had no recurrences but later had to correct his results since longer follow-up revealed several recurrent lesions [37]. One has to look upon all outcome studies with a grain of salt because the numbers are rather small and the follow-up period varies considerably.

The same observations have been made on the effect of decompression and secondary enucleation of the cyst [38]. In theory, at first glance, this would seem to be a better approach, provided the attached mucosa had been removed. It appears, however, that the same range of recurrences are noticed and the follow-up is rather short in most of these studies [33]. The seemingly complete metaplasia apparently is not as complete as one would wish and probably has not completely eliminated the very active cells of the original basal layer.

Last but not least; is their room for resections of parts of the jaw that is affected? The answer should be no, unless there is a recurrence in a difficult to reach area. If resections are considered one has to keep in mind also to resect the attached mucosa, since recurrences may arise in the bone grafts, as several case reports show [39]. This proves the fact that recurrences do develop from these epithelial islands left behind. Resection inevitably would, thus, imply an intraoral and extraoral communication, with subsequent risks for immediate reconstructions, if no microsurgical repairs are used.

In conclusion the suggested management strategy will result in acceptable results but is not water tight. Recurrences of unicystic ameloblastomas have not been seen by this author, an observation that was also made by Pogrel [33] when using liquid nitrous cryotherapy. Less than 10% recurrences were seen in case of KCOT using this protocol. A regular follow-up is recommended, at a yearly basis the first 5 years, followed by at least 15 years in which the patient is seen every 2 years. The majority of recurrences are seen the first 5 years, but this author has seen recurrences after 15 years and more. A considerable recurrence tendency was seen after simple enucleation of KCOT in the dentate areas.

References

- Gardner DG, Kessler HP, Morency R, Schaffner DL (1988) The glandular odontogenic cyst: an apparent entity. *J Oral Pathol* 17:359–366
- Weathers DR, Waldron CA (1973) Unusual multilocular cysts of the jaws (botryoid odontogenic cysts). *Oral Surg Oral Med Oral Pathol* 36:235–241
- Shear M, Speight PM (2007) Cysts of the oral and maxillofacial regions. Blackwell, Munksgaard
- Ramer M, Valauri D (2005) Multicystic lateral periodontal cyst and botryoid odontogenic cyst. Multifactorial analysis of previously unreported series and review of the literature. *New York State Dent J* 71:47–51
- Gurol M, Burkes EJ, Jacoway J (1995) Botryoid odontogenic cyst: analysis of 33 cases. *J Period* 66:1063–1073
- Bodner L, Manor E, Shear M, van der Waal I (2011) Primary intraosseous squamous cell carcinoma arising in an odontogenic cyst: a clinicopathologic analysis of 116 reported cases. *J Pathol Med* 10:733–738
- Stoelinga PJW (1971) Over kaakkysten. University of Nijmegen, Nijmegen-Midden
- Frankl Z, Bouyssou M (1976) Präcanzerose und maligne Veränderungen in der Auskleidung odontogener Zysten und ihre therapeutischen Konsequenzen. *Quintessenz* 7:93–97
- Kreidler J, Haare S, Kamp W (1985) Karzinomagenese in kieferzysten. *Dtsch Zahnärztl Z* 40:548–550
- Stoelinga PJW, Bronkhorst FB (1988) The incidence, multiple presentation and recurrence of aggressive cysts of the jaws. *J Craniomaxillofac Surg* 16:184–195
- Kaplan I, Anavi Y, Hirshberg A (2007) Glandular odontogenic cyst: a challenge in diagnosis and treatment. *Oral Dis* 14:575–581
- Fowler CB, Brannon RB, Kessler HP et al (2011) Glandular odontogenic cyst: analysis of 46 cases with special emphasis on microscopic criteria for diagnosis. *Head Neck Pathol* 5:364–375
- Gorlin RJ, Pindborg JJ, Redman RS et al (1964) The calcifying odontogenic cyst. A new entity and possible analogue of the cutaneous epithelioma of Malherbe. *Cancer* 17:723–729
- Praetorius F, Hjorting-Hansen E, Gorlin RJ, Vickers RA (1981) Calcifying odontogenic cyst. Range, variations and neoplastic potential. *Acta Odontol Scand* 39:227–240
- Philipsen HP, Reichart PA (1998) Unicystic ameloblastoma. A review of 193 cases from the literature. *Oral Oncol* 34:317–325
- Ackermann GL, Altini M, Shear M (1988) The unicystic ameloblastoma: a clinicopathological study of 57 cases. *J Oral Pathol* 17:541–546
- Vickers RA, Gorlin RJ (1970) Ameloblastoma: delineation of early histopathologic features of neoplasma. *Cancer* 26:699–710
- Philipsen HP (2005) Keratocystic odontogenic tumor. In: Barnes L, Eveson JW, Reichart P, Sidransky D (eds) *Head and neck tumours, WHO classification of tumours*. IARC Press, Lyon, pp 306–307
- Philipsen HP (1956) Om keratocyster (kolesteatomer) i kaeberne. *Tandlaegebladet* 60:963–80 (*Cancer* 1970 26:699–710)
- Stoelinga PJW (1973) Recurrences and multiplicity of cysts. In: Kay LW (ed) *Transactions 4th ICOS, 1971*. Munksgaard, Copenhagen, pp 77–80
- Toller PA (1970) Protein substances in odontogenic cyst fluids. *Br Dent J* 128:317–322
- Stoelinga PJW (2003) Etiology and pathogenesis of keratocysts. *Oral Maxillofac Surg Clin N Am* 15:317–324
- Stoelinga PJW (2005) The treatment of odontogenic keratocysts by excision of the overlying, attached mucosa, enucleation and treatment of the bony defect with Carnoy solution. *J Oral Maxillofac Surg* 63:1662–1666
- Pogrel MA (1993) The use of liquid nitrogen cryotherapy in the management of locally aggressive bone lesions. *J Oral Maxillofac Surg* 51:283–290
- Schmidt BL, Pogrel MA (2001) The use of enucleation and liquid nitrogen cryotherapy in the management of odontogenic keratocysts. *J Oral Maxillofac Surg* 59:720–725
- Stoelinga PJW, Peters JH (1973) A note on the origin of keratocysts of the jaws. *Int J Oral Surg* 2:37–44

27. Stoelinga PJW (2001) Long-term follow-up on keratocysts treated according to a defined protocol. *Int J Oral Maxillofac Surg* 30:14–20
28. Gosau M, Draener FG, Frerich B et al (2010) Two modifications in the treatment of keratocystic odontogenic tumors and the use of Carnoy's solution—a retrospective study lasting between 2 and 10 years. *Clin Oral Invest* 14:24–34
29. Blanas N, Freund B, Schwartz M, Furst IA (2000) Systematic review of the treatment and prognosis of the odontogenic keratocyst. *Oral Surg* 90:553–558
30. Sharif FNH, Oliver R, Sweet C, Sharif MO (2010) Interventions for the treatment of keratocystic odontogenic tumors. *Cochrane Database Syst Rev* 8:CD008464
31. Lau SL, Samman N (2006) Recurrence related to treatment modalities of unicystic ameloblastoma: a systematic review. *Int J Oral Maxillofac Surg* 35:681–690
32. Chapelle KAOM, Stoelinga PJW, de Wilde PCM et al (2004) Rational approach to diagnosis and treatment of ameloblastomas and odontogenic keratocysts. *Br J Oral Maxillofac Surg* 42: 381–390
33. Pogrel MA (2011) Oral presentation XXth ICOMS, Santiago 2011
34. Brondum N, Jensen VJ (1991) Recurrence of keratocysts and decompression treatment. A long-term follow-up of forty-four cases. *Oral Surg Oral Med Oral Pathol* 72:265–269
35. Mendes RA, Carvalho JC, van der Waal I (2010) Characterisation and management of the KCOT in relation to its histopathological and biological features. *Oral Oncol* 46:219–225
36. Pogrel MA (2003) Decompression and marsupialisation as a treatment for the odontogenic keratocyst. *Oral Maxillofac Surg Clin N Am* 15:415–427
37. Pogrel MA (2010) Personal communication Egyptian Association Meeting, Cairo
38. Marker P, Brondum N, Clausen PP et al (1996) Treatment of large odontogenic keratocyst by decompression and later cystectomy. *Oral Surg* 82:122–131
39. Stoelinga PJW (2003) Excision of the overlying, attached mucosa, in conjunction with enucleation and treatment of the bony defect with carnoy solution. *Oral Maxillofac Surg N Am* 15:407–414