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## RESEARCH ARTICLE

# ROLE OF CBCT IN HALLER CELLS IDENTIFICATION AND ITS CLINICAL SIGNIFICANCE

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**ABSTRACT**

**Introduction:** Haller cells are also known as infraorbital ethmoidal cells. These are the anterior extentions of ethmoid sinuses, located in median orbital floor. Haller cells are implicated as cause of sinusitis symptoms or orofacial pain. They may become infected and can spread infection to the orbit, also can complicate endoscopic sinus surgery. Their identification on conventional radiographic examination is limited, further necessitating need for advanced imaging like CBCT.

**Aims and Objectives:** The purpose of this study was to demonstrate prevalence of Haller cells as visualized in CBCT images and to evaluate correlation between Haller cells with ipsilateral maxillary sinusitis and ipsilateral orbital floor dehiscence.

**Material and Method:** A retrospective study was planned in which 200 CBCT scans were analyzed by two observers independently. Haller cells were identified by using diagnostic criteria used by Mathew *et al* in his study. The data obtained were tabulated and analyzed by using SPSS software.

**Result:** Out of 200 CBCT scans, 99 showed presence of Haller cells. There was statistically significant association between the existence of Haller cells and ipsilateral maxillary sinusitis (20.93%) as well as ipsilateral orbital floor dehiscence (53.48%).

**Conclusion:** CBCT is a fascinating imaging modality that has enhanced the scope of oral and maxillofacial radiologist and the advantage is that diagnosis of pathologies which have Haller cells as implicated etiological role is become easier. Our study has evaluated and established the relationship of existence of Haller cells its size and shape with ipsilateral maxillary sinusitis and orbital floor dehiscence by using advanced imaging technique CBCT.



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## INTRODUCTION

Haller's cells are named after anatomist Albert Von Haller, who in 1765 had first identified this ethmoidal pneumatization of orbital floor (Von Haller, 1803; Ahmed *et al.,* 2006). Haller cells are anatomical variation of paranasal sinuses (Ahmed *et al.,* 2006; Basic *et al.,* 1999). They are located medial to the infra-orbital canal and lateral to the nasolacrimal duct (Fig.1). They are considered as the anterior extentions of ethmoidal sinuses in to the orbital floor or superior aspect of maxillary sinus, therefore also named as orbito-ethmoidal cells or maxillo-ethmoidal cell (Ahmed *et al.,* 2006; Yanagisawa *et al.,* 2001). However, the name infraorbital ethmoidal cell is more recommended as it explains location and origin of structure which gained fame as Haller cells. Haller cells have been implicated in diseases of maxillary sinus, orbital floor dehiscence, orofacial pain and others. Detailed description of these significances and contributing authors are presented here (Table 1).

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Haller cells can be visualized using conventional radiographic techniques like orthopantamogram and specialized techniques which include computed tomography, endoscopy and cone beam computed tomography. Orthopantamogram gives only two dimentional information about Haller cells. Endoscopy alone cannot diagnose Haller's cells because they are present lateral to the uncinate process. There are chances that Haller's cells may be missed on coronal CT, depending on the window settings and/or section thickness used, especially when they are small and thin walled (Bolger *et al.,* 1991). Haller cells can be visualized in CBCT as it provides section as thin as 1.5mm, moreover it also has advantages of low radiation dose, more comfortable to the patient and also cost effective. Since Haller cells have profound clinical significance we studied them on CBCT as they are best visualized on CBCT. To the best of our knowledge, this is the first study that uses CBCT for the evaluation of Haller cells in Indian population. The basic aim of the study was to find out prevalence of Haller cells according to age, sex and gender as visualized on CBCT amongst the study population. Objective of study was to evaluate relationship between,

**Table 1. Description of clinical significances of Haller cells**

| Author/year | Clinical significance of haller cells |
|---|---|
| Bolger at el, 1991 | Considered Haller cells as one of the predisposing factor for orofacial pain and headache. |
| Earwaker at el, 1993 | Haller cells can be a cause of mucocele. |
| Sebrechts et al, 2000 | Haller cells inflammation can be a potential reason of orbital unilateral edema. |
| Dale et al, 2004 | When larger in size Haller cells can cause compression of infundibulum of maxillary sinus which further lead to the blockage of mucociliary flow thereby causing stagnation of fluid ,which provide favorable environment for of bacterial growth which predispose to the maxillary sinusitis (Fig.2). |
| Alkire and Bhattacharyya, 2010 | Evaluated the effects of septum deviation, choncha bullosa and Haller's cells on the occurrence of acute rhinosinusitis, and their results showed that just obstruction caused by Haller's cells can lead to the disease. |
| Shishir Ram Swamy, 2015 | Haller cells restrict accessibility to the maxillary sinus or the anterior ethmoidal cells during the endonasal procedure, and can lead to the intraoperative complications like inadvertent perforations of orbital floor. Therefore, their identification prior to surgery is very important. |
| Dibangshu ghosh, 2015 | Haller cells causes thinning of orbital floor (Fig.2), thus when get infected may lead to further spread of infection to the orbit. |

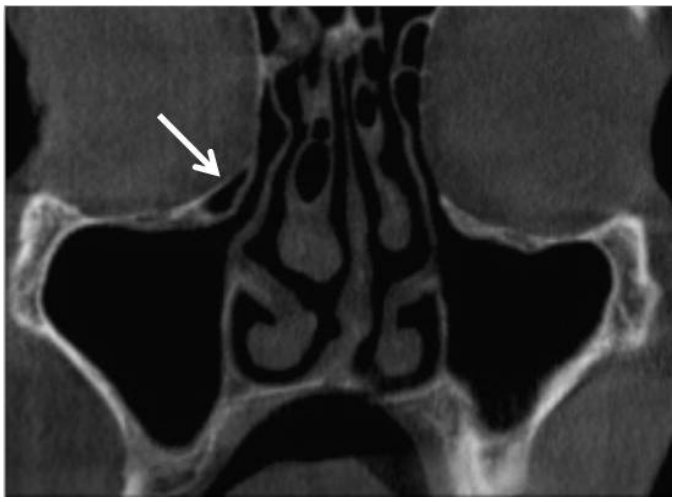

**Fig. 1. Coronal cone beam CT at Paranasal sinus level shows radiolucent, well corticated Haller cell on left side (arrow)**

- Presence of Haller cells with ipsilateral maxillary sinus disease.
- Presence of Haller cells with ipsilateral orbital floor dehiscence amongst study population.

## MATERIALS AND METHODS

This was a retrospective study in which 200 CBCT scans were evaluated. All CBCT scans were acquired with Planmeca promax 3D Mid machine in department of oral medicine and maxillofacial radiology. The evaluation of images were done by using Romexis 3.1 software, in coronal section, keeping Slice thickness of 0.4 mm, by two different observers at time interval of one month. Images requested for various dento-maxillofacial indications, including dental implants, orthodontic and temporomandibular joint evaluation were screened and scans showing complete maxilla extending from maxillary alveolus to the orbit (90mm maxilla and full face scans) were included in the study. Scans showing any intrinsic or extrinsic sinus pathology (tumor, cyst), abnormality due to trauma, scans distorted due to artifact, scans of patients younger than 16yrs of age were excluded, as according to Gray's anatomy, sinonasal cavity does not reach its full development until adolescence (Gray, 1989). The study was approved by the ethical committee of institute. Specially designed proforma with details of age of patient mentioning the Haller cells presence, size, shape and pathologies of maxillary sinus and orbital floor dehiscence recorded independently by two observers.

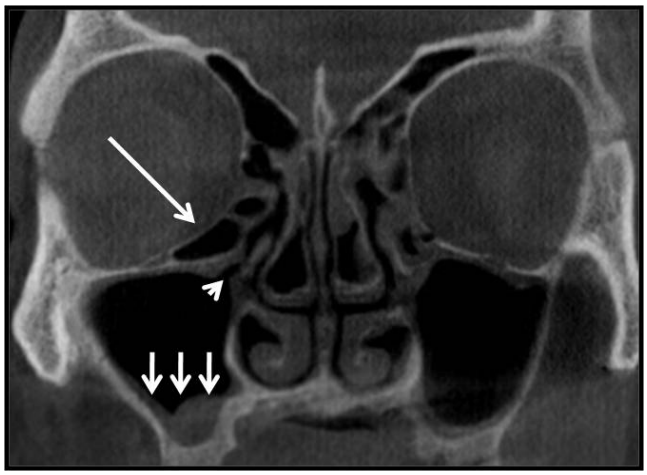

**Fig. 2. Coronal cone beam CT shows, Haller cell causing thinning of bone of orbital floor (long arrow), compression of infundibulum of left maxillary sinus (arrow head), thickened mucosa of left maxillary sinus (short arrow)**

### Criteria of recognition

Haller cells can be recognized by the criteria given by Mathew et al. (2013), as air filled cavities located medially on orbital floor and/or lamina papyracea, inferior to the bulla ethmoidalis (large ethmoidal cell) (Fig.1). Haller cells are surrounded by the ethmoidal capsule which distinguishes them from infraorbital recess of maxillary sinus (Mathew *et al.,* 2013). Haller cells can be of any sizes and shape such as oval, round, triangular, pear or irregular (Fig.3a,b,c). They can be single or multiple in number and can be present unilaterally or bilaterally (Fig.3d). While measuring the size of Haller cells, maximum mediolateral dimension was measured. According to measurement Haller cells were categorized as small size < 2mm, medium size = 2mm-4mm, large size > 4mm (Fig.4). Maxillary sinusitis was recognized as radiographic evidence of thickening of sinus mucosa and/or fluid accumulation at any level (Fig.5). The finding of mucous retention cyst was not considered as a sinus disease. Orbital floor dehiscence is considered as loss of bone density of orbital bone in areas where Haller cell were present (Fig.6). The areas with very thin bony wall were also accepted as a dehiscence (Mathew *et al.,* 2013) (Fig.2). Two observers were recruited for evaluation of the scans independently. Data obtained was subjected to statistical analysis, the $x^2$ test was used to evaluate the association of Haller cells with ipsilateral maxillary sinusitis and ipsilateral orbital floor dehiscence, using SPSS software. Kohen-kappa test was used to calculate inter-obeserver agreement. $P<0.05$ was considered to be statistically significant.

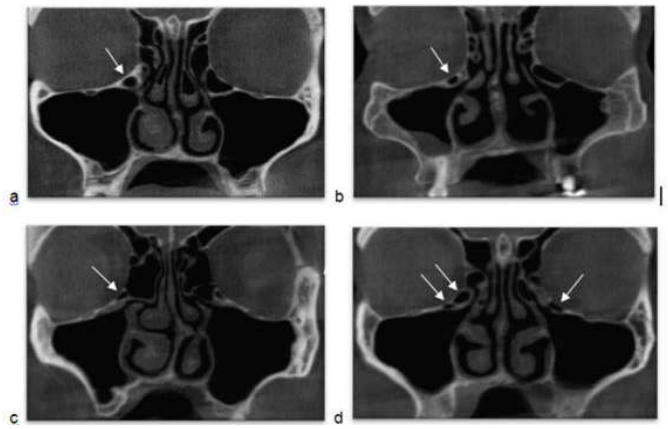


**Fig. 3. Coronal cone beam CT shows different shapes of Haller cells, a. round, b. oval, c. triangular, d. multiple and bilateral Haller cells**

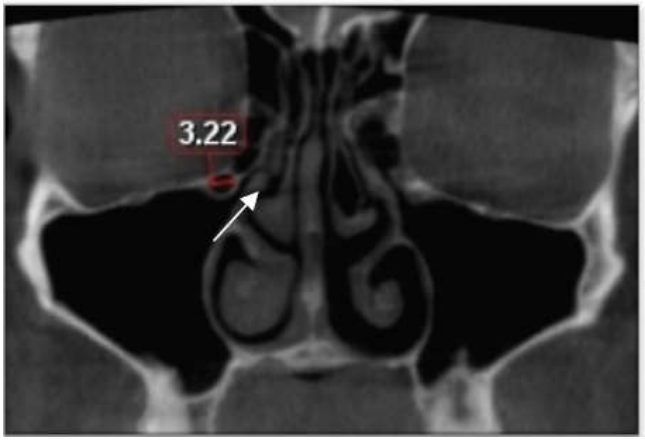


**Fig. 4. Coronal cone beam CT shows, measurement of Haller cells (arrow)**

## RESULTS

In 200 CBCT scans of patients, 138(69%) were male and 62(31%) were female. youngest patient was 16yr and oldest patient was 73yrs old (mean age 32 yrs). Haller cells were recognized in 99 (49.5%) cases, 73(52.89%) in male and 26(49.93%) in female. No significant statistical correlation was observed between occurrence of Haller cells and gender (p-value>0.05). Prevalence of Haller cells was found more in younger patients specifically in age group of 16yr-25yr (Table 2).

**Table 2. Distribution of Haller cells in different age group**

| Age group | Percentage of occurrence |
|---|---|
| 16YRS-25YRS | 39(30.23%) |
| 26YRS-25YRS | 29(22.48%) |
| 36YRS-45YRS | 16(12.40%) |
| 46YRS-55YRS | 4(3.10%) |
| 56YRS-65YRS | 6(4.65%) |
| 66YRS-75YRS | 5(3.87%) |

**Table 3. Distribution of Haller cells according to shape**

| Shape of haller cells | Percentage of occurrence |
|---|---|
| Oval | 70(51.85%) |
| Round | 52(38.51%) |
| Pear | 6(4.44%) |
| Triangular | 5(3.70%) |
| Irregular | 2(1.48%) |

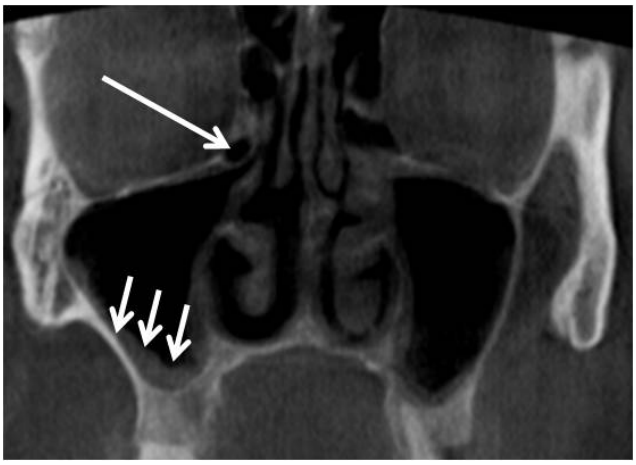

**Fig. 5. Coronal cone beam CT shows, Haller cell (long arrow), mucosal thickening of right maxillary sinus (short arrow).**

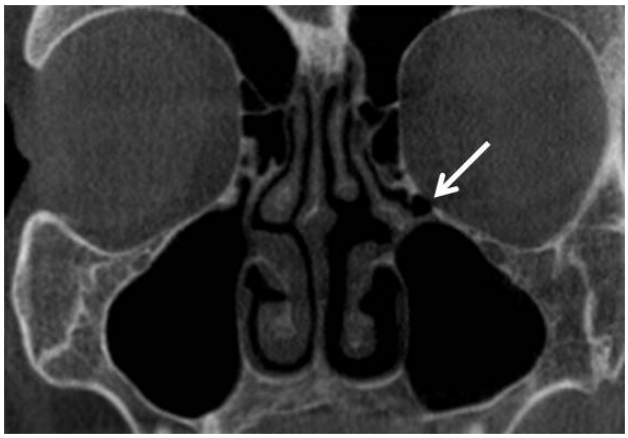

**Fig. 6. Coronal cone beam CT shows, Haller cells causing orbital floor dehiscence (arrow)**

Out of total 400 sites Haller cells were present at 129 sites. Haller cells were found to be unilateral in 69 and bilateral in 30 cases, commonly seen on right side 69(30.23%), left side 60(23.25%). There was no significant statistical association between occurrence of Haller cells and their site of occurrence (p-value>0.05). Haller cells were found in different shapes (Table 3) and sizes (Table 4).

**Table 4. Distribution of Haller cells according to size**

| Size of haller cells | Percentage of occurrence |
|---|---|
| Small (<2mm) | 27(20%) |
| Medium (2mm-4mm) | 86(63.70%) |
| Large (>4mm) | 22(16.29%) |

Oval shaped and medium sized Haller cells were seen more commonly in our study population. Haller cells concurring with ipsilateral maxillary sinusitis were encountered in 27 (20.93%) cases (13 on the right side, 14 on the left side). Maxillary sinusitis was more observed in medium and large size Haller cells. Significant statistical association between presence of Haller cells and ipsillateral maxillary sinusitis observed (p-value<0.05) (Table 5). Concomitant presence of orbital floor dehiscence with Haller cells was encountered in 69 cases (34 on right side and 35 on left side). $x^2$ test showed significant association between presence of Haller cells and ipsilateral orbital floor dehiscence with p-value <0.05 (Table 6). Kohen kappa shows almost perfect agreement between two observers (Table 8).

**Table 5. Association between Haller cells and ipsilateral maxillary sinusitis**

| | Maxillary sinusitis present | Maxillary sinisitis absent | Total sites | $X^2$ statistic | P value | Interpritation |
|---|---|---|---|---|---|---|
| Haller cells present | 27 | 102 | 129 | | | |
| Haller cells absent | 22 | 249 | 271 | | | |
| Total sites | 49 | 351 | 400 | 13.3463 | 0.0002 | Significant |

**Table 6. Association between Haller cells and ipsilateral orbital floor dehiscence**

| | Orbital floor dehiscence present | Orbital floor dehiscence absent | Total sites | $X^2$ statistic | P value | Interpritation |
|---|---|---|---|---|---|---|
| Haller cell present | 69 | 60 | 129 | | | |
| Haller cell absent | 00 | 271 | 271 | | | |
| Total sites | 69 | 331 | 400 | 131.146 | <0.0001 | Significant |

**Table 7. Incidental findings associated with Haller cells observed during analysis of CBCT scans of patients.**

| Incidental findings | Right | Left | Both | Total (out of 200) | In concurrence with haller cells (out of 129) |
|---|---|---|---|---|---|
| Concha bullosa | 17 | 22 | 27 | 66(33%) | 34 (26.3%) |
| Deviated nasal septum | 12 | 21 | - | 33(16.5%) | 11 (8.5%) |
| Hyperplasia of inferior terbinate | 10 | 14 | 1 | 25(12.5%) | 11 (8.5%) |
| Maxillary sinus septa | 8 | 5 | 9 | 22(11%) | 7 (5.4%) |

**Table 8. Value of kappa and inter-observer variability**

| | Value of k | Interpretation |
|---|---|---|
| Presence of haller cells | 0.84 | Almost perfect agreement |
| Presence of maxillary sinusitis | 0.91 | Almost perfect agreement |
| Presence of orbital floor dehiscence | 0.80 | Almost perfect agreement |

**Table 9. Previous researches on prevalence of Haller cell using different imaging modalities and variable sample size**

| Research | Year | Imaging modality | Sample size | Prevalence(%) |
|---|---|---|---|---|
| Valizadeh *et al* | 2010 | Opg | 310 | 37 |
| Azila a *et al* | 2011 | Hrct | 120 | 62 |
| Raina *et al* | 2012 | Opg | 96 | 16 |
| R mathewa *et al* | 2013 | Cbct | 50 | 60 |
| Khayam *et al* | 2013 | Opg | 200 | 32.5 |
| Solanki *et al* | 2014 | Opg | 1000 | 19.2 |
| a l – rabri | 2014 | Ct | 435 | 24 |
| Pekinar *et al* | 2014 | Cbct | 150 | 43.3 |
| Khojastepour *et al* | 2014 | Cbct | 281 | 68 |
| Ramaswamy *et al* | 2015 | Digital opg | 400 | 20.75 |

## DISCUSSION

Previous literature showed a wide range of variability in the prevalence of Haller cells, ranging from 2.7% to 45.1% (Mathew *et al*., 2013). Variability in prevalence may be due to 1) use of different imaging modality, sample size, patient age group and race, subjective judgment regarding the presence and absence of Haller cells. 2) Changeability in definition of Haller cells. Kenned and Zinreich (Kennedy and Zinreich, 1988) recognized Haller cells as ethmoid cells projecting below the ethmoid bulla within the orbital floor in region of opening of the maxillary sinus. Kainz *et al.,* 1993 defined Haller cells as cells within orbital floor. Bolger *et al.,* 1991 considered Haller cells as any cell located between the ethmoid bulla, the orbital lamina of the ethmoid bone and the orbital bone and the orbital floor. Methew *et al.,* 1988 recognized Haller cells as air cells, of any size, located along the medial portion of the orbital floor and/or the lamina papyracea inferior to the bulla ethmoidalis, and continuity with the ethmoid capsule. We used this criteria for idenifiction of Haller cells as it is the most recent research finding. Prevalence of Haller cells in our study was found 49.5% which is relatively high. This could be explained on basis of the imaging modality used in the investigation, CBCT is volumetric imaging technique, so it can capture any Haller cell present, irrespective of their size.

In this study many Haller cells that was identified were less than 1.5mm in size, such small sized Haller cells could easily be missed in interslice intervals in multislice CT scans. This shows sensitivity of CBCT in the detection of small delicate bony structure. We can say that prevalence of Haller cells was more when advanced imaging technology (eg. CBCT) was used (Table 9). In this study we analyzed variation of Haller cells on CBCT with respect to age, gender, site, number, shape and size which were sparsely reported in past. Prevalence of Haller cells amongst younger generation is found more in our study, this finding is consistent with the finding of Raina *et al.,* 2000; Kantarci *et al.,* 2004. This could also be because we had maximum patients in the age group below 25 years and meager numbers of elderly patients for the study. More valid information could be obtained if haller cells studied and compared in different age groups. Significant association noted between prevalence of Haller cells in male and female which is similar with the finding of Raina *et al.,* 2000; Basic *et al.,* 1999. In our study we found Haller cells occurring predominantly unilaterally and on right side, this finding is consistent with finding of Ahemad *et al.,* 2006 and Raina *et al.,* 2012 but Khayam *et al* and Methew *et al.,* 2013 found Haller cells more bilaterally which is contradictory to our finding. Oval and round shaped Haller cells were common in our study, Raina *et al.,* 2012 also showed same result in his study.

Medium sized Haller cells reported maximum during our study, where as Mathew *et al.,* 2013 reported more of large sized Haller cells in his study. It is seen in our study that significant association exists between presence of Haller cells and ipsilateral maxillary sinusitis, which is contradictory with results of Mathew *et al.,* 2013. However, there are other authors who found Haller cells as one of the etiologic factor in maxillary sinusitis certainly when the cells are large enough to cause ample of narrowing of maxillary infundibulum (Sebrechts *et al.,* 2000). This finding supports the theory of obstruction causing maxillary sinusitis. Equal prevalence of Haller's cells in cases with and without Sinus disease was noted in the studies of Bolger *et al.,* 1991 and Earwaker (Earwaker, 1993) and; whereas Milczuk *et al.,* 1993 reported Haller's cells associated with ipsilateral sinus disease in 66.7% of his patients. The limitation of our analysis is that maxillary sinusitis could have been overrated since infectious sinusitis cannot be differentiated radioghraphicaly from allergic sinusitis (Mathew *et al.,* 2013). We found significant association between presence of Haller cells and ipsilateral orbital floor dehiscence. Dehiscent orbital floor could make orbit vulnerable in cases of Haller cell disease and also during surgical instrumentation of ostiomeatal complex. Subrechts *et al.,* 2000 reported three cases of unilateral orbital cellulitis, resulting from isolated inflammation of Haller cells. Management of these cases required endoscopic incision and drainage of infected Haller cells. As there is no lymphatic system in orbit, they therefore assumed that infection is spreading through a dehiscence in orbital floor, lamina papyracea or sutures in the medial orbital floor (Mathew *et al.,* 2013). Thus they considered the pathology of Haller cells as potential cause of unilateral orbital cellulites. In the cases of Haller cell inflammation, due to hypertrophic mucosa it is difficult to recognize existent dehiscence of orbital floor. Hence in cases of inflamed Haller cells orbital floor dehiscence should always be considered unless otherwise proven (Kennedy and Zinreich, 1988). Other observations recorded during examination of scans include concha bullosa, deviated nasal septum, hyperplasia of inferior turbinate, maxillary sinus septa associated with Haller cells (Table 7). These findings are not reported previously and needs further research for establishing the association with Haller cells.

**Conclusion**

Present study showed quite high prevalence of Haller cells and significant association between presence of Haller cells with ipsilateral maxillary sinusitis and ipsilateral orbital floor dehiscence. Haller cells have clinical significant aspects and our study has established this correlation using advance imaging technique CBCT, which play a key role in oral and maxillofacial radiology. CBCT allows more precise evaluation of bony anatomy with other advantages such as low patient radiation dose, low cost and less cumbersome to the patient.

In future CBCT analysis of patients with definite signs and symptoms of maxillary sinusitis may strongly suggested to further investigate the association between size of Haller cells and maxillary or ethmoidal sinusitis. Thus all oral and maxillofacial radiologist should scrutinize the scan more carefully to detect or rule out other coexisting pathology when Haller cells are observed.

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