ORIGINAL RESEARCH

Clinical Significance of Haller Cells: A Cone Beam Computed Tomography Study

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ABSTRACT

Aim: To evaluate the prevalence of Haller cells and the association between their existence and size of these cells with maxillary sinusitis and orbital floor dehiscence on cone beam computed tomography (CBCT) scans.

Materials and methods: This was a retrospective study conducted on 300 CBCT scans with 200 ×170 cm field of view (FOV) taken for various purposes like implants and temporomandibular joint (TMJ) analysis. The CBCT scans and demographic details, such as age and gender of the patients obtained from the institution's Digital Imaging and Communications in Medicine (DICOM) archive folder. The scans were checked for the presence of Haller cells, maxillary sinusitis, and orbital dehiscence. Chi-square test was used to assess the association between Haller cells and maxillary sinusitis and orbital dehiscence and p-values of 0.05 were considered to be statistically significant.

Results: A statistically significant association was noted between the existence of Haller cells and maxillary sinusitis. There was no statistically significant difference in the mean size of the Haller cells between both the groups, although the more number of medium and large size Haller cells are noted in the population with sinusitis. Orbital dehiscence and Haller cells have shown statistically significant association.

Conclusion: The explanation of maxillary sinusitis based on mechanical obstruction is likely. This study provides evidence for the usefulness of CBCT scan in delineation of the sinonasal anatomy.

Clinical significance: The present study also marks the usefulness of CBCT scan in delineating osteomeatal complex at substantially higher precision with lesser radiation and low cost.

Keywords: Cone beam computed tomography, Haller cells, Maxillary sinusitis, Orbital dehiscence, Sinonasal anatomy.

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INTRODUCTION

Maxillary sinus or antrum of Highmore is the largest of all paranasal sinuses. It is located in the maxillary bone and opens in to the middle meatus of nasal cavity, which is comparatively at a higher level than the level of sinus (Fig. 1).[1] In the middle meatus it opens in the lower part of hiatus semilunaris into the narrow ethmoidal infundibulum and then enters into nasal cavity.[2] Because of this anatomical location, the free drainage of the maxillary sinus is hindered as it does not open into the nasal cavity directly.[3] Thus, any divergence in this region is very crucial as it may contribute to the obstruction to the free drainage of this sinus. Many variations in the anatomy of lateral wall of nasal cavity, such as deviated nasal septum (DNS), concha bullosa, paradoxical middle turbinates, Haller cells, and agger nasi cells are described in the literature.[4-6]

Haller cells were discovered by Albrecht von Haller in 1765 and were subsequently named after him.[7] They are also called as infraorbital ethmoid cells (Fig. 2), because of their location on the medial aspect of orbital floor and their origin from anterior ethmoid cells.[8] Their presence on the orbital floor may also cause reduction in the density of the same, i.e., orbital dehiscence (Fig. 2).[9] They are usually seen as incidental findings on regular computed tomography (CT) scans. Their location lateral to the maxillary infundibulum on the medial portion of the orbital floor makes them in a crucial position, which may interfere the normal mucociliary flow as they

Fig. 1: The opening of maxillary sinus into the middle meatus of nasal cavity, which is comparatively at a higher level (blue arrow) and Haller cells obstruction of free mucociliary flow (orange arrow)
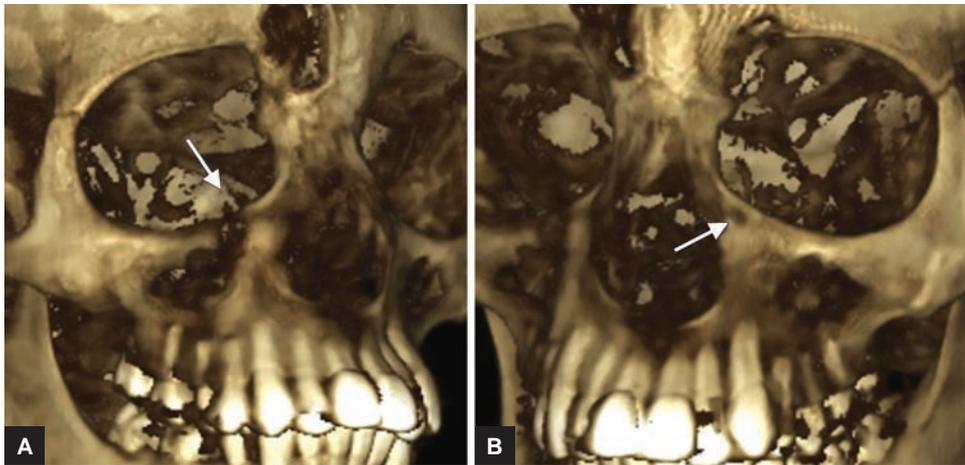
Figs 2A and B: Three-dimensional image showing orbital dehiscence (A) and Haller cell (B)
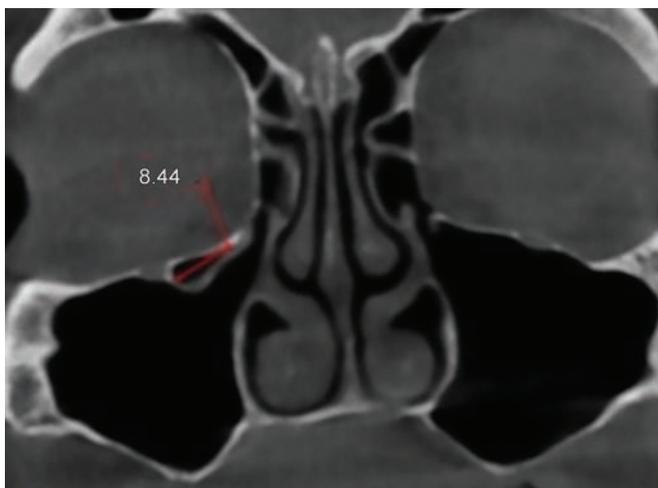

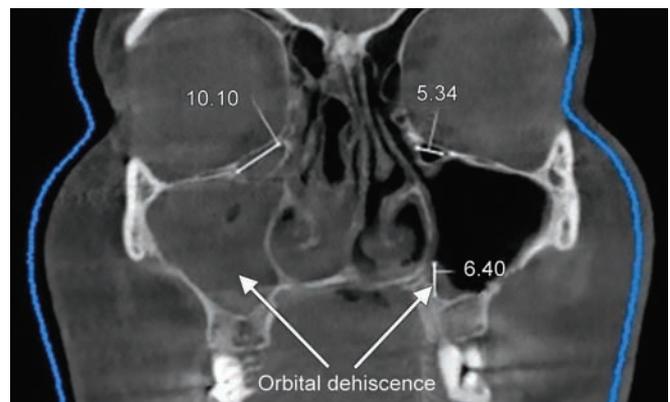**Fig. 3:** Haller cell on the right side measuring 8.44 mm

Fig. 4: Radiological evidence of maxillary sinusitis

cause narrowing the infundibulum and ostium and may predispose to recurrent maxillary sinusitis.[10-12] Apart from these, they are also of crucial concern before and during the surgical procedures.[13-16]

Thus, the present study was undertaken to evaluate the prevalence of Haller cells on the CBCT scans and the correlation between the presence and size of Haller cells with maxillary sinusitis and orbital dehiscence.

MATERIALS AND METHODS

This was a retrospective study conducted after obtaining the approval from Institutional Ethics Committee. The CBCT scan records along with the demographic details, such as age and gender were retrieved from the institution's DICOM archive folder. A total of 300 CBCT scans with full FOV from January 2016 to January 2017, which were taken for various purposes like implant evaluation, assessment of facial asymmetry, and TMJ evaluation covering the region of interest and with adequate resolution, were included in the study. The scans were obtained

using Planmeca ProMax 3D Mid (Planmeca USA, Inc., Roselle, IL) with 200×170 cm FOV with 90 kVp 5.6 Ma and X-ray pulse time of 30 ms. Scans of the patients with the history of trauma or surgery in maxillofacial region or the systemic diseases effecting growth and development of maxillofacial skeleton and the clinical or radiographic evidence of developmental anomalies and pathologies of maxilla facial region were excluded. The scans of the patients who were below 16 years of age were also excluded from the study owing to the fact that the complete development of sinonasal anatomy will be attained only after adolescence.[17] The Haller cells on the CBCT scans were recognized as air cells, which are continuous with the ethmoid capsule located along the infraorbital rim on the medial portion and/or the lamina papyracea inferior to the bulla ethmoidalis (Fig. 3). This continuity with the ethmoid capsule differentiates Haller cells from the infraorbital recess of the maxillary sinus.[18] The radiographic evidence of thickening of sinus mucosa (>2 mm) and/or fluid accumulation at any level in the maxillary sinus was recognized as maxillary sinusitis (Fig. 4),[19,20] and the orbital dehiscence was identified as the reduced
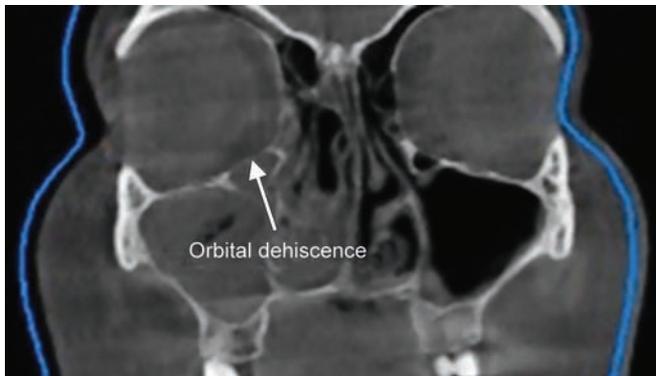
Fig. 5: Reduced density in the orbital floor due to Haller cell suggestive of orbital dehiscence

bone density or only mucoperiosteal layer separating the Haller cells from orbital floor (Fig. 5).[21-23] Cone beam computed tomography scan volumes selected for the study were transferred to another workstation, which has 19-inch HP LE 1911 liquid crystal display computer (Hewlett Packard Company, Palo Alto, California, USA) with a resolution of 1280 ×1024 pixels. The scan volumes were in the DICOM format. The transferred volumes were assessed using Planmeca Romexis software (version 4.1.2 R, Planmeca USA, Inc., Roselle, IL). The scans selected for the study were checked for the presence of Haller cells, maxillary sinusitis, and orbital dehiscence.

Later the presence of Haller cells was correlated with maxillary sinusitis and orbital dehiscence. The largest diameter of the Haller cells was considered as the size of the Haller cells (Fig. 3). Then the Haller cells were categorized into three groups, i.e., small (<2 mm), medium (2–4 mm), and large (>4 mm). All assessed data were transferred to Microsoft Excel spreadsheet (Microsoft Corp., Redmond, Washington, USA), and a descriptive statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 20.0 (SPSS Inc., Chicago, Illinois, USA). The chi-square test was used to compare the associations among Haller cells, maxillary sinusitis, and orbital dehiscence. The size of the Haller cells was also correlated with maxillary sinusitis and orbital dehiscence by dividing the total study sample was categorized into two different groups independently depending on the presence and absence

of maxillary sinusitis and orbital dehiscence, e.g., group I in which there is radiological evidence of sinusitis and group II in which there is no sinusitis. The size difference of the Haller cells between the groups was assessed to find out the association between the size of Haller cells with maxillary sinusitis and orbital dehiscence.

RESULTS

The study population consisted of 300 CBCT scans of which 133 were of females and 167 were of males accounting for 55.35% and 44.14% respectively. The age of the study population ranged from 16 to 44 years and the mean age group was found to be 24.22 years with a standard deviation of 8.942. The prevalence of the Hcells in the study was 48.2% (Table 1). We found that the prevalence of the Haller cells was more in females (56.9%) compared with males (43.1%), although the association was not significant (p > 0.05). Pearson's correlation was used to find correlation between age and the presence of Haller cells and the results showed that there was a negative weak correlation between age and number of Haller cells. The radiological evidence of maxillary sinusitis in the study population was found to be 41%, out of which 21.6% was seen unilaterally and 19.4% bilaterally (Table 1). The prevalence of orbital dehiscence in the study population was 19.3%. The study results showed that the prevalence of Haller cells was 43.8% unilaterally and 4.4% bilaterally (Table 1). The evidence of Haller cells on left side was 22.8% and on right side was 21%. Of all the Haller cells, 40 were small sized (<2 mm), 81 medium sized (2–4 mm), and 24 large sized (>4 mm). The association between Haller cells and sinusitis noted in our study was statistically significant (p < 0.001) (Table 2). Two sample independent t-test was used to compare mean size of Haller cells between the two groups of population, i.e., the group with sinusitis and the other without sinusitis. And the results revealed that the there was no statistically significant difference in the mean size of the Haller cells between both the groups, although the more number of medium and large size Haller cells are noted in the population with sinusitis. The results of our study also showed a statistically significant association between

Table 1: Prevalence of Haller cells, maxillary sinusitis, and orbital dehiscence

| Number of scans | Unilateral | | Bilateral | Total | Absent | Total |
	Right	Left				
Haller cells	63	68	14	145	155	300
	(21%)	(22.8%)	(4.4%)	(48.2%)	(51.8%)	(100%)
Maxillary sinusitis	44	21	59	124	176	300
	(14.7%)	(7%)	(19.4%)	(41%)	(59%)	(100%)
Orbital dehiscence	30	21	7	58	242	300
	(10%)	(7%)	(2.5%)	(19.3%)	(80.7%)	(100%)

Table 2: Association of Haller cells with maxillary sinusitis and orbital dehiscence

Haller cells	Maxillary sinusitis			Orbital dehiscence		
	Absent	*Present*	*Total*	*Absent*	*Present*	*Total*
Absent	104	51	155	153	2	155
	(34.3%)	(17%)	(51.3%)	(51%)	(0.6%)	(51.3%)
Present	72	73	145	89	56	145
	(24.3%)	(24.3)	(48.6%)	(29.6%)	(18.7%)	(48.6%)
Total	176	124	300	242	58	300
	(59%)	(41%)	(100%)	(80.7%)	(19.3%)	(100%)

p-value < 0.01%

Haller cells and orbital dehiscence (p < 0.001) (Table 2). Two sample independent t-test was employed to compare mean size of Haller cells between the two groups, i.e., the group I which showed orbital dehiscence and group II in which orbital dehiscence is absent. The results showed a statistically significant difference (p > 0.05) between the two groups marking the significant role of Haller cells in orbital dehiscence.

DISCUSSION

From the time of its introduction to oral and maxillofacial radiology since 2001, CBCT, which is a three-dimensional imaging modality, has been widely used for planning dental implants.[24,25] As it generates high-resolution images, it has many advantages of assessing the bony aspects of maxillary sinus and complex anatomy of nasal cavity by using a low dose of radiation.[26] There is a remarkable variation in the prevalence of Haller cells in the literature from 1987 to 2016 ranging from 4.7 to 78%.[27] This discrepancy may be because of the different criteria used in defining the Haller cells and also various imaging modalities used. The prevalence of Haller cells in the present study is 48.2%. The various criteria used in different studies in the earlier research include: (1) Ethmoidal air cells protruding on to the orbital floor near the opening of maxillary sinus below the ethmoid bulla by Kennedy and Zinreich;[28] (2) Any cell situated between the orbital lamina of the ethmoid bone, orbital floor, and ethmoid bulla by Bolger et al;[29] (3) Haller cells as the cells situated on the orbital floor by Kainz et al.[30] In the present study, criteria followed by Mathew et al[21] were used. In the past decade, many studies were conducted on Haller cells using orthopantamogram (OPG) and CT.[11] Though CT provides high-contrast images than CBCT, the smaller size Haller cells can be missed between the slices.[26] In OPG, the Haller cells may be underestimated due to the superimposition of various anatomical structures.[31] These problems are minimized with CBCT as there is no superimposition by other anatomical structures and Haller cells of less than 1.5 mm can also be easily visualized in CBCT. The prevalence of Haller cells in the CBCT study conducted by Mathew et al[21] was 60%, Khojastepour et al[32]

was 68%, and Jangam et al[26] was 78%. The prevalence of unilateral Haller cells is more than that of bilateral Haller cells, which is consistent with the studies conducted by Raina et al[33] and Ahmad et al.[31] However, the results were not consistent with the results of other earlier studies.[21] This variation may be due to the over estimation of the unilateral and bilateral occurrence of Haller cells in the present study, i.e., group of unilateral prevalence has excluded the Haller cells that has been counted under the group of bilateral prevalence. Statistically significant association was noted between the prevalence of Haller cells with maxillary sinusitis in our study. These results were in agreement with the results of studies by Kamdi et al[34] and Fadda et al.[35] However, the results of Mathew et al,[21] Khayam et al,[36] Göçmen et al,[37] and Pekiner et al[38] showed that there is no association between Haller cells and maxillary sinusitis and equal prevalence of Haller cells in scans with and without Haller cells was noted in the studies by Bolger et al[29] and Earwaker.[18] There was no statistically appreciable difference in the mean size of the Haller cells noted between the scans with and without Haller cells, although the scans with maxillary sinusitis have shown more number of medium- and large-sized Haller cells than scans with no maxillary sinusitis. This observation was in consistent with the results noted in the study conducted by Mathew et al[21] and not consistent with the results of studies conducted by Khojastepour et al[32] and Jangam et al.[26] Our study also revealed that there was significant association between the presence and size of Haller cells and orbital dehiscence. This finding of our study was also in agreement with the results of Mathew et al[21] and Kamdi et al.[34] Dehiscence of orbital floor makes the floor vulnerable for infection and fracture due to instrumentation during the surgeries involving osteomeatal complex. Three cases of orbital cellulitis originating from the Haller cell inflammation were reported by Sebrechts et al.[34,39] Because of hypertrophy of mucosa due to inflammation in the Haller cells, it may become difficult to recognize existent dehiscence of orbital floor. Therefore, it is advisable to consider orbital floor dehiscence in cases of inflamed Haller cells unless otherwise proven.[40] The enlarged orbital cells can also reach infraorbital nerve and cause hypoesthesia.[41]

LIMITATIONS OF THE STUDY

- In the present study, maxillary sinusitis has been overestimated because infectious sinusitis cannot be distinguished from allergic sinusitis only based on radiographic analysis.
- Various other findings like concha bullosa, DNS, inferior turbinate hypertrophy, and septa of maxillary sinus also need further research for establishing the association with Haller cells.
- Larger sample size along with the clinical correlation should be used to clear the confusion whether the sinusitis is because of mechanical obstruction due to Haller cells or infectious process or due to both.

CONCLUSION

In this retrospective analysis, we have observed that there is no age and gender correlation with Haller cells. The prevalence of Haller cells was remarkably high and also showed a significant association with its presence and size with maxillary sinusitis and orbital dehiscence. This finding could favor the theory of interference of normal mucociliary flow of maxillary sinusitis by Haller cells.

CLINICAL SIGNIFICANCE

The present study also marks the usefulness of CBCT scan in delineating osteomeatal complex at substantially higher precision with lesser radiation and low cost.

ACKNOWLEDGMENTS

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