Ubiquity and attribution of Haller cells – A CBCT study

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SUMMARY

With the increasing popularity of sinus surgeries and the prolific advances in imaging technology, there is a major inclination towards the in-depth study of the anatomy of paranasal sinuses and the osteomeatal complex. Anatomical variations like deviation of nasal septum, paradoxical middle turbinate, double middle turbinate, and concha bullosa are seen in routine clinical examinations, but variations like Haller cells and Onodi cells require explicit radiological support. CBCT has the unique advantage of obtaining isometric images in all three planes with 3-Dimensional viewing and circumvent the obscurity of images due to superimposition. CBCT enables detection of even miniscule Haller cells along with discernment into the disease process and is a crucial preoperative planning tool. There has been a dearth of studies in the literature in this regard, and our study is a promising attempt to elucidate the significance of Haller cells with respect to surgical aspects.

Key words: Haller cells – Cone Beam Computed Tomography (CBCT) – Sinus surgery

INTRODUCTION

Haller cells were first identified by Albrecht von Haller (1708–1777) in 1765 and were subsequently named after him (Proetz et al., 1953). The Haller cells are now named infraorbital ethmoidal cells as they are an extension of the anterior ethmoidal cells and are located in the medial orbital floor, medial to the infraorbital canal and lateral to the naso-lacrimal duct.

With the increasing popularity of sinus surgeries and the recent advances in imaging technology, there is a major proclivity towards the detailed study of the anatomy of paranasal sinuses and the osteomeatal complex. It is well known that minor but significant anatomical variations can lead to sinusitis and cause inadvertent complications during endonasal surgeries. One of the notable variations is Haller cells. These Haller cells are seen as incidental findings in a computerized tomography examination of the paranasal sinuses.

The position of Haller cells in the medial portion of the orbital floor, lateral to the maxillary infundibulum below the level of the ethmoidal bulla, places them in a key position to disturb the normal pattern of mucociliary flow and predispose to recurrent maxillary sinusitis (Stammberger et

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al., 1988; Bolger et al., 1991). Haller cells, though often an incidental finding may trigger different actions, are pathologically important due to the obstruction of the mucociliary drainage from the maxillary sinuses leading to sinusitis. Larger cells can also lead to significant orofacial pain. Several radiographic studies have shown a significant relationship between Haller cells' size (greater than 3 mm) and the incidence of maxillary sinusitis (Kantarci et al., 2004). Extensive knowledge guides the endoscopic surgeon in preventing the grave complication of orbital injury. The strategic location of Haller cells in the infraorbital region can lead to damage to the lamina papyrecae if sufficient caution is not taken. Anatomical variations like deviation of nasal septum, paradoxical middle turbinate, double middle turbinate, and concha bullosa are seen in routine clinical examinations, but variations like Haller cells and Onodi cells require explicit radiological support.

To date, there have been only a few studies recognizing and comparing image quality in Cone Beam Computed Tomography (CBCT) scans with that on Multi slice Computed Tomography (Miracle et al., 2009).

Cadaver and clinical studies have provided the principal evidence for the application of CBCT imaging to endoscopic sinus surgery, concluding that both spatial and soft-tissue contrast were sufficient to aid surgical navigation in the Sino nasal cavity (Rafferty et al., 2005). CBCT has the unique advantage of obtaining isometric images in all three planes with 3-Dimensional viewing and circumvent the obscurity of images due to superimposition.

CBCT enables detection of even miniscule Haller cells along with discernment into the disease process and is a crucial preoperative planning tool. In this regard, there has been a dearth of studies in the past, so our study is an endeavor to elucidate the significance of Haller cells with surgical aspects.

MATERIALS AND METHODS

This is an in-vitro study conducted in the Department of Oral Medicine and Radiology, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru.

Purposive sampling was used to collect the sample, and sample size was calculated using the formula n= (z2) P(1-P)/d2, where n = sample size, z = statistic for level of confidence, P = expected prevalence, and d = allowable error. This formula assumes P and d are decimal values, but it would also be correct if they were percentages, with the exception that the term (1-P) in the numerator would become (100-P).

An ethical clearance to conduct the study was obtained from the IEC of the JSS Academy of Higher Education and Research (IEC No 27/2021 dated 13-12-2021).

The source of data collection was done in two parts: prospective and retrospective. The archaic CBCT images satisfying the eligibility criteria were procured from the Department of Oral Medicine and Radiology for the retrospective part.

Data were collected prospectively following the CBCT (in house PLANMECA PROMAX 3D MID) procedure of patients who met the eligibility criteria for their own dental treatment needs at the Department of Oral Medicine and Radiology.

The analysis of the images was carried out by software ROMEXIS VIEWER. The images viewed had a 75micrometer voxel size for a better resolution.

Inclusion criteria:

- CBCT images show the complete maxilla extending from the alveolar bone to the orbit (full face scan and 90mm maxilla scan) with superior diagnostic quality.
- Images were obtained for orthodontic procedures, dental implants, and other maxillofacial indications without a history of maxillary trauma or obvious anomalies clinically.
- Images procured for orofacial pain suggestive of chronic sinusitis.

Exclusion criteria:

- Subjects and images of subjects younger than 18 years of age are not involved, as the sinuses are not completely developed.

- Subjects with midfacial anomalies, previous trauma, and surgeries of the midface
- Images which are not of optimum quality
- Presence of artefacts
- Images which do not show the area of interest clearly

Selected CBCT images were evaluated in coronal and axial views for detecting the Haller cell morphology and in parasagittal views for identifying the type of the cells. The visibility, location, laterality, and type of Haller cell were examined by an expert Oral & Maxillofacial Radiologist twice, and an average of the two was considered to avoid intra-examiner variability.

The types of morphology variation of Haller cell were classified as:

- Small < 2mm
- Medium 2 to 4mm
- Large > 4mm in size

Based on the internal arrangement, they were divided into:

- Unilocular
- Multilocular

A mean and standard deviation were employed for the evaluation of continuous data and a percentage proportion for categorical data. Statistical evaluation was considered by using the Chi-square test for categorical data and the student test for continuous data at a 95% confidence interval. P values of less than 0.05 were considered significant. SPSS version 22 was employed for the computation of data.

CBCT images were then analysed for the presence of Haller cells (infraorbital ethmoid cells).

However, there is as yet no general definition of the so-called Haller cell (Bolger et al., 1991). In our study, we followed the definition of Haller cells specified by Simeunovic (2008): “Ethmoid air cells that advance in the orbital floor or the roof of the maxillary sinus, respectively, as far as the vicinity of the maxillary ostium, which may build the lateral wall of the infundibulum.” We did not include cells located in the infundibulum or formations originating from posterior ethmoid cells, which are categorized as Onodi cells.

The Onodi cell first described by Adolf Onodi in 1904 is a posterior ethmoid cell that lies superior to the sphenoid sinus, and is in close proximity to at least one optic nerve or internal carotid artery (ICA). This close proximity of the Onodi cell and ICA is a risk factor for surgical complications (Yoshida et al., 2005).

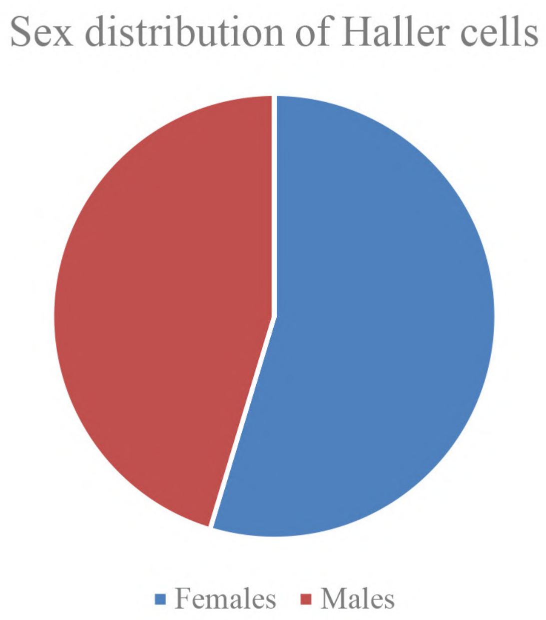

Fig. 1.- Sex distribution of Haller cells.

RESULTS

Out of 139 patients included in our study, 76 (54.6%) were females and 63 (45.4%) were males (Fig. 1), with ages ranging from 20 to 70 years of age with a mean age of 32.3 years.

Haller cells were present in 2 (2.8%) in up to 20yrs of age, 47 (64.5%) in 21-30 years, 6 (8.3%) in 31-40 years, 8 (10.8%) in 41-50, 8 (10.8%) in 51-60 years, 2 (2.8%) in 61-70 years of age group (Table 1, Fig. 2).

Table 1. Age wise distribution of Haller cells.

Years	Males	Females	Total
Up to 20	1	1	2 (2.8%)
21 - 30	21	26	47 (64.5%)
31 - 40	4	2	6 (8.3%)
41 - 50	6	2	8 (10.8%)
51 - 60	2	6	8 (10.8%)
61 - 70	0	2	2 (2.8%)
Total	**34**	**39**	**73**

Haller cells were identified in 73 (52.5%), being unilateral on right side in 24 (17.3%), left side in 25 (17.9%) and bilateral in 24 (17.3%) of the cases (Table 2).

Table 2. Laterality of Haller cells.

Unilateral (Right)	24 (17.3%)
Unilateral (Left)	25 (17.9%)
Bilateral	24 (17.3%)

The pattern of Haller cells was found to be bilateral and unilateral. In certain instances, the locularity varied in the bilateral occurrence of cells which was statistically considered as a separate entity and tabulated.

Unilateral unilocular pattern of Haller cell was more common seen in 22 (22.7%) on right side, 24 (24.8%) on left side, followed by bilateral unilocular in 18 (18.6%) on right side, bilateral unilocular in 17 (17.6%) on left side, bilateral multilocular on right side in 6 (6.2%), bilateral multilocular on left side in 7 (7.2%). The least common type of cells was unilateral multilocular on right side in 2 (2%) and unilateral multilocular on left side in 1 (1%) (Table 3, Fig. 3). The mean diameter of the Haller cells is 4.52+/-2.79 mm.

Table 3. Pattern of Haller cells.

Unilateral Unilocular Right	22 (22.7%)
Unilateral Unilocular Left	24 (24.8%)
Bilateral Unilocular Right	18 (18.6%)
Bilateral Unilocular Left	17 (17.6%)
Bilateral Multilocular Right	6 (6.2%)
Bilateral Multilocular Left	7 (7.2%)
Unilateral Multilocular Right	2 (2%)
Unilateral Multilocular Left	1 (1%)

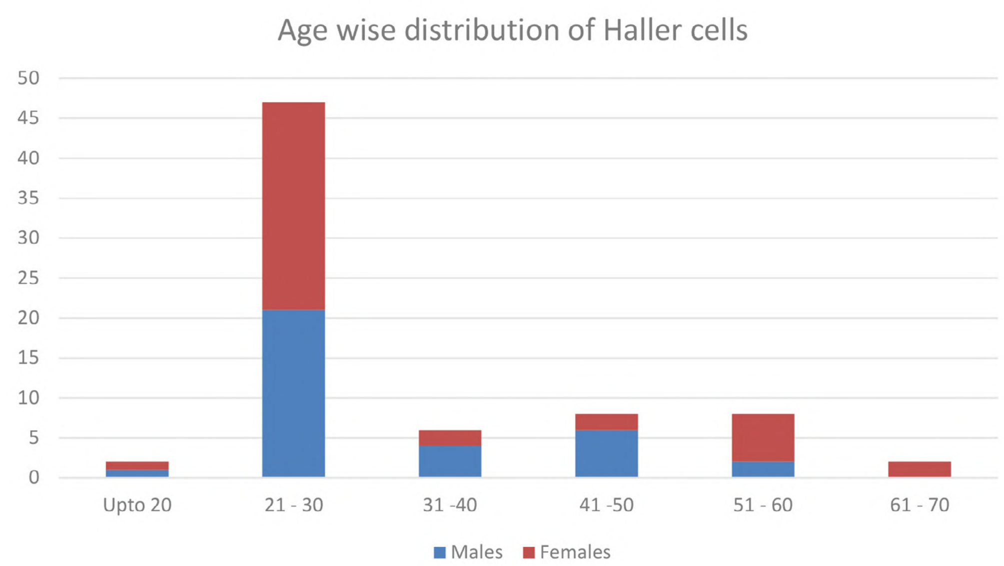

Fig. 2.- Age wise distribution of Haller cells.

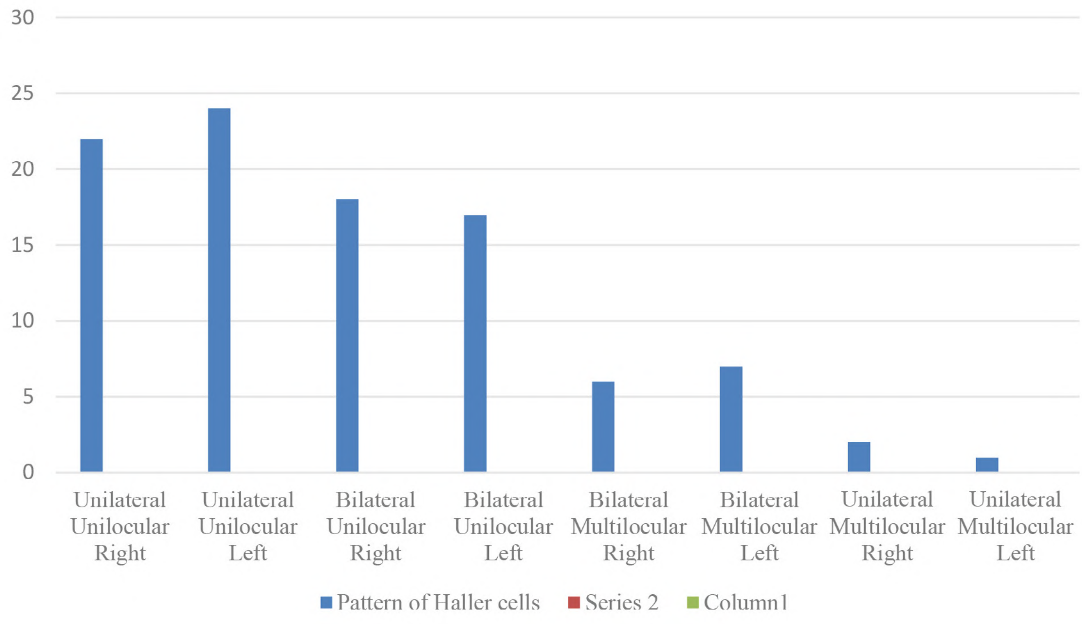

Fig. 3.- Pattern of Haller cells.

DISCUSSION

The ethmoid bone is an intricate bone consisting of a cribriform plate, a median perpendicular ethmoid plate, and two ethmoidal labyrinths. The ethmoidal labyrinths have a varied level of pneumatization, forming the anterior and posterior ethmoidal cells. The variations of ethmoidal cells occur when there is an extension into the surrounding paranasal sinuses. The most important and common variety is the extension into the maxillary sinus, forming the Haller cells.

According to the literature in English, the prevalence of Haller cells is remarkably variable, ranging from 2.7% to 45.1% (Bolger et al., 1991; Perez-Pinas, 2000). This enormous variability in the frequency of Haller cells is probably owing to the inconsistency in the definition of Haller cells. Kennedy and Zinreich (1988) considered Haller cells as ethmoid cells projecting below the ethmoid bulla within the orbital floor in the region of the opening of the maxillary sinus. Bolger et al. (1991) defined Haller cells as any cell located between the ethmoid bulla, the orbital lamina of the ethmoid bone, and the orbital floor. Kainz et al. (1993) recognized Haller cells as cells within the orbital floor.

The variability in the prevalence of Haller cells could also be explained on the basis of the patients' age group and race, and on the imaging techniques used (Rysz et al., 1993).

In our study, we have included the criteria by Mathew et al. (2013), who considered the distinction between the Haller cells and the infraorbital recess of the maxillary sinus (Fig. 4). The prevalence of Haller cells was high in our study population (52.52%). It is comparable to the studies of Mathew et al. (2013). A retrospective study done by Kamdi et al. (2018) revealed a prevalence of 49.5%. The higher incidence of Haller cells in our study is probably due to the advanced technique and interpretation of CBCT.

The CBCT facilitates identification of Haller cells as minute as 1mm, as the slice thickness of the scan is around 0.4 to 0.66 mm. The volumetric analysis of CBCT enables the identification of Haller cells of any size. In contrast, it is not feasible in other radiographs or with multi-slice computed tomography. In our study, we are emphasizing the usefulness of CBCT in the detection and analysis of Haller cells. The higher number of females included in the study could be attributed to a larger proportion of females visiting the department due to increased awareness about dental hygiene and aesthetic purposes. It can also be attributed to willingness for extensive evaluation and treatment.

In our study, the male to female prevalence ratio was 1:1.20. There was no statistical significance between the prevalence of Haller cells in both groups. This was consistent with the results obtained by Kamdi et al. (2018). A study done by Raina et al. (2012) indicated a male-to-female ratio of 1.46:1 for the presence of Haller cells.

The distribution of Haller cells with respect to gender was not statistically significant (Raina et al., 2012). We also noticed a female preponderance in our study, but the ratio was not statistically significant.

The prevalence of Haller cells was the highest (53.25%) in 82 patients in the 21-30 age group, followed by 31 (20.13%) in the 31-40 age group. It is similar to the study done by Kamdi et al. (2018) on 16-25 years of age. The similarities and differences in the occurrence of Haller cells in this age group can be attributed in the maximum number of subjects included in the study.

Our study concluded that the unilateral occurrence of Haller cells was appreciated in 24 on Right side and 25 on Left side, summing up to 49 (35.2%) than in 24 (17.3%) bilateral occurrences. Haller cells were more frequently detected on the left than the right (statistically no significance noted).

Study by Kamdi et al. (2018) showed a preponderance of cells on the right side. The same result was noted by Ahmed et al. (2006) on panoramic radiographs. There is no clinical significance to the locularity of the Haller cells, though we recommend detailed investigation into this aspect.

In the study performed by Alkire et al. (2010), the authors compared the impact of septal deviation, concha bullosa, and Haller cells on the occurrence of rhinosinusitis. They concluded that only the obstruction caused by Haller cells was statistically relevant to the development of this pathologic condition. Septal deviation and concha bullosa are easily detected during routine clinical examinations or diagnostic nasal endoscopies.

The most important presence of Haller cells cannot be detected by any other method except radiologically. Therefore, a study on this aspect is emphasized.

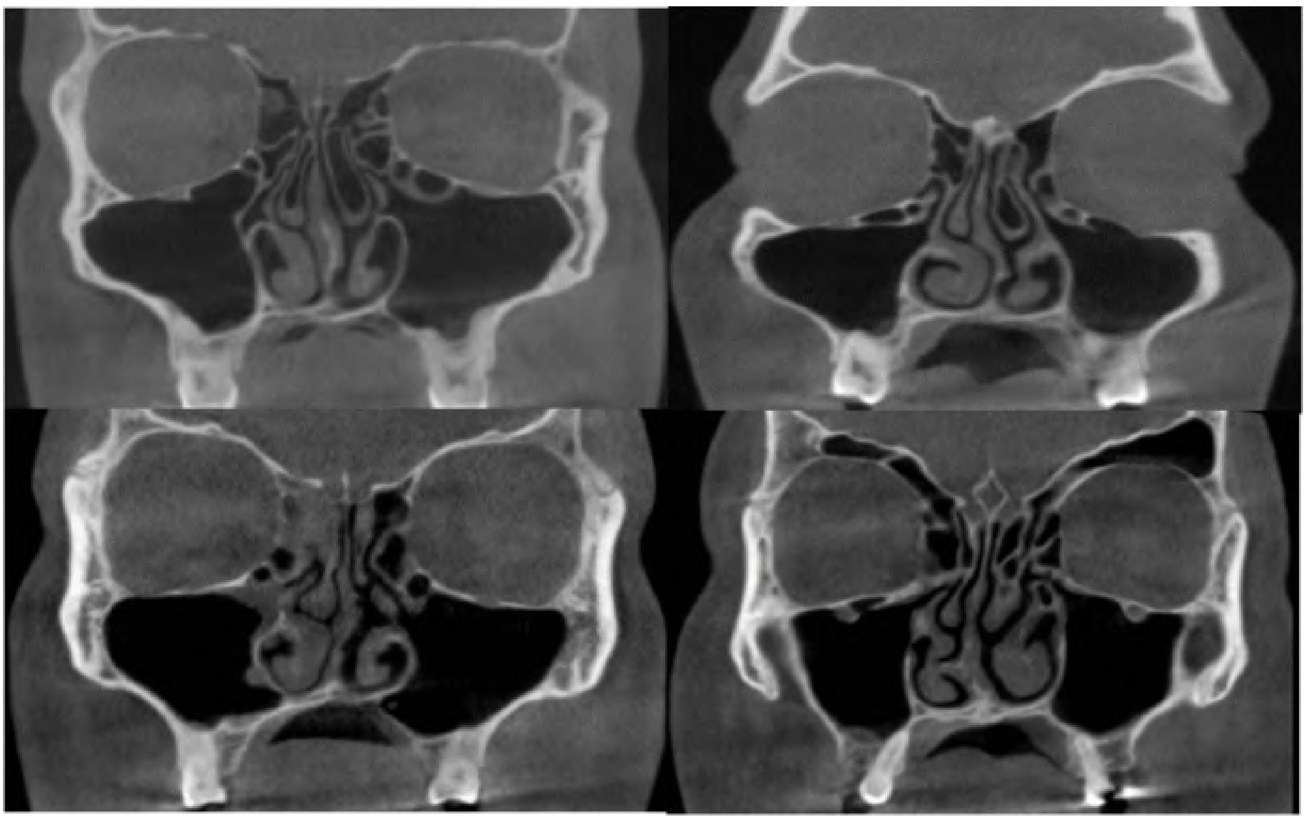

Fig. 4.- Variable presentation of Haller cells in our study on CBCT.

The presence of infraorbital ethmoidal (Haller) cells can increase the risk of orbital injury during ethmoidectomy (Nouraei et al., 2009). Functional Endoscopic Sinus Surgery (FESS) is the primary approach used today for the surgical treatment of chronic sinusitis. Diagnosis of Haller cells, however, is difficult in endoscopy due to their lateral location (Choi, 2020). Failure to recognize the Haller cell also increases the risk of orbital injury during ethmoidectomy (Nouraei et al., 2009). Orbital injury is one of the most dreaded complications of FESS. Lamina papyracea, being a paper-thin bone, is more prone to injury. The close proximity of Haller cells makes adequate knowledge important in such situations. Orbital injury can range from post-operative periorbital oedema, which can be treated conservatively, to injury to the Lateral Rectus muscle causing gaze palsy, which has a grim prognosis.

Hammad and Gomaa (2012) evaluated the role of some anatomical nasal abnormalities (deviated nasal septum, concha bullosa, and Haller cell) in rhinogenic headache, vacuum headache, and pressure headache. They proposed that, as a main cause of referred headache, Haller cells can occupy the infundibulum or be associated with another anatomical variation, such as concha bullosa, and can predispose to sinusitis. In the absence of sinusitis, it might block the sinus drainage pathway, resulting in sinus Mal ventilation, Vacuum headache, and Pressure headache.

CONCLUSION

Haller cells are a clinical entity which, in spite of being a common occurrence, has not been extensively considered. In view of its significant association with the cause of orofacial pain, maxillary sinusitis, a detailed study is a pressing priority. With the advanced techniques of CBCT it is plausible to have a detailed study of Haller cells. Our study is a forthright attempt to illuminate the detailed prevalence of the cells, their laterality, and their association with sinusitis. The study aims at forewarning the surgical personnel to plan intervention and foresee untoward complications.

Notes:

Ethical approval for the procedures performed in studies involving human participants were in conformity with the ethical standards of the institutional and /or national research ethical committee. The study strictly adhered to the 1964 Declaration of Helsinki and later amendments. Informed consent was taken from all individual participants who were included in the study voluntarily.

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