ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.5336/dentalsci.2024-102311

# Evaluation of the Relationship Between Haller Cell and Concha Bullosa with Cone Beam Computed Tomography: Cross-Sectional Study

## Haller Hücresi ve Konka Bülloza Arasındaki İlişkinin Konik Işınlı Bilgisayarlı Tomografisi ile Değerlendirilmesi: Kesitsel Araştırma

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**ABSTRACT Objective:** The objective of this study is to determine the prevalence of concha bullosa and Haller cells in a subpopulation from the Eastern Anatolia Region. Also to find out whether there is a correlation between the presence of concha bullosa and the presence of Haller cells. **Material and Methods:** 507 (290 females, 217 males) cone beam computed tomography images were retrospectively evaluated. The presence of Haller cells and concha bullosa were evaluated separately for the right and left sides in frontal section images. Chi-square and Spearman correlation tests were used for the statistical analysis of the data. A significance level of $p<0.05$ was considered. **Results:** The mean age of the participants was calculated as 34.16±12.76 years. 57.2% (n=290) of the participants were female and 42.8% (n=217) were male. Concha bullosa was detected in 74.1% (n=215) and Haller cell in 37.2% (n=108) of the female; concha bullosa was detected in 71.4% (n=155) and Haller cell in 38.2% (n=83) of the male. Haller cell was detected in 37% (n=191), concha bullosa in 73% (n=370) and both Haller and concha bullosa in 29.2% (n=148) of the participants. A high positive correlation was observed between right concha bullosa and a moderate positive correlation was observed between left concha bullosa and right Haller cells and left Haller cells (r: 0.503, 0.420). **Conclusion:** No statistically significant correlation was found between concha bullosa and Haller cells. However, the presence of concha bullosa and Haller cells on the right or left side increases the likelihood of these formations on the opposite side. Therefore, this should be taken into consideration in surgical procedures and before diagnosis. Cone beam computed tomography can be used as a very suitable method due to its low radiation and cost.

**Keywords:** Concha bullosa; cone beam computed tomography; Haller cells; turbinate

**ÖZET Amaç:** Bu çalışmanın amacı, Doğu Anadolu Bölgesi'nin bir alt popülasyonunda konka bülloza ve Haller hücrelerinin prevalansını değerlendirmektir. Ayrıca konka bülloza varlığı ile Haller hücrelerinin varlığı arasında bir korelasyon olup olmadığını bulmaktır. **Gereç ve Yöntemler:** 507 (290 kadın, 217 erkek) konik ışınlı bilgisayarlı tomografi görüntüsü retrospektif olarak değerlendirildi. Haller hücrelerinin varlığı ve konka bülloza ayrı ayrı sağ ve sol taraflar için frontal kesit görüntülerinde değerlendirildi. Verilerin istatistiksel analizi için ki-kare ve Spearman korelasyon testleri kullanıldı. **Bulgular:** Katılımcıların yaş ortalaması 34,16±12,76 yıl olarak hesaplandı. Katılımcıların %57,2'si (n=290) kadın, %42,8'i (n=217) erkekti. Kadınların %74,1'inde (n=215) konka bülloza, %37,2'sinde (n=108) Haller hücresi; erkeklerin %71,4'ünde (n=155) konka bülloza, %38,2'sinde (n=83) Haller hücresi saptandı. Haller hücresi katılımcıların %37'sinde (n=191), konka bülloza %73'ünde (n=370) ve hem Haller hem de konka bülloza %29,2'sinde (n=148) tespit edilmiştir. Sağ konka bülloza ile sağ Haller hücreleri ve sol Haller hücreleri arasında yüksek pozitif korelasyon ve sol konka bülloza ile sağ Haller hücreleri ve sol Haller hücreleri arasında orta pozitif korelasyon gözlenmiştir (r: 0,503, 0,420). **Sonuç:** Konka bülloza ile Haller hücreleri arasında istatistiksel olarak anlamlı bir korelasyon bulunmamıştır. Ancak, sağ veya sol tarafta konka bülloza ve Haller hücrelerinin varlığı, karşı tarafta da bu oluşumların görülme olasılığını artırmaktadır. Bu nedenle cerrahi işlemlerde ve tanı öncesinde bu durum göz önünde bulundurulmalıdır. Konik ışınlı bilgisayarlı tomografi düşük radyasyon ve maliyeti nedeniyle çok uygun bir yöntem olarak kullanılabilir.



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Peer review under responsibility of Turkiye Klinikleri Journal of Dental Sciences.

***Received:*** 20 Feb 2024 ***Received in revised form:*** 24 May 2024 ***Accepted:*** 15 Jun 2024 ***Available online:*** 24 Jun 2024

Haller air cells, first described by Albrecht Von Haller in 1756, have become a significant area of study due to their implications in sinus pathology and maxillofacial surgery. Due to their anatomical location, Haller cells are best examined using non-invasive imaging techniques, particularly conventional sinus imaging methods and tomographic techniques.[1] Haller cells, despite being normal anatomical variations, are frequently implicated in sinus pathology. The proximity of these air cells to the ostiomeatal complex can obstruct sinus drainage, leading to recurrent sinusitis.[2] Furthermore, the anatomical variability and close proximity of Haller cells can pose complications during surgical interventions, such as functional endoscopic sinus surgery.[3] Concha bullosa refers to a condition where partial or complete air-filled cells are found within the middle nasal turbinate, usually situated in the median concha. It constitutes one of the most frequently encountered anatomical variations within the osteomeatal region. Despite extensive research, the precise etiology of concha bullosa remains elusive. Nevertheless, it is noteworthy that these air cells are frequently co-occurring with pathologies affecting the osteomeatal complex.[3] The concurrent utilization of computed tomography (CT) scans in the assessment of sinonasal diseases has contributed to an augmented detection rate of concha bullosa involving the middle turbinate. The expansion of pneumatization within the middle turbinate typically emanates from the frontal recess or the agar nasi cells.[4]

Although Haller cells and concha bullosa are anatomical variations, they hold significant clinical importance due to the potential complications they may cause. Despite their often-asymptomatic nature, they can lead to recurring sinusitis and orbital complications. Therefore, a comprehensive understanding of Haller cells is paramount, particularly in the preoperative planning of sinus and orbital surgeries. The aim of this study is to learn the prevalence of concha bullosa and Haller cells in a subpopulation of the Eastern Anatolia Region. Additionally, this study aims to investigate the potential correlation between the presence of concha bullosa and Haller cells. While many studies have examined the relationship between Haller cells and anatomical variations near the maxillary sinus, there is a lack of extensive research on the association between the prevalence of Haller cells and concha bullosa. Therefore, we believe that this study will provide a significant addition to the current scientific knowledge on this topic.

## MATERIAL AND METHODS

The study received approval from the Van Yüzüncü Yıl University Non-Interventional Clinical Research Ethics Committee (date: September 18, 2023, no: 2023/09-19). Following the principles outlined in the Declaration of Helsinki, this retrospective investigation obtained informed consent from all individuals whose data were included. In this study, a post hoc power analysis was conducted using G*power version 3.1.9.2 (Franz Faul, University of Kiel, Germany). The effect of gender on the presence of concha bullosa and Haller cells was investigated with chi-square analysis. Additionally, the relationship between the presence of Haller cells and concha bullosa was evaluated with chi-square analysis. The analysis showed that, with an alpha coefficient of 0.05, the effect of gender was studied in 507 patients with a power of 99% and a ratio of R1/R2: 0.75. The effect of the presence of Haller cells was studied in 507 patients with a power of 100% and a ratio of R1/R2: 2.3, with an alpha coefficient of 0.05. In the study, cone beam CT (CBCT) images from the archives of the department of oral and maxillofacial radiology at our faculty were utilized. In our department, informed consent forms are routinely obtained from each patient prior to the acquisition of CBCT. 507 CBCT images acquired for diagnostic purposes between January 2018 and December 2022 at the department of oral and maxillofacial radiology of our institution were retrospectively reviewed.

Inclusion criteria encompassed individuals aged between 16 and 71 years, possessing permanent dentition, and devoid of prior orthodontic or orthognathic interventions, as well as craniofacial syndromes or evident pathologies. Exclusion criteria included prior orthodontic or orthognathic procedures, impacted teeth or root displacement due to factors such as cysts or tumors in the maxillary sinuses or nasal cavity, systemic bone disorders, craniofacial abnormalities, syndromes affecting bone structure, history of trauma

or fractures in the maxillary, nasal, or ophthalmic regions, skeletally significant asymmetry, large mucus retention cysts, and CBCT images of subpar quality due to metal or motion artifacts.

## EVALUATION AND OBTAINING CBCT DATA

The KaVo 3D eXam tomography device, manufactured in Biberach, Germany, and situated within the department of oral and maxillofacial radiology at our institution, was utilized for conducting CBCT measurements. This equipment undergoes routine annual maintenance and repair. All tomographic procedures were executed at settings of 120 kVp, 5 mAs, with a scan duration of 7 seconds, resulting in a voxel size of 0.4 mm and a field of view of 130 mm. The CBCT images were converted to Digital Imaging and Communications in Medicine format for analysis. The assessment for the presence of Haller cells and concha bullosa on the right and left sides in frontal sections was carried out by an oral and maxillofacial radiologist with five years of experience (Figure 1, Figure 2). The presence of Haller cells and concha bullosa was recorded separately for the right and left sides as either present or absent. However, the presence of a concha bullosa was determined based on criteria wherein pneumatization exceeding 50% of the vertical height of the middle turbinate, measured from superior to inferior in the coronal plane, was considered indicative.[5] In this study, the characterization of Haller cells, as delineated by Simeunovic, encompasses ethmoid cells that extend towards the orbital floor or the roof of the maxillary sinus, respectively, up to the vicinity of the maxillary ostium, potentially constituting the lateral wall of the infundibulum. Cells situated within the infundibulum or formations originating from posterior ethmoid cells were not considered in our analysis.[6] Data were analyzed to investigate the correlations according to gender, sides, and the presence of Haller cells and concha bullosa.

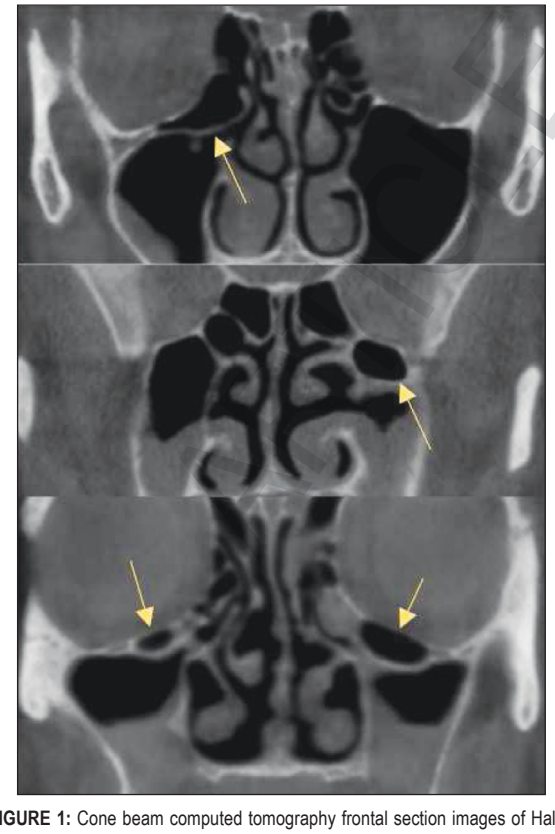

**FIGURE 1:** Cone beam computed tomography frontal section images of Haller cells with yellow arrow.

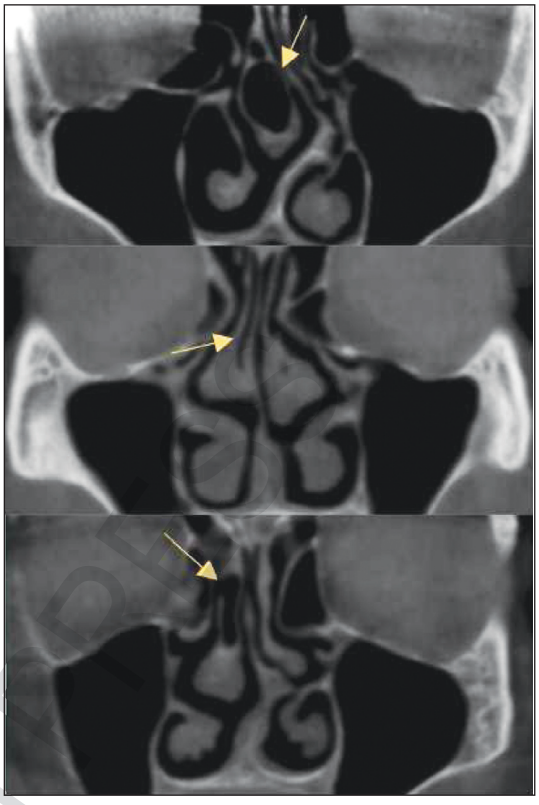

**FIGURE 2:** Images of concha bullosa observed in cone beam computed tomography frontal sections with yellow arrow.

## STATISTICAL ANALYSIS

The data were subjected to analysis using IBM SPSS Version 23 (IBM Co., Armonk, NY). Since the data did not exhibit a normal distribution according to the

Kolmogorov-Smirnov test, the correlation between the data was assessed using the Spearman correlation test. The chi-square test was used for the evaluation of categorical data. A significance level of $p<0.05$ was adopted for all analyses.

## RESULTS

The mean age of the participants was calculated as 34.16±12.76 years. Among the participants, 57.2% (n=290) were female and 42.8% (n=217) were male. Concha bullosa was detected in 74.1% (n=215) of females and 71.4% (n=155) of males, while Haller cell was detected in 37.2% (n=108) of females and 38.2% (n=83) of males. Both Haller cell and concha bullosa were observed in 29.2% (n=148) of participants (Table 1).

The presence of Haller cells and concha bullosa did not exhibit a statistically significant difference according to gender (p=0.121, p=0.119, respectively). However, a statistically significant difference was observed between the presence of Haller cells and concha bullosa (p=0.016), a statistically significant but low correlation was observed between them. (p=0.02, r=0.069). There were no statistically significant differences observed in the presence of Haller cells and concha bullosa based on directions ($p>0.05$). Additionally, a statistically significant but moderate positive correlation was observed between the presence of Haller cells on the right and left sides simultaneously ($p<0.001$, r=0.420). A statistically significant and high positive correlation was also observed between the simultaneous presence of concha bullosa on the right and left sides ($p<0.001$, r=0.503). While a statistically significant difference was noted between the coexistence of Haller cells and concha bullosa on the right side (p=0.046), a very low correlation was observed (r=0.079). Conversely, no statistically significant difference was observed between the coexistence of Haller cells on the right side and concha bullosa on the left side (p=0.158), with a very low correlation observed (r=0.049). Similarly, no statistically significant difference was found between the coexistence of Haller cells on the left side and concha bullosa on the right side (p=0.280), and a very low correlation was observed (r=0.031). Finally, no statistically significant difference was found between the coexistence of Haller cells on the left side and concha bullosa on the left side (p=0.124), with a very low correlation observed (r=0.056) (Table 2).

**TABLE 1:** Table showing the distribution of concha bullosa and Haller cells according to sex.

| | | Gender | | |
|---|---|---|---|---|
| | | **Female** | **Male** | **Total** |
| Concha bullosa | Yes | 414 | 294 | 708 |
| | No | 166 | 140 | 306 |
| | **Total** | **580** | **434** | **1,014** |
| Haller cells | Yes | 200 | 166 | 366 |
| | No | 380 | 268 | 648 |
| | **Total** | **580** | **434** | **1,014** |
| Concha bullosa-right | Yes | 215 | 155 | 370 |
| | No | 75 | 62 | 137 |
| | **Total** | **290** | **217** | **507** |
| Concha bullosa-left | Yes | 199 | 139 | 338 |
| | No | 91 | 78 | 169 |
| | **Total** | **290** | **217** | **507** |
| Haller cells-right | Yes | 108 | 83 | 191 |
| | No | 182 | 134 | 316 |
| | **Total** | **290** | **217** | **507** |
| Haller cells-left | Yes | 92 | 83 | 175 |
| | No | 198 | 134 | 332 |
| | **Total** | **290** | **217** | **507** |

## DISCUSSION

In 88% of instances involving Haller cells, these structures were found to originate from the anterior portion of the ethmoid cells, while the remaining 12% had their origin in the posterior region.[5] Valenzuela-Fuenzalida et al. conducted a comprehensive meta-analysis, amalgamating findings from multiple sources and reported the prevalence of Haller cells to be 30% (with a range of 18%-41%). In present study, the prevalence of Haller cells was determined to be consistent with the broader body of literature and notably exceeded the average reported prevalence.[7-13] For instance, Selcuk et al. calculated a prevalence rate of 28.5% based on CT images of 330 patients from the Central Anatolia Region.[14] Tercanli Alkis et al. investigated the effect of different temperature and humidity levels on the occurrence of maxillary mucus retention cysts in individuals residing in two provinces of Türkiye with varying altitudes.[15] The study did not observe a statistically significant dif-

**TABLE 2:** Distribution, statistics and correlation table of concha bullosa and Haller cells according to directions.

| | | Concha bullosa | | | | |
|---|---|---|---|---|---|---|
| | | **Yes** | **No** | **Total** | **p*** | **r**** |
| Haller cell | Yes | 271 | 95 | 366 | **0.016** | **0.069** |
| | No | 437 | 211 | 648 | | |
| | **Total** | 708 | 306 | 1014 | | |
| | | **Concha bullosa-right** | | **Total** | **p** | **r** |
| Concha Bullosa-left | Yes | 300 | 70 | 370 | **<0.001** | **0.503** |
| | No | 38 | 99 | 137 | | |
| | **Total** | 338 | 169 | 507 | | |
| | | **Haller cell-left** | | **Total** | **p** | **r** |
| Haller cell-right | Yes | 115 | 76 | 191 | **<0.001** | **0.420** |
| | No | 60 | 256 | 316 | | |
| | **Total** | 175 | 332 | 507 | | |
| | | **Concha bullosa-right** | | **Total** | **p** | **r** |
| Haller cell-right | Yes | 148 | 43 | 191 | **0.046** | 0.079 |
| | No | 222 | 94 | 316 | | |
| | **Total** | 370 | 137 | 507 | | |
| | | **Concha bullosa-left** | | **Total** | **p** | **r** |
| Haller cell-left | Yes | 123 | 52 | 175 | 0.124 | 0.056 |
| | No | 215 | 117 | 332 | | |
| | **Total** | 338 | 169 | 507 | | |
| | | **Concha bullosa-right** | | **Total** | **p** | **r** |
| Haller cell-left | Yes | 131 | 44 | 175 | 0.280 | 0.031 |
| | No | 239 | 93 | 332 | | |
| | **Total** | 370 | 137 | 507 | | |
| | | **Concha bullosa-left** | | **Total** | **p** | **r** |
| Haller cell-right | Yes | 133 | 58 | 191 | 0.158 | 0.049 |
| | No | 205 | 111 | 316 | | |
| | **Total** | 338 | 169 | 507 | | |

*Chi-square analyses; **Spearman correlation test. p: 0.05



ference. However, a low-level correlation was found between the likelihood of maxillary mucus retention cysts and air temperature and humidity levels. It was demonstrated that air temperature, different altitudes, atmospheric pressure, pollution, and humidity levels do not have a statistically significant effect on mucus retention cysts, which are pathologies of the sinonasal region. Nevertheless, the observed low correlation suggests a potential influence on anatomical variations in this region. Marçal et al. demonstrated a significant correlation between air temperature and the likelihood of mucus retention cyst occurrence.[16] The effect of air temperature and humidity levels on mucus retention cysts, which are pathologies of the sinonasal region, varies in the literature. In addition, some researchers who argue that any obstruction occurring in the nasal region can lead to changes in sinus pressure, resulting in pneumatization.[1] In light of these data, factors such as air temperature, different altitudes, atmospheric pressure, pollution, and humidity levels suggest a potential influence on anatomical variations in the sinonasal region. It is noteworthy that Haller cell prevalence rate appeared slightly elevated among individuals residing in the eastern part of Türkiye. Given that Eastern Anatolia is characterized by higher altitudes compared to Central Anatolia, a thorough investigation into whether altitude plays a role in the etiology of Haller cells may offer valuable insights into this phenomenon. However, more comprehensive studies are needed for this purpose.

Furthermore, in a separate investigation, conducted in 2020, researchers analyzed CBCT images of 99 patients. Their study revealed a statistically significant association, wherein individuals with maxillary sinus hypoplasia exhibited a lower prevalence of Haller cells in comparison to those without hypoplasia.[17]

In a recent study by Moshfeghi et al., an examination of 120 CBCT images indicated a statistically significant increase in the presence of Haller cells in cases associated with orbital floor dehiscence.[18] This finding lends support to the notion that a majority of Haller cells originate from the anterior region of the ethmoid cells. Collectively, the available literature underscores the significance of considering maxillofacial air cell variations, particularly within the maxillary sinus, as they play a pivotal role in the etiology of Haller cells.

Furthermore, Kaygusuz et al. conducted a CT study involving 99 patients, wherein they did not discern any statistically significant differences among the observed anatomical formations within the nasal region.[10] Correspondingly, our study aligns with Kaygusuz et al.'s findings, revealing no statistically significant disparities between concha bullosa and Haller cells.[10] De Cock et al. investigated the efficacy of CBCT and CT imaging methods in evaluating sinonasal anatomy and pathology. Their study demonstrated that CT imaging provides better results for pathologies involving soft tissue, such as sinonasal polyposis. Additionally, they found that CBCT imaging is more effective in evaluating normal anatomical structures and variations due to a 42% lower radiation dose compared to CT.[19] Therefore, in this study, which evaluates anatomical structures such as Haller's cells and concha bullosa, both the image efficacy and the sample size support the reliability of the results.

Shams et al. and Yazdi et al. evaluated CBCT data and reported that concha bullosa does not differ by gender.[20,21] In contrast, Budu et al. evaluated CT data from 256 individuals and reported that concha bullosa is more frequently observed in women compared to men.[22] Vasegh et al. evaluated CBCT data from 385 individuals and reported that concha bullosa is more frequently observed in women compared to men.[23] Based on the current literature, the distribution of concha bullosa varies by gender. Ahmad et al. evaluated panoramic radiographs of 233 individuals and reported that Haller's cells are more frequently observed in women compared to men.[24] Shahab et al. evaluated CBCT data from 381 individuals and reported that Haller cell is more frequently observed in women compared to men.[25] These differences are suggested to stem from variations between races, ages and the diversity of evaluation criteria. However, this study also concluded that the presence of Haller's cells and concha bullosa does not show a predisposition based on gender.

Mahapatra et al. evaluated CBCT images of 200 individuals and reported that Haller's cells are more frequently observed on the right side compared to the left side.[26] El-Din et al. evaluated CT images of 879 individuals and reported that concha bullosa is more frequently observed on the right side compared to the left side.[27] In this study, consistent with the literature, both the presence of Haller's cells and concha bullosa were statistically significantly more frequently observed on the right side.

In a study conducted by Lee et al., the examination of anatomical variations and their correlations with postoperative complications was undertaken through the analysis of CT images from a cohort comprising 81 patients. In conclusion, patients with Haller cells have been observed to experience more postoperative complications compared to those with other anatomical variations in the nasal region.[11] The presence of Haller cells, particularly in midface surgeries, increases the likelihood of postoperative complications compared to other anatomical variations. CBCT imaging techniques offer the ability to assess this region's anatomy with a lower radiation dose.[19] Thus, identifying the presence of Haller cells can aid in preventing preoperative complications.

Likewise, in a study by Khojastepour et al. that involved the analysis of CBCT images from 120 patients, a statistically significant association was found between the presence of Haller cells and the incidence of maxillary sinusitis.[28] In contrast, Capelli and Gatti, in their evaluation of CBCT images from a sample of 140 patients, did not identify any statistically significant dis-

parities between chronic rhinosinusitis and the presence of Haller cells and concha bullosa.[29]

Shin et al. conducted an investigation wherein they assessed the prevalence of concha bullosa and Haller cells through the examination of CT images in 31 cases of maxillary sinus fungal ball (MSFB).[30] Their study revealed that the prevalence of Haller cells was elevated in MSFB cases in comparison to the control group, although this increase did not attain statistical significance. However, statistically significant higher prevalence of concha bullosa has been observed in individuals with MSFB. This may suggest the potential influence of nasal region anatomical variations on the etiology of MSFB.

Göçmen et al. evaluated the effect of concha bullosa and Haller's cells on maxillary sinus inferior pneumatization. In their study, which assessed CBCT images of 300 individuals, they did not observe a statistically significant difference between maxillary sinus inferior pneumatization and concha bullosa and Haller's cells, which are variations of pneumatization.[31]

The limitation of this study is that the correlation between concha bullosa and Haller's cells was investigated only in individuals of similar race. Conducting similar studies in different races will enable us to understand the relationship between anatomical variations observed in the sinonasal region. Furthermore, investigating the prevalence of Haller's cells in patients with maxillary deficiency, especially those excluded from our study due to orthodontic reasons, will allow us to understand the etiological factors of these variations.

## CONCLUSION

Although concha bullosa and Haller cells observed as a result of intraosseous pneumatisation originate from similar etiological events, there is no statistically significant correlation in terms of their simultaneous occurrence. However, the presence of concha bullosa and Haller cells on the right or left side increases the likelihood of these formations on the opposite side. Furthermore, it was observed that the probability of encountering Haller cells and concha bullosa did not exhibit gender-based differences. Therefore, this should be taken into consideration in surgical procedures and before diagnosis. CBCT can be used as a very comfortable method due to its low radiation and cost.


### *Source of Finance*

*During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.*


### *Conflict of Interest*

*No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.*

### *Authorship Contributions*

*This study is entirely author's own work and no other author contribution.*



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