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RESEARCH ARTICLE

Prevalence and Morphometric Analysis of Körner's Septum Using Cone-Beam Computed Tomography: Insights from a 240 Temporal Bone Study

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Abstract: Körner's septum (KS), a bony structure at the junction of the mastoid and temporal squama, plays a critical role in anatomical and surgical contexts. This study aimed to evaluate the prevalence, topography, and thickness of KS using cone-beam computed tomography (CBCT) in 120 patients, encompassing 240 temporal bones. KS was present in 62.5% of cases, with higher prevalence in males (71%) than females (53%), and incomplete KS observed in 75% of temporal bones. The head of the malleus and superior semicircular canal were the most common anatomical landmarks for KS, with the greatest thickness observed at the head of malleus and the least at the tympanic sinus. Significant variability in KS thickness was noted across landmarks ($p < 0.05$). While CBCT proved valuable in identifying KS, its limitations, including lack of radiodensity reliability, should be addressed in future studies. These findings enhance understanding of KS morphology and underscore its relevance in diagnostic and surgical applications.

Keywords: Körner's septum, Cone-beam computed tomography, Temporal bone anatomy, Otologic surgery, Morphometric analysis.

INTRODUCTION

Körner's septum (KS), also referred to as the petrosquamous lamina, is a bony structure formed at the junction between the mastoid and temporal squama, representing the remnant of the petrosquamous suture. This septum not only divides the antrum into petrous (deep) and squamous (superficial) portions but also extends posteriorly toward the mastoid process and ascends above the middle ear's air spaces to reach the posterior aspect of the mandibular fossa.

Although some sources attribute the first description of KS to A. H. Cheatle in his Hunterian Lectures, it was actually A. Hartmann who first drew attention to this feature nearly two decades earlier. Hartmann described a large cavity in the temporal bone—referred to as the antrum petrosum—that is partially separated from the antrum mastoideum by an osseous projection from the tegmen. [1]

Körner was instrumental in emphasizing the clinical significance of the septum, yet its morphological importance has received limited attention in the literature. After William House introduced the use of a microscope in temporal bone dissection in 1958, Shulman and Rock highlighted that a prominent KS could be mistaken for the bony covering of the sigmoid sinus, potentially leading to complications such as inadvertent entry into a false antrum or injury to the facial nerve. [2]

The advent of advanced imaging technologies, particularly with the introduction of computed tomography (CT) in the early 1970s, significantly enhanced the ability to study KS. Researchers such as Virapongse et al. utilized these advancements to investigate the septum. [3] Modern high-resolution computed tomography (HRCT) has since become a standard tool for preoperative evaluation of the temporal bone. Recently, cone-beam CT has emerged as an alternative to HRCT in otologic diagnostics, offering comparable accuracy with reduced radiation exposure. This imaging modality is particularly useful for assessing anatomic variations, including the presence of KS and mastoid pneumatization. [4]

Despite occasional mentions of KS in the literature, detailed studies focusing on its structure remain absent. This study aims to evaluate the prevalence of Körner's septum and analyze its topographical characteristics. [5-8]

METHODS

The study was conducted at Saveetha Medical College and Hospital, affiliated to SIMATS, Chennai, India, during 2022. It utilized anonymized cone-beam computed tomography (CBCT) images of the temporal bone acquired for clinical (dental or maxillofacial) purposes. The imaging was performed using the Planmeca Promax 3D Mid scanner with parameters of 400 × 400 × 400 µm voxel dimensions, source voltage of 90 kV, and current of 12 mA.

Out of an initial cohort of 200 patients, images showing any temporal bone pathology were excluded, resulting in a final sample of 120 patients (62 male and 58 female, encompassing 240 temporal bones). The ages of the patients ranged from 15 to 80 years, with a mean age of 40 ± 15 years. [9]

The scans were analyzed using RadiAnt DICOM Viewer 4.0.3 (64-bit), and the collected data underwent statistical analysis using StatSoftStatistica 13.1 software. The identification of Körner's septum (KS) and its thickness measurements were carried out on horizontal sections at three anatomical landmarks: the level of the superior semicircular canal (SSC), the head of the malleus (HM), and the tympanic sinus (TS). The KS was deemed present if a bony lamina was observed at any of the three specified points. Additionally, the KS was classified as complete when all three portions were present and incomplete when one or two portions were absent. [10.11]

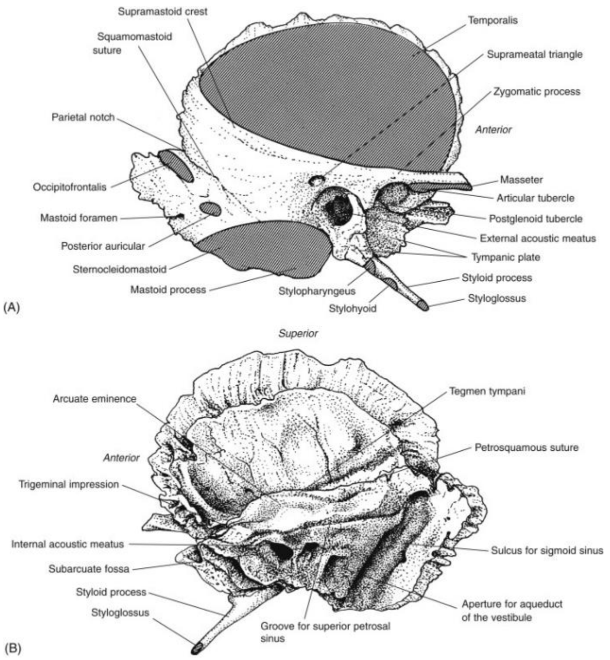

Figure 1: Prevalence and Thickness of Körner's Septum in Temporal Bone Anatomy: A CBCT Study

RESULTS

The study successfully identified all anatomical landmarks (head of malleus [HM], superior semicircular canal [SSC], and tympanic sinus [TS]) for each part of Körner's septum (KS) in all evaluated CBCT scans. KS was detected in at least one of the measurement points in 50 out of 80 sets of CBCT images, representing 62.5% of the cases and 75 out of 160 temporal bones. [12] The frequency of KS was higher in males (71%) compared to females (53%), although this difference was not statistically significant ($p > 0.05$). Bilateral KS was observed in 50% of the cases (25 subjects out of 50). A complete KS, identified at all three measurement points, was present in 25% of temporal bones (19 out of 75), and bilaterally in only 3 subjects (2% of the total population). Incomplete KS was more common, found in 75% of the temporal bones (56 out of 75). [13]

KS was most frequently observed at the level of the head of malleus, with a prevalence of 34% (54 out of 160 cases), with 39% in males (32 cases) and 28% in females (22 cases). At the level of the superior semicircular canal, KS was found in 33% of cases (53 out of 160), with 35% in males (29 cases) and 31% in females (24 cases). [14] At the level of the tympanic sinus, KS was detected in 19% of cases (31 out of 160), with an equal distribution between males and females (19% each, 16 males and 15 females). [15]

The average thickness of KS significantly varied across the three measured landmarks (Kruskal-Wallis test, $p < 0.05$). The greatest average thickness was found at the level of the head of malleus, while the lowest average thickness was observed at the level of the tympanic sinus. The average thickness, standard deviation, median, minimum, and maximum values for each landmark are presented in Table 1. [16]

Table 1: Thickness of Körner's Septum at Different Measured Levels

Landmark	n (%)	Avg ± SD (mm)	Median (mm)	Min–Max (mm)
SSC	66 (33%)	0.87 ± 0.35	0.73	0.28–1.74
HM	68 (34%)	1.00 ± 0.38	0.93	0.26–2.60
TS	38 (19%)	0.53 ± 0.17	0.51	0.19–0.78

(n: number of cases; avg: average value; SD: standard deviation; SSC: superior semicircular canal; HM: head of malleus; TS: tympanic sinus)

DISCUSSION

Although Körner's septum (KS) has been recognized by anatomists and otologists for over a century [3, 7], there remains a lack of detailed studies on its morphometry and variant classification. Proctor et al. proposed that the persistence of KS, whether complete or partial, results from developmental failure in the mastoid air cell system [12]. However, other authors have suggested that KS is not limited to the antrum but can also consist of at least three distinct portions [5, 10, 12, 13].

There is significant variability and confusion in the naming conventions for different parts of KS. Proctor et al. described three segments of the squama, each associated with specific junctions to the pars petrosa: (1) the anterior edge near the temporomandibular joint forming the roof, (2) the superior wall of the external acoustic meatus, and (3) the posterior region overlapping the petrous bone. They also mentioned the internal petrosquamous suture and the posterior external petrosquamous suture as defining characteristics. Interestingly, Proctor et al. suggested that this structure can be called KS or petrosquamous lamina if the junction persists only within the mastoid process [12]. Similarly, Virapongse et al. referred to these structures using different terminology, such as the ventral petrosquamosal suture, located ventrolaterally to the protympanum and Eustachian tube isthmus. They noted that the mid-portion of the petrosquamous suture is difficult to identify in axial images within the epitympanum, possibly appearing as a bony spicule above the ossicular chain, though this has not been conclusively proven [17, 18]. In our study, we did not encounter these structures in the axial and coronal images. However, we did identify the superior portion of the attic outer wall as being continuous with KS inside the mastoid process, which we describe as the anterior portion of KS. The final portion of KS, the dorsal or mastoid part, was defined by Virapongse et al., who distinguished between its superior and inferior sections. Importantly, KS does not always form a complete structure, as it can be interrupted in several locations [19, 21]. This raises the question of whether such interruptions are due to developmental arrest or disease-related bony destruction. To date, no comprehensive classification of KS has been proposed. Furthermore, there is disagreement about the structure known as 'the cog'; some authors equate it with the tympanic or mid-portion of KS [10], while others, like Tóth, describe it as a small bony plate extending from the tignum transversum to the Glaserian fissure, eventually breaking medially between the anterior malleal space and the anterior epitympanic recess [18].

In our study, we focused on three key areas where KS might be found. At the level of the tympanic sinus, in close relation to the mastoid part of the facial canal, we examined the posterior portion of KS. The superior semicircular canal was used as a landmark for the superior portion of KS. This portion can also exist as the only persistent part of KS and may guide otosurgeons to the posterior crus of the incus [13]. The superior part of KS occasionally extends anteriorly and fuses with the outer attic wall, which we termed the anterior portion of KS, identifiable on CBCT scans in both axial and coronal planes. Literature reports suggest that the prevalence of KS varies in different populations, ranging from approximately 6.5% [5] to as high as 45% [1] in temporal bones without a history of aural pathology. The latter value is similar to our findings, with KS observed in 47% of the temporal bones. KS was identified in 28% of 356 ears that underwent tympanoplasty in the study by Cigdem et al. [4]. Toros et al., under similar conditions, found KS in nearly 24% of operated temporal bones [17]. Goksu et al. encountered KS in 21% of temporal bones, with a higher prevalence (30.4%) in ears with chronic otitis media compared to normal ears (6.58%). Furthermore, Goksu et al. observed that KS was incomplete in 33% of cases, meaning at least one portion was absent. This contrasts with our results, where only 25% of the temporal bones had a complete KS. Additionally, no studies in the existing literature address the possible associations between KS prevalence and gender or side, which remains a gap in our understanding.

A unique finding in our study is the variability in the thickness of KS at different points. We found that KS was significantly thinner at the level of the tympanic sinus compared to the superior semicircular canal and head of the malleus ($p < 0.05$). Interestingly, the thickness at the level of the superior semicircular canal did not differ between males and females, while the thickness at the head of the malleus was greater than at other portions.

Cone-beam CT (CBCT) has been increasingly utilized since its introduction in the mid-1990s, particularly in dental and maxillofacial radiology. While high-resolution CT is considered the gold standard for imaging the temporal bone, there is a growing body of literature exploring CBCT's potential in otorhinolaryngology [8, 22], particularly for pre-operative cochlear implantation assessment and postoperative follow-up. CBCT has distinct advantages, including lower radiation doses and rapid acquisition times, making it especially suitable for pediatric patients [8]. However, CBCT has limitations in radiodensity measurement, as it does not provide reliable Hounsfield units for density analysis [16].

This limitation could affect the interpretation of fine temporal bone structures, as detailed radiodensity measurement may not be available. Micro-CT offers a higher spatial resolution, but it is generally used for smaller sample sizes and cannot be applied to living subjects, thus limiting its use in studying temporal bone anatomy in clinical populations.

Another limitation of this study was the absence of clinical data. All examinations were conducted for dental or maxillofacial reasons, and the data were anonymized prior to enrollment. Consequently, we were unable to collect information about the patients' ear diseases or other clinical conditions, which limited our ability to correlate our findings with specific medical histories. Only images with visible pathologies were excluded, but this limitation nonetheless reduces the comparability of our results with studies that include clinical data.

CONCLUSION

This study provides valuable insights into the anatomical prevalence, characteristics, and variability of Körner's septum (KS) in a cohort of 120 patients, with 240 temporal bones analyzed using cone-beam computed tomography (CBCT). Our findings suggest that KS is a common anatomical feature, present in 62.5% of cases, with notable gender differences and variability in its completeness. A significant portion of temporal bones exhibited incomplete KS, with the head of the malleus and superior semicircular canal being the most frequently identified anatomical landmarks. The study also highlighted that KS varies in thickness depending on the location, with the greatest thickness observed at the level of the head of malleus and the least at the tympanic sinus.

These results underline the importance of understanding KS for both diagnostic and surgical purposes, particularly in otologic and maxillofacial surgeries where the septum may be mistaken for other structures. Despite being identified in previous studies, the full morphometric and variant classification of KS remains an area for further investigation. Future studies that incorporate clinical data and correlate KS prevalence with specific pathologies may further enhance our understanding of this structure's clinical significance.

Finally, while CBCT proved to be a valuable tool for assessing KS in this study, its limitations—such as the absence of reliable radiodensity measurements and the inability to correlate imaging findings with clinical conditions—should be considered when interpreting the results. Nevertheless, CBCT continues to offer a promising non-invasive method for the evaluation of temporal bone structures, providing valuable insights for preoperative planning and postoperative monitoring in clinical settings.

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