Original Article

An Observational Study of Morphological Variations in Henle's Spine and Macewen's Triangle in the North Indian Population

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Abstract

Background: The temporal bone is a complex anatomical structure housing the middle ear and its ossicles, alongside the inner ear components, including the vestibule, cochlea, and semicircular canals. The suprameatal triangle is a depression situated immediately behind and above the external acoustic meatus in the squamous temporal bone. Suprameatal depression may show a bony spine or crest in its anterior margin, the suprameatal spine, which may vary in shape, size and position. Henle's spine, also known as the suprameatal spine, serves as an important anatomical landmark guiding the lateral wall of the mastoid antrum. This study investigates morphological variations in suprameatal depressions and spines in human skulls. Morphology of the suprameatal triangle was assessed regarding the Presence and depth of depressions (absent, shallow, or deep); the Presence and type of suprameatal spine. **Material and Methods:** An observational study was conducted in the Department of Anatomy of a tertiary care centre in Northern India, analysing 120 dry adult human skulls of known sex. Skulls with at least one intact temporal bone were included; fetal and bilaterally damaged skulls were excluded. Variations were studied bilaterally with correlation to sex and side. **Results:** The crest-type suprameatal spine predominated in both males and females. Suprameatal depression was absent in 9.6% of skulls, deep in 49.2%, and shallow in 41.2%. **Conclusion:** This study elucidates the prevalence and morphological variations of suprameatal structures, emphasising their clinical relevance for otolaryngologists, neurosurgeons, and researchers during mastoid surgeries, cochlear implantation, and skull base approaches.

Keywords: Henle's spine, Suprameatal triangle, gender, north Indian.

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Introduction

The temporal bone is one of the most complex anatomical spaces that contains the middle ear and its ossicles, as well as the inner ear, which includes the vestibulocochlear apparatus.[1,2] The suprameatal triangle, also known as McEwen's triangle or the mastoid fossa, is a bony depression located immediately posterior and superior to the external acoustic meatus. The squamous part of the temporal bone forms it. It is bounded superiorly by the supramastoid crest, anteriorly by the posterosuperior margin of the external acoustic meatus, and posteriorly by a vertical line along the posterior edge of the meatal orifice.[3,4] A bony projection called the suprameatal spine or Henle's spine (also known as spina suprameatica) can often be observed in the anterior margin of this depression.[5] This structure varies in shape, size, and position.[1,3] The suprameatal spine provides an additional attachment site for ligaments securing the cartilaginous portion of the external acoustic meatus, as well as for the temporal muscle and fascia.[3,6,7]

Both McEwen's triangle and Henle's spine are among the most consistent anatomical landmarks on the lateral aspect of the temporal bone, remaining stable after adolescence.[3,8] These structures are particularly important surgically because the mastoid antrum lies medially to the suprameatal depression at an approximate depth of 1.25 cm.[3] This knowledge is critical for otolaryngologists during surgical approaches to the middle ear, mastoid antrum, and cochlear implant procedures.[1,3,9] Furthermore, Henle's spine serves as a vital surface landmark for locating the middle fossa dura in cases where the linea temporalis is absent.[10] It also aids in identifying various foramina encountered during skull base surgeries and assists otologists, neurosurgeons, and researchers in assessing the position of the malleus handle.[2,5] A comprehensive understanding of the morphological variations of these structures is essential for surgeons operating in the tympanomastoid region. Accurate diagnosis and successful surgical intervention require detailed anatomical knowledge of the temporal bone's topographic landmarks.[12] Measuring the distances between Henle's spine and deeper anatomical landmarks can guide surgeons during complex procedures. Typically, mastoidectomy begins with identifying lateral surface landmarks on the mastoid bone, followed by localisation of deeper structures.[13,14]

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Despite their clinical significance, there is a paucity of literature addressing the morphological variations of these landmarks and their correlation with sex and laterality, particularly within South Asian populations. This study was therefore undertaken to examine the morphological variability of the suprameatal depression and Henle's spine in North Indian adult skulls at a tertiary care hospital.

Materials and Methods

The study was conducted on skulls retrieved from the Department of Anatomy in the North Indian population. The work was done as part of postdoctoral research, and institutional ethics clearance was obtained.

Sample Size: Morphological variations in the temporal bones of both sides were studied in 120 well-preserved, dry adult human skulls retrieved from the department and identified by sex and age. Out of 120 skulls, 80 were of males, and 40 were of females.

Inclusion criteria: Dry adult human skulls with at least one side intact, with the temporal bone free of anomalies, pathologies, and fractures, were considered for the study.

Exclusion criteria: Foetal skulls and skulls with bilaterally broken temporal bones or with anomalies.

The Morphology of suprameatal triangles and Henle's spine were studied using McWilliam's classification by noting the following: -

A. Depression: presence or absence, whether deep or shallow if present

B. Suprameatal spine: presence or absence

C. Type of suprameatal spine: crest or triangular

The data obtained was tabulated according to the presence, depth and shape of the suprameatal depression and spine, respectively. Gender and side differences were also evaluated and subsequently analysed statistically using SPSS version 17, with the chi-square test.

Results

Suprameatal depression (SMD)- Out of a total of 120 skulls examined, the suprameatal triangle was absent in 23 (9.6%), deep in 118 (49.2%), and shallow in 99 (41.2%) cases. On the right side, absence was observed in 7 male skulls (8.8%) and four female skulls (10%), whereas on the left side, absence was observed in 5 male skulls (6.2%) and seven female skulls (17.5%). A deep suprameatal triangle was identified on the right side in 36 male skulls (45%) and 20 female skulls (50%), and on the left side in 41 male skulls (51.2%) and 21 female skulls (52.5%). A shallow triangle was noted on the right side in 37 male skulls (46.2%) and 16 female skulls (40%), and on the left side in 34 male skulls (42.5%) and 12 female skulls (30%). These variations were not statistically significant with respect to sex or laterality. [Table 1]

Suprameatal Spine (SMS): Out of a total of 120 skulls examined, the suprameatal spine was present in 218 instances (90.8%) and absent in 22 cases (9.2%). On the right side, the SMS was observed in 72 male skulls (90%) and 38 female skulls (95%), while on the left side, it was present in 74 male skulls (92.5%) and 34 female skulls (85%). Absence of the SMS was noted on the right side in 8 male skulls (10%) and two female skulls (5%), and on the left side in 6 male skulls (7.5%) and six female skulls (15%). No statistically significant differences were observed between sexes or between the right and left sides with respect to the presence of the suprameatal spine [Table 2].

Type of Suprameatal Spine (SMS): Regarding the morphological types of the suprameatal spine, the crest type was observed in 44 male skulls (55%) and 23 female skulls (57.5%) on the right side, and in 46 male skulls (57.5%) and 19 female skulls (47.5%) on the left side. The triangular type was found on the right side in 28 male skulls (35%) and 14 female skulls (35%), and on the left side in 28 male skulls (35%) and 15 female skulls (37.5%). No statistically significant differences were noted between sexes or sides with respect to the type of suprameatal spine. [Table 3]

Table 1: Frequency and laterality of Suprameatal Depression in Male and Female Skulls

Gender	Absent	Deep	Shallow	P value
Male (n=160)	12 (7.5%) R-7, L-5	77 (48.1%) R-36, L-41	71 (44.4%) R-37, L-34	0.67*
Female (n=80)	11 (13.8%) R-4, L-7	41 (51.2%) R-20, L-21	28 (35.0%) R-16, L-12	0.49$
Total (n=240)	23 (9.6%) R-11, L-12	118 (49.2%) R-56, L-62	99 (41.2%) R-53, L-46	0.18#

*- Comparison of frequency of type of SMD and laterality among male skulls, $- Comparison of frequency of type of SMD and laterality among female skulls, #- Comparison of frequency of type of SMD among male and females

Table 2: Frequency and laterality of Suprameatal Spine in Male and Female Skulls

	Suprameatal Spine		
Gender	Absent	Present	P-value
Male (n=160)	14 (8.8%) R-8, L- 6	146 (91.2%) R-72, L-74	0.58*
Female (n=80)	8 (10.0%) R-2, L-6	72 (90.0%) R-38, L-34	0.14$
Total (n=240)	22 (9.2%) R-10, L-12	218 (90.80%) R-110, L-108	0.75#

*- Comparison of frequency of presence and laterality of Suprameatal spine among male skulls, $-Comparison of frequency of presence and laterality of Suprameatal spine among female skulls, #- *- Comparison of frequency of presence of Suprameatal spine among male and female skulls.

Table 3: Frequency and laterality of Types of Suprameatal Spines in Male and Female Skulls

Gender	Types of Suprameatal Spines			Total
	Absent	Crest	Triangular	
Male (n=160)	14 (8.8%) R-8, L-6	90 (56.2%) R-44, L-46	56 (35.0%) R-28, L-28	0.85*
Female (n=80)	9 (11.2%) R-3, L-6	42 (52.5%) R-23, L-19	29 (36.2%) R-14, L-15	0.49$
Total (n=240)	23 (9.6%) R-11, L-12	132 (55.0%) R-67, L-65	85 (35.4%) R-42, L-43	0.78#

*- Comparison of frequency of type and laterality of Suprameatal spine among male skulls, $-Comparison of frequency of type presence and laterality of Suprameatal spine among female skulls, #- *- Comparison of frequency of type of Suprameatal spine among male and female skulls.

Discussion

The suprameatal triangle and suprameatal spine represent essential anatomical landmarks in otologic surgery due to their proximity to the mastoid antrum, which lies medially within approximately 1.25 cm of the depression. Historically, Hermann Schwartze and Adolf Eysell identified the shortest surgical pathway to the mastoid antrum as originating just beneath the temporal line at the level of the superior wall of the external acoustic meatus, approximately 7–8 mm posterior to Henle's spine.[10,13] This critical anatomical relationship underscores the importance of these landmarks in surgical interventions involving the middle ear and mastoid antrum.

Although the suprameatal triangle and Henle's spine are among the most consistent and reliable topographic features on the lateral temporal bone, considerable variation exists in their morphology, including differences in shape, size, depth, and anatomical position. Such variability can offer valuable insights into the underlying deeper structures, thereby assisting surgeons—particularly those with less experience—in anticipating potential surgical challenges and complications. The current study observed that the suprameatal depression (SMD) was absent in 9.6% of skulls overall, with a higher prevalence of absence on the left side in females (17.5%) and on the right side in males (8.8%). Deep SMD was more common (51.2%) than shallow SMD (35%), with females exhibiting a predominance of the deep variant compared to males. The suprameatal spine (HS) was absent in 9.2% of skulls, more frequently on the left side in females (15%) and on the right side in males (10%). Notably, the crest type of HS was more prevalent (55%) than the triangular type (35.8%) across both sexes and sides. Although these differences were not statistically significant, they suggest modest associations with sex and laterality.

The current study could not directly assess correlations between these morphological variations and underlying deeper structures due to the risk of damaging well-preserved skulls, which are valuable educational resources. Nevertheless, the findings have important implications for surgical approaches involving the ear, middle cranial fossa, and sigmoid sinuses. Additionally, these morphological observations may assist forensic experts in sex and age determination in medicolegal contexts. Further research integrating cadaveric and radiological imaging data is warranted to expand upon these findings.

Literature exploring the relationship between morphological variation in the SMD and HS and sex and laterality, particularly in South Asian populations, remains scarce. Most studies have primarily focused on prevalence and morphological types without evaluating their correlation with gender or side of the skull. Our investigation involved a larger sample of skulls with known sex and age, enabling a more robust analysis of these correlations.

Comparative studies offer some corroboration and contrast to these findings. Peker et al., examining 594 Anatolian skulls, reported a significantly higher absence of SMD in females than in males, with SMD generally shallow in females and deep in males. Saadia et al. observed higher SMD absence in females among 100 Egyptian skulls, with a similar pattern of deep SMD predominance in males and shallow SMD in females. Our study aligns with Peker et al. regarding the higher absence of SMD in females. Still, it reports a higher overall absence frequency and a predominance of deep SMD in North Indian females, possibly attributable to epigenetic differences noted by McWilliams, as well as to more precise sex determination from labelled skulls rather than forensic estimations.

Regarding HS morphology, Peker et al. identified the crest type as more prevalent than the triangular type, with HS absent in 6.4% of cases.[3] Aslan et al.'s study of formalin-preserved temporal bones reported equal prevalence of crest and triangular types, with HS absence in 20%, highlighting variability likely influenced by sample size.[14] Other investigations by Hauser and De Stefano, and by Saadia et al., generally support the crest type as dominant, though statistical significance for sex and laterality remains inconclusive.[1] Intraoperative observations by B.G. Prakash et al. similarly noted the crest type as predominant, without correlation to sex or gender. Our findings mirror these trends, with HS absent in 9.2% of skulls and crest type more common overall, underscoring the possibility of epigenetic variation within Indian populations.

Finally, these anatomical landmarks play vital roles beyond basic otologic surgery, informing approaches to the skull base, cerebellopontine angle, and cochlear implantation. They also assist forensic anthropologists in sex determination from cranial fragments, a critical challenge in medicolegal investigations.[15]

Conclusion

This study provides valuable insights into the prevalence and morphological variation of the suprameatal depression and Henle's spine across gender and laterality. Detailed knowledge of these variations is crucial for otolaryngologists, neurosurgeons, and researchers during mastoid surgeries, cochlear implantation, and skull base approaches. Moreover, these findings hold significant forensic relevance for sex and age estimation in medicolegal cases. Future research integrating cadaveric, radiological, and intraoperative data will further elucidate the clinical and anthropological implications of these anatomical landmarks.

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Conflicts of interest

There are no conflicts of interest.

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