Original Article

# Morphological Study of Wormian Bones in Dry Human Skulls in Uttar Pradesh Region

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## Abstract

**Background:** Wormian bones are supernumerary bones that grow in cranial sutures and fontanelles. These auxiliary bones exhibit significant anatomical differences among populations and have clinical implications in neurosurgical practice, forensic studies, and radiological interpretation. Anatomists and clinicians must acquire knowledge about their morphological patterns and patterns of distribution. **Material and Methods:** It is a cross-sectional observational study conducted in the Department of Anatomy, Motilal Nehru Medical College, Prayagraj, Uttar Pradesh, and the Departments of Anatomy at Rajshree Medical College, Rajshree Medical and Research Institute, Bareilly, Uttar Pradesh. One hundred and forty dry human skulls of sex and age were considered. Fractured skulls, skull injuries, or pathological skulls were ruled out. The presence, number, location, and topographic distribution of Wormian bones along different sutures of each skull were systematically measured. Descriptive statistics were used to analyse data, and the chi-squared test was used where necessary. **Results:** Wormian bones were found in 47 skulls (33.57%). The lambdoid suture had the highest (44.68%), and then the coronal suture (19.15%), the sagittal suture (14.89%), and the asterion (12.77%). The average Wormian bones of the affected skull were 2.34 with a standard deviation of 1.56 (1-8). These ossicles were most concentrated in the lambda region (29.09%). Single Wormian bones were found in 19 skulls (40.43%), and multiple bones were found in 28 skulls (59.57%). Statistical analysis showed a significant correlation between the presence of Wormian bones and the lambdoid suture ($p < 0.001$). **Conclusion:** This article shows that Wormian bones are a fairly common anatomical anomaly among the North Indian population. The most common place of occurrence is the lambdoid suture. Awareness of these differences is imperative for proper interpretation of radiological data, forensic identification, and risk-free neurosurgical methods.

**Keywords:** Wormian bones, Sutural bones, Lambdoid suture, Skull morphology, Anatomical variations, Supernumerary ossicles.

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## Introduction

Wormian bones, which are also referred to as sutural bones and supernumerary bones, are additional types of skeletal bones that grow in sutures and fontanelles in the cranial and chest.[1] These anatomical structures were named after the Danish anatomist Ole Worm, who first described them in detail in the seventeenth century.[2] During embryologic development, Wormian bones form from independent ossification centers, distinct from the main ossification centers of the cranial bones, which are formed by ossification centers in the sutural connective tissue.[3]

The Wormian bones are thought to form due to multifactorial etiologies involving genetic determinants, cranial developmental stress, metabolic disorders, and other pathological conditions.[4] These ossicles have been linked to many clinical disorders, which include osteogenesis imperfecta, cleidocranial dysostosis, hydrocephalus, hypothyroidism, and rickets.[5] In addition, a higher occurrence of Wormian bones has also been reported in intentional cranial deformation cases and craniosynostosis.[6]

The clinical implications of Wormian bones span a variety of fields of medicine. These bones are useful indicators of population and of individual characterization in forensic anthropology.[7] Wormian bones radiographically can be confused with skull fractures, and this could result in clinical confusion, misdiagnosis, and subsequent poor clinical treatment.[8] To prevent complications during craniotomies and other intracranial operations, neurosurgeons should be mentally prepared to learn these anatomical variations in detail.[9]

Earlier studies have shown significant differences in the population-based incidence and distribution patterns of Wormian bones. Research conducted in other geographical settings has also reported prevalence rates of 8%-80%.[10] Studies by Cirpan et al. reported an incidence of 53.4% in Turkish skulls,[11]

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whereas Natsis et al. reported 51.5% in Greek skulls.[12] Indian studies have yielded mixed results, with incidence rates ranging from 32% to 68% across diverse areas.[13]

Although a lot of literature has been written about the Wormian bones, there is a lack of thorough morphological information on the population of North Indians, especially of the Uttar Pradesh region. This type of regional anatomy data is necessary to define local population-specific baseline parameters and to support clinical practice in the local healthcare environment.

The current research project was conducted to identify the incidence, morphology, and topography of Wormian bones in the skulls of a North Indian population. The specific objectives included: (1) establishing the percentage of skulls demonstrating Wormian bones, (2) determining the incidence of Wormian bones with respect to specific cranial sutures, and (3) analysing the topographic distribution patterns of these accessory ossicles.

## Materials and Methods

**Study Design and Setting:** This cross-sectional observational study was conducted at the Department of Anatomy, Motilal Nehru Medical College, Prayagraj, Uttar Pradesh, India, and the Department of Anatomy, Rajshree Medical College, Rajshree Medical and Research Institute, Bareilly, Uttar Pradesh. The study was conducted over 8 months, from February 2024 to September 2024.

**Sample Selection:** A total of 140 dry human skulls of unknown sex and age, preserved in the departmental osteology museum, were included in this investigation. All skulls were of Indian origin and had been procured through legitimate anatomical donations over the preceding decades.

**Inclusion Criteria:** Skulls that were intact, complete, and demonstrated clearly visible suture lines were included in the study. Only adult skulls with evidence of complete sutural development were considered for analysis.

**Exclusion Criteria**

The following characteristics were excluded when it came to the skulls: (1) evidence of trauma or fractures, (2) pathological deformity or abnormal shape, (3) incomplete or fragmented skull, (4) damaged or obliterated suture lines, and (5) gross abnormality of the anatomy.

**Examination Procedure:** One by one, the skulls were carefully analyzed in sufficient natural and artificial light. The cranial vault was inspected externally and systematically for the presence of Wormian bones. In particular, sutures and areas were assessed as follows:

**Lambdoid suture (bilateral)**

1. Coronal suture (bilateral)
2. Sagittal suture
3. Squamous suture (bilateral)
4. Parieto-mastoid suture (bilateral)
5. Occipito-mastoid suture (bilateral)
6. Lambda region
7. Asterion (bilateral)
8. Pterion (bilateral)
9. Bregma region

**Parameters Evaluated**

**The following parameters were recorded for each skull:**

- Presence or absence of Wormian bones
- Total number of Wormian bones
- Location with respect to specific sutures
- Topographic distribution (unilateral/bilateral)
- General morphological characteristics (shape and size)

**Measurement Techniques**

The measurements were all taken using standard anthropometric instruments, including digital vernier calipers (accuracy: 0.01 mm), a measuring tape, and a compass divider. The size of the Wormian bones above was recorded where possible.

**Data Gathering and Data interpretation.**

All the observations were arranged methodically in a pre-designed pro forma. The data were keyed into Microsoft Excel 2019 and then analyzed using IBM SPSS Statistics version 26.0 (IBM Corporation, Armonk, NY, USA). All descriptive statistics were presented as frequencies, percentages, means, standard deviations (SDs), and ranges. Chi-square tests were used in which categorical variables were to be related. A value of 0.05 or less was taken to be statistically significant.

## Results

There is an average of 1.85 total Wormian bones per skeletal frame. <|human|>Mean Total Wormian Bones per skeletal frame. Of 140 human skulls found to be dry, 47 had Wormian bones, giving an incidence rate of 33.57. The rest (93 out of 100) of the skulls (66.43) showed no sign of Wormian bones. 110 individual Wormian bones were identified across the 47 positive skulls, with a mean of 2.34 + 1.56 per affected skull (range: 1 to 8).

The Distribution Based on the Number of Wormian Bones.

One single Wormian bone was found in 19 skulls (40.43% of positive skulls), whereas more than one was found in 28 skulls (59.57%). The most common multiple bones on skulls were the Wormian bones (n= 11, 23.40 percent) and the number of bones (n= 8, 17.02 percent). [Table 1] gives the distribution's finer details.

**Table 1: Distribution of Skulls According to Number of Wormian Bones Present**

| Number of Wormian Bones | Number of Skulls (n) | Percentage (%) | Cumulative Percentage (%) |
|---|---|---|---|
| 0 | 93 | 66.43 | 66.43 |
| 1 | 19 | 13.57 | 80.00 |
| 2 | 11 | 7.86 | 87.86 |
| 3 | 8 | 5.71 | 93.57 |
| 4 | 4 | 2.86 | 96.43 |
| 5 | 2 | 1.43 | 97.86 |
| 6 | 2 | 1.43 | 99.29 |
| 8 | 1 | 0.71 | 100.00 |
| Total | 140 | 100.00 | - |

Mean ± SD: 2.34 ± 1.56 (for positive skulls); Range: 1–8.

The Wormian Bones and Their Incidence in Relation to the Sutures.

The lambdoid suture had the greatest number of Wormian bones, with 49 (44.55% of all Wormian bones) and 21 skulls (44.68% of positive skulls). Wormian bones were present in the coronal suture (12.73% or 14) and the sagittal suture (10, 9.09%). Lower frequencies were observed at the parietomastoid and squamous sutures. The statistical result showed that the lambdoid suture had a significant association with Wormian bone occurrence ($\chi^2 = 32.45$, $p = 0.001$). Table 2 gives the entire suture-wise distribution.

**Table 2: Distribution of Wormian Bones According to Cranial Sutures**

| Suture/Location | Number of WBs (n) | Percentage of Total WBs (%) | Number of Skulls Affected | Percentage of Positive Skulls (%) | p-value |
|---|---|---|---|---|---|
| Lambdoid suture | 49 | 44.55 | 21 | 44.68 | <0.001* |
| Coronal suture | 14 | 12.73 | 9 | 19.15 | 0.082 |
| Sagittal suture | 10 | 9.09 | 7 | 14.89 | 0.156 |
| Parietomastoid suture | 16 | 14.55 | 8 | 17.02 | 0.198 |
| Squamous suture | 12 | 10.91 | 6 | 12.77 | 0.267 |
| Occipitomastoid suture | 9 | 8.18 | 5 | 10.64 | 0.324 |
| Total | 110 | 100.00 | - | - | - |

* Statistically significant ($p < 0.05$); WBs: Wormian Bones; Chi-square test applied

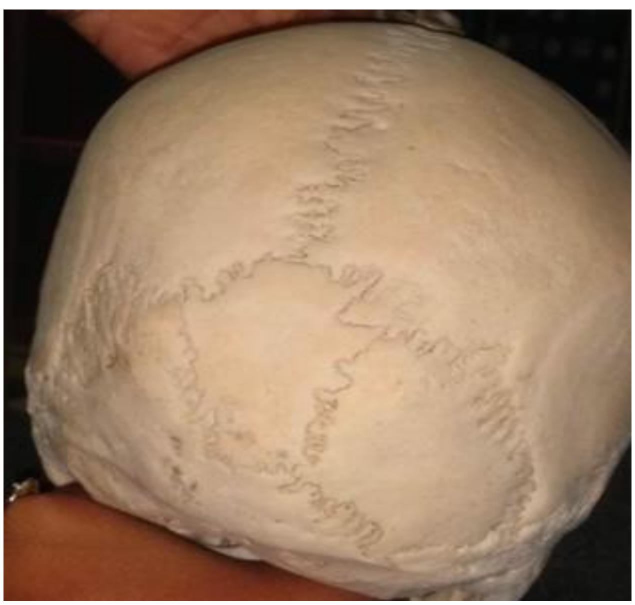
**Wormian bone Topography Distribution.**

Topographic distribution analysis indicated that the area of greatest concentration of Wormian bones was the lambda region, which showed 32 ossicles (29.09) at or immediately adjacent to this region. The most common location was the second (asterion, 18.18%), followed by the third (mid-lambdoid region, 17.27%). The bregma and pterion areas recorded the lowest incidence. Bilateral distribution was observed in 21 skulls (44.68% of positive skulls), and unilateral distribution was observed in 26 skulls (55.32%). The descriptive topographic distribution is delivered in [Table 3].

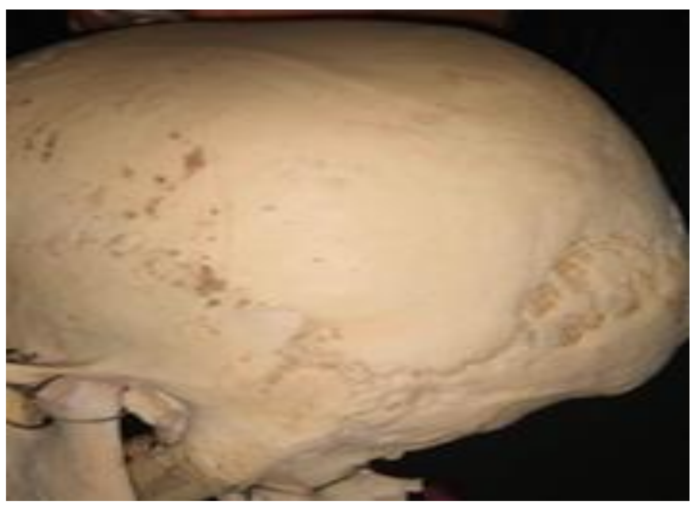
**Table 3: Topographic Distribution of Wormian Bones in the Skull**

| Anatomical Location | Number of WBs (n) | Percentage (%) | Unilateral (n) | Bilateral (n) |
|---|---|---|---|---|
| Lambda region | 32 | 29.09 | - | - |
| Asterion | 20 | 18.18 | 8 | 6 |
| Mid-lambdoid region | 19 | 17.27 | 10 | 4 |
| Lateral lambdoid region | 15 | 13.64 | 7 | 4 |
| Coronal suture region | 12 | 10.91 | 8 | 2 |
| Pterion | 7 | 6.36 | 5 | 1 |
| Bregma region | 3 | 2.73 | 2 | - |
| Sagittal region | 2 | 1.82 | 2 | - |
| Total | 110 | 100.00 | - | - |

WBs: Wormian Bone



Two sutural wormian bones between parietal and occipital bone.



Sutural wormian bone between sutures of parietal and occipital bone on right side of skull

**Morphological Characteristics**

The Wormian bones found in this research paper exhibited different morphological features. Irregular were the most commonly used shapes (42.73%), quadrilateral (26.36%), triangular (18.18%), and polygonal (12.73%). These were minute ossicles that were less than 5 mm in size to the giant bones that were more than 30 mm. A single head exhibited an eminent Inca bone (OsIncae used at the lambda) of size 38 x 35 mm.

## Discussion

The current study provides detailed morphological information on Wormian bones in human dry skulls from the North Indian community. The total 33.57% incidence reported in this study is consistent with past statistics from different geographical areas, though population fluctuations are extensive.

Our study has reported prevalence rates similar to those reported by Murlimanju et al., who reported an incidence rate of 34.6 in South Indian skulls.[14] On the same note, Gopinathan et al. reported a 32.4% prevalence in their study of cadaveric skulls from Central India.[15] Nonetheless, our results are lower than those of other populations. The prevalence in Greek skulls was 51.5%, as reported by Natsis et al,[12] whereas the prevalence in Turkish specimens was 53.4%.[11] Such differences could be explained by genetic, environmental, and methodological variations in defining and identifying Wormian bones.

The fact that the Wormian bones along the lambdoid suture are dominant in 44.68% of positive skulls, which is in line with the results of many previous studies, supports this. Himabindu et al. described a similar incidence, with 1/3 of the lambdoid suture involved,[16] and other Indian studies have reported the same incidence at the same site.[17] It is unclear why the incidence of Wormian bones is relatively high in the lambdoid suture, but this may be explained by the fact that, during cranial development, more complex biomechanical forces are exerted on this region. The comparative complexity of the suture in this area is relatively higher.

The most frequent topographic position of the Wormian bones was the lambda area (29.09%), which is also congruent with Praba and Venkatramaniah.[18] The os lambda in a massive form, labeled OsIncae or Inca bone, is a well-known anatomical variant that has been attributed to some ethnic groups.[19] The anatomical variant, classified as a single bone in our study (a bone of the Inca is 38-35 mm), represents considerable variation in the bones. Clinicians must not mistakenly interpret it.

The second most frequently used site (18.18%), the asterion, is clinically of particular importance because it serves as a surgical landmark for posterior fossa approaches.[20] Wormian bones at this site can also distort the relationship between surface features and underlying venous sinuses, thereby increasing the risk of surgery. Neurosurgeons should note this anatomical difference during surgical planning.

The finding of several Wormian bones in 59.57% of positive skulls, indicating a mean of 2.34 bones per affected skull, suggests that the developmental processes that cause the formation of Wormian bones could result in more than a single anomaly. This observation confirms the hypothesis that some individuals may have a genetic or developmental tendency toward sutural ossicles.[21]

The morphological complexity of Wormian bones, ranging from small ossicles to large interparietal bones, indicates the fluctuating nature of their developmental histories. The abnormal forms that are dominant in our sample (42.73%) support this assumption, as they are formed by accessory ossification centers in the sutural connective tissue.[22]

Clinically, the results of this research can be applied in several ways. Radiologically, the radiograph of the skull and CT scans require that the patterns of Wormian bones and their prevalence be considered in proper interpretation to exclude the possibility of fracture misdiagnosis.[23] The Wormian bones can serve as additional identity markers for the person, especially when this analysis is conducted alongside other bone features in the context of forensic practice.[24]

Some shortcomings of this research should be mentioned. It was not possible to determine the sex and age of the specimens, and to exclude the study of demographic associations. The sample was also based on one geographical area, and one would not be able to generalize to the rest of the population. Further research using a larger sample population, demographic analysis, and genetic analysis would be insightful regarding the etiology and population-specific features of Wormian bones.

## Conclusion

The present morphological analysis indicates that Wormian bones are fairly common morphological variants among the North Indian population, with an incidence of 33.57. These accessory Bones are found most commonly at the lambdoid suture and next commonly in the coronal suture, then the sagittal suture. The topographic concentration of Wormian bones is the greatest in the lambda region, and another important location is the asterion. Wormian bones are more often found in multiples than in isolation. The results play an important role in the anatomical records of the population of North India and hold a great clinical value in radiological interpretation, forensic identification, and neurosurgical planning. Awareness of such common variants is important for avoiding diagnostic errors and ensuring safe operating practices for clinicians and anatomists.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### Conflicts of interest

There are no conflicts of interest.


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