# The Presence of a Persistent Mendosal Suture in an Ancient Adult Human Cranium from India

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## Abstract

The presence of mendosal sutures is mostly known from fetuses, neonates, and infants and is discussed in medical circles as an osteological condition. However, its presence in an adult human skull, in the archaeological context, has been rarely reported. Here, we report the discovery of a vivid, well-defined persistent mendosal suture in a middle-aged male human cranium excavated from the site of Kumhar Tekri in central India. The site dates from the third and second centuries BCE and was largely a burial mound consisting of skeletal remains and other grave goods. The left side of the cranium was largely missing and has since been reconstructed. The mendosal suture appears to be present above the superior nuchal line, originates above the asterion on both sides, and traverses across the occiput, thus creating a distinct and large mendosal bone between it and the lambdoidal suture. There appear to be no major morphological changes to the cranium due to the presence of the mendosal suture, except for a small curvature of the occiput. This finding is significant as no such case of a mendosal suture is unprecedented in archaeological and paleopathological research. Similarly, a persistent mendosal suture may be used in forensic identification and age estimation. Further research on such cranial sutures is vital.

## Keywords

Accessory occipital suture, India, human cranium, Inca bone, mendosal bone, mendosal suture

## Introduction

The "mendosal suture" is defined as "an accessory suture of the occipital bone which is situated somewhat superior to the transverse sinus" (Lang, 1983). Also

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known as the "accessory occipital suture," it runs inferiomedially to the lambdoidal suture, on the occipital bone, transversely. It originates from the asterion at either end but can also originate from above and below it (Gayretli et al., 2011). The mendosal suture begins fusing before the birth of an infant, completely fuses in utero (Nayak et al., 2007), or may be present at birth. If present at birth, it eventually completely fuses between the ages of 2–4 years (Mann et al., 1986). In some cases, neonates may be misdiagnosed with a cranial fracture when their mendosal suture is misidentified. Care must be taken to prevent such incidents (Miller et al., 2010). Others believe that it may fuse during childhood, up to the age of 10 years (Lang, 1983), and can even occur into early adulthood, up to 20 years (Pawlik, 1956)—a rare phenomenon (Nayak et al., 2007; Tubbs et al., 2007). Such a condition is known as "persistent mendosal suture." Given the relative consistency of the occurrence of mendosal sutures (of various degrees) relative to age, the suture may also be utilized in forensic sciences for age estimation of the remains of an individual.

During the development of the cranial bones, the transverse occipital fissure lies between the interparietal portion and the supraoccipital bones of the developing occipital bone. This fissure becomes the mendosal suture. The mendosal suture separates the inferior portion of the occipital bone from the interparietal portion (Smith et al., 2017). In the case of a prominent persistent mendosal suture, a large sutural bone can form between the mendosal suture and the lambdoidal suture (Lang, 1983). This prominent bone in an adult can be termed the "mendosal bone" from the Latin *mendosus*, meaning "faulty" or "incorrect" (Escandon et al., 2022). It has been a matter of debate whether the occurrence of the mendosal bone is the same as an *Os Incae* (Inca bones). Inca bones of the occiput are additional cranial bones that form on the occiput due to the formation of additional occipital accessory sutures. They were first described in the nineteenth century among Peruvian crania (Hanihara & Ishida, 2001), hence the name. Back then, they were dubbed as "Os interparietale" or "interparietal bones" (Le Double, 1903). This debate has been elaborated upon, in the context of KT-16, in the section "Discussion."

The presence of a mendosal suture has been associated with some physiological conditions such as bathrocephaly (Davanzo et al., 2014; Gallagher et al., 2013; Smith et al., 2017), in which there is a prominent and benign bulge at the occiput. However, the occurrence of a mendosal suture does not seem to be associated with any kind of craniomorphological anomaly at an age beyond infancy. Cases exhibiting mendosal sutures at an advanced age do not present any alarming consequences.

## Materials and Methods

Research on the mendosal suture is rare due to the rarity of the incidence of this morphological feature itself. This study deals with the presence of a prominent and persistent mendosal suture in an adult human cranium from an ancient site in India. The cranium has preserved the entirety of the mendosal suture and the

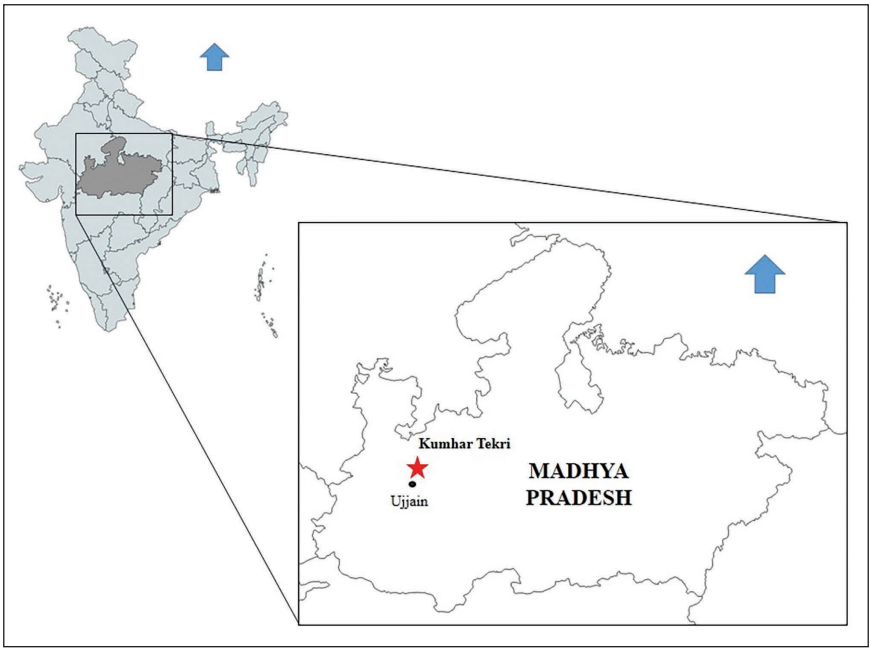


**Figure 1.** Geographic Location of the Site of Kumhar Tekri in Madhya Pradesh, India.

mendosal bone. The authors came across the specimen while observing the skeletal remains kept at the Ancient Human Skeletal Repository at the Head Office of the Anthropological Survey of India.

The specimen "KT-16" is a partial human cranium from the site of Kumhar Tekri (lit. Potter's Hill), also known as Kumbhar Tekri (23° 12′ 53″ N and 75° 49′ 48″ E) in the Indian state of Madhya Pradesh (Figure 1). The site was an ancient mound, which was excavated by the Department of Archaeology of the former state of Gwalior in 1939. It is located around 9 km northeast of the modern city of Ujjain. The site was named so after the abundant pottery discovered dating from the period of the Mauryan Empire there (Sarkar, 2005).

The cranium used in this study belonged to one of the 42 burials discovered from the ancient mound. The skeletal remains were given to the Anthropological Survey of India in 1945 and presently are a part of the organization's Ancient Human Skeletal Repository. Radiometric and relative dating dated the site to around the third and second centuries BCE (Sarkar, 2005). The studied cranium belonged to a male aged around 40–45 years at the time of death (Gupta & Basu, 1970).

The cranium, when discovered, was partial. The lower end of the right maxilla and the majority of the left side of the cranium were missing, which were reconstructed later (Figures 2 and 3). The necessary measurements of the cranium were taken using a sliding caliper and a spreading caliper and measured in centimeters (cm).


**Figure 2.** Norma Frontalis of KT-16.

**Note:** The Left Side of the Cranium is Partially Reconstructed.

As this study deals with the occurrence of a persistent mendosal suture and various measurements involving it, the authors have defined two new cranial landmarks for easier explanation (Table 1).

For analysis, the symbols A–G have been used for the various landmarks on the occiput to ensure clarity of the measurements taken and the calculations conducted (Table 2).

## Results

The maximum cranial length (*g-op*) of the cranium is 17.9 cm, with its maximum cranial breadth (*eu-eu*) estimated to be 13.4 cm. This shows that the cranium is dolichocephalic. The maximum cranial height is 12.5 cm (*b-ba*). The norma occipitalis (Figure 3) exhibits a prominent mendosal suture running across the mid-sagittal plane, bisecting the posterior cranium into a distinct superior mendosal bone and an inferior occipital portion.

The sutures of the skull are very prominent and distinct, including the mendosal suture. In Figure 3, the suture EBF is the mendosal suture, while the suture

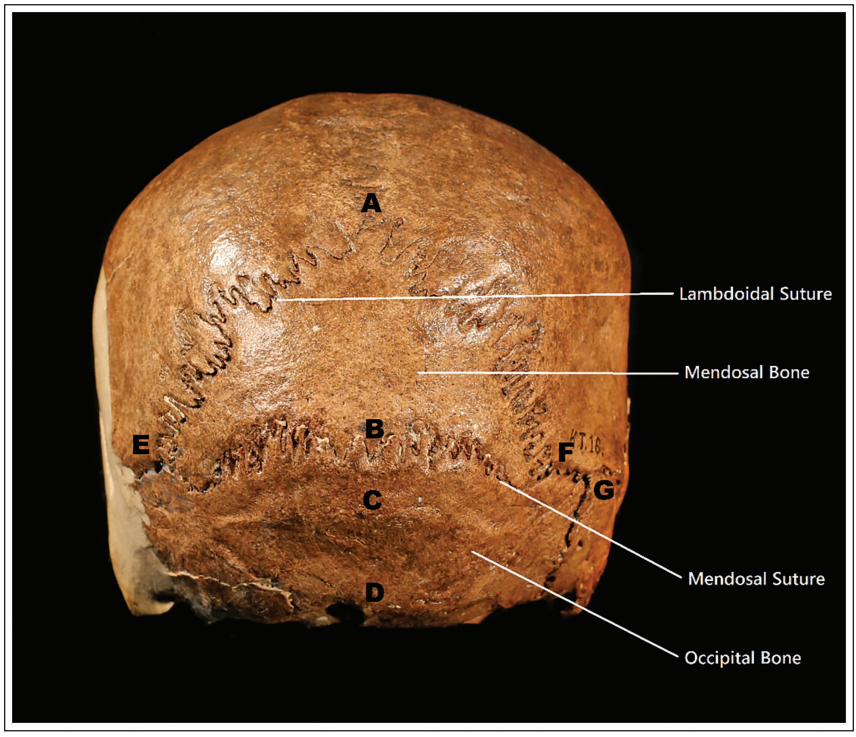


**Figure 3.** Norma Occipitalis of KT-16.

**Note:** Lambda (A), Mendion (B), Inion (C), Mid-point of Inferior Nuchal Line (D), Left Mendosion (E), Right Mendosion (F), and Right Asterion (G) are Visible, Along With Other Key Features.

**Table 1.** New Cranial Landmarks Involving the Mendosal Suture (as Defined by the Authors).

| Name of the Landmark | Abbreviation | Definition |
|---|---|---|
| Mendosion | *mds* | The point on the left and/or right side of the cranium from where the mendosal suture originates just above or below the asterion (*ast*). If the mendosal suture originates at the *ast*, then the *mds* and *ast* are at the same point. |
| Mendion | *mdn* | The point where the mendosal suture passes through the mid-sagittal plane. |

EAF is the lambdoidal suture. The mendosal suture runs across the entirety of the posterior portion of the neurocranium without any interruption. It has a distinct raised area surrounding it, almost appearing like an occipital protuberance (X), as seen in Figure 4. This protuberance lies superior to the superior nuchal line and appears to have been caused due to the presence of the mendosal suture. A similar case of an enlarged occipital protuberance, in an infant skull, was reported by

**Table 2.** Symbols for Various Landmarks Used for This Study.

| Name of the Landmark | Abbreviation | Symbol Used |
|---|---|---|
| Lambda | *l* | A |
| Mendion | *mdn* | B |
| Inion | *i* | C |
| Midpoint on the inferior nuchal line | – | D |
| Mendosion (left) | *mds* | E |
| Mendosion (right) | *mds* | F |
| Right asterion | *ast* | G |

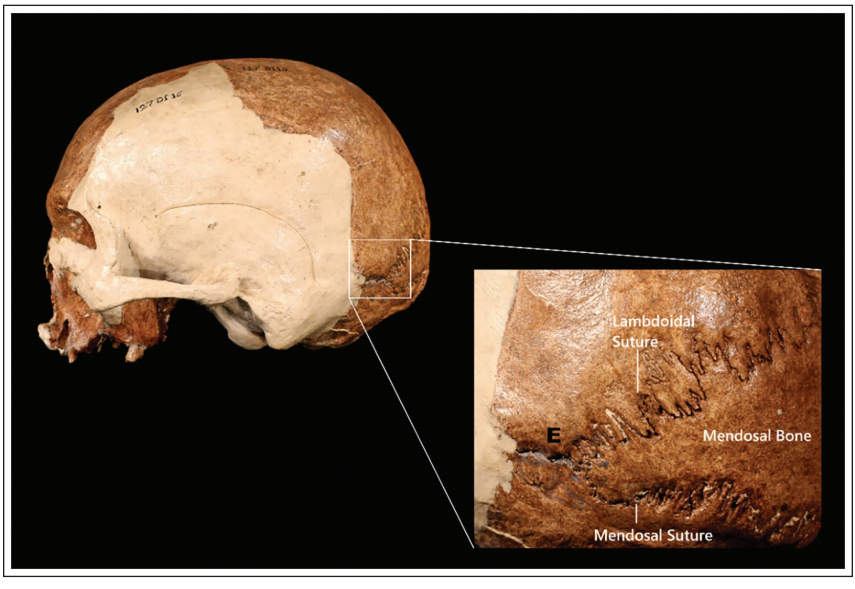


**Figure 4.** Norma Lateralis of the Left-hand Side of KT-16 Showing the Left Mendosion (E) Originating Above the Missing Asterion

Gallagher et al. (2013). But that study was aimed at researching the correlation between mendosal sutures and the condition of bathrocephaly. However, the presence of the mendosal suture does not seem to have caused any osteological anomalies in the crania used in our present study. On the right-hand side, the mendosal suture begins from the F located above G (Figure 4). E is prominently visible on the left-hand side as well, but the *ast* is absent on this side given that it laid in the reconstructed part (Figure 5). So, it may be deduced that the mendosal suture begins above the *ast* on the left side also.

The length of the mendosal suture on the right-hand (FB) side is 5.0 cm and 5.1 cm on the left-hand side (EB), thus giving a total length (EF) of the mendosal suture as 10.1 cm (Figure 3). The distance of *ast-mds* (GF) on the right side is 1.7 cm (Figure 3). But as the *ast* is missing on the left side, the same measurement

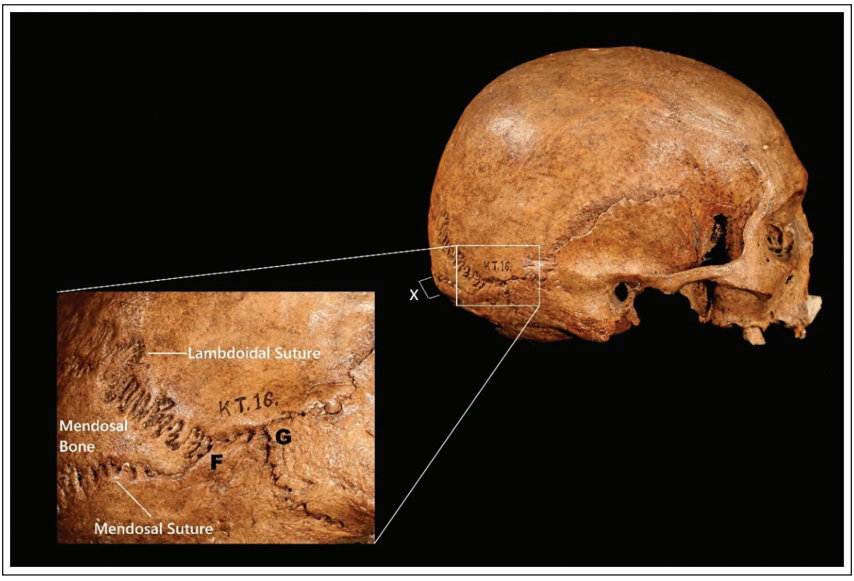


**Figure 5.** Norma Lateralis of the Right-hand Side of KT-16.

**Notes:** The Right Mendosion (F) Lies Above the Right Asterion (G). An Occipital Protuberance (X) Can Be Observed Around the Mendosal Suture.

could not be taken. The length of the lambdoidal suture from the right *mds* (F) to the left *mds* (E), via the *l* (A), is 16.9 cm, where FA is 6.9 cm and EA is 7.0 cm. As the left *ast* is missing, the total length of the lambdoidal suture from *ast-ast* could not be measured. The linear length of *l-mdn* (AB), along the mid-sagittal plane, is 5.1 cm.

Thus, the mendosal bone of AEBF is a concave quadrilateral, which can be considered to be made of two scalene triangles ΔAFB (right) and ΔAEG (left) sharing the common AB as an internal diagonal of the concave quadrilateral. The area of such a scalene triangle can be calculated by Heron's formula, that is, $\sqrt[2]{S(S-x)(S-y)(S-z)}$, where $S = (x + y + z)/2$. "$S$" is the semi-perimeter of the triangle, and "$x$," "$y$," and "$z$" are the lengths of the sides of the triangle. Therefore, the area of ΔAFB (right) is 12.72 $cm^2$ and of ΔAEG (left) is 12.98 $cm^2$, respectively, giving the total area of the mendosal bone (or the concave quadrilateral) as 25.70 $cm^2$.

The *mdn* lies 1.5 cm above the *i* (BC = 1.5 cm) and 4.8 cm above the midpoint on the inferior nuchal line (BD = 4.8 cm). Therefore, the mendosal suture does not run along the superior nuchal line and the eternal occipital protuberance but lies above it.

## Discussion

Though the presence of the mendosal suture has previously been associated with bathrocephaly, KT-16 does not bear any such evidence. Even if the individual had

any physiological conditions because of the presence of the mendosal suture, they are indeterminable. Overall, the cranium appears unremarkable, with the mendosal suture being its highlighting feature. This point had also been noted by Gupta and Basu (1970, p. 41), who stated that "The occiput is rounded and the presence of the biparietal bone is noteworthy," and they made no further comments on it. The identification of the mendosal bone as a "biparietal bone" was incorrect as the bone clearly lies inferior to the lambdoidal suture. Gupta and Basu (1970) missed the significance of the feature owing to the paucity of research on the mendosal suture in the 1960s.

According to Williams et al. (1995), Inca bones occur between lambdoidal and mendosal sutures (Cirpan et al., 2014). This makes the "mendosal bone" a type of "Inca bone." The mendosal suture or accessory occipital suture can enclose this particular kind of *Os Incae* (Inca bone) referred to as an *Os Incae Totum* (complete undivided Inca bone) (Hanihara & Ishida, 2001). It is characterized by the large bone enclosed between the lambdoidal and mendosal sutures, with the bone being triangular or quadrilateral in shape, based on the pattern and symmetry of the mendosal suture. If the mendosal suture is transverse and more or less horizontal, then it forms the base of the triangular shape and the lambdoidal suture forms its arms. If the mendosal suture meets upward at the sagittal plane, then the shape of the enclosed bone is that of a concave quadrilateral (arrowhead). On the other hand, if the mendosal suture meets downward at the sagittal plane, then the enclosed bone is convex quadrilateral (diamond) in shape. In the case of KT-16, it is the former case of a concave, quadrilateral-shaped mendosal bone, as illustrated in Figure 3 and in the section "Results."

It is evident that the presence of the persistent mendosal suture is a unique feature for an individual to have. In forensic anthropology, such unique osteological features are used to identify individuals from their skeletal remains. A feature such as a persistent mendosal suture may also be utilized in this regard. Cranial sutures are known to be a key marker for identifying individuals from their cranial remains (Sekharan, 1985, 1989). If the antemortem cranial suture records of an individual are known, they may be compared with the post-mortem remains in question in order to identify an individual. However, care must be taken while comparing and matching the sutural morphology. The uniqueness and rarity of the occurrence of such a mendosal suture should not be taken for granted. Detailed observation of the mendosal suture must be undertaken to confirm the identity of the individual, with other cranial features corroborating the identity. It is crucial to possess antemortem radiological records of an individual's cranial morphology recording the sutures accurately. But such records are rare, which can be a hindrance in such a method of identification. On the other hand, the persistent mendosal suture is seen in adults of an advanced age beyond their 20s (as elaborated upon in the section "Introduction"), and cranial sutural morphology can change extensively in subadults and preadolescents (Jayaprakash & Srinivasan, 2013). Therefore, its usage in the identification of individuals is encouraged only among adults.

Most of the research on mendosal sutures has been conducted on living individuals (especially neonates and infants) using radiographic techniques. Analyses on dry crania are rare, and in such cases, most of the occurrences of the mendosal suture have been of a faint appearance, of lesser length, and do not appear to traverse the entirety of the occiput. In this regard, KT-16 appears to be unique in presenting such a clinical case of an adult middle-aged individual. As it is a dry skull, the measurements were taken and evaluated manually, as related mechanical instruments were at hand. Analyzing KT-16 using 3D imaging will enhance the quality of such a study and will provide more accurate results.

## Conclusion

The presence of a mendosal suture with a distinct mendosal bone in a middle-aged adult is a rare phenomenon. Scientific literature on mendosal sutures is rather limited due to the rarity of such cases. Ideally, the mendosal suture of KT-16 should have fused much earlier in life, but it did not due to unknown reasons. *Os Incae* have been reported to be genetically hereditary and have higher incidences among communities with late-Pleistocene East Asian ancestry (East Asians, Southeast Asians, Northeast Indians, and Native Americans) and among sub-Saharan Africans (Hanihara & Ishida, 2001). Whether the occurrence of the mendosal suture and the mendosal bone in KT-16 was due to genetics or whether the individual was related to the aforementioned populations cannot be ascertained. But it is certain that the cranium KT-16, from the ancient Iron Age site of Kumhar Tekri, is a significant and important specimen in the archaeological and paleopathological context of India and also highlights the possible usage of such a unique feature in forensic identification of an individual adult.

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