Granular Foveolae in the Groove of the Sigmoid Sinus: Anatomical Study

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Abstract

Granular foveolae in the groove of the sigmoid sinus have rarely been reported in the literature compared to numerous published reports on the granular foveolae near the superior sagittal sinus and its sulcus on the internal aspect of the calvaria. The present study was performed to better elucidate their prevalence and locations. One hundred and ten adult dry skulls (220 sides) were analyzed for the presence of granular foveolae within the groove of the sigmoid sinus. The exact position of the foveolae was documented and the diameter of the granular foveola were measured. Granular foveolae were found in the groove of the sigmoid sinus on 3.6% of sides. These were at or within a mean of 1.3 cm inferior to the transverse-sigmoid junction. When a mastoid foramen was noted in the groove, it was always located more inferior to the granular foveolae when present. The mean diameters of the granular foveolae of the left groove of the sigmoid sinus was 2.8 mm and 4 mm for right grooves. The mean depth of the granular foveolae of the left groove of the sigmoid sinus was 2.7 mm and 3.5 mm for right grooves. Granular foveolae were statistically larger and deeper on right versus left sides (p < 0.05). Granular foveolae of the groove of the sigmoid sinus were identified most commonly on right sides and on 3.6% of all sides. If identified on medical imaging, these uncommon structures at the skull base should be considered normal anatomical variations.

Introduction

Of the intracranial dural venous sinuses, the sigmoid sinus is continuous with the transverse sinus once the transverse sinus leaves the attached edge of the tentorium cerebelli. The grooves of the transverse and sigmoid sinuses of the cranium are indentations created by the dural venous sinuses of the same name [1]. The attached edges of the tentorium cerebelli anchor onto the banks of the grooves of the transverse sinus which are embedded within the occipital bone. The groove of the sigmoid sinus is a continuation of the groove of the transverse sinus traveling inferiorly in the temporal bone toward the jugular foramen.

Granular foveolae (arachnoid foveolae) are bony depressions or pits near these sulci created by adjacent arachnoid granulations [2]. While these granulations are not present at birth, they are grossly identifiable by around 18 months in humans [2]. These arachnoid granulations of the posterior cranial fossa must be differentiated from meningoceles, cavernous hemangiomas, dural venous sinus thrombosis, and meningiomas [3, 4].

The foveolae created by these arachnoid granulations are commonly associated with and seen near the lacunae laterales along the superior sagittal sinus (Fig. 1) in the frontoparietal region and these have been studied in the past [2, 3]. What is less well known and documented is the occurrence of these bony granular foveolae adjacent to the grooves of the transverse and sigmoid sinuses. Although it is well known that arachnoid granulations can occasionally be found in the region of the transverse and sigmoid venous sinuses, the presence of the resulting bony granular foveolae in the same area adjacent to the groove for the sigmoid sinus is what this study aims to demonstrate. It is important to clarify the
existence of these granular foveolae in this region so as not to confuse these structures with pathology or emissary vein foramina in the same region.

**Materials And Methods**

One hundred and ten dry skulls (220 sides) from adult human specimens were analyzed for the presence of granular foveolae within the groove of the sigmoid sinus. The specimens were derived from the osteological collection of our university. The exact age and sex of the specimens were not known. When magnification was necessary, a surgical microscope was used (Zeiss, Germany). The exact position of the granular foveolae was documented. The diameter and depth of the granular foveolae were measured using microcalipers (Mitutoyo, Kawasaki, Japan). Morphometric data were compared based on side. Descriptive and inferential statistics were calculated with statistical significance set at $p < 0.05$. The authors state that every effort was made to follow all local and international ethical guidelines and laws that pertain to the use of human cadaveric donors in anatomical research [5].

**Results**

Granular foveolae were found in the groove of the sigmoid sinus on eight out of 220 sides (3.6%) (Figs. 2–4). Granular foveolea were found on two left sides (0.9%) and six right sides (2.7%). All granular foveola were located in the groove and not in the adjacent bone. There was never more than one fovelola in these grooves. Granular foveolae of the groove for the sigmoid sinus were most often located in its superior part near the junction with the groove for the transverse sinus (Fig. 2). These were at or within a mean of 1.3 cm (range 0.7–1.46 cm) inferior to this junction. When a mastoid foramen was noted in the groove of the sigmoid sinus, it was always located more inferior to the granular foveolae when present. Granular foveolae of the groove of the sigmoid sinus were most often located on right sides ($n = 6; p < 0.05$). The diameters of the granular foveolae of the left groove of the sigmoid sinus ranged from 2.4–3.3 mm (mean 2.8 mm) and for right groove of the sigmoid sinus ranged from 2.5–4.2 mm (mean 4 mm). The depth (Fig. 1) of the granular foveolae of the left groove of the sigmoid sinus ranged from 2.5–3.1 mm (mean 2.7 mm) and for right groove of the sigmoid sinus ranged from 3.1–3.9 mm (mean 3.5 mm). Granular foveolae were statistically larger and deeper for right versus left sides ($p < 0.05$).

**Discussion**

We identified granular foveolae in 3.6% of the grooves of the sigmoid sinus. These were statistically more common on right sides. The existence of granular foveolae adjacent to the groove of the sigmoid sinus is important to highlight as these foveolae can be mistaken on imaging for pathological structures such as osteolytic lesions, mastoid air cells, thrombus, or emissary vein foramina e.g., mastoid foramen [6–8]. Moreover, some have mapped out these structures along the inner side of the calvaria in order to avoid their injury during craniofacial reconstruction procedures [4].
Tsutsumi et al. [7] evaluated 102 patients with MRI and found arachnoid granulations in the transverse sinus in 41 (40.2% of right sides and 37.3% of left sides). Of these, the majority were located in the sinuses middle and lateral thirds. In the sigmoid sinus, these authors found arachnoid granulations in 18 patients (17.6%) on the right and in 19 patients (18.6%) on the left. In 32 patients, using CT and MRI to evaluate arachnoid granulations in the venous sinuses of the posterior cranial fossa, Roche and Warner [3] found that the most common location of the arachnoid granulations in the transverse sinus was its middle third followed by its lateral third. These authors also found three granulations in the superior portion of the sigmoid sinus and one in its middle portion. Of all granulations, only one showed signs of 'bone remodeling' of the inner table of the skull. Therefore, these data suggest that granular foveolae are much less common than the number of arachnoid granulations of the posterior cranial fossa in any given patient.

**Conclusions**

Granular foveolae of the groove of the sigmoid sinus have rarely been reported in the literature compared to numerous published reports on the granular foveolae near the superior sagittal sinus and its sulcus on the internal aspect of the calvaria. These were identified most commonly on right sides and on 3.6% of all sides. If identified on medical imaging, these uncommon structures at the skull base should be considered normal anatomical variations.

**Declarations**

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**Ethics approval** As our study used cadavers, our institution does not require an Institutional Review Board approval and is, thus, exempt.

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References


Figures
Figure 1

Internal surface of the removed calvaria demonstrating two granular foveola adjacent to the sulcus for the superior sagittal suture.
Figure 2

Right-sided groove for the sigmoid sinus with a granular foveola (arrow).
Figure 3

Right-sided granular foveola (probe) just inferior to the transverse-sigmoid junction.
Figure 4

Right-sided granular foveola (arrow) distal to the transverse-sigmoid junction.