Calcification and ossification of the convexity of the falx cerebri and related subdural space in human cadavers

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ABSTRACT

Objectives: The present work was planned to report the incidence of calcification and ossification of an isolated cranial dural fold. The form, degree of severity and range of extension of such changes will be described. Involvement of the neighboring brain tissue and blood vessels, whether meningeal or cerebral, will also be determined. The results of this study might highlight the occasional incidence of intracranial calcification and ossification in images of the head and their interpretation, by radiologists and neurologists, to be of dural or vascular origin.

Methods: Two human formalin-fixed cadavers, one middle-aged female another older male, were investigated at the Anatomy Laboratory, College of Medicine, King Faisal University, Dammam, Kingdom of Saudi Arabia during the period from 2000 to 2003. In each cadaver, the skullcap was removed and the convexity of the cranial dura mater, as well as the individual dural folds, were carefully examined for any calcification or ossification. The meningeal and cerebral blood vessels together with the underlying brain were grossly inspected for such structural changes. Calcified or ossified tissues, when identified, were subjected to histological examination to confirm their construction.

Results: The female cadaver showed a calcified parietal emissary vein piercing the skullcap and projecting into the scalp. The latter looked paler and deficient in hair on its right side. The base of the stump was surrounded by a granular patch of calcification. The upper convex border of the falx cerebri was hardened and it presented granules, plaques and a cauliflower mass, which all proved to be osseous in structure. The meningeal and right cerebral vessels were mottled with calcium granules. The underlying temporal and parietal lobes of the right cerebral hemisphere were degenerated. The male cadaver also revealed a calcified upper border of the falx cerebri and superior sagittal sinus. Osseous granules and plaques, similar to those of the first specimen, were also identified but without gross changes in the underlying brain.

Conclusion: Calcification or ossification of an isolated site of the cranial dura mater and the intracranial blood vessels might occur. These changes should be kept in mind while interpreting images of the skull and brain. Clinical assessment and laboratory investigations are required to determine whether these changes are idiopathic, traumatic, or as a manifestation of a generalized disease such as hyperparathyroidism, vitamin D-intoxication, or chronic renal failure.

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Radiologists and neurologists have sporadically reported calcification and ossification of the cranial dura mater and subdural space. Isolated dural calcification commonly affects the convexity of the cerebral dura mater, the falx cerebri, and the superior sagittal venous sinus; sometimes in association with an epidural hematoma.[1] Total dural calcification is a rare condition that may be

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idiopathic, or appear in patients suffering from hyperparathyroidism and chronic renal failure.[2,3] Calcified subdural hematoma and masses are also rarely reported.[4-6] Calcification or ossification of the cerebral dura mater may acquire an epidural extension to invade an epidural hematoma,[7,8] an interosseous hematoma,[9] or the meningeal blood vessels.[10] It also may involve the underlying brain tissue and the optic dural sheath[11-13] or bioabsorbable osseous fixative materials.[14,15] The aim of the present work is to document the incidence of isolated dural calcification and ossification, to describe their exact nature, and to discover the neighboring structures that might be involved. The results of this study might be of great concern to radiologists and neurologists encountering such rare cases, which would be either asymptomatic or manifested by neurological deficits.

Methods. Two human cadavers, one middle-aged female and one older male, were utilized in this study. They were amongst the cadavers dissected for teaching the medical students in the Anatomy Laboratory, College of Medicine, King Faisal University, Dammam, Kingdom of Saudi Arabia, during the period from 2000 to 2003. The scalp of each cadaver was carefully inspected, and the skullcap was sawn, removed and its inner aspect examined. The convexity of the cranial dura mater was thoroughly studied, incised at its periphery and reflected, and then the brain was removed. The outer and inner aspects of the cerebral dura mater as well as the brain were morphologically examined for any abnormal features. Abnormal masses or plates of bone-resembling tissue were identified, described and subjected to routine histological examination using decalcification, staining and light microscopy.

Results. ***Cadaver 1.*** Gross inspection of the inner surface of the skull cap of the female cadaver revealed an irregular softish stump within the posterior one-third of the cap, piercing the bone just to the right of the median sulcus for the superior sagittal venous sinus. An oval granular pale patch that had a "sand-like appearance" surrounded the base of this stump. The granules of this area had extended to involve the grooves for the branches of the middle meningeal artery particularly those of the right side. The stump was observed to erupt on the posterior median part of the scalp, which appeared paler and less hairy than its counter left part. Histological examination of this unusual stump showed that it had the structure of small veins containing blood elements but with calcified walls. The upper convex border of the falx cerebri, of the same specimen, was felt tough and its sides exhibited granular masses and thin plaques of bone-like tissue **(Figures 1a & b)**. The granular masses were irregular in shape and mostly disposed along the anterior two-thirds of this border. One of these masses was relatively large, cauliflower-like and projecting both externally towards the skullcap and internally into the subdural space **(Figure 1a & b)**. The osseous plaques erupted from both sides of the anterior half of the upper convex border of the falx, and they projected into the subdural space both on the surfaces of the cerebrum and on the sides of the falx **(Figures 1a & b)**. The parietal and temporal lobes of the underlying right cerebral hemisphere were paler and less vascular than outer lobes and their gyri and sulci were amalgamated together **(Figure 1a)**. The upper group of the medial cerebral veins, draining into the superior sagittal venous sinus, were also invaded by sand-like grains giving them a "mottled appearance" **(Figure 1b)**. Other major dural folds were morphologically free from such unusual changes. Microscopic examination of the granular masses and plaques revealed that they were bony in construction. A zone of transitional cartilage was demonstrated at the sites of attachment of the bony plaques to the fibrous tissue of the falx cerebri.

Cadaver 2. In the male cadaver, the upper convex border of the falx cerebri and the superior sagittal venous sinus were also hardened. This border showed granular bone masses at the beginning of the sinus **(Figure 2)** and osseous plaques along the sides of the sinus **(Figures 2, 3a & b)**. The other major folds looked apparently free from calcification or ossification **(Figure 2)**. Histological examination of the unusual granular masses and plaques confirmed their bony structure.

Discussion. Dural calcification or ossification has been reported to be a manifestation of hyperparathyroidism or chronic renal failure,[1-3] or as post-traumatic with concomitant chronic epidural or subdural hematoma[4-8] and interosseous hematoma.[9] Calcification of the meningeal blood vessels has also been noticed in cat specimens.[10] Moreover, intra calcification is known to be a rare condition sometimes related to age or might be hereditary,[11] idiopathic,[12,13] or following intracranial insertion of bioabsorbable osseous fixatives.[14] Cerebral calcification is occasionally asymptomatic and unrecognized.[14]

Although a case with calcified convexity of the dura mater and acute epidural hematoma has been reported,[1] the literature is deficient in revealing isolated dural fold calcification and related intracranial new bone formation. The current study reports 2 cadavers, one of each sex, with calcified upper convex border of the falx cerebri and well-formed bony granules and plaques that projected from the sides of this border into the subdural space. These osseous elements extended

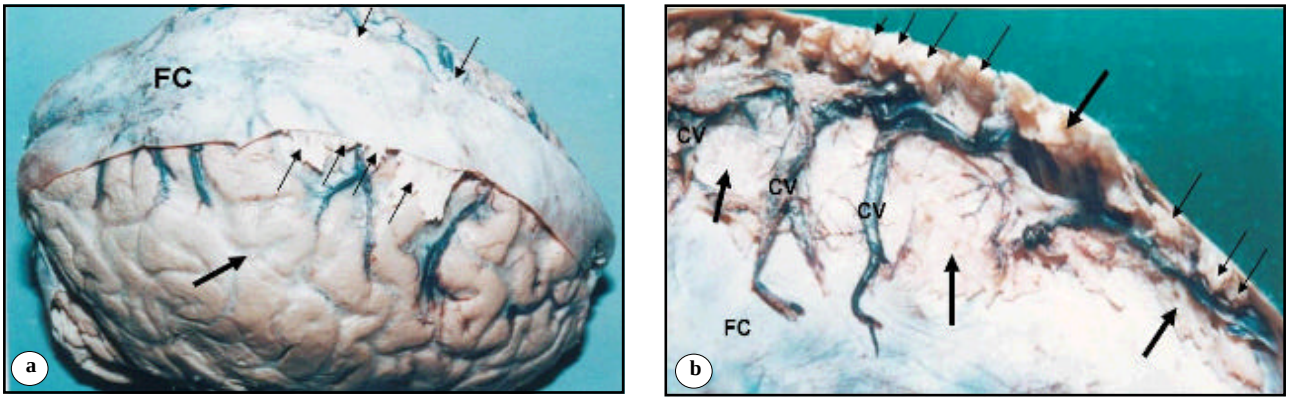

Figure 1 - A photograph of the convexity of the falx cerebri (FC) of the same specimen showing in, **a)** plaques of bone tissue (thin arrows) in the subdural space extending on the superolateral surfaces of both cerebral hemispheres. The middle of the right cerebral hemisphere (thick arrow) looks paler, less vascular and grossly degenerated, **b)** showing a magnified part of the FC revealing the osseous granular masses (thin arrows) and the bony plaques (thick arrows) extending into the subdural space. Calcified granules also invade the upper medial cerebral veins (CV) giving them a "mottled appearance".

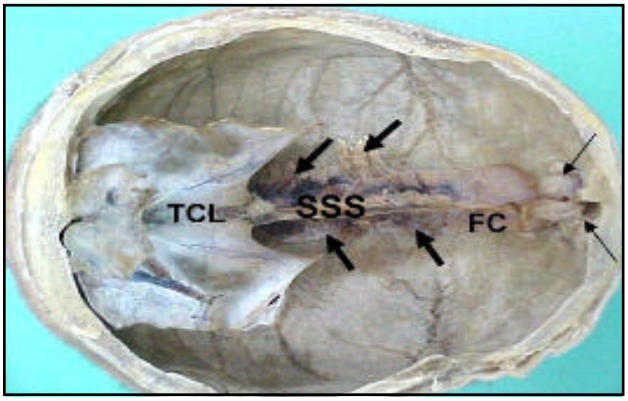

Figure 2 - A photograph of an inferior view of the convexity of the falx cerebri (FC) and the dura mater of the skull cap of an older male cadaver, showing granular bone masses (thin arrows) and osseous plaques (thick arrows) at the beginning and the sides of the superior sagittal venous sinus (SSS). The inferior surface of the tentorium cerebelli (TCL) is apparently free from calcification or ossification.

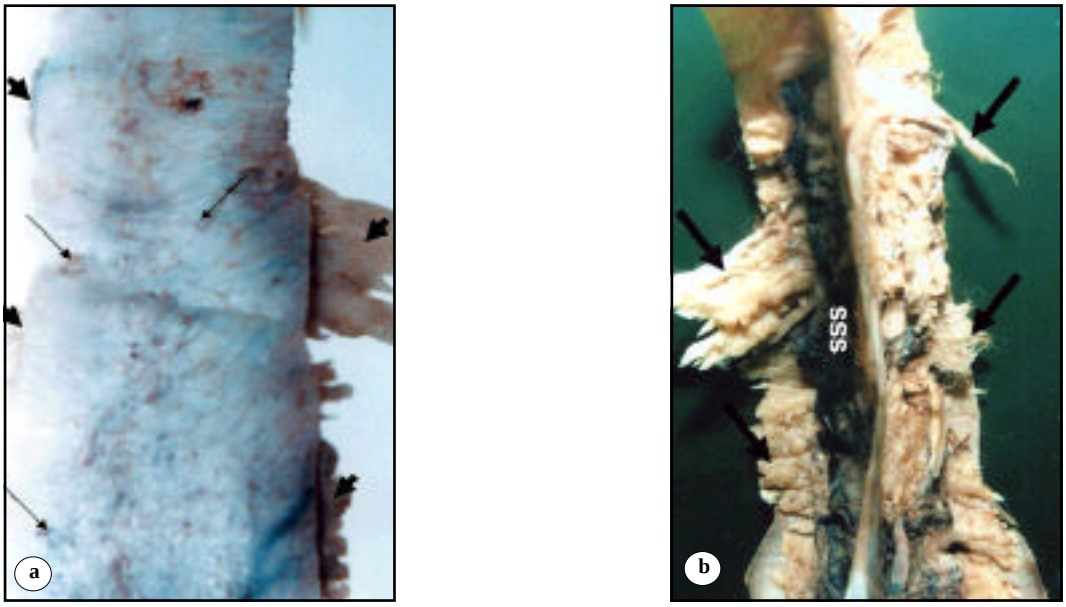

Figure 3 - Photographs of the dissected upper convex border of the falx cerebri, **a)** revealing the outer bony plaques (thick arrows) along the course of the superior sagittal sinus (SSS), **b)** revealing the inner arachnoid granulations (thin arrows) are seen projecting through the dura in the vicinity of the sinus.

over the superolateral surfaces of the cerebral hemispheres. The superior sagittal venous sinus was observed to be infiltrated with calcium granules giving it a firm consistency. The meningeal and upper medial cerebral vessels were also involved, and they had a "mottled appearance."

In the middle-aged female cadaver, the calcified stump piercing the skull cap proved microscopically to be formed of small veins with the conclusion that they are the parietal emissary veins being involved in this process. In such a specimen, the underlying right cerebral hemisphere and the overlying right half of the scalp showed degenerative changes suggesting that this condition might be post-traumatic or vascular in origin. A whitish granular oval patch of calcification having the appearance of sand-grains, which encroached laterally on the middle meningeal vessels, as they pierced the skullcap, surrounded the calcified parietal emissary veins. Dural folds, other than the falx cerebri, looked free from calcification or ossification in both cadavers studied.

In the older male cadaveric specimen examined, the falx cerebri, the superior sagittal sinus, and the cerebral veins draining into the sinus were calcified and mottled. The plaques and the granular masses of newly formed tissue proved to be also osseous in nature. No degenerative changes were grossly observed in the underlying brain carrying the probability that this condition might be an example of idiopathic isolated calcification of the cranial dura mater that might be related to age.

In conclusion, the results of the current investigation support the concept that isolated calcification and ossification of the cranial dura mater may occur with or without concomitant gross brain lesion. Such findings should be taken into consideration during imaging of the skull of individuals presenting asymptomatically or with neurological manifestations.

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