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Review

Recognizing and Distinguishing the Phenomenon Referred to as Meningioma

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Abstract: Background: The reliability of a recent review of meningiomas in the archeologic record was difficult to assess, given the inverted sex ratio of the report and other contents apparently at variance with anatomical/medical findings in scientifically identified cases. It therefore seemed appropriate to reexamine the nature of meningiomas and derive improve criteria for their recognition in the archeologic record and distinguish them from hemangiomas and bone marrow hyperplasia (recognized in the form of porotic hyperostosis). **Methods:** Medically documented cases of meningiomas were examined to establish a macroscopic standard distinguishing them. Alleged cases in the archeologic record were examined for conformity with those criteria. **Results:** An en face pattern of uniform mesh with contained whorls appears pathognomonic for meningiomas. This contrasts with the non-uniform marrow expansion displacement of trabeculae in porotic hyperostosis and non-uniform vascular displacement of trabeculae in hemangiomas. Reassessment of past attributions revealed few cases of meningiomas that could be confidently diagnosed. Those identified have sex ratios parsimonious with medical literature reports. **Conclusions:** Criteria suggested for identifying meningiomas permit distinguishing from hemangiomas, bone marrow hyperplasia (porotic hyperostosis) and from the macroscopically observable surface spicules characteristic of osteosarcomas. Examination for fulfillment of criteria for meningiomas and hemangiomas seems to provide a picture (including sex ratios) mirroring that of the clinical literature, concluding that Cook and Danforth's disparate ratios were related to less fastidious case selection. Additionally, confidence in recognizing porotic hyperostosis may be compromised because of apparent similar macroscopic alterations to those seen with hemangiomas.

Keywords: meningioma; hemangioma; cranial pathology; porotic hyperostosis; differential diagnosis; osteosarcoma

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1. Introduction

I have long sought clarification of post hoc examples and the literature related to meningiomas. A variety of cranial pathologies of disparate sizes and morphologies (e.g., refs. [1,2] have been attributed. Given past experience with the trans-phylogenetic uniformity of findings for a given disease [3,4], it seems reasonable to conduct an intensive examination of what is being referred to as meningioma. The purpose of this review of documented clinical cases and review the anthropologic literature for diagnosis accuracy by:

1. Examining medically documented cases of meningioma to develop evidence-based criteria for their recognition and for distinguishing them from the disorders in their differential diagnosis; and
2. Reviewing the archeologic record to identify validly diagnosed occurrences, distinguishing them from hemangiomas and cranial bone marrow hyperplasia.

1.1. Derivation

Meninges, the membranes enclosing the brain, arise from multi-potential mesenchymal cells. Thus, they can differentiate into a variety of cell types (e.g., fibrous, osseous,

hematopoietic, vascular), explaining the variety of derived tissues referred to as meningiomas [5]. Meningiomas are generally slow-growing tumors derived from the membranous layers surrounding the brain and spinal cord [6]. Arising from arachnoid granulations, they cluster around venous sinuses and dural folds [7].

1.2. History

First reported by Felix Plater 1614 [8] and subsequently named by Harvey Cushing in 1922 [9], meningiomas have been referred to as neoplastic (i.e., endotheliosis of the meninges, epithelioma, angioendoethelioma, dural endothelioma, meningoblastoma, arachnoidal or meningeal fibroblastoma, mesothelioma of the meninges, dural sarcoma and fibrosarcoma), infectious (i.e., dura mater fungus or fungus tumors) and even as psammoma [10]. Most are actually benign, with only one to nine percent interpreted as malignant or atypical [11,12].

1.3. Prevalence

The prevalence of meningiomas is 7.7–8.4 per 100,000 adults [13–15]. Kostandy et al. [16] reported prevalence of 0.3/100,000 in childhood (males 2:1). This ratio in children contrasts with the 2–4-fold female predominance noted in adults [13–15], indistinguishable from that noted with hemangiomas [17–19]. Nakasu et al. [20] reported the presence of meningiomas in 2.3% of autopsies. They noted that 8.2% were multiple, but that none of their sample had neurofibromatosis. The latter is noteworthy, as fifty percent of individuals with type 2 neurofibromatosis develop meningiomas [21]. Sosman [22] suggested the role of trauma in their development. Increased body fat also appears to be a risk factor for meningioma development [21].

1.4. Clinical Symptoms

Only one in four individuals with meningiomas are symptomatic [13,15]. Clinical symptoms include headache, mental status (thought process) changes, ataxia (impaired balance), vertigo (dizziness), seizures, paresis (impaired muscle function), paresthesia (pins and needles feelings), aphasia (loss of speech), visual disturbance and hearing, dependent upon the brain region juxta-positional to the meningioma.

1.5. Character

Starr and Cha [23] (p. 722) divided meningiomas into "expansile masses with wide dural attachment or 'en plaque' patterns of growth in a sheet-like pattern along the dura". It is the macroscopically recognizable ectocranial appearance of the latter group that is the subject of the current analysis. Medically confirmed cases are reported as having flat cranial accretions [24,25], which Kostandy et al. [7] referred to as the plaque variant. The thickened bone contains tumor cells [26,27].

1.6. Radiographic Appearance

Pertinent radiologic findings include increased vascularity, calcification and bone destruction or hyperostosis in 25–50% [24,25,28,29]. They may present as predominantly osteolytic (e.g., Jónsdóttir et al. [30]) or as osteoblastic phenomena. Meningiomas have whorl-shaped inhomogeneous areas [31–34] and may have a nodular appearance [35]. A focal, diffuse, rim-like or punctate calcification may be noted [36]; lobulated masses have also been reported [27,28,36]. Rohringer et al. [13] reported finding the mushroom form (herein referred to as nodular) only in malignant cases. What seems to be absent from all medically confirmed cases is a honeycomb appearance [19,37–39].

Additional diagnostic signs have been suggested, although have yet to be verified in individuals with independently confirmed (e.g., medical) diagnoses. Campillo [39] suggested exaggerated middle meningeal artery imprinting as a possible sign of a meningioma, while Waldron [40] hypothesized that increased vascular channels might facilitate

diagnosis. Sosman [22] suggested diagnostic significance of vascular channels radiating from the lesion.

1.7. Controversy as to Macroscopic Appearance

One of the terms (what might be referred to as ectocranial "protuberances") often utilized in histologic descriptions of cranial alterations has caused confusion, as it is usually applied by radiologists to a very different phenomena. That term is spicules. Huggins [29] suggested that some meningiomas present with spikes parallel to the cranial surface, although neither Pechenkina et al. [41], Kim et al. [24] nor Phemister [25] identified any such findings. Arana et al. [31] referred to surface alterations as spicules, despite the smooth or multinodular ectocranial appearance, as Daffner et al. [42] noted. Rohringer et al. [13] suggested that the macroscopic appearance does not permit distinguishing malignant from benign meningiomas, although they reported finding the mushroom (what we refer to as nodular) form only in malignant cases. Rowbotham [43] (p. 605) used the term spicules to describe "right-angled speculation had been laid down in layers parallel with the two tables of the skull". The endocranial surface was spiculated or eroded, but the ectocranial surface was smooth upon macroscopic examination.

Another challenge relates to use of the term "sponge-like" for the spaces (surface-visible holes) in a sponge or to its surrounding matrix. A sponge-like pattern seems to be a matter of perception of the pertinent attributes of a sponge—the holes or the matrix form the search image we use for recognition of a structure as sponge-like. This has led to confusion related to distinguishing meningiomas and hemangiomas.

1.8. Differential Diagnosis

The major differential diagnostic considerations related to macroscopic recognition of meningiomas include hemangiomas and bone marrow hyperplasia (e.g., thalassemia related/induced porotic hyperostosis). Also requiring consideration (Table 1) are fibrous dysplasia, Paget's disease, osteoma, xanthomatous disease, histiocytosis, Proteus syndrome (characterized by asymmetrical body part hamartomatous overgrowth), hemangiopericytomas, lymphomas, schwannomas, fibrous tumors, chondrosarcomas, metastases, plasmacytomas and chondromas, astrocytomas, gliosarcomas, hemangioblastomas, giant cell tumors, osteomyelitis and fungal lesions [8,23,44]. In their series of 185 CT (computerized tomographic) studies, Arana and Martí-Bonmati [36] reported 18.9% histiocytosis, 15.1% osteoma, 12.9% epidermoid and dermoid cysts, 12.4% metastasis, 10.8% meningioma, 9.1% hemangioma and 6.4% fibrous dysplasia, with 14.4% miscellaneous diseases.

Table 1. Differential diagnosis of meningiomas [17,21,30,31,44].

Diagnosis/Finding	Pressure Erosion	Interstices *	Fenestrated	Sclerosis	Honeycomb	Prominent Vessel
Meningioma	Present	Parallel	Absent	Present	Absent	Present
Hemangioma	Present	Variable	Present	Absent	Present	Present
Marrow hyperplasia	Present	Variable	Present	Absent	Present	Absent
Fibrous dysplasia	Absent	Absent	Absent	Variable	Absent	Absent
Paget's disease	Absent	Absent	Absent	Cotton wool	Absent	Absent
Hamartoma	Absent	Absent	Absent	Present	Absent	Absent
Osteoma	Absent	Absent	Absent	Present	Absent	Absent
Epidermoid/dermoid cyst	Present	Absent	Absent	Absent	Absent	Absent
Xanthomatous	Present	Absent	Absent	Absent	Absent	Absent

Table 1. *Cont.*

Diagnosis/Finding	Pressure Erosion	Interstices *	Fenestrated	Sclerosis	Honeycomb	Prominent Vessel
Histiocytosis	Absent	Absent	Absent	Absent	Absent	Absent
Hemangiopericytoma	Absent	Absent	Absent	Absent	Absent	Absent
Hemangioblastoma	Absent	Absent	Absent	Absent	Absent	Absent
Giant cell tumor	Absent	Septated	Absent	Present	Multi-locular	Absent
Lymphoma	Absent	Absent	Absent	Absent	Absent	Absent
Schwannoma	Absent	Absent	Absent	Absent	Absent	Absent
Fibrous tumor	Absent	Absent	Absent	Absent	Absent	Absent
Chondrosarcoma	Absent	Calcifications	Absent	Calcifications	Absent	Absent
Metastasis	Absent	Absent	Absent	Variable	Absent	Absent
Multiple myeloma	Present	Absent	Absent	Absent	Absent	Absent
Chondroma	Present	Absent	Absent	Absent	Absent	Absent
Astrocytoma	Absent	Absent	Absent	Absent	Absent	Absent
Gliosarcoma	Present	Absent	Absent	Absent	Absent	Absent
Osteomyelitis	Present	Variable	Variable	Present	Absent	Absent
Fungal	Present	Absent	Absent	Absent	Absent	Absent
Actinomycosis	Present	Absent	Absent	Absent	grape-like	Absent

* Striations.

Hemangiomas occasionally present as "a hard, blue-domed lump on the skull, lying beneath the pericranium, which can be lifted off it". They appear as a round or oval area of rarefication with irregular borders, but never serpiginous [44]. What seems to be absent from all medically confirmed cases of meningiomas is a honeycomb appearance, a phenomenon reported with hemangiomas [37–39,44]. The latter are characterized by an irregularly fenestrated meshwork with greatly variable interstices between bony trabeculae [43], which may be responsible for the honeycomb appearance.

Bone marrow hyperplasia (such as that related to thalassemia) alters the appearance of the outer cortex. It also presents as an irregularly fenestrated meshwork with greatly variable interstices between bony trabeculae [44–46]. The resultant radiating bone spicules give a granular osteoporosis, widening of the diploic space and thinning with perforation of outer table of skull and subperiosteal proliferation, producing a "hair on end" appearance on X-ray. The latter is observed in 8–12% of individuals with thalassemia [19,47]. Tyson and Alcauskas [48] reviewed Hrdlička's paleopathology collection at the San Diego Museum of man. Peruvian skulls 1915-2-145, 147, 151 and 154, diagnosed as having porotic hyperostosis, also have a sponge-like appearance, while 1915-2-158 had a sponge-like applicée composed of parallel spicules. They are characterized by an irregularly fenestrated meshwork with greatly variable interstices between bony trabeculae [44], which may be responsible for the honeycomb appearance

Arana et al. [31] and Kim et al. [24] noted that the irregular endocranial surface facilitated distinguishing meningiomas from fibrous dysplasia and from osteomas with their smooth inner surfaces and button appearance. The diffuse cranial thickening and cotton wool radiologic appearance of Paget's disease is distinguishable from meningiomatous ectocranial alterations [49]. Schüler Christian disease (xanthomata) does not have striations or honeycomb findings. Meningiomas lack the serpiginous shape characteristic of histiocytosis, epidermoid cysts and osteomyelitis [19,34]. Epidermoid and dermoid cysts cause pressure erosions with expansion of surrounding bone, but not new bone formation, although saponification does produce internal calcification in dermoid cysts [34].

As a further differential consideration, the contemporary case reported by Huggins et al. [29] was a post-traumatic lump followed by swelling. Moth-eaten osteolysis was associated with remodeling. The possibility of a primary lesion aggravated by a hematoma seems likely.

1.9. Recognition, Phylogenetic Distribution and Antiquity

The first clinical case of meningioma is apparently that of Platter in 1614, according to Bir et al. [50]. The oldest archaeological report of a meningioma is that of Czarnetzki et al. [51] in a 366,300 year old *Homo steinheimensis.*

Meningiomas are not limited to humans, but have also been reported in cats and dogs, especially dolichocephalic dog breeds (e.g., collies, shepherds) of the latter [52].

The current study was pursued to identify macroscopically observable differences among the surface appearances of meningiomas, hemangiomas and bone marrow hyperplasia, as manifest by porotic hyperostosis.

2. Materials and Methods

Medically (clinically) documented cases of meningiomas, hemangiomas and cranial marrow hyperplasia in adults were examined to establish a macroscopic standard for confident identification of meningiomas and for distinguishing them from hemangiomas and marrow hyperplasia, manifest as porotic hyperostosis. Images and descriptions of archeologic site alleged meningioma cases (derived from PubMed and Google searches and from 40 years of personal files) (Table 2), including those suggested by Cook and Danforth [1], were then examined for conformity with those criteria.

Table 2. Reassessment of archaeological site cranial pathology attributed to meningiomas.

Dating (Century)	Sex	Location	Atypical Features	Reassessment	Reference
3653rd BCE	?F	Germany	*Homo steinheimensis*	Likely	[52]
2000th BCE	?	France	Osteolytic with thick groove	Hemangioma	[53–55]
34th BCE	F	Egypt	Honeycomb ecto-cranial, smooth endocranial expansion	Hemangioma	[56]
32nd BCE	M	Germany	Vascular impression as basis	Uncertain	[57]
45th–10th BCE	M	Denmark	Centripetal columns	Not meningioma	[58]
	M	France	Amorphous surface	Challenged	[1,55]
	M	Catalonia	Osteolytic with thick groove	Osteolytic	[40]
	F	Catalonia	Endocranial enostoma	Uncertain	[40]
	?	Catalonia	Endocranial hypervascularization	Uncertain	[40]
33rd–21st BCE	F	Austria	Hemangiomatous pattern	Hemangioma	[59]
12th–11th BCE	F	Egypt	Called honeycomb, but actually perpendicular, but uniform spicules	Sarcoma	[56,60]
8th–5th BCE	M	China	Sponge-like	Hemangioma	[41]
8th BCE–1st CE	F	England	Focal "bump"	Possible	[61]
	M	Peru	Lysis with irregular trabeculae	Cancer	[62]
1st–4th CE	F	England	Low-resolution image	Possible	[60]

Table 2. *Cont.*

Dating (Century)	Sex	Location	Atypical Features	Reassessment	Reference
3rd–9th CE	M	Scotland	Honeycomb	Hemangioma	[30]
	?	Spain	Endocranial "enostoma"	Uncertain	[41]
	?	Spain	Endocranial enostosis	Uncertain	[41]
8th–11th CE	?	England		Likely	[40]
10th–18th CE	M	Alaska		Possible	[63]
11th–13th CE	M	Germany	Classic honeycomb	Hemangioma	[64]
12th–13th	M	Poland	No description	Uncertain	[65]
12th–14th	F	Illinois	Indefinite; no images or description	Uncertain	[66]
13th–14th	F	England	Sponge-like surface	Hemangioma	[67]
13th–16th CE	M	Czech Republic	No ectocranial alterations	Uncertain	[68]
14th CE	F	Sweden	Focal "bump"	Possible	[69]
Pre 15th CE	M	California	Honeycomb, "hair-on-end"	Sarcoma	[70]
	F	Peru		Likely	[13]
	M	Peru	Focal bump	Possible	[13]
Post 15th CE		Mexico	Irregular intraocular mass	Unlikely	[71]
16th–17th CE	?F	Belize	Honeycomb	Hemangioma	[1,72]
18th CE	M	Germany	Inadequate drawing quality	Uncertain	[73]
19th–20th CE	F	New York	No such presentation listed	Non-existent	[74]
Unspecified	M	England	Aberrant endocranial vessel	Uncertain	[40]
	F	England	Holes, endocranial vasculature	Uncertain	[40]
	M	England		Likely	[40]
	F	Sri Lanka	Multinodular	Likely	[75]
	F	Peru	Sponge-like applicée	Hemangioma	[48]
	M	Peru	Towering spicules	Osteosarcoma	[75,76]

3. Results

Establishment of criteria for macroscopically recognizing meningiomas and distinguishing them from hemangiomas and porotic hyperostosis.

A honeycomb appearance of the surface of the pathology was found only in hemangiomas and cases of porotic hyperostosis in which the marrow and its trabeculae are actually exposed, in contrast to those in which only surface "pores" are recognizable. This is parsimonious with their previous characterization as an irregularly fenestrated meshwork with greatly variable interstices between bony trabeculae [44].

The most pathognomonic surface sign of a meningioma appears to be a relatively uniform mesh (Figure 1D) with whorl patterns (Figure 1C). Figure 1A illustrates the plates of new bone that form the basis of this pattern. That contrasts with the trabeculae displaced by expansion of marrow spaces in porotic hyperostosis (Figure 1B). The latter gives rise to the non-uniform fenestrations seen in Figure 1E. This appears indistinguishable from the effect on trabeculae of hemangioma-related expansion of vasculature (Figure 1F). The trabeculae in meningiomas are parallel (Figure 1A), contrasted with the variably oriented components (Figure 1B).

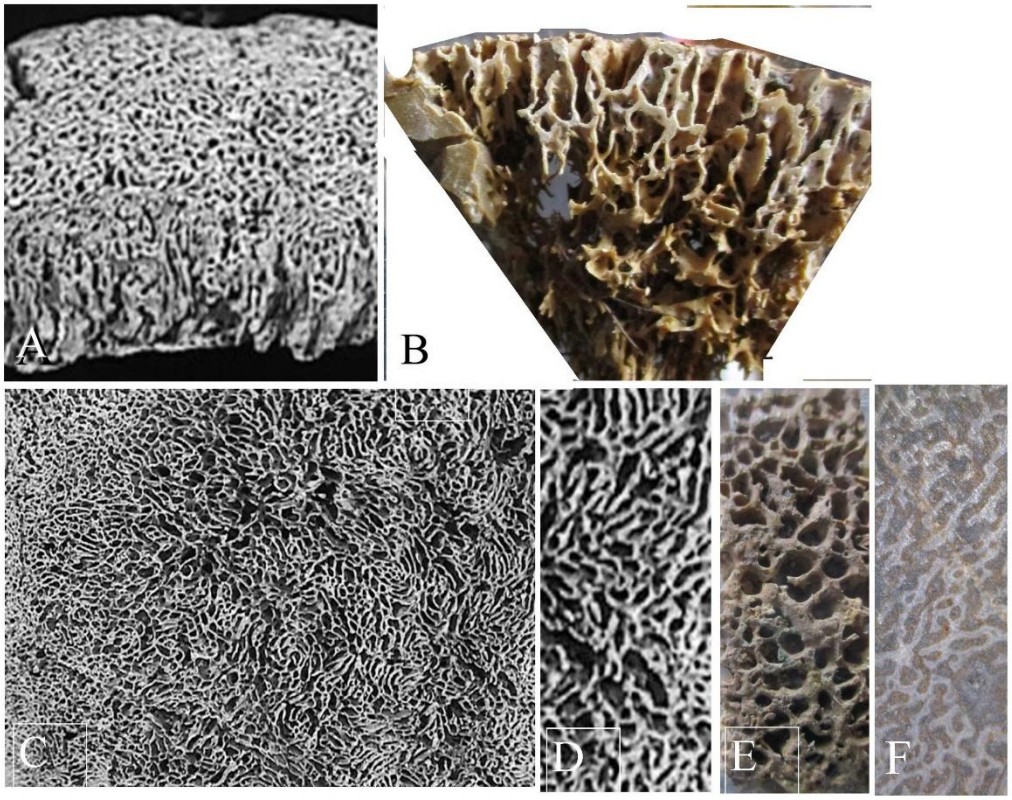

Figure 1. Cranial pathology. (**A**) Oblique view of meningioma fragment; mesh-like surface created by parallel plates. (**B**) Cross-section of porotic hyperostosis; irregular trabeculae surrounding marrow spaces. (**C**) En face view of meningioma fragment shown in (A); whorled pattern of meshwork. (**D**) Enlarged view of (**C**); uniform meshwork. (**E**) En face view of porotic hyperostosis; irregular meshwork. (**F**) En face view of hemangioma; irregular meshwork.

Analysis of the accuracy of past archeologic cases attribution as meningiomas.

Reassessment of past attributions revealed few cases that fulfilled criteria (Table 2) for meningiomas, identified cases actually representing hemangiomas and identified inadequate support for confident diagnosis in many others. Furthermore, Cook and Danforth's [1] citation of Siriani et al. [74] reporting 19th–20th century meningioma in an individual from the Erie County Poor House apparently represents their unassessed utilization of a secondary or tertiary citation, as there is no record of any such presentation at the 2014 Paleopathology Association meeting. Excluding uncertain cases, those with alternative diagnoses and unconfirmed citations, the ratio of women to men is 5:4 for meningiomas.

Danforth et al. [72] state that the Belize skull fragment resembles that reported by Schamall et al. [57], which actually appears to be a hemangioma, not a meningioma. Their diagnostic approach appeared somewhat convoluted and perhaps circular. They stated (p. 1046) that "virtually, no source discusses a case with as much vault thickness present in Burial 157 as being nutritional in origin". (That statement appears to be their attempt to rule out iron deficiency or other nutritional deficiencies and thus porotic hyperostosis.) They continued, "All scholars who have seen Burial 157 note that it far exceeds that of any proposed case of porotic hyperostosis that they had observed". That contrasts with Figure 1, which clearly documents the extent of porotic hyperostosis-derived diploic space expansion. Cook and Danforth [1] (p. 1047) also ruled out the latter because "it would be highly unlikely that any sort of genetic resistance would emerge in only a few generations", according to their limited differential considerations, failing to consider marrow hyperplasia induced by parasite-related blood loss. They ruled out hemangioma because "the inner table" (of their fragment) "does not show the porosity characteristic

of hemangiomas", although porosity has never been documented as a "characteristic of hemangioma". Absence of a honeycomb appearance does make the meningioma diagnosis more likely, but the possibility of porotic hyperostosis (e.g., from parasite-induced blood loss) was not excluded.

Abbott and Courville [70] examined San Nicolas Island and Inuit skulls in the San Diego Museum collection, noting twenty with neoplastic lesions. Osteomas account for eleven, cancer for seven and large hyperostosis were present in two. Number 158 was interpreted [1] (p. 103) as "formed by the fused radiating spicules and the intervening openings having been compared by Moodie [13] to the structure of certain corals . . . had the appearance of honeycomb on its surface. It was only a few millimeters thick at the most and could easily be scraped away from the inner table of the skull". The surface, however, is relatively uniform, with no protruding spicules. While Moodie related it to a meningioma, the associated lytic area and "hair-on-end" radiologic appearance seem more suggestive of a sarcoma. The possibility of malignant rather than benign meningioma could be entertained. Indeed, Rogers' [56] report of a "diffuse honeycomb type of hyperostosis in a 20th dynasty Egyptian skull was attributed to a sarcomatous meningioma, or simply a sarcoma. Number 17661 was noted to have "spongy hyperostosis with an irregular, pitted and cratered surface". What Abbott and Courville [70] referred to as "vertical spicules" seemed contained within and not extending beyond the lesion surface. Derivation of such spicules from deposition along stretched periosteally sourced vessels was suggested. The report by Bianco et al. [62] illustrates an exostosis with a major lytic component and irregular trabeculae incompatible with a diagnosis of meningioma. Cancer is more likely. Kompanje's [73] republication of Salzmann's [77] 1730 drawing of an alleged meningioma in a 43 year old contained insufficient details for diagnosis.

The partially healed osteitis that Bennike [58] (p. 201) suggested might be a meningioma is especially of interest. She illustrated a Mid to Late Neolithic male with a relatively large lytic skull lesion, surrounded by circumferential minimally elevated, flat centripetally oriented "columns". Unlike previously published images of skull pathology, the edges (not the columns) have almost a rosette appearance, similar to the edges noted with metastatic carcinoma that is hypothesized [78] to be uterine, ovarian or breast cancer-related. The male attribution of the skull makes the latter unlikely. Ricci et al. [79] considered meningiomas in the differential diagnosis for the multicentric cranial lucencies, but the ill-defined borders are more suggestive of metastases.

4. Discussion

Examination of the purported occurrences of meningiomas reported by Cook and Danforth [1] and of additionally recognized cranial pathology (delineated in Table 2) suggested the need for reevaluation. The sex ratio reported by Cook and Danforth [1] is converse to that observed in clinical samples [13–15]. This may be explainable, as their report seems to conflate several diagnostic entities. Herein are established criteria derived from medically confirmed cases and refined documentation of the prevalence of meningiomas over time.

Structural organization seems to be a major macroscopic characteristic that distinguishes among meningiomas, hemangiomas and marrow hyperplasia (e.g., porotic hyperostosis). Unique and apparently pathognomonic for meningiomas among these entities is the whorl pattern. Superficially having a sponge-like appearance; the appearance is the result of tumor-derived thin plates of bone (directed perpendicular to the original cortex). This contrasts with the non-uniform, thick bony corridors which constitute the osseous component of hemangiomas. It also contrasts with the irregular surface distribution and variable thickness of the osseous component of marrow hyperplasia.

Examination for fulfillment of criteria for meningiomas, hemangiomas and sarcomas seems to provide a picture more parsimonious with the clinical literature. Excluding uncertain cases and those otherwise diagnosed, a 4:2 female predominance of meningiomas in archaeological cases is indistinguishable from clinical reports [13–16,44]. It should

be noted that the epidemiology of archeologically recognized meningiomas will likely underestimate their prevalence, given the propensity of this tumor to occur in later life [80]. However, that "cut off", reducing potential recognition of full population prevalence, does not appear to affect sex ratio assessment.

Criteria are suggested for identifying meningiomas and distinguishing them from hemangiomas, bone marrow hyperplasia (porotic hyperostosis) and the macroscopically observable surface spicules characteristic of osteosarcomas. The parallel trabeculae of meningiomas may be the product of the contained tumor cells [27,47]. As a final observation, confidence in recognizing porotic hyperostosis may be compromised because of apparent similar macroscopic alterations to those seen with hemangiomas. After all, hemangiomas are more commonly recognized at autopsy than the hair-on-end phenomena [31].

5. Conclusions

The findings in reports alleging meningiomas in the paleopathology literature were subjected to comparison with the macroscopic appearance medically documented cases of the phenomenon and of disorders in its differential diagnosis. Those reports often appeared to be at variance with anatomical/medical findings in scientifically identified cases, especially related to distinguishing hemangiomas and bone marrow hyperplasia (recognized in the form of porotic hyperostosis). Analogy, often used to characterize findings in past reports, failed to delineate the component considered significant, resulting in misinterpretations.

A uniform mesh surface pattern with contained whorls appears pathognomonic for meningiomas, in contrast to the non-uniform marrow expansion displacement of trabeculae in porotic hyperostosis and the non-uniform vascular displacement of trabeculae in hemangiomas. Criteria suggested for identifying meningiomas permit distinguishing from hemangiomas, bone marrow hyperplasia (porotic hyperostosis) and from the macroscopically observable surface spicules characteristic of osteosarcomas. Reassessment of past attributions revealed few cases of meningiomas that could be confidently diagnosed as well as recognizing potential for misdiagnosis of porotic hyperostosis. Most previous claims of meningiomas are not supported by criteria-based review, and the diagnosis has been incorrectly applied, at least in some instances, to porotic hyperostosis.

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References

1. Cook, D.C.; Danforth, M.E. Meningiomas in ancient human populations. *Cancer* **2022**, *14*, 1058. [CrossRef] [PubMed]
2. Zhang, Q.; Zhang, Q.; Han, T.; Zhu, H.; Wang, Q. An Iron Age skull with a bone neoplasm from Nilka County, Xinjiang, China. *Int. J. Osteoarchaeol.* **2019**, *29*, 1034–1041. [CrossRef]
3. Rothschild, B.M.; Martin, L.D. *Skeletal Impact of Disease*; New Mexico Museum of Natural History Press: Albuquerque, NM, USA, 2006.
4. Rothschild, B.M.; Schultze, H.-P.; Pelligrini, R. *Herpetological Osteopathology: Annotated Bibliography of Amphibians and Reptiles*; Springer: Heidelberg, Germany, 2012.
5. Anegawa, S.; Hayashi, T.; Torigoe, R.; Furukawa, Y. Diffuse calvarial meningioma: Case report and review of the literature. *J. Neurosurg.* **1999**, *90*, 970–973. [CrossRef] [PubMed]
6. Cushing, H.; Eisenhardt, L. *Meningiomas: Their Classification, Regional Behavior, Life History and Surgical End Results*; Charles C Thomas: Springfield, IL, USA, 1938.
7. Kostandy, G.; Ottley, R.; Salama, S.; Ghaly, M.; Taha, H.; Sosler, B.; Maqbool, S.; Ashamalla, H. Intracranial meningiomas: A clinical update. *Resid. Staff. Physician* **2001**, *47*, 35–48.
8. El-Sobky, A.; Elsayed, S.M.; El Mikkawy, M.E. Orthopaedic manifestations of Proteus syndrome in a child with literature update. *Bone Rep.* **2015**, *3*, 104–108. [CrossRef] [PubMed]

9. Okonkwo, D.O.; Laws, E.R. Meningiomata: Historical Perspective. *Meningiomata* **2009**, 3–10. Available online: https://link.springer.com/chapter/10.1007/978-1-84628-784-8_1 (accessed on 11 July 2022).
10. Al-Rohdan, R.F.; Laws, E.R., Jr. Meningioma: A historical study of the tumor and its surgical management. *Neurosurgery* **1990**, *26*, 832–847. [CrossRef]
11. Ettinger, S.J. *Textbook of Veterinary Internal Medicine: Diseases of the Dog and Cat*; Saunders: Philadelphia, PA, USA, 1983.
12. Lee, J.H. *Meningiomata: Diagnosis, Treatment, and Outcome*; Springer Science & Business Media: Berlin, Germany, 2008; pp. 3–13.
13. Rohringer, M.; Sutherland, G.R.; Louw, D.F.; Sima, A.A. Incidence and clinicopathological features of meningioma. *J. Neurosurg.* **1989**, *71*, 665–672. [CrossRef]
14. Mehta, N.; Bhagwati, S.; Parulekar, G. Meningiomas in children: A study of 18 cases. *J. Pediatric Neurosci.* **2009**, *4*, 61–65.
15. Wiemels, J.; Wrensch, M.; Claus, E.B. Epidemiology and etiology of meningioma. *J. Neuro-Oncol.* **2010**, *99*, 307–314. [CrossRef] [PubMed]
16. Moodie, R.L. Studies in paleopathology. XVIII. Tumors of the head among pre-Columbian Peruvians. *Ann. Med. Hist.* **1926**, *8*, 394–412.
17. Escoda, A.P.; Baudin, P.N.; Mora, P.; Cos, M.; Gañan, J.H.; Narváez, J.A.; Aguilera, C.; Majós, C. Imaging of skull vault tumors in adults. *Insights Imaging* **2020**, *11*, 1–16. [CrossRef]
18. Toynbee, J. An account of two vascular tumors developed in the substance of bone. *Lancet* **1845**, *2*, 676.
19. Yang, Y.; Guan, J.; Ma, W.; Li, Y.; Xing, B.; Ren, Z.; Su, C.; Wang, R. Primary intraosseus cavernous hemangioma in the skull. *Medicine* **2016**, *95*, e3069. [CrossRef]
20. Nakasu, S.; Hirano, A.; Shimura, T.; Llena, J.F. Incidental meningiomas in autopsy study. *Surg. Neurol.* **1987**, *27*, 319–322. [CrossRef]
21. Niedermaier, T.; Behrens, G.; Schmid, D.; Schlecht, I.; Fischer, B.; Leitzmann, M.F. Body mass index, physical activity, and risk of adult meningioma and glioma: A meta-analysis. *Neurology* **2015**, *85*, 1342–1350. [CrossRef]
22. Sosman, M.C. Radiology as an aid in diagnosis of skull and intracranial lesions. *Radiology* **1927**, *9*, 396–404. [CrossRef]
23. Starr, C.J.; Cha, S. Meningioma mimics: Five key imaging features to differentiate them from meningiomas. *Clin. Radiol.* **2017**, *72*, 722–728. [CrossRef] [PubMed]
24. Kim, K.S.; Rogers, L.F.; Goldblatt, D. CT features of hyperostosing meningioma en plaque. *Am. J. Roentgenol.* **1987**, *149*, 1017–1023. [CrossRef] [PubMed]
25. Phemister, D.B. The nature of cranial hyperostosis overlying endothelioma of the meninges. *Arch. Surg.* **1923**, *6*, 554–572. [CrossRef]
26. Cushing, H. The cranial hyperostosis produced by meningeal endothelioas. *Arch. Neurol. Psychiatry* **1922**, *8*, 139–154. [CrossRef]
27. Satter, A.M.; Talha, K.A.; Rashid, F.; Selina, F.; Khan, M.D. Hossain AT, Shaikh AK. Invasion of meningioma cell in bony hyperostosis-An observational study of 34 cases. *Bangladesh J. Neurosci.* **2011**, *27*, 78–82. [CrossRef]
28. Ginsberg, L. Radiology of meningiomas. *J. Neuro.-Oncol.* **1996**, *29*, 229–238. [CrossRef]
29. Huggins, T.J.; Ragsdale, B.D.; Schnapf, D.O.; Madewell, J.E.; Youngblood, L. RPC from the AFIP. *Radiology* **1981**, *141*, 709–713. [CrossRef]
30. Jónsdóttir, B.; Ortner, D.J.; Frohlich, B. Probable destructive meningioma in an archaeological adult male skull from Alaska. *Am. J. Phys. Anthropol.* **2003**, *122*, 232–239. [CrossRef]
31. Arana, E.; Diaz, C.; Latorre, F.F.; Menor, F.; Revert, A.; Beltrán, A.; Navarro, M. Primary intraosseous meningiomas. *Acta Radiol.* **1996**, *37*, 937–942. [CrossRef]
32. Terstegge, K.; Schorner, W.; Henkes, H.; Heye, N.; Hosten, N.; Lanksch, W.R. Hyperostosis in meningiomas; MR findings in patients with recurrent meningioma of the sphenoid wings. *Am. J. Neuroradiol.* **1994**, *15*, 555–560. [PubMed]
33. Arana, E.; Marti-Bonmatí, L. CT and MR imaging of focal calvarial lesions. *Am. J. Roentgenol.* **1999**, *172*, 1683–1688. [CrossRef]
34. Garfinkle, J.; Melançon, D.; Cortes, M.; Tampieri, D. Imaging pattern of calvarial lesions in adults. *Skelet. Radiol.* **2011**, *40*, 1261–1273. [CrossRef]
35. Jayaraj, K.; Martinez, S.; Freeman, A.; Lyles, K.W. Intraosseous meningioma–a mimicry of Paget's disease? *J. Bone Miner. Res.* **2001**, *16*, 1154–1156. [CrossRef] [PubMed]
36. Choi, J.S.; Bae, Y.C.; Kang, G.B.; Choi, K.-U. Intraosseous hemangioma of the orbit. *Arch. Craniofacial Surg.* **2018**, *19*, 68–71. [CrossRef]
37. Nair, P.; Srivastava, A.K.; Kumar, R.; Jain, K.; Sahu, R.N.; Vij, M.; Jain, M. Giant primary intraosseous calvarial hemangioma of the occipital bone. *Neurol. India* **2011**, *59*, 775–776.
38. Sargent, N.; Reilly, E.B.; Posnikoff, J. Primary hemangioma of the skull. Case report of an unusual tumor. *Am. J. Roentgenol.* **1965**, *95*, 874–879. [CrossRef]
39. Campillo, D. The possibility of diagnosing meningiomas in paleopathology. *Int. J. Osteoarchaeol.* **1991**, *1*, 225–230. [CrossRef]
40. Waldron, T. An unusual cluster of meningiomas? *Int. J. Osteoarchaeol.* **1998**, *8*, 213–217. [CrossRef]
41. Pechenkina, K.; Wenquan, F.; Xiaodong, L. What's that big thing on your head? Diagnosis of a large lesion on an Eastern Zhou skull from Henan, China. *Int. J. Paleopathol.* **2019**, *26*, 84–92. [CrossRef]
42. Daffner, R.H.; Yakulis, R.; Maroon, J.C. Intraosseous meningioma. *Skelet. Radiol.* **1998**, *27*, 108–111. [CrossRef]
43. Rowbotham, G.F. The hyperostosis in relation with the meningiomas. *Br. J. Surg.* **1939**, *26*, 593–623. [CrossRef]

44. Wyke, B.D. Primary hemangioma of the skull: A rare cranial tumor. Review of the literature and report of a case, with special reference to the roentgenographic appearances. *Am. J. Roentgenol.* **1949**, *61*, 302–316.
45. Thillaud, P.L. *Paléopathologie Humaine*; Kronos, B.Y., Ed.; London, UK, 1996.
46. Hanakova, H.; Vyhnanek, L. Palaeopathologische Befunde aus dem Gebit der Tchechoslovakei. *Sb. Nar. Muz. V Praze* **1981**, *37B*, 1–90.
47. Roy, R.N.; Banerjee, D.; Chakraborty, K.N.; Basu, S.P. Observations on radiological changes of bones in thalassaemia syndrome. *J. Indian Med. Assoc.* **1971**, *57*, 90–95. [PubMed]
48. Tyson, R.A.; Alcauskas, E.S. *Catalogue of the Hrdlička Paleopathology Collection*; San Diego Museum of Man: San Diego, CA, USA, 1980.
49. Dihlmann, W. Computed tomography in typical hyperostosis cranii (THC). *Eur. J. Radiol.* **1981**, *1*, 2–8. [PubMed]
50. Bir, S.C.; Msaiti, T.K.; Bollam, P.; Nanda, A. Felix Platter and a historical perspective of the meningioma. *Clin. Neurol. Neurosurg.* **2015**, *134*, 75–78. [CrossRef] [PubMed]
51. Czarnetzki, A.; Schwaderer, E.; Pusch, C.M. Fossil record of meningioma. *Lancet* **2003**, *9381*, 408. [CrossRef]
52. Luginbuhl, H.; Frankhauser, R.; McGrath, J.T. Spontaneous neoplasms of the nervous system in animals. *Prog. Neurol. Surg.* **1968**, *23*, 85–164.
53. De Lumley, H. Une Cabane Acheuléenne dans la Grotte du Lazaret (Nice). *Mémoire De La Société Préhistorique Française* **1969**, *1962*, 223–232.
54. De Lumley, M.-A.; Piveteau, J. Les restes humains de la grotte du Lazaret (Nice, Alpes-Maritimes). In *Grotte du Lazaret. Les Restes Humains Fossiles de la Grotte du Lazaret (Archéologie/Préhistoire)*; De Lumey, Ed.; CNRS: Paris, France, 2018; pp. 224–231.
55. De Lumley Becam, G.; Colard, T.; Duplay, J.; Paquis, P.; Quatrehomme, G. Pathologie de l'homme du Lazaret. In *Les Restes Humains Fossils de la Grotte du Lazaret (Nice, Alpes-Maritimes, France): Des Homo Erectus Europeen Evolues en Voie de Neandertalisation*; De Lumley, M.A., Ed.; CNRS: Paris, France, 1969; pp. 469–480.
56. Rogers, L. Meningiomas in pharaoh's peoples: Hyperostosis in ancient Egyptian skulls. *Br. J. Surg.* **1949**, *36*, 423–424. [CrossRef] [PubMed]
57. Weber, J.; Czarnetzki, A. A primary interosseous meningioma in a skull of the medieval period of southwestern Germany. *Int. J. Osteoarchaeol.* **2002**, *12*, 385–392. [CrossRef]
58. Bennike, P. *Paleopathology of Danish Skeletons*; Akademisk Forlag: Copenhagen, Denmark, 1985.
59. Schamall, D.; Teshler-Nicola, M.; Hűbsch, P.; Kneissel, M.; Plenk, H.J.r. Differential diagnosis on ancient skeletal remains: Conventional methods and novel application of BSE-mode in SEM on a skull of the early Bronze Age. *Coll. Antropol.* **1999**, *23*, 843–894.
60. Brothwell, D. The evidence of neoplasms. In *Diseases in Antiquity*; Brothwell, D.J., Sandison, A.T., Eds.; Charles C Thomas: Springfield, IL, USA, 1967; pp. 320–345.
61. Stead, I.M. Iron Age Cemeteries in East Yorkshire: Excavations at Burton Fleming, Rudston, Garton-on-the-Wolds, and Kirkburn. In *English Heritage Archaeological Report 22*; British Museum Press: London, UK, 1991.
62. Bianco, P.; Corsi, A.; Gattini, F.; Porta, D. Facial reconstruction and meningioma-related hyperostosis in a 2000 BP man from the Peruvian Andes. *J. Paleopathol.* **2008**, *20*, 5–19.
63. Brothwell, M.; Brothwell, D. Evidence for ancient meningiomas and a probable case from Medieval Tarbat, Scotland. *Int. J. Paleopathol.* **2016**, *13*, 65–69. [CrossRef]
64. Weber, J.; Spring, A.; Czarnetzki, A. Parasagittales meningeom bei einem 32500 jahre alten schädel aus dem südwesten von Deutschland. *Dtsch. Med. Wochenschr.* **2002**, *127*, 2757–2760. [CrossRef] [PubMed]
65. Gladykowska-Rzeczycka, J. Tumors in antiquity in east and middle Europe. In *Human Paleopathology: Current Synthesis and Future Options*; Ortner, D.J., Aufderheide, A.C., Eds.; Smithsonian Press: Washington, DC, USA, 1988; pp. 251–256.
66. Cook, D.C. Three cranial tumors from Late Woodland sites: Diagnosis and cultural implications. *Proc. Indiana Acad. Sci.* **1985**, *84*, 94.
67. Anderson, T. An example of meningiomatous hyperostosis from Medieval Rochester. *Med. Hist.* **1992**, *36*, 207–213. [CrossRef]
68. Smrčka, V.; Kuželka, V.; Melkva, J. Meningioma probable reason for trephination. *Int. J. Osteoarchaeol.* **2003**, *13*, 325–330. [CrossRef]
69. Landtblom, A.M. Did St. Birgitta suffer from epilepsy? A neuropathography. *Seizure* **2004**, *131*, 161–167. [CrossRef]
70. Abbott, K.H.; Courville, C.B. Historical notes on the meningiomas. I. A study of hyperostosis in prehistoric skulls. *Bull. L. A. Neurol. Assoc.* **1939**, *4*, 101–113.
71. Campillo, D.; Salas-Cuesta, M.E. Signs of meningiomas in a skull of the Mexican colonial period. *Int. J. Osteoarchaeol.* **1995**, *5*, 144–150. [CrossRef]
72. Danforth, M.E.; Kramer, K.; Cook, D.C.; Cohen, M.N. The youngest meningioma. *Int. J. Osteoarchaeol.* **2019**, *29*, 1042–1050. [CrossRef]
73. Kompanje, E.J. A patient with a large intra- and extracranial tumor, most probably a primary extradural meningioma, described in 1730. *J. Neuro-Oncol.* **2004**, *67*, 123–125. [CrossRef]
74. Sirianni, J.E.; Byrnes, J.F.; Odien, J.E. An osteoblastic infracranial meningioma en plaque: A curious case from the Erie County Poorhouse Cemetery. In Proceedings of the Annual Paleopathology Association Meeting, Calgary, AB, Canada, 8–9 April 2014. Available online: https://physanth.org/documents/44/2014_AAPA_meetings_supp.pdf (accessed on 6 April 2022).

75. Ortner, D.J.; Putschar, W.G. *Identification of Pathological Conditions in Human Skeletal Remains*; Smithsonian Press: Washington, DC, USA, 1981; p. 378.
76. MacCurdy, G.G. Human skeletal remains from the highlands of Peru. *Am. J. Phys. Anthropol.* **1923**, *6*, 217–329. [CrossRef]
77. Salzman, D.J. Tumor capitis a carne fungosa productus & cum carie crania notabili conjunctus. *Acta Phys.-Med. Acad. Caesareae Leopold.-Carol. Nat. Curiosum* **1730**, *2*, 225–228.
78. Rothschild, B.M. Metastatic Cancer and Multiple Myeloma: One Ancient, the Other a Disease of Modernity? *Anthropol. Anz.* **2022**, *in press*.
79. Ricci, R.; Lama, R.; Di Tota, G.; Pietrangelo, F.; Vecchio, F.; Evangelista, A.; Capelli, A.; Capasso, L. Skull osteolytic lesions in a XV century child: A case of childhood malignancy. *J. Paleopathol.* **1994**, *6*, 151–159.
80. Cucu, A.L.; Costea, C.F.; Perciaccante, A.; Caruleanu, A.; Turliuc, S.; Costachescu, B.; Poeta, I.; Turliuc, M.D. The history of Archne through historic descriptions of meningiomas from prehistory to the present. *World Neurosurg.* **2019**, *128*, 37–46. [CrossRef]