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Article

Recognizing and Distinguising 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 that distinguishing among 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 has sex ratios parsimonious with medical literature reports. **Conclusions:** Criteria suggested for identifying meningiomas permits 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

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., 18,87) have been so-attributed. Given past experience with the trans-phylogenetic uniformity of findings for a given disease [63,64], it seems reasonable to conduct an intensive examination of what is being referred to as meningiomas. The purpose of this review of documented clinical cases and review the anthropologic literature to 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
2. Revewing the archeologic record to identify validly diagnosed occurrences, distinguishing them from hemangiomas and cranial bone marrow hyperplasia.

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1.1. Derivation

Meninges, the membranes enclosing the brain, arise from multi-potential mesenchymal cells. Thus, they can therefore differentiate into a variety of cell types (e.g., fibrous, osseous, hematopoietic, vascular), explaining the variety of derived tissues referred to as meningiomas [4]. Meningiomas are generally slow-growing tumors derived from the membranous layers surrounding the brain and spinal cord [22]. Arising from arachnoid granulations, they cluster around venous sinuses and dural folds [44]. .

1.2. History

First reported by Felix Plater 1614 [58] and subsequently named by Harvey Cushing in 1922 [54], meningiomas have been variously 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 [2]. Most are actually benign, with only one to nine percent interpreted as malignant or atypical [33,46,61].

1.3. Prevalence

The prevalence of meningiomas is 7.7-8.4 per 100,000 adults [49,61,83]. Kostandy et al. [44] 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 [49,61,83], indistinguishable from that noted with hemangiomas [32,78,84,86]. Nakasu et al. [52] 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 [53]. Sosman [73] suggested the role of trauma in their development. Increased body fat also appears to be a risk factor for meningioma development [53].

1.4. Clinical symptoms

Only one in four individuals with meningomas is symptomatic [61,83]. Clinical symptoms include headache, mental status (thought process) changes, ataxia (impaired balance), vertigo (dizziness), seizures, paresis (impaired muscle function), paresthesias (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 [74, 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 [42,57], which Kostandy et al. [44] referred to as the plaque variant. The thickened bone contains tumor cells [20,69].

1.6. Radiographic appearance

Pertinent radiologic findings include increased vascularity, calcification and bone destruction or hyperostosis in 25-50% [35,39,42,57]. They may present as predominantly osteolytic (e.g., Jónsdóttir et al., 2003) or as osteoblastic phenomena. Meningiomas have whorl-shaped inhomogeneous areas [6,76] and may have a nodular appearance [5]. A focal, diffuse, rim-like or punctate calcification may be noted [34] lobulated masses have also been reported [40,42,57]. Rohringer et al. [61] reported finding the mushroom (herein, referred to as nodular) form only in malignant cases. What seems to be absent from all medically-confirmed cases is a honeycomb appearance [16,51,68,84].

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Additional diagnostic signs have been suggested, although have yet to be verified in individuals with independently-confirmed (e.g., medical) diagnoses. Campillo [14] suggested exaggerated middle meningeal artery imprinting as a possible sign of a meningioma, while Waldron [80] hypothesized that increased vascular channels might facilitate diagnosis. Sosman [73] 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 [39] suggested that some meningiomas present with spikes parallel with the cranial surface, although neither Kim et al. [42] nor Phemister [56] identified any such findings. Arana et al. [6] referred to surface alterations as spicules, despite the smooth or multinodular ectocranial appearance, as Daffner et al. [24] noted. Rohringer et al.[61] 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 [65 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 on 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. Sponge-like pattern seems to be a matter of perception of the pertinent attributes of a sponge: The holes or the matrix forms 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), haemangiopericytomas, lymphomas, schwannomas, fibrous tumors, chondrosarcomas, metastases, plasmacytomas and chondromas, astrocytomas , gliosarcomas, haemangioblastomas, giant cell tumors, osteomyelitis and fungal lesions [31.73,85]. In their series of 185 CT (computerized tomographic) studies, Arana and Martí-Bonmati [5] reported 18.9% histiocytosis, 15.1% osteoma, 12.9% epidermoid and dermoid cysts, 12.4% metastasis, 10.8% meningioma, 9.1% hemangioma, 6.4% fibrous dysplasia, with 14.4% miscellaneous diseases.

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Table 1. Differential diagnosis of meningiomas [5,73,76,77,84]

DiagAbsentsis/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
Histiocytosis	Absent	Absent	Absent	Absent	Absent	Absent
Haemangiopericytoma	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
Schwanoma	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 presentation 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 [85]. What seems to be absent from all medically-confirmed cases of meningiomas is a honeycomb appearance, a phenomenon reported with hemangiomas [16,51,68,85]. The latter are characterized by an irregularly fenestrated meshwork with greatly variable interstices between bony trabeculae [85], 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 [37,85]. 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 [66,84]. Tyson and Alcauskas [79] 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

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between bony trabeculae (Wyke, 1949), which may be responsible for the honeycomb appearance

Arana et al. [6] and Kim et al. [42] 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 (see chapter 11) is distinguishable from meningiomatous ectocranial alterations [30]. Neither Schüler-Christian disease (xanthomata) have striations or honeycomb findings. Meningiomas lack the serpiginous shape characteristic of histiocytosis, epidermoid cysts and osteomyelitis [5,84]. Epidermoid and dermoid cysts cause pressure erosions with expansion of surrounding bone, but not new bone formation, although saphonification does produce internal calcification in dermoid cysts [5]..

One further differential consideration: The contemporary case reported by Huggins et al. [39] 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. [11]. The oldest archaeological reports of a meningioma is that of Czarnetzki et al. (2003) 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 [47].

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 Pub Med and Google searches and from 40 years of personal files) (Table 2), including those suggested by Cook and Danforth [18], 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
3,653rd BCE	?F	Germany	*Homo steinheimensis*	Likely	23
2,000th BCE	?	France	Osteolytic with thick groove	Hemangioma	27,28,29
34th BCE	F	Egypt	Honeycomb ecto-cranial, smooth endocranial expansion	Hemangioma	60
32th BCE	M	Germany	Vascular impression as basis	Uncertain	81
45th-10th BCE	M	Denmark	Centripedal columns	Not meningioma	9
	M	France	Amorphous	Challenged	18, citing 29

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			surface		
	M	Catalonia	Osteolytic with thick groove	Osteolytic	14
	F	Catalonia	Endocranial enostoma	Uncertain	14
	?	Catalonia	Endocranial hypervascularization	Uncertain	14
33rd-21st BCE	F	Austria	Hemangiomatous pattern	Hemangioma	70
12th-11th BCE	F	Egypt	Called honeycomb, but actually perpendicular, but uniform spicules	Sarcoma	12,60
8th-5th BCE	M	China	sponge-like	Hemangioma	56
8th BCE-1st CE	F	England	Focal "bump"	Possible	75
	M	Peru	Lysis with irregular trabeculae	Cancer	10
1st-4th CE	F	England	Low resolution image	Possible	12
3rd-9th CE	M	Scotland	honeycomb	Hemangioma	13
	?	Spain	Endocranial "enostoma"	Uncertain	14
	?	Spain	Endocranial enostosis	Uncertain	14
8th-11th CE	?	England		Likely	80
10th-18th CE	M	Alaska		Possible	41
11th - 13th CE	M	Germany	classic honeycomb	Hemangioma	82
12th-13th	M	Poland	No description	Uncertain	36
12th-14th	F	Illinois	Indefinite; no images or description	Uncertain	17
13th-14th	F	England	Sponge-like surface	Hemangioma	3
13th–16th CE	M	Czech Republic	No ectocranial alterations	Uncertain	72
14th CE	F	Sweden	Focal "bump"	Possible	45
Pre 15th CE	M	California	Honeycomb, "hair-on-end"	Sarcoma	1
	F	Peru		Likely	50
	M	Peru	Focal bump	Possible	50
Post 15th CE		Mexico	Irregular intraocular mass	Unlikely	15
16th-17th CE	?F	Belize	Honeycomb	Hemangioma	18,25
18th CE	M	Germany	Inadequate drawing quality	Uncertain	43
19th-20th CE	F	New York	No such presentation listed	Non-existent	71

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Unspecified	M	England	Aberrant endocranial vessel	Uncertain	80
	F	England	Holes, endocranial vasculature	Uncertain	80
	M	England		Likely	80
	F	Sri Lanka	Multinodular	Likely	55
	F	Peru	Sponge-like applicée	Hemangioma	79
	M	Peru	Towering spicules	Osteosarcoma	48,55

*Originally reported as thalassemia by Thomas (2016).

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 those 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 (Wyke, 1949)

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).

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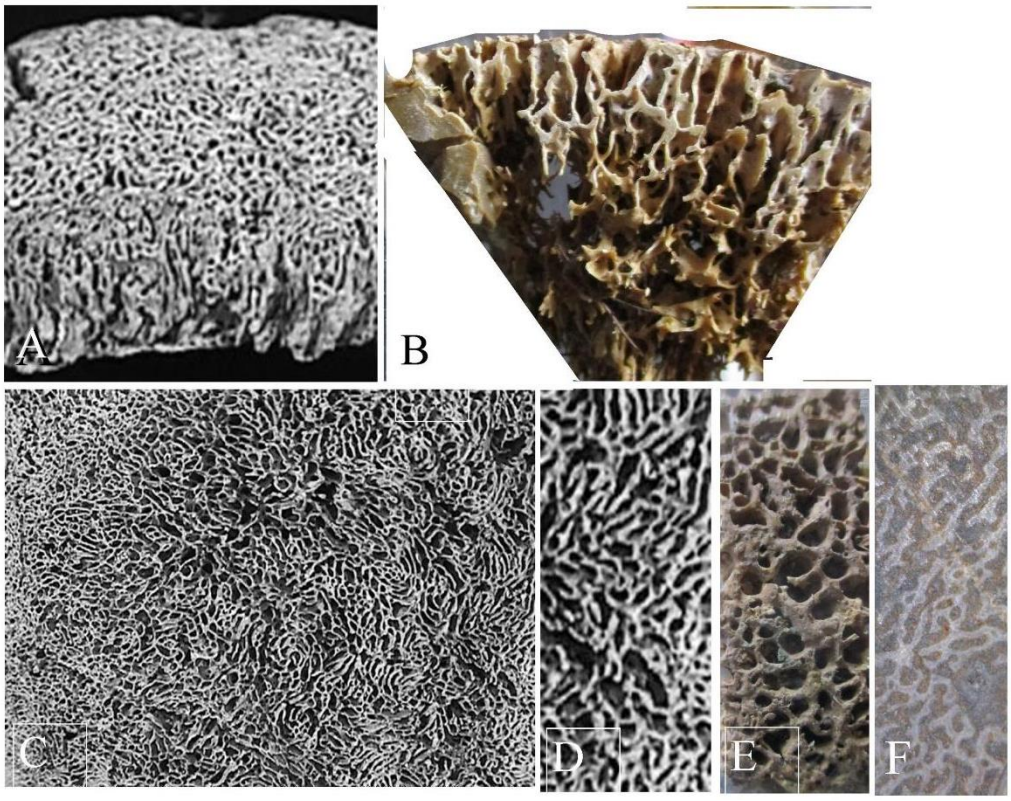

Figure 1. Cranial pathology. (**A**) Oblique view of meningioma fragment. Mesh-like surface created by parallel plates; (**B**) Cross-section of porotic hyperostosis. Irregular trabeculae surrounding marrow spaces; (**C**) En face view of meningioma fragment shown in A. Whorled pattern of meshwork; (**D**) 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. Further, Cook and Danforth's ([18] citation of Siriani et al. [71] as 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 ratios women to men is 5:4 for meningiomas.

Danforth et al. [25] state that the Belize skull fragment resembles that reported by Schamall et al. [70], 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 hyperosrtosis that they had observed." That contrasts with figure 1, which clearly documents the extent of porotic hyperostosis-derived diploic space expansion. Cook and Danforth [18 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

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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 [1] examined San Nicolas Island and Inuit skulls in the San Diego Museum collection, noting twenty with neoplastic lesions. Osteomas account for 11, cancer for seven and large hyperostoses were present in two. Number 158 was interpreted [18, p. 103] as "formed by the fused radiating spicules and the intervening openings having been compared by Moodie [50] 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' [59] 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 [1] 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. [10] illustrates an exostosis with major lytic component and irregular trabeculae incompatible with a diagnosis of meningioma. Cancer is more likely. Kompanje's [43] republication of Salzmann's [67] 1730 drawing of an alleged meningioma in a 43 year old contained insufficient details for diagnosis.

The partially healed osteitis that Bennike [9, 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 centripedally-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 [62] to be uterine, ovarian or breast cancer-related. The male-attribution of the skull makes the latter unlikely. Ricci et al. [59] considered meningiomas in the differential 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 [18] and of additionally recognized cranial pathology (delineated in Table 2) suggested the need for reevaluation. The sex ratio reported by Cook and Danforth [18] is converse to that observed in clinical samples [49,61,83]. ..That 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 a major macroscopic characteristic that distinguishes among meningiomas, hemangiomas and marrow hyperplasia (e.g., porotic hyperostosis). Unique and apparently pathognomonic for meningionas 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 constitutes 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 [32,49,61,83,85}. 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 [19]. 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 ([20,66]. One 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 [5].

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 diagnostic differential. 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). While 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 permits 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 of previous claims of meningiomas are not supported by criteria-based review, noting that the diagnosis has been incorrectly applied, at least in some instances to porotic hyperostosis.

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