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Psammoma Bodies in Meningioma

Appearance by Scanning Electron Microscopy

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Summary. Psammoma bodies from eight meningiomas have been examined by both light and scanning electron microscopy (SEM). The bodies are primarily composed of calcium apatite which is deposited within a nidus of tightly laminated collagen fibers.

Key words: Meningioma – Psammoma bodies – Electron microscopy.

Introduction

Psammoma bodies are a well recognized microscopic feature of many meningiomas (Cushing and Eisenhardt, 1939; Meyer, 1859; Russell and Rubinstein, 1971; Virchow, 1900). It is this microscopic calcification, when present in sufficient quantity, that is visualized in meningiomas on skull roentgenograms. Previous studies (Earle, 1965; Kepes, 1961; Luse, 1960) have demonstrated that the psammoma body consists of laminated deposits of calcium salts with a proteinaceous matrix. This calcific nidus is then surrounded by a whorl of tumor cells of varying thicknesses. This latter features has long been appreciated with light microscopy. Numerous theories have been proposed to explain the incitement of these structures (Napolitano et al., 1964; Russell and Rubinstein, 1971) but no definitive proofs have been offered.

During tumor evaluation with scanning electron microscopy (SEM), several meningiomas have been studied containing numerous psammoma bodies demonstrated by light microscopy. The surface characteristics of these psammoma bodies by SEM were found to be quite similar in all these tumors studied. These cases are being presented to illustrate the structural characteristics as demonstrated by SEM. These structural characteristics do suggest a possible mechanism for psammoma body formation.

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Table 1. Meningioma Patients for Psammoma evaluation

Case No.	Initials	Age	Site
1	M.T.	62	Parasagittal
2	L.Y.	16	Frontal convexity
3	L.B.	70	Parietal convexity
4	V.M.	34	Parasagittal
5	F.S.	46	Tuberculum sella
6	L.D.	56	Temporal convexity
7	K.E.	50	Intraorbital
8	H.H.	73	Frontal convexity

Materials and Methods

Tissue was obtained at the time of surgical craniotomy for tumor removal in eight patients. Sections for light microscopy were prepared in the usual manner. After fixation in buffered formalin the tissue was embedded in paraffin, sectioned and stained with hematoxylin-eosin. Others were stained for reticulin fibers by the method of Gomori.

For SEM the tissue was intially fixed in 10% formalin and progressively dehydrated in acetone. The tissue was then transferred to a critical point drying system[1] (Sorvall) and adhered to an SEM chuck (1/2 inch) with colloidal silver paste[2] (Pella). The specimens were then coated with goldpalladium (125A°) using a Hummer[3] # 1 sputtering device. Scanning was performed using an AMR Scanning Electron Microscope (Model 1000) with an accelerating voltage of 20 Kv in the Raster mode. This was coupled with an energy dispersive X-ray analysis (EDAX) International Model 707A for spectral analysis. Scans were photographed using Kodak Tri-X Pan professional film which was processed according to Kodak's standard instructions.

Patient Material

A total of eight patients were studied. They varied from 16 to 73 years of age.

This was the initial operation for meningioma for all patients, All lesions were encountered at the more typical intracranial sites except for case # 7 who had a menigioma involving the intraorbital optic nerve sheath with no intracranial extension.

Results

Light Microscopy

All eight tumors demonstrated numerous psammoma bodies since this was the basis for inclusion. These were in all instances roughly spherical and ranged from a diameter of 10–60 microns. The psammoma bodies were usually found in groups, but occasionally a single body couuld be isolated. The whorling pattern of the surrounding cells was clearly demonstrated (Fig. 1 A) for most of the psammoma bodies. The Gomori stains revealed that many of the psam-

[1] Sorvall, Newton, Connecticut 06470. Critical Point Drying System

[2] Ted Pella Company, P.O. Box 510, Tustin, California 92680. Colloidal Silver Paste

[3] Technics, Inc., 5510 University Street, Alexandria, Virginia 22310. Hummer # 1

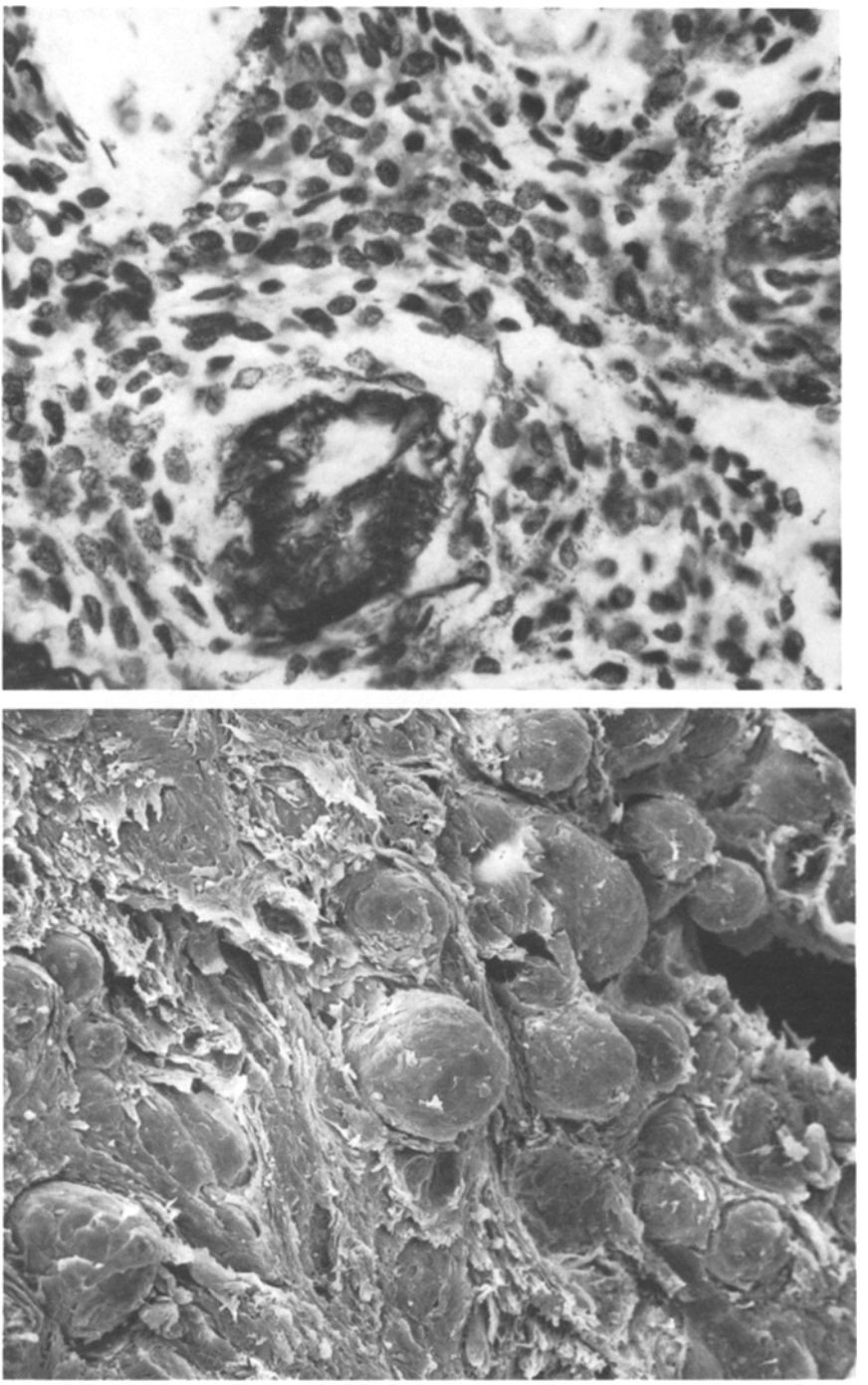
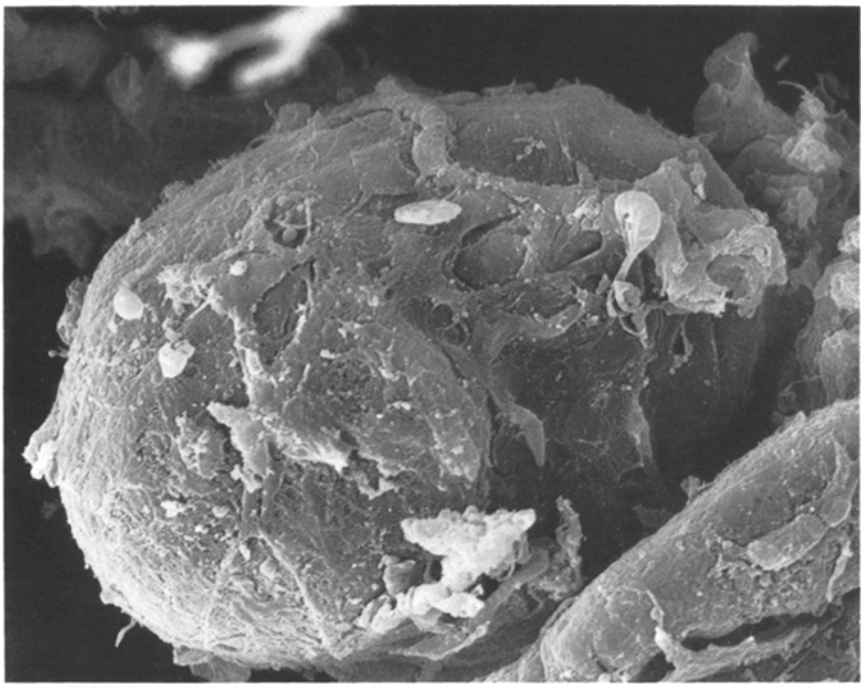


Fig. 1. Patient # 8. **A** Clearly reveals the typical whorling pattern surrounding the psammoma body. H&E 520×. **B** Surface revealing multiple psammoma bodies with surrounding cellular network, SEM 500×. **C** Single psammoma body with surface characteristics of overlapping collagen fibers and cellular processes. SEM 500×. **D** Illustrates the detail of fibers on surface of the same psammoma body as in **C**. SEM 10,000×. **E** EDAX for psammoma body from **C,D.** Note the high peaks for phosphorus and calcium. The silver and gold peaks are from these materials introduced during preparation of the specimen for SEM.



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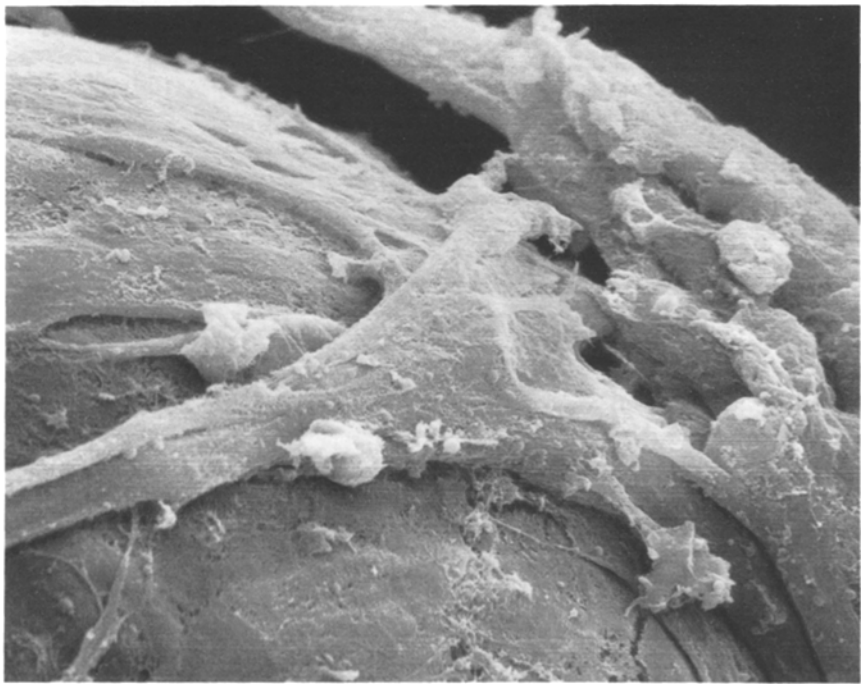

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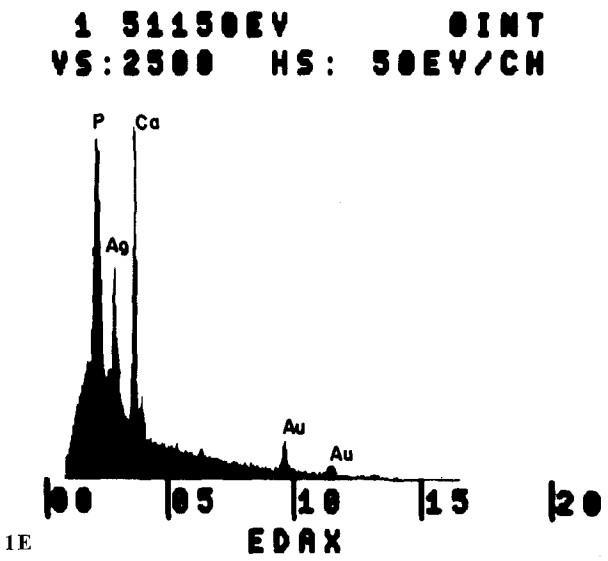

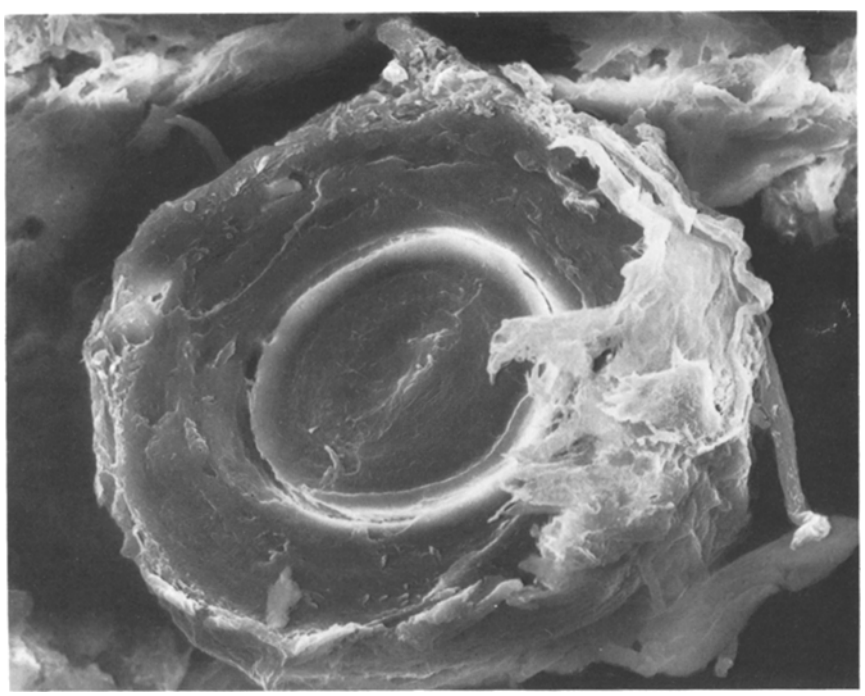

Fig. 2. Patient # 7. Cross section of psammoma body to display concentric layering and densely calcified center. SEM 5000×, of H and E stained parafin section.

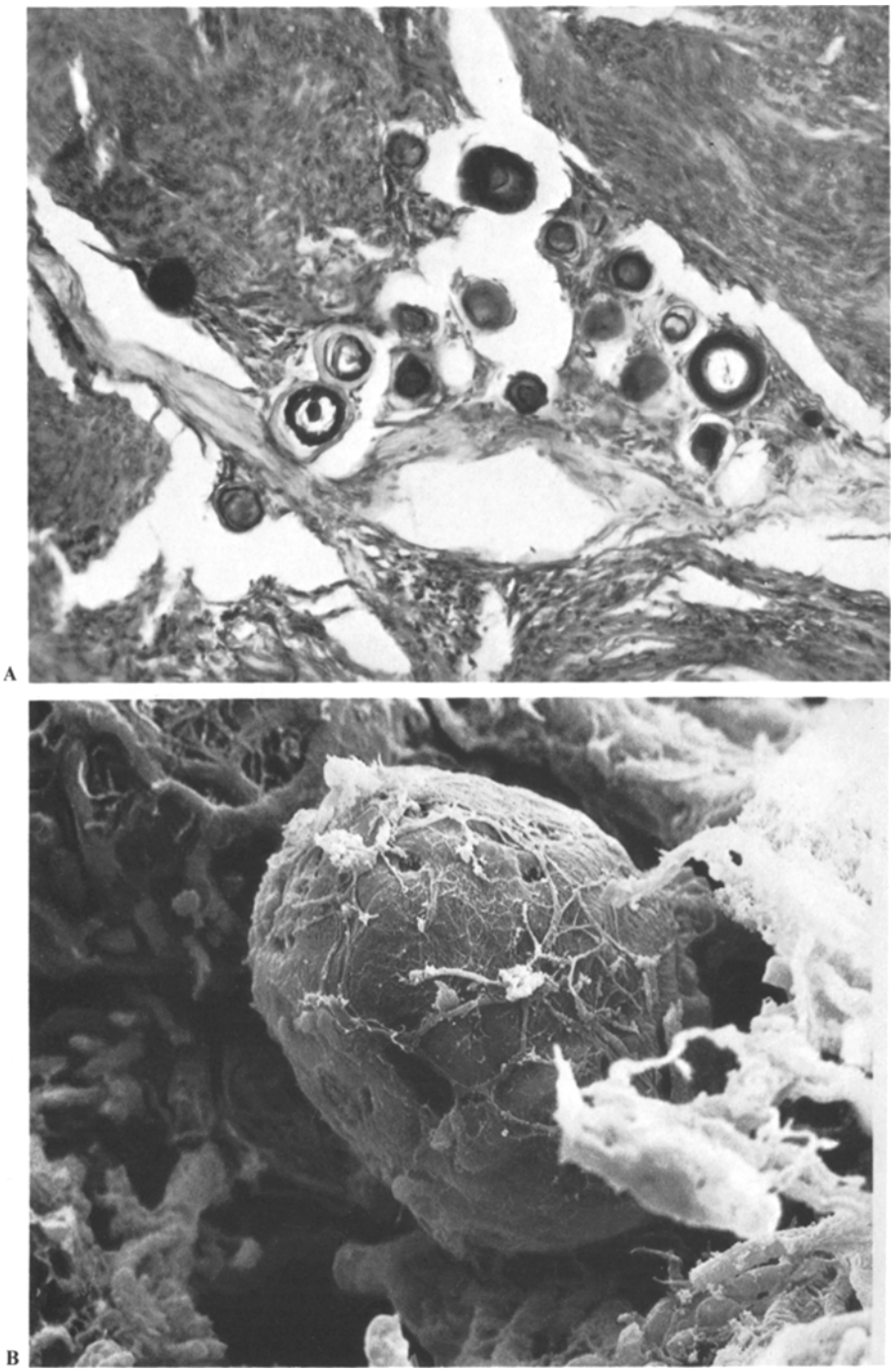

Fig. 3A and B. Patient # 6. **A** Group of typical psammoma bodies with surrounding meningioma. H&E 156×. **B** Single psammoma body with pattern of fibers on surface clearly delineated. SEM 1000×.

moma bodies were surrounded by concentric whorls of dense fibers whose appearance suggest collagen.

SEM

The psammmoma bodies were located and photographed in all cases using the SEM techniques. The roughly spherical bodies were usually intact with their surface being covered with these overlapping fibers or cellular processes (Figs. 1C, 3B). These processes were felt to represent collagen fibers. An occasional psammoma body was split by prepatation and the cross section (Fig. 2) clearly demonstrated the concentric layering of its internal structure.

EDAX analysis revealed high peaks for calcium (3.690 $\kappa\alpha$) and phosphorus (2.013 $\kappa\alpha$) as well as the expected Silver, gold and palladium introduced during tissue preparation Fig. 1E). These calcium and phosphorus peaks are similar to those seen in other biological apatites such as teeth and bone.

Discussion

Since the histological nature of meningiomas was initially described by Virchow (1900) and Meyer (1859) the whorling cellular pattern and the presence of psammoma bodies has been regarded as some of the more characteristic features. Psammoma bodies are, of course, not limited to meningiomas having been reported in serous carcinoma of the ovaries (Aure, et al., 1971), thyroid cancer (Klinck and Winship, 1959) and intradermal nevus (Weitzner, 1968) to mention a few.

Virchow (1900) believed that the "sand bodies" in meningiomas may develop from either cellular elements or from the fibrous stroma. Cornil and Ranvier (1880) believed that they developed from the endothelial cells of blood vessels obliterated by hyalin thrombi. Others (Masson, 1923; Ribbert, 1910) thought that the hyalinization and calcification of cellular whorls were responsible. The tumor cells were felt to "secrete" collagen fibers which then became impregnated with calcium salts. Globus (1937) believed that these bodies were only calcified vascular buds. Essbach (1943) noted that the origin of psammoma bodies could be connected with calcification in vessels, vessel walls and immediately adjacent tissues; they also originate through calcification of necrotic parts of the tumor. Henschen (1955) summarized several other hypotheses including: (a) that the majority of psammoma bodies originate through direct transformation of tumor cells, especially in tumors with marked whorl formation (Bouchard, Robin); (b) they originate from fibrous coils contained in fibrous tissue and in elastin rich meningiomas (Hortega); (c) perivascular origin (Arnold, Masson); (d) swelling, hyalinization and subsequent calcification of connective tissue trabeculae. Some pathologists (Bailey and Bucy (1931), Kernohan and Sayre (1952) feel that whorl formation can develop independently from blood vessels and that such behavior is characteristic for meningothelial cells. Supporting this point, whorl formation has been demonstrated in tissue cultures of meningioma cells (Kersting and Lennarzt, 1957; Rizzoli, Randall, Smith, unpublished work).

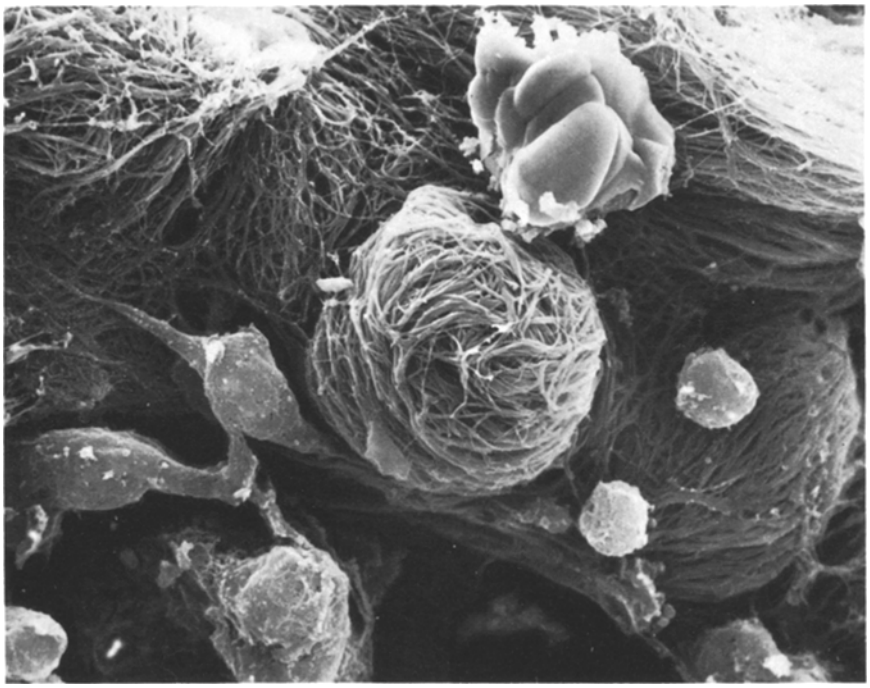

Fig. 4. Patient # 4. Dense tangle of collagen fibers. Such dense tangles may represent the nidus about which the psammoma bodies enlarged SEM 2000×.

Review of the present material seems to favor, as has been suggested (Virtanen et al., 1976), this deposition of collagen fibers in a whorled pattern by the meningothelial tumor cells (Fig. 4) resembles a ball of twine. As this nidus of fibers becomes more compact, there is protein breakdown and deposition of calcium salts. With time the center of these formations may become quite crystalline (Fig. 2). The surface of these spheres continues to be layered by collagen fibers as this entire process sequentially evolves from the center to periphery of the psammoma body.

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