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Fibrous Histiocytoma: An Analysis of the Storiform Pattern*

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Summary. A storiform pattern is an important structural feature of fibrous histiocytoma (FH). In this analysis reconstructions of histological patterns were carried out from drawings. Highly cellular FH with only a suggestion of storiform pattern and small star-formations were seen, there were other lesions with more pronounced fiber formation which showed more distinct and larger storiform stars. These structures can frequently be followed for only 3 sections of 5 micron thickness. In contrast to leiomyomas or meningioma, no regular or consistent orientation of these structures with respect to vessels is evident.

Storiform structures apparently develop at the periphery of adjacent proliferating cells groups. They show a typical and diagnostically significant histological pattern, which was found to some degree in all FH examined.

Key words: Fibrous histiocytomas – Structural patterns – Reconstruction of storiform structures.

Introduction

The term fibrous histiocytoma encompasses a number of mesenchymal tumors which were formerly called by a number of different names including fibroma, fibrosarcoma, myxofibroma or myxoma, emphasising difficulties in classification.

According to the WHO classification (Enzinger et al., 1967) fibrous histiocytomas (FH) are tumours of "histiocytic and fibroblastic cells", the former characterized by phagocytosis, the latter by fiber formation. Signs of phagocytosis are neither ubiquitous nor obligatory. The typical star-like "storiform" arrangement of cells and fibers is therfore considered to be an important diagnostic criterion for FH.

* This study is dedicated to Prof. Dr. E. Uehlinger, who celebrates his 80th birthday

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This study is an analysis of storiform pattern by reconstruction and a comparison of these morphological structures at various levels in serial sections.

Material and Methods

18 consecutive cases with fibrous histiocytomas (FH) were examined by 20 serial sections, each measuring 5 μ in thickness. In 3 cases methacrylate embedded 2-μ-thick sections were also studied, after silver impregnation.

The sections were assessed using a drawing microscope (Wild). Distinctive and, where possible, continuous morphological structures, like blood vessels, served for topographical orientation which was optimised by an ocular grid. The projected fields of view were drawn on transparant paper. To obtain a three-dimensional effect comparable with technical exploded-view sketches, each deeper step was adjusted to the preceding section and displaced by the same amount in vertical and horizontal direction. The limits of the areas reconstructed had to be drawn arbitrarily, since discrete structures (e.g. colonic adenomas) were not involved.

The cases studied showed variable expression of the storiform pattern. The results obtained were compared with tumors showing different structural patterns, for example leiomyoma or mengioma.

Results

8 cases showed cellular proliferation and fiber formation with a distinct storiform pattern. In 2 further cases the storiform pattern was indistinct. The remaining 8 cases in which there was little fiber formation, revealed only a suggestion of storiform arrangement of cells.

FH with little fiber formation show converging spindle cells with few fibers and the beginning of star formation to the side of capillaries, in consecutive sections. Eventually a perfect, small and mainly cellular storiform structure appears, which is devoid of capillaries (Fig. 1a and b). FH with pronounced fiber formation reveal a crossing over of fiber bundles with larger fibrous storiform structures appearing and disappearing as various levels of 5-micron-thick sections are compared (Fig. 2). The centers of these structures are typically free of nuclei, fibers and capillaries.

As the storiform star formations come and go with changing levels of sectioning they retain their typical off-set position with reference to capillaries and larger blood vessels (Fig. 3a and b).

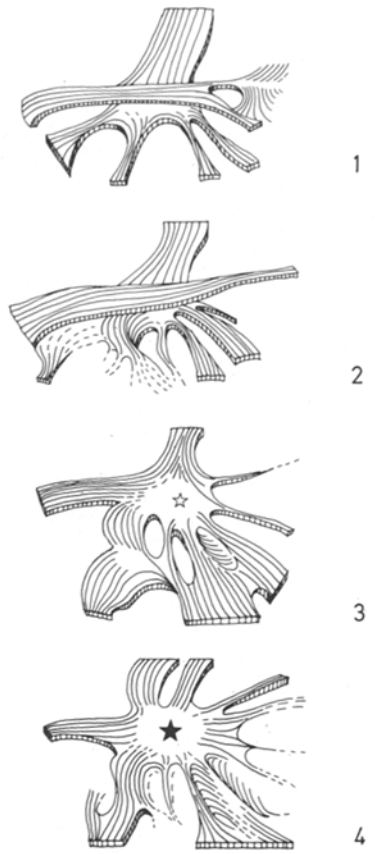
A individual storiform structure could usually be traced through 3 consecutive cut sections (each 5-micron-thick). In only 10% are there central capillaries,

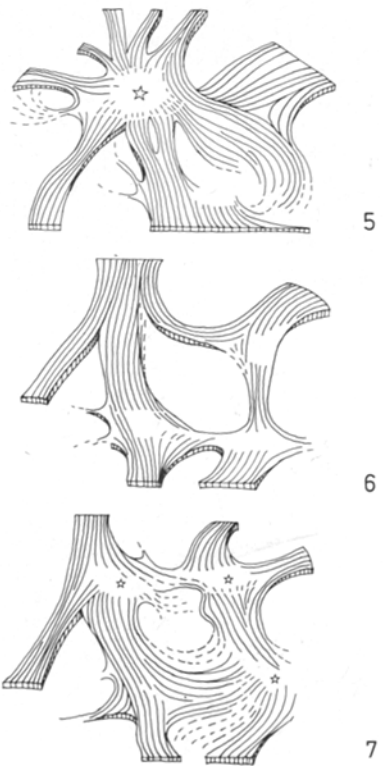
Fig. 1. a A small cellular storiform structure appears off-set from a capillary (→) and is fully developed in section 4 (★). **b** Original histological section: storiform structure. Silver impregnation, ×400

Fig. 2. At the meeting point of fiber bundles a large storiform structure appears in section 3 (☆). It is fully developed in section 4 (★) and dissapears in section 5 (☆). In section 5 and 7 several blank areas can be seen-possibly the origin of storiform structures.

1a

b





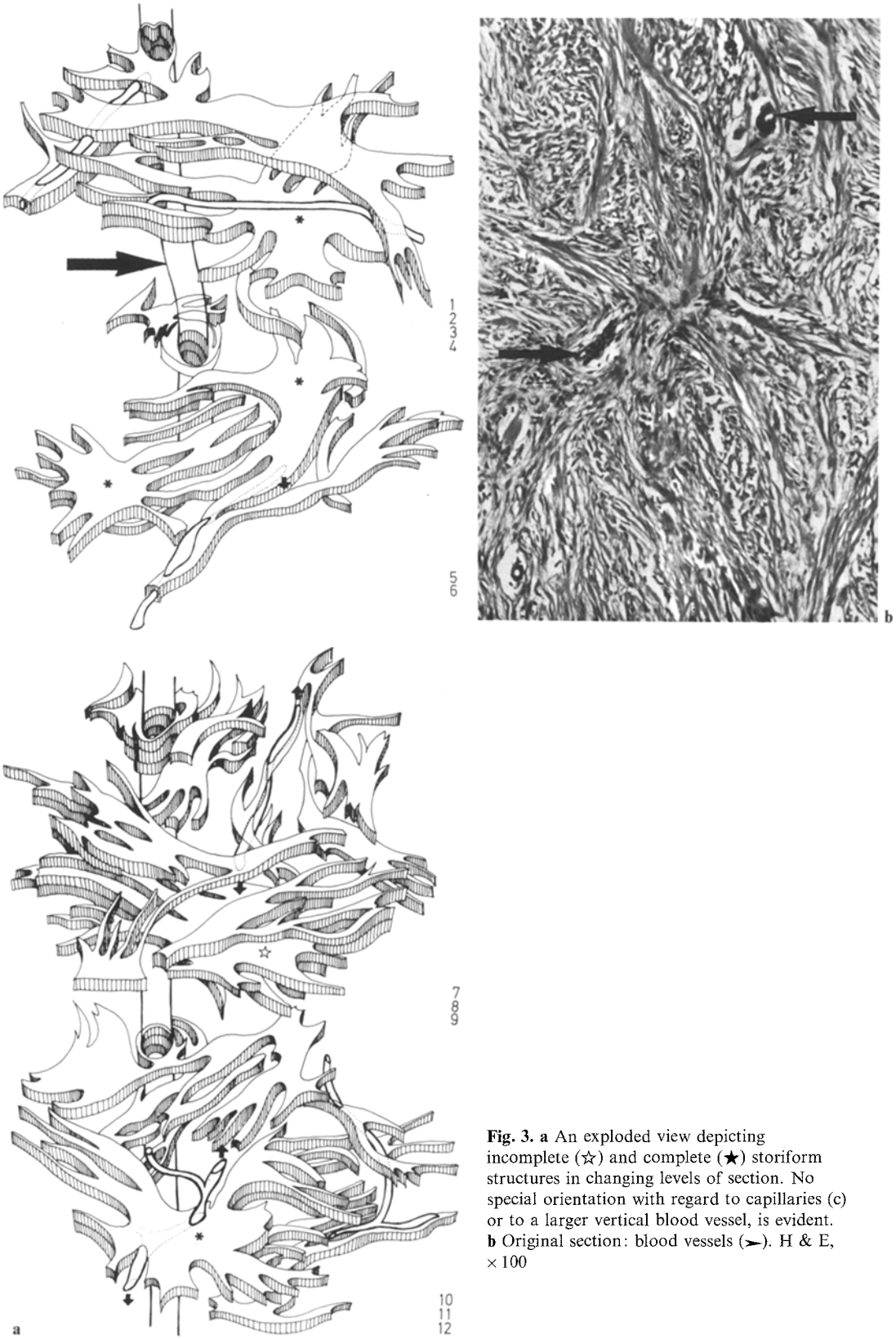


Fig. 3. a An exploded view depicting incomplete (☆) and complete (★) storiform structures in changing levels of section. No special orientation with regard to capillaries (c) or to a larger vertical blood vessel, is evident. **b** Original section: blood vessels (➢). H & E, × 100

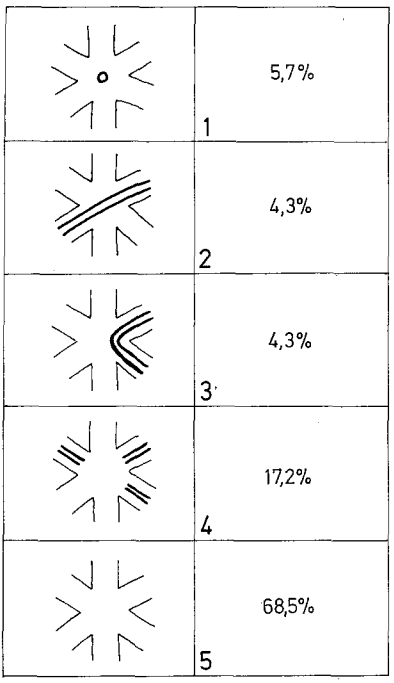


Fig. 4. Possible relationships between storiform star-formations and capillaries (heavy lines). Centers without blood-vessels

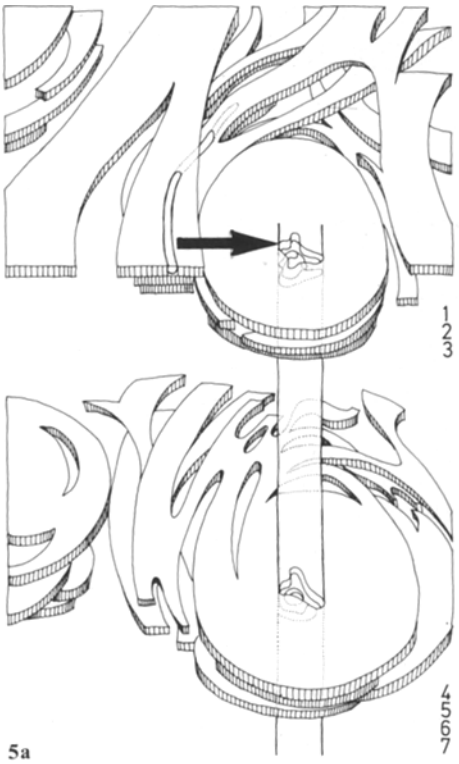
which do not necessarily form a vertical axis. In 90%, the centers of storiform structures are not only free of capillaries, but also free of cells (Fig. 4).

In contrast, leiomyomas show a consistently perivascular arrangement of cells and fiber bundles, with a centrifugal decrease of fiber density. Adjacent longitudinal bundles run at a right angle to the perivascular bundles (Fig. 5a and b).

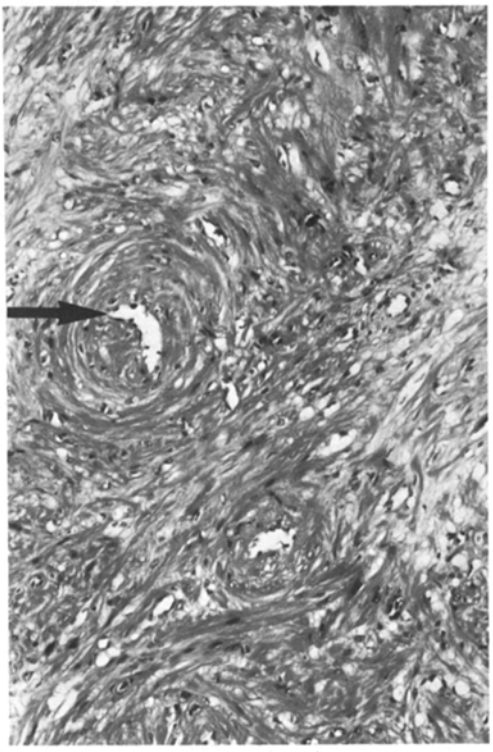
Vascular meningiomas show a distinct perivascular arrangement of cells and fibers. Concentrically arranged perivascular portions seen in cross section, blend with longitudinally cut fibers (Fig. 6a and b). There is a centrifugal increase in fiber density.

In contrast to other tumors, like leiomyomas (C) or meningiomas (D), FH show no regular and particular vascular orientation. In three-dimensional reconstructions, hemispherical or spherical cell and fiber compartments are evident in FH (Fig. 7).

Our reconstructions suggest that the storiform pattern is not a result of centrifugal cellular proliferation with radial fiber formation. Cellular storiform patterns of small size and larger fibrous forms make their appearance between hemispherical or spherical compartments, i.e. in the small free spaces at the periphery of groups of proliferating cells (Fig. 8). Translation of the two-dimensional pattern into a three-dimensional reconstruction yields a spherical pattern with star-formations at the peripheral crossing-points of these spheres (Fig. 9).



5a



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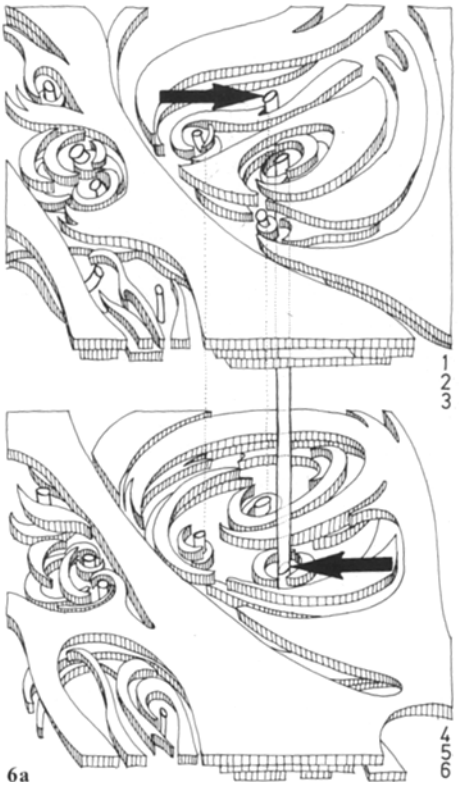

6a

b

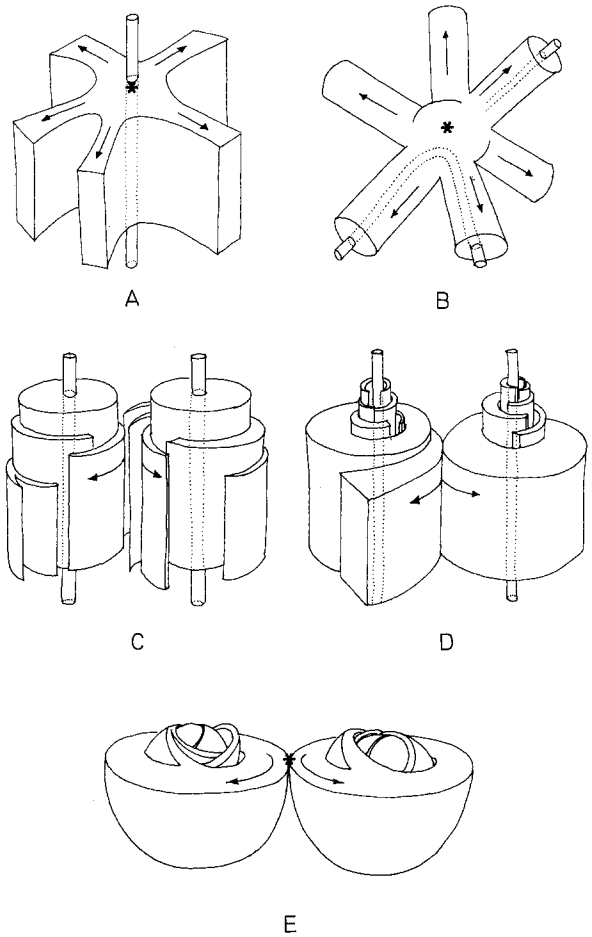

Fig. 7. Theoretical possibilities of relationships between blood vessels and cellular proliferation with fiber formation (A, B). – Reconstructions of: C) leiomyoma, D) meningioma and E) fibrous histiocytoma.

Discussion

Fibrous histiocytomas are mesenchymal tumors, which are listed among connective tissue tumors in the WHO classification (Enzinger et al., 1969). They may be benign or malignant, variably pleomorphic and dermal or deep-seated (Acker-

Fig. 5. a Leiomyoma with vertical vascular axis and typical concentric perivascular arrangement of cells and fibers. **b** Original histological section: blood vessels (➢). H & E, × 100

Fig. 6. a Meningioma: several smaller vascular axes; partial and segmental discontinously overlapping perivascular arrangement of cells and fibers. **b** Original histological section: blood vessels (➢). H & E, × 100

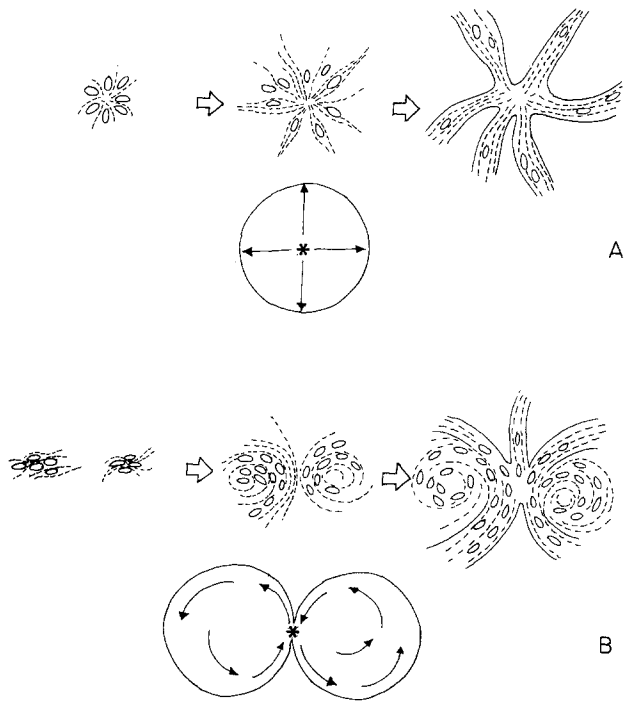

Fig. 8. Concepts of genesis of storiform structures: A) conventional idea (after Vilanova and Flint, 1974) of rosette-like initial structure, with radially growing centrifugal cell proliferation and fiber formation. – B) our findings explain the occurrence of storiform structures as the result of peripheral contact of proliferating cellular groups, whereby the center of the storiform formation constitutes the "no-man's-land" inbetween these groups

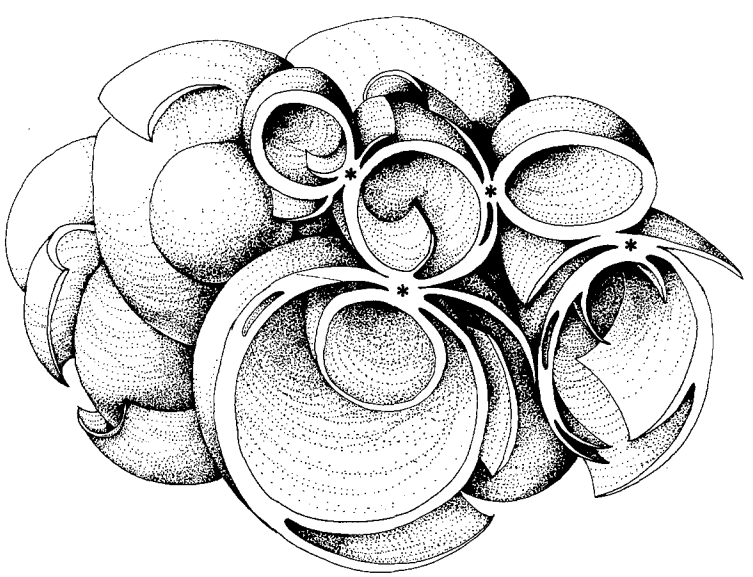

Fig. 9. 3-dimensional reconstruction of FH. Spherical appearance with indistinct and distinct storiform structures (*).

man et al., 1974). Best known and most frequently found is the benign, non-pleomorphic dermal type synonymous with dermatofibroma. "Dermatofibrosarcoma protuberans" can be considered as a non-pleomorphic type of intermediate behavior. These two types show a distinct storiform pattern. A scanty storiform pattern may, however, be the important histological clue for identification of malignant pleomorphic histiocytomas, which might otherwise be unidentifiable if phagocytic activity cannot be demonstrated.

Our analysis of storiform structures in non-pleomorphic fibrous histiocytoma is intended to help in more precise diagnosis of fibrous histiocytomas and is an attempt to improve the definition of the storiform pattern itself. The term "storiform" was coined by Bednar (1957) in describing storiform neurofibroma. The word was derived from the Latin "storia", meaning matting, refering to the matted texture of cells and fibers. Alternative terms include star-like (Penner, 1951), spoke-wheel (Taylor and Helwig, 1962), spiral nebula (Kauffmann and Stout, 1961), rosette (McPeak et al., 1967), for this eye-catching histological pattern. A common designation is "whorling pattern", but storiform appears to be the most universally used term. The typical storiform structure is a star with about 5 beams (or a wheel with about 5 spokes). The center is free of cells and fibers. The individual spokes show centrifugally increasing deviation, but with cellular connections between radial fibers. The sketches of our reconstructions were simplified to facilitate illustration and it must be emphasised that between the drawn-out strands of cells and fibers, a loose aggregation of cells with little fiber formation and without distinctive pattern, is present. In some cases the storiform pattern is indistinct and incomplete, or only suggested. In contrast to the typical storiform structure with marked fiber formation, as seen in dermatofibrosarcoma protuberans, highly cellular lesions with only little fiber formation show smaller and less distinct storiform structures, which are typically better recognized at medium magnification and disappear under high power. They may be seen better after silver impregnation.

Small, mainly cellular, storiform structures with little fiber formation were identified in this reconstructive analysis. This star-formation was more emphimeral than the larger structures seen in those lesions with marked fiber formation. However, even these larger stars often disappeard within 3 levels of serial sections, each 5-micron-thick.

A histiocytic origin for these tumors was suggested from the results of cell cultures (Ozello, Stout and Murray, 1963). Auböck (1975), Taxy and Battifora (1977) support the histiocytic nature of FH because from their fine structural findings. The latter emphasise a marked vascularity and the presence of capillaries within the hub of the spokewheels which, in their series of 16 cases, only appeared on electronmicroscopy. Taylor and Helwig (1962) and Bandmann (1957) both found the center of the storiform structures empty and avascular. Fine-structural examination of one typical "avascular" storiform center carried out by us revealed neither evidence of vascular structures nor collagen.

In our series central blood vessels in storiform structures were rare (10%) and appeared to be haphazard. In contrast, leiomyomas and miningiomas revealed a distinct and regular relationship between cellular proliferation, fiber formation and blood vessels.

A perivascular cell arrangement in FH was suggested by Senear and Caro (1936) and Gross and Wolbach (1943) ("sclerosing hemangioma"). The latter, like Carstens and Schrodt (1974) consider an endothelial origin of the proliferated cells in FH probable from their fine-structural findings.

The transition of small cellular storiform structures to large fibrous ones appears to be possible from this study, which illustrates intermediate forms with an indistinct storiform pattern but with increasing fiber content. The reconstructions carried out suggest an arbitrary relationship between storiform structures and blood vessels, and disagree with a suggested origin of storiform structures from centrifugal cell proliferation (Vilanova and Flint, 1974). On the contrary, a storiform pattern appears to be the result of contacts between adjacent groups of proliferating cells. A no-mans-land free of cells and fibers, between the expanding cell groups, apparently forms the center of a storiform structure. These intermediate areas, free of cells and fibers, become evident in three-dimensional reconstructions of FH which reveal a more or less spherical configuration of groups of proliferated cells with fiber formation. The true centers of these proliferative units are not histologically evident and do not appear to be the centers of "whorling" structures in the storiform pattern seen in FH.

A storiform pattern is found not only in benign FH or dermatofibrosarcoma protuberans. It may be a significant diagnostic clue for the true fibrohistiocytic nature of poorly differentiated primitive and myxoid pleomorphic malignant mesenchymal tumors (Weiss and Enzinger, 1977; Meister and Konrad, to be published).

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