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Incidence and Histological Structure of the Storiform Pattern in Benign and Malignant Fibrous Histiocytomas

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Summary. A starlike arrangement of cells and fibers, the "storiform pattern", was found to be a typical, but not obligatory, histological feature of benign and malignant fibrous histiocytomas. In 155 benign fibrous histiocytomas storiform structures were missing in 29 cases, chiefly of the fibroblastic type comparable with classical "dermatofibroma". 12 of 70 malignant fibrous histiocytomas did not reveal storiform structures, especially the cellular pleomorphic variant, i.e. the classical pleomorphic sarcoma.

Storiform structures were either small and highly cellular with few fibers (collagen type III), or larger, less cellular, but with abundant fibers (collagen type I). There was no sharp demarcation between these two extremes, but many transitional structures or patterns were seen. The histiocytic nature of the cells was demonstrated in both variants of storiform structures by immunhistochemical methods on paraffin embedded material. Alpha$_1$-antichymotrypsin was especially valuable in this respect.

Key words: Benign and malignant fibrous histiocytomas – Storiform pattern – Incidence – Histological structure

Introduction

Fibrous histiocytomas are by definition tumors of histiocytes and fibroblast-like cells (Enzinger, 1969). However, the histiocytic component is not always easily recognizable and fibroblastic qualities are not a very specific feature.

A "storiform" pattern of proliferated cells and fibers is considered to be characteristical for fibrous histiocytomas. This storiform pattern had been analysed in a previous study (Meister et al. 1979). The aims of the second part

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Dedicated to Prof. Dr. W. Büngeler to his 80th birthday

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of the "storiform story" are to examine a) the incidence and b) the histological structure of the storiform pattern.

Material and Methods

155 consecutive cases of benign fibrous histiocytoma and 70 cases of malignant fibrous histiocytoma were studied, with regard to cellularity, fiber formation and the presence of storiform structures. Three subtypes could be distinguished for benign and malignant histiocytoma: 1. "histiocytic" (cellular) type, 2. intermediate (or mixed) type and 3. "fibroblastic" (fibrous) type (Meister et al. 1978a; Meister et al. 1980).

The incidence and grade of storiform pattern was evaluated for these three subtypes.

The histological composition and the variants of storiform structures were examined with particular regard to cellularity and fiber formation. H & E stains and silver preparations were available for all cases.

Results

a) Incidence of Storiform Pattern

1. Storiform pattern could *not* be recognized in 29 of 155 cases of benign fibrous histiocytoma (Fig. 1). It was most frequently missing in fibroblastic (fibrous) type 3, which corresponds to classical "dermatofibroma". These cases were classified as fibrous histiocytomas by other criteria, as for instance xanthomatous

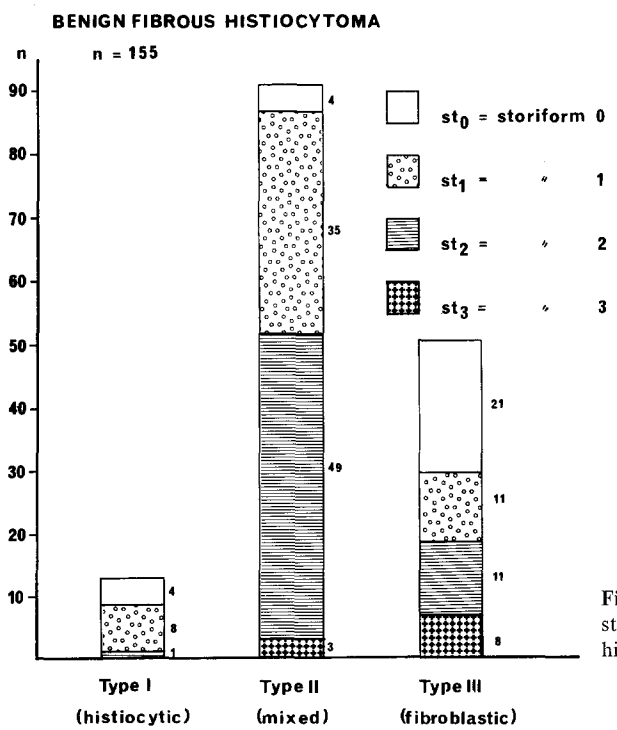

Fig. 1. Incidence and degree of storiform pattern in benign fibrous histiocytoma

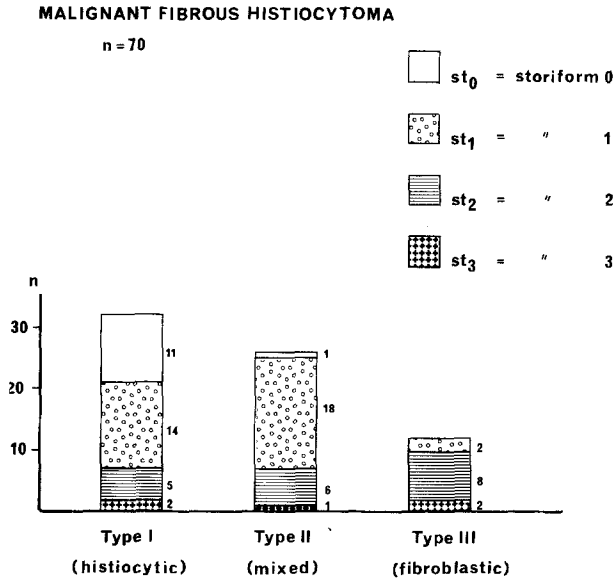

Fig. 2. Incidence and degree of storiform pattern in malignant fibrous histiocytoma

cells and/or phagocytosis with haemosiderin deposits. A semiquantitative distinction of + to + + + for the storiform pattern did not reveal a significantly different distribution pattern for each of the three subtypes.

2. 12 of 70 malignant fibrous histiocytomas did not reveal storiform pattern (Fig. 2). Absence of storiform structures was noted chiefly in group 1, the histiocytic type, with numerous pleomorphic, frequently multinucleated cells, compatible with the former "pleomorphic sarcoma". In only one of the intermediate and in none of the markedly "fibroblastic" (fibrous) type of malignant fibrous histiocytoma was a storiform pattern absent. The "fibroblastic" (fibrous) type with only scattered pleomorphic multinucleated tumor cells would formerly probable have been called (pleomorphic) fibrosarcoma.

b) Histological Structure of the Storiform Pattern

These results show that a storiform pattern is related to proliferation of spindle cells and not necessarily associated with formation of fibers of collagen I or III. Indeed, storiform structures may be highly cellular with only few reticulin fibers (collagen type III) (Fig. 3a, b), or of somewhat larger dimension with numerous fuchsinophilic fibers (collagen type I) and only low cellularity (Fig. 4a, b).

These differences in histological appearance were not evaluated separately with regard to their incidence within individual tumors or different subtypes of fibrous histiocytoma. There is frequently a combination and mixture of small cellular and larger fibrous storiform structures, or intermediate (mixed) storiform structures. Only exceptionally did cases with fibrous histiocytomas show, side by side, areas with highly cellular and less cellular storiform structures.

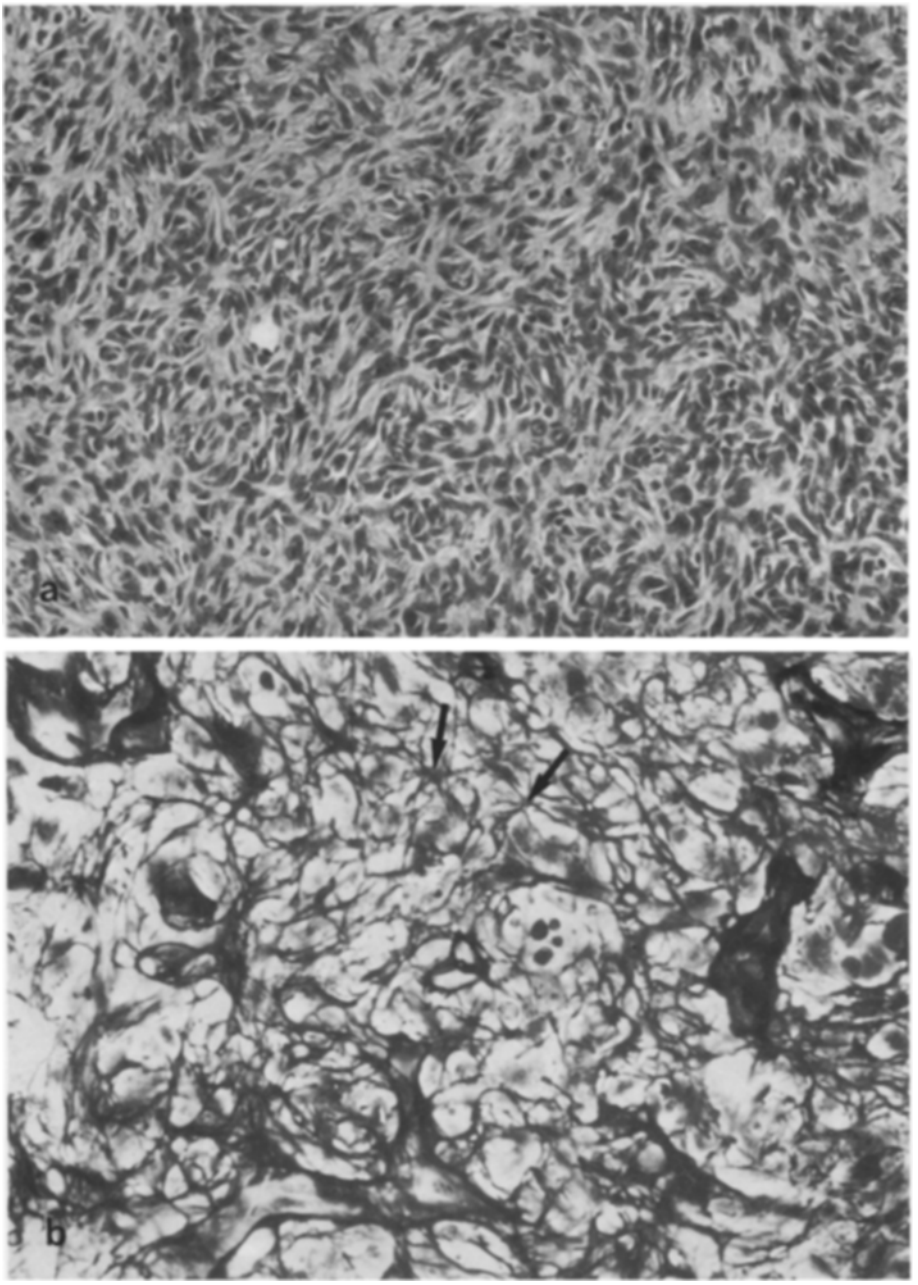

Fig. 3. a Highly cellular fibrous histiocytoma, with little fiber formation and whorling or star-like arrangement of cells forming ill-defined storiform structures of small size. H & E, ×160. **b** Highly cellular storiform structure chiefly with fibers of collagen III (reticulin), which occasionally outline a storiform structure (→). Silver impregnation, ×160

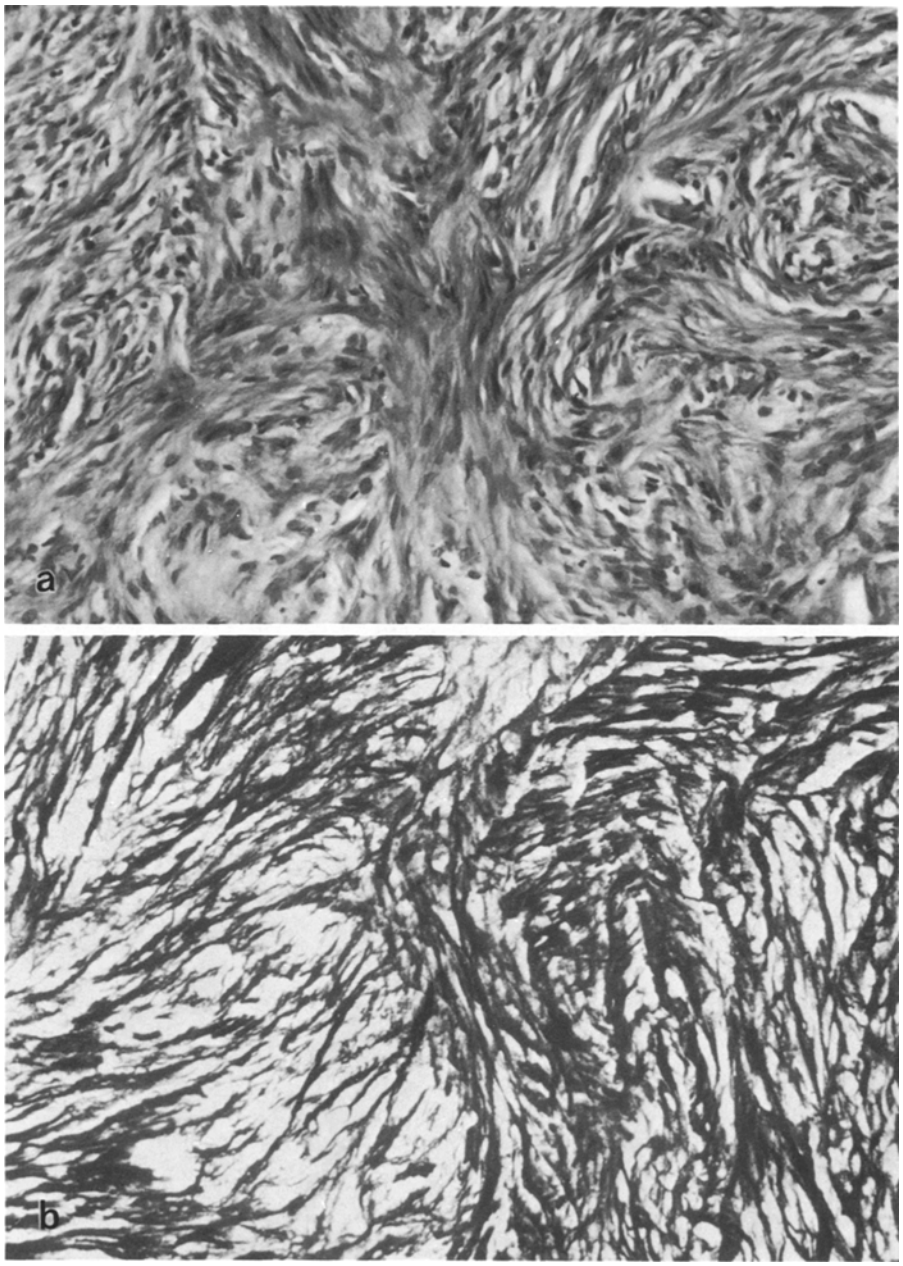

Fig. 4. **a** Large, fibrous storiform structure with less cellularity and larger fibers of collagen I: star-like formations of fibers with hypocellular centers. H & E, ×160. **b** Large fibrous structure with broad and long fibers of collagen I. Silver impregnation, ×160

Malignant fibrous histiocytomas characteristically show atypical and often multinucleated tumor cells characteristically associated with larger storiform structures with well developed fibers.

Discussion

Our results support the opinion that storiform pattern is characteristic for fibrous histiocytomas but not pathognomonic: it may be absent in fibrous histiocytoma and may be present in other tumors (Auböck 1975; Hajdu 1979; Metz 1978).

The presence of a storiform pattern is also dependant on the definition of fibrous histiocytoma and on its histological variants: it is almost obligatory in highly cellular lesions showing moderate fiber formation and in cases which qualify as "dermatofibrosarcoma protuberans" (Burkhardt et al. 1966; McPeak et al. 1967; Taylor and Helwig 1962). It is necessarily present in storiform variant of fibrous histiocytoma (Vilanova and Flint 1974). In our series of 155 fibrous histiocytomas, subtype II included "dermatofibrosarcoma protuberans" and "progressive, recurring dermatofibroma" (Meister et al. 1979). Storiform pattern is most often absent in fibrous histiocytomas with marked scar-like fiber formation = classical dermatofibromas (Burkhardt 1966; Vilanova and Flint 1974). It is also described in about half of the cases showing a vascular variant of fibrous histiocytoma, compatible with sclerosing haemangioma (Vilanova and Flint 1974). Malignant fibrous histiocytoma can also show a storiform pattern, which may predominate.

Excluding "dermatofibrosarcoma protuberans", which was included within the series of 155 fibrous histiocytomas (Meister et al. 1978a) the malignant fibrous histiocytomas seen in this series were all pleomorphic. It was pleomorphic, highly cellular type I which most frequently lacked the storiform pattern.

We must also emphasise that a storiform pattern may be mature and distinct, or immature and poorly defined (Hashimoto et al. 1974; Vilanova and Flint 1974) and may be present only focally (Limacher et al. 1978; Headington et al. 1978). The focal nature of the storiform pattern is described in both benign and malignant fibrous histiocytomas (Churg and Kahn 1977; O'Brian and Stout 1964; Taxy 1977; Meister et al. 1978a, 1980, 1981). In our experience with varying fiber formation and cellularity, a storiform pattern is more likely to be found in highly cellular areas in benign non-pleomorphic tumors than in malignant pleomorphic fibrous histiocytomas. There may be all different grades of a spectrum reaching from small highly cellular storiform structures, to larger hypocellular structures. A possible "maturation" from small cellular to larger fibrous structures is discussed (Vilanova and Flint 1974). This is reasonable, as formation of collagen type I which predominates with large storiform structures needs more time in its development.

Many storiform structures are inbetween two extremes. Sometimes within a individual storiform structure, various segments may show different cellular composition. Therefore, we found that it was senseless to relate histological variants of storiform structures to various subtypes of fibrous histiocytoma. However, it has to be concluded that highly cellular tumors or tumor areas

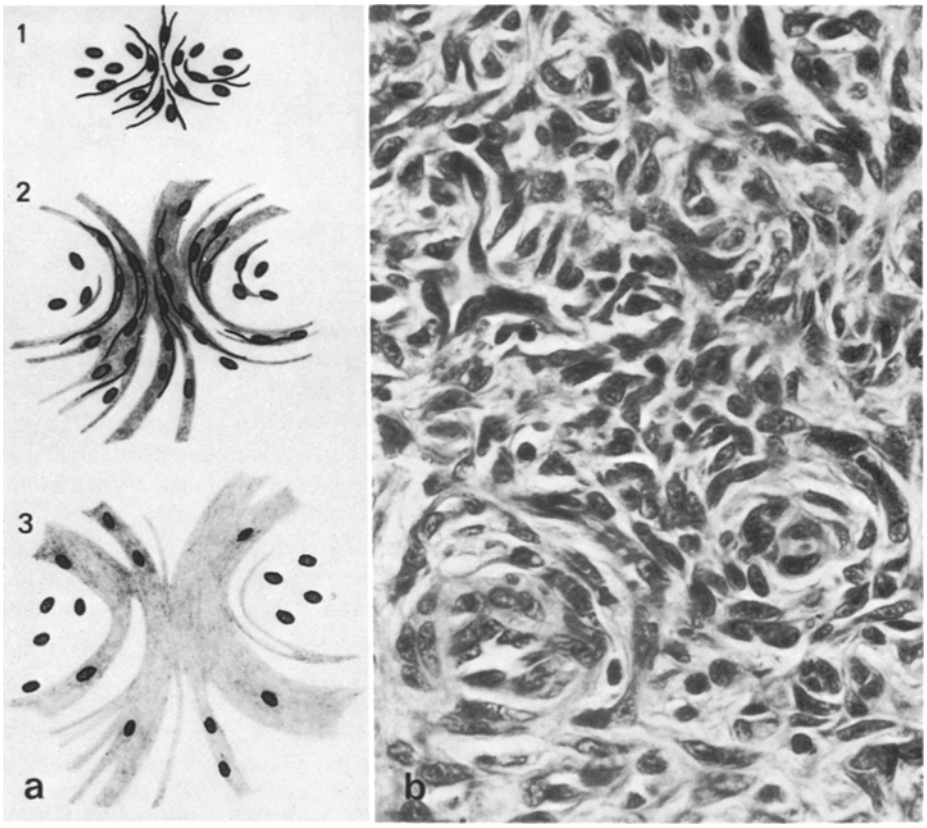

Fig. 5. **a** Schematic drawing of a 3-dimensional reconstruction of 1) small, 2) intermediate (or mixed), and 3) large storiform structure. With 1) fibers of collagen III, 2) collagen III and I, 3) mainly broader fibers of collagen I. A star-like ("storiform") structure appears between two adjacent foci of cellular proliferation. **b** Highly cellular fibrous histiocytoma with two foci of perivascular concentric proliferation of spindle cells and a developing storiform structure inbetween. H & E, ×400

reveal smaller and highly cellular storiform structures, whereas in fibroblastic (fibrous) tumors larger fibrous storiform structures have to be expected, if they are present at all.

The histiocytic nature of the cells contributing to storiform structures is occasionally evident from foam cells, or haemosiderin deposits, denoting phagocytosis in an area of haemorrhage. In a greater number of cases the nature of the cells can be demonstrated immunohistochemically in paraffin embedded material by lysozyme or, better, by alpha$_1$-antichymotrypsin (Meister et al. 1980; Meister and Nathrath 1981). Hypocellular fibrous storiform structures may also reveal scattered histiocytes. Furthermore, fibroblast-like spindle cells may show positive immunohistochemical marking compatible with their histiocytic origin. Perivascular centrifugal cell proliferation was only rarely found within the center of fibrous histiocytoma. In general the centers of storiform structures

were hypocellular, probably-representing a peripheral no-man's land between groups of proliferating cells (Vilanova and Flint 1974; Hajdu 1979; Meister et al. 1979). This concept is supported by the results of 3-dimensional reconstructions of small, medium and large size storiform structures (Fig. 5a, b). This pattern is also suggested by cellular concentric pericapillary proliferating units, adjacent to avascular centers of storiform structures.

The incidence of storiform pattern with tumors other than fibrous histiocytomas and its benign and malignant variants is difficult to estimate. Reports of storiform structures within fibrosarcoma (Taylor and Helwig 1962) touch on the question of nomenclature, as these tumors could also have been classified as (fibroblastic) malignant fibrous histiocytoma. This is especially true as the storiform pattern with malignant fibrous histiocytoma appears to be associated with distinct fiber formation. In some cases the distinction between malignant fibrous histiocytoma and fibrosarcoma apparently may be impossible. Moreover, pleomorphic malignant fibrous histiocytomas have to be distinguished from similar appearing pleomorphic rhabdomyosarcomas or liposarcomas. Nevertheless, there are reports of storiform pattern with peripheral nerve tumors, for example neurofibromas, neurolemmomas and neurogenic sarcomas, and with malignant melanomas (spindle cell type), cellular blue nevi and nodular fasciitis. A wide variety of lesions as thymoma, thecoma, mesothelioma and Kaposi-sarcoma may also be associated with this pattern (McPeak et al. 1967; Metz 1978; Auböck 1975; Meister et al. 1978b).

Storiform structures can also be observed in granulation tissue (Meister 1981). It should also be remembered that the term "storiform" was coined for lesions which originally were considered to be "pigmented or non-pigmented neurofibromas of the skin" (Bednar 1957).

In conclusion, it may be assumed that a storiform pattern is related to proliferation of spindle cells with varying fiber formation (collagen type I and/or III). Fibrous histiocytomas, which are tumors of histiocytic and fibroblast-like cells, are tumors of this type and the accent may be on either one of these two components.

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