Storiform pattern in dermatopathology

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Introduction

The diagnosis of skin and soft tissue tumours can be challenging at times. The pattern in dermatopathology represents a specific arrangement of tumour cells, stroma, or both within the tumour mass. Various patterns described in dermatopathology are pagetoid pattern, storiform, interstitial, palisading, petaloid, rosette, ripple, and others. The term 'storiform' was derived from the Latin word 'storea', which means 'matting', and was coined by Bednar in the year 1957. It depicts a typical pattern of a star-like 'spiral nebula', spoke-like 'whorling', and 'rosette' arrangement of cells and fibres [Figure 1a-1d].[1] It is better appreciated under low magnification and with silver impregnation. This paper attempts to summarise the dermatological conditions, where the storiform pattern is visualised, and additional clues in arriving at a diagnosis.

Dermatofibroma

Early lesions of dermatofibroma are more cellular and later become sclerotic. It is a circumscribed non-encapsulated dermal tumour with a Grenz zone. It comprises spindled fibroblasts and histiocytes, classically arranged in a storiform pattern [Figures 2a, 2b and 2c].[1]

Dermatofibrosarcoma protuberans (DFSP)

Histopathological examination of DFSP reveals monomorphic spindle cells loosely scattered in the dermis in a storiform

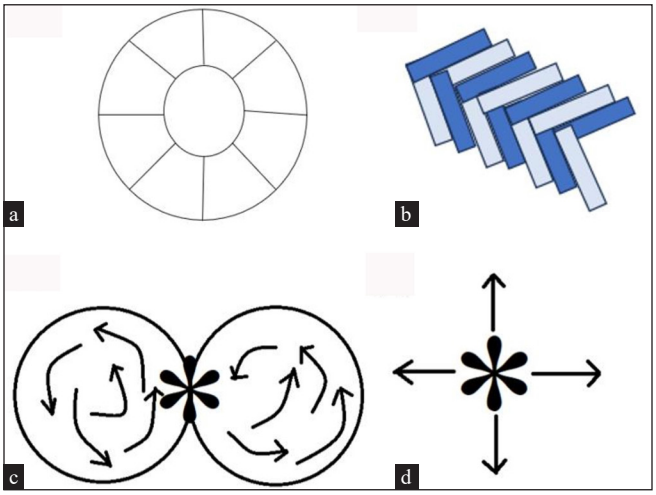

Figure 1: Schematic diagram of various storiform patterns; a) Cartwheel pattern radiating from a central hub, b) Woven pattern with right angle bundles/fascicles, c) Whorl-like pattern, d) Pinwheel pattern radiating from a central point.

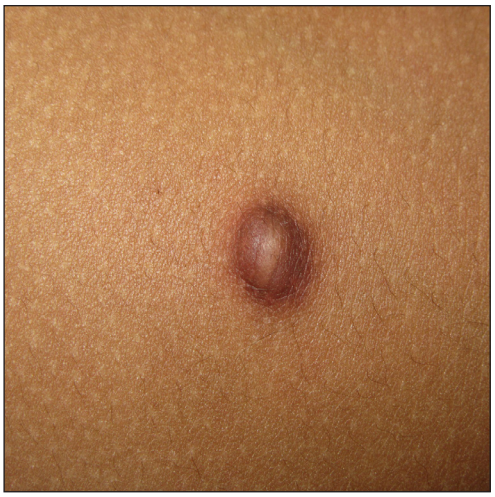

Figure 2a: Dermatofibroma presenting as a brown firm nodule.

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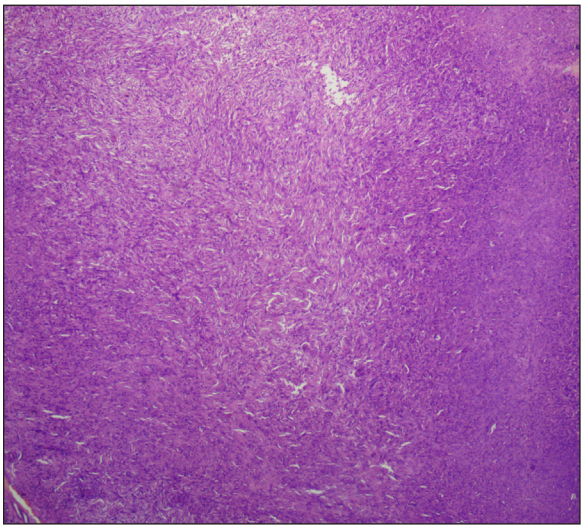

Figure 2b: Histopathology of dermatofibroma shows spindle cells in a storiform pattern [Haematoxylin and eosin, 50x].

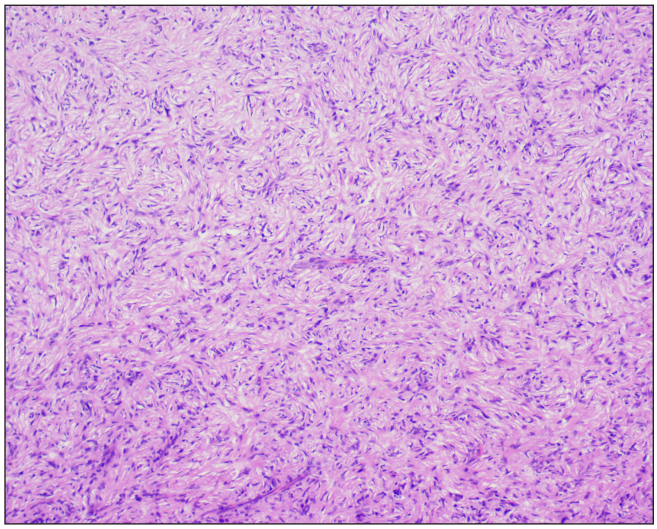

Figure 2c: Histopathology of dermatofibroma shows fibroblasts and epithelioid-shaped histiocytes [Haematoxylin and eosin, 100x].

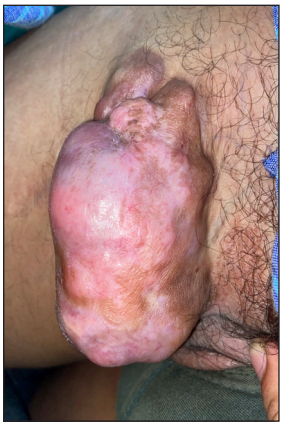

Figure 3a: Dermatofibrosarcoma protuberance presenting as a protuberant hypopigmented to skin-coloured nodule over the lower abdomen.

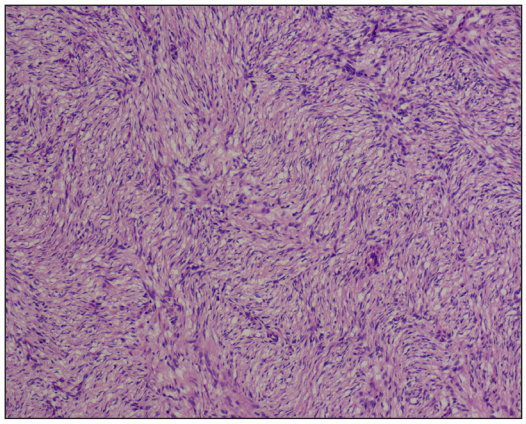

Figure 3b: Histopathology of dermatofibrosarcoma protuberance reveals spindled cells arranged in a storiform pattern. [Haematoxylin and eosin, 100x].

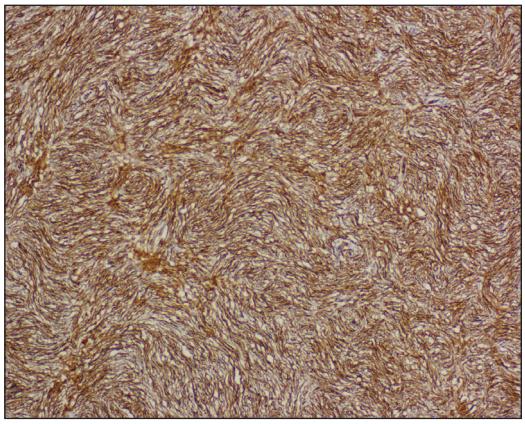

Figure 3c: Immunohistochemistry of dermatofibrosarcoma protuberance demonstrates positive staining for CD34 [IHC, 100x].

pattern [Figures 3a, 3b, and 3c] and extend into subcutis to form a honeycomb pattern.[1]

Cutaneous Rosai-Dorfman disease

Pathologically, cutaneous Rosai-Dorfman disease (cRDD) is characterised by nodular to diffuse infiltrates of polygonal to spindle-shaped histiocytes with feathery borders arranged in a storiform pattern, emperipolesis, lymphoid aggregate, and germinal centres at the periphery.[2]

Spindle cell xanthogranuloma variant of juvenile xanthogranuloma

Spindle cell xanthogranuloma variant of juvenile xanthogranuloma reveals well-defined nodular infiltrates of spindle cells in a storiform pattern, with Touton-like giant cells and lymphocytes.[3]

Sarcomatoid variant of anaplastic large cell lymphoma

Sarcomatoid type of anaplastic large cell lymphoma reveals plump spindle-shaped cells in a storiform pattern and diffuse interstitial mucinous degeneration with or without septal panniculitis.[4]

Superficial CD34-positive fibroblastic tumour

This is characterised by a circumscribed area of intersecting fascicles of bland spindled to pleomorphic epitheloid cells arranged in a storiform pattern, vascular ectasia, lymphoid cells, and collagenous stroma.[5]

Malignant peripheral nerve sheath tumours

Malignant peripheral nerve sheath tumours (MPNST) comprise of two tissue components; a majority displays dense monotonous proliferation of small- to -medium-sized angulated or round cells with hyperchromatic atypical nuclei

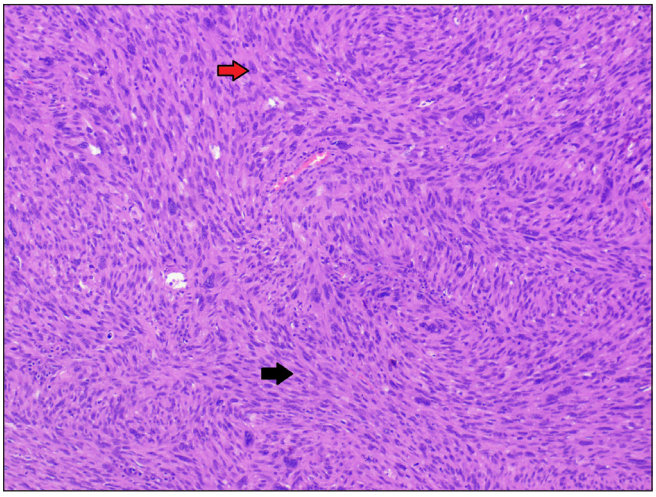

Figure 4: Histopathology of malignant peripheral nerve sheath tumour reveals epitheloid cell-like (red arrow) and spindled cells (black arrow) in a storiform pattern embedded in a mucinous stroma [Haematoxylin and eosin, 100x].

and indistinct pale eosinophilic cytoplasm in a diffuse sheet-like fashion. The minor portion comprises of pleomorphic spindle cells with hyperchromatic, elongated wavy nuclei and eosinophilic, wispy cytoplasm arranged in a storiform pattern [Figure 4].[6]

Erythema elevatum diutenum

Early erythema elevatum diutenum (EED) shows leukocytoclastic vasculitis features while late cases show perivascular onion skinning pattern of fibrosis, storiform fibrosis with clefting between collagen bundles, xanthomatisation with mixed inflammatory infiltrates composed of neutrophils, plasma cells, eosinophils and lymphohistiocytes.[7]

Granuloma faciale

Histopathology reveals grenz zone, eosinophilic vasculitis, and diffuse mixed inflammatory infiltrate composed of neutrophils, eosinophils, plasma cells, and lymphohistiocytes. Similar to EED, storiform fibrosis is described due to perivascular fibrosis with clefting.[8]

Fibrohistiocytic lipoma

Histopathology shows a well-circumscribed lipoma along with spindle cell features similar to DFSP, where an evenly distributed honeycomb or solid mass-like proliferation of plump spindle cells is seen in a storiform pattern or fascicular patterns.[9]

Superficial acral fibromyxoma

Histopathology depicts a dermal non-encapsulated soft tissue tumour containing spindle-shaped fibroblasts arranged in a fascicular or storiform pattern in the myxo-collagenous stroma.[10]

Granular cell tumour

This tumour is composed of oval- to spindle-shaped cells, primarily grouped in short fascicles or displaying a storiform pattern with desmoplastic stroma.[11]

Histoid Hansen

The classic histopathologic features here include epidermal atrophy, grenz zone, and underlying leproma composed of fusiform histiocytes organised in a storiform pattern.[12]

Pigmented storiform neurofibroma

Classically, neurofibroma (NF) does not have a storiform pattern, but one variant called pigmented storiform NF has been described in the literature, which shows a clear grenz zone and mid-dermis reveals spindle cells with bubblegum cytoplasm and wavy nucleus arranged in storiform pattern [Figures 5a, b and c].[13]

Neurothekeoma

This presents as multiple nodules in the deep dermis and subcutis composed of a storiform arrangement of spindled

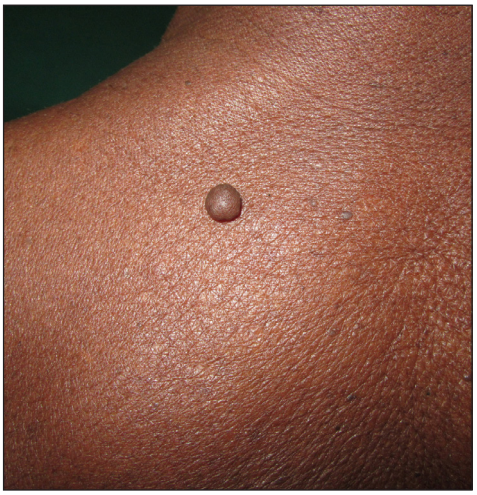

Figure 5a: Pigmented neurofibroma: Solitary brown dome-shaped papule.

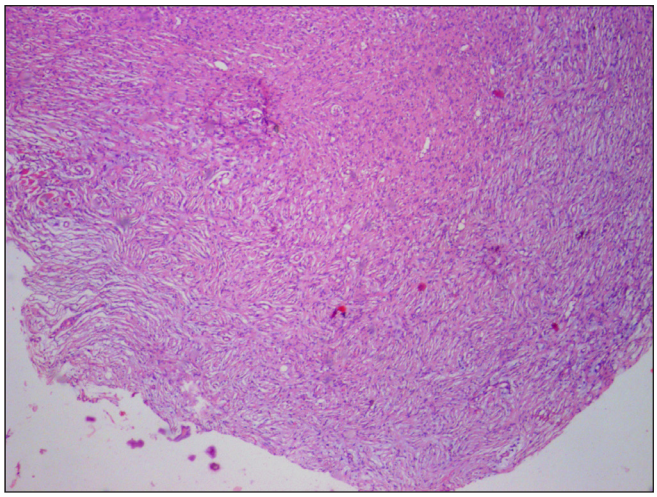

Figure 5b: Histopathology of neurofibroma showing spindled tumour cells arranged in a storiform pattern. [Haematoxylin and eosin, 50x].

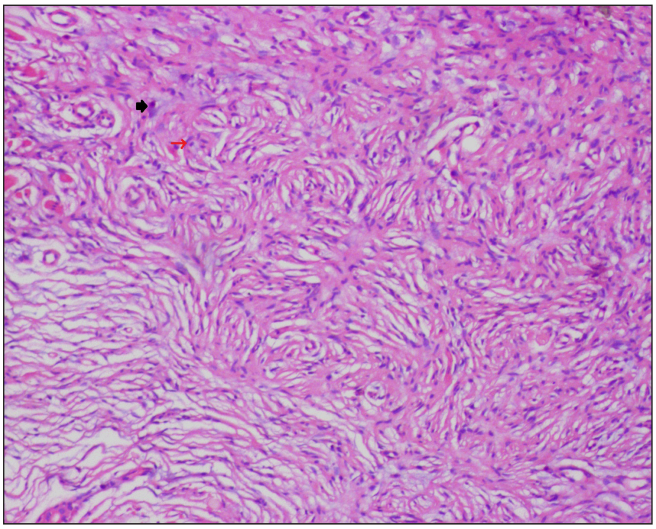

Figure 5c: Histopathology of neurofibroma reveals spindled cells with pale bubblegum cytoplasm and wavy nuclei in a storiform pattern (red arrow) and mast cells (black arrow) [Haematoxylin and eosin, 100x].

and epithelioid mononuclear cells, variable nuclear atypia with myxoid stroma.[14]

Nodular fasciitis

Histopathology shows variable cellularity composed of spindled, star-shaped to plump fibroblasts that are arranged focally as vague storiform patterns or in a haphazard array ('tissue culture appearance'), where mitotic figures, myxoid stroma, capillary proliferation and extravasated red blood cells with cleft-like spaces are seen.[15]

Perineurioma (storiform perineurial fibroma)

Histopathology reveals non-encapsulated, well-circumscribed spindle cells with elongated bipolar cytoplasmic processes and inconspicuous fusiform nuclei with pale eosinophilic cytoplasm in a storiform pattern.[16]

Progressive nodular histiocytosis

Histopathology of progressive nodular histiocytosis (PNH) shows an atrophic epidermis; the dermis shows spindle cells arranged in classical storiform pattern along with abundant histiocytes with large nuclei foamy cytoplasm along with hemosiderin-laden macrophages and Touton giant cells.[17]

Spitz naevus

Histopathology shows symmetrical, sharply demarcated, dome-shaped, regularly spaced nests of naevus cells. Limited pagetoid spread in the lower epidermis, junctional clefting, and coalescent eosinophilic globules known as Kamino bodies are seen. Naevus cells are epithelioid to spindle-shaped and arranged in a storiform pattern occasionally along with zonation.[18]

Storiform collagenoma

Histopathology demonstrates a circumscribed, hypocellular area of abundant collagen with plywood-like clefts between the collagen and fibroblasts revealing spindle-shaped nuclei in a storiform pattern [Figures 6a and b].[19]

Keloid

On the histopathology of the keloid, the epidermis shows acanthosis, and loss of distinction between papillary and reticular dermis is noted. The abundance of eosinophilic collagen tissue is arranged in a whorled, storiform, or haphazard fashion, along with dense mucin deposits, fibroblast proliferation, and mast cells.[20]

Immunoglobulin G4 (IgG4)-related disease

This is characterised by lymphoplasmacytic infiltration, obliterative lymphocytic venulitis, and fibrosis in a storiform

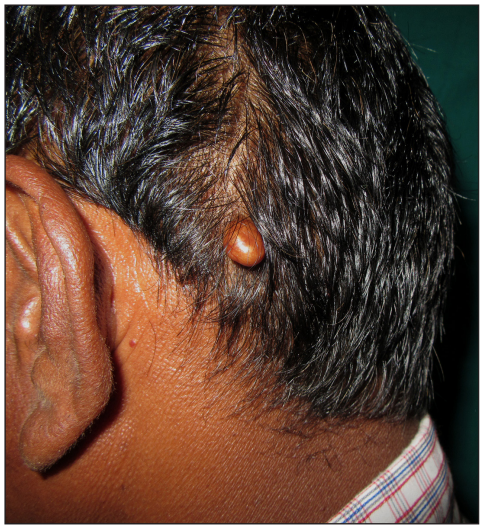

Figure 6a: Storiform collagenoma: Solitary brown pedunculated hard nodule on the scalp.

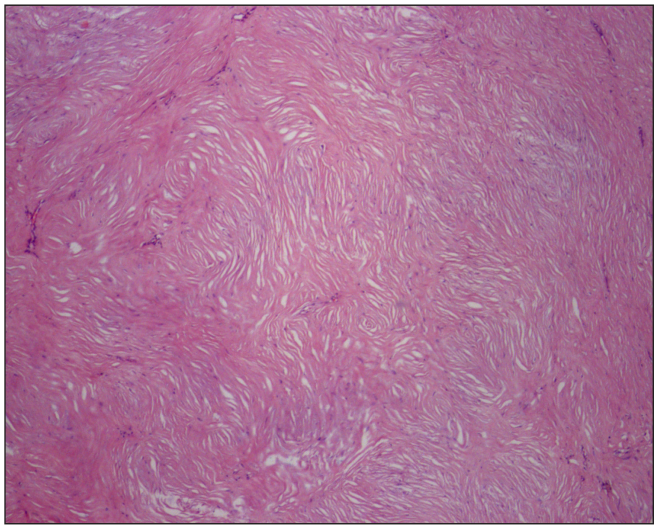

Figure 6b: Histopathology of storiform collagenoma depicts the hypocellular area of abundant collagen in a storiform pattern [Haematoxylin and eosin, 100x].

manner. Lymphoplasmacytic infiltration is characterised by lymphoid follicles with the germinal centre and dense plasma cell infiltration.[21]

Other rare conditions where the storiform pattern is described include solitary fibrous tumour, myofibroma, pseudomyogenic hemangioendothelioma, cutaneous histiocytic sarcoma, mycobacterial spindle cell tumour, angiomyofibrobastoma, cutaneous B-cell lymphoma with a storiform stromal reaction, synovial sarcoma, melanoma, neurofibrosarcoma, and gingival fibroma.

Overall, the storiform pattern is seen in neoplasms of spindle cell origin, such as fibroblast, fibrohistiocytic, neural, melanocytic, and smooth muscle origin, and also from disorders that show fibrosis. A summary of clinical presentation, immunohistochemistry (IHC), and special stains in dermatosis revealing a storiform pattern is represented in Tables 1 and 2.

To conclude, a storiform pattern can be associated with the histopathology of various cutaneous spindle and non-spindle cell tumours. This article enlists all the entities associated

Table 1: Summary of clinical features of skin conditions showing storiform pattern

Conditions showing a storiform pattern	Type	Clinical presentation
Dermatofibroma	Benign fibro histiocytic tumour	Solitary skin-coloured firm papule over extremities with a characteristic dimple sign
Dermatofibrosarcoma protuberans	Locally aggressive malignant neoplasm of fibroblastic differentiation	Keloid-like protuberant plaque over the trunk and extremities
Cutaneous Rosai-Dorfman disease	Non-Langerhans histiocytic disease	Presents as papules and nodules in the head and neck region with cervical lymphadenopathy
Spindle cell xanthogranuloma variant of juvenile xanthogranuloma	Non-Langerhans cell histiocytosis	Solitary, well-circumscribed skin-coloured dark red nodule
Sarcomatoid variant of anaplastic large cell lymphoma	Anaplastic large cell lymphoma	Generalised lymphadenopathy with extranodal involvement of skin, bone, bone marrow, liver, lungs and gastrointestinal tract Cutaneous lesions present as solitary or multiple skin-coloured papules and nodules
Angiomyofibroblastoma	Benign soft tissue tumour with unclear origin	Presents as a slow-growing asymptomatic nodule
Superficial CD34-positive fibroblastic tumour	Low-grade spindle cell neoplasm	Slow-growing asymptomatic subcutaneous mass
Malignant peripheral nerve sheath tumour	Soft tissue (neural) tumour	Presents as a soft tissue mass with pain and numbness along the nerve distribution
Erythema elevatum diutenum	Chronic fibrosing vasculitis	Presents as red-brown papules and plaques over the extensor aspect
Granuloma faciale	Chronic fibrosing eosinophilic vasculitis	Clinically presents as red-brown papules and nodules over the face with follicular prominence
Fibrohistiocytic lipoma	Tumour of fat origin	Presents as a soft mobile mass over the extremities
Superficial acral fibromyxoma	Fibrous tumour	Presents as a solitary papule over the periungual regions of hands and feet
Granular cell tumour	Neuroectodermal tumour	Presents as a solitary painless nodule over mucosa and skin
Cutaneous histiocytic sarcoma	Mature histiocytic malignant neoplasm	Presents as a localised solitary nodule or can have disseminated involvement of lymph nodes and gastrointestinal tract with constitutional symptoms
Histoid Hansen	Variant of leprosy	Multiple shiny skin-coloured, dome-shaped papules and nodules with a predilection to the extensor aspect
Pigmented storiform neurofibroma	Variant of neruofibroma	Solitary or rarely multiple skin-coloured to hyperpigmented soft papules at any site
Neurothekeoma	Nerve sheath tumour	Solitary skin-coloured, brown, well-circumscribed, asymptomatic to slightly painful papule or nodule
Nodular fasciitis	Benign self-limiting tumour of fibroblastic or myofibroblastic origin	Solitary superficially placed rapidly growing nodule
Perineuroma	Soft tissue neoplasm composed of perineural tissue	Solitary papule over extremities, which may be asymptomatic to weakness or numbness along the nerve distribution
Progressive nodular histiocytosis	Non-Langerhans cell histiocytosis	Discrete yellow-brown superficial papules and deep nodules
Pseudomyogenic (epithelioid sarcoma-like) hemangioendothelioma	Low-grade vascular tumour of endothelial origin	Indolent to painful ulcerative nodules
Spitz naevus	Benign tumour of epithelioid to spindle-shaped melanocytic cells	Presents as dome-shaped, skin-coloured to hyperpigmented papules, either solitary or eruption of multiple lesions over extremities
Storiform collagenoma.	Tumour of fibroblast origin	Solitary firm papule, mostly described in Cowden syndrome

(*Contd*...)

Table 1: (*Contd*...)

Conditions showing a storiform pattern	Type	Clinical presentation
Mycobacterial spindle cell pseudotumour	Tumour-like spindle cell proliferation engorged with mycobacterial species	Asymptomatic solitary mass
Myofibroma	Benign tumour of fibroblastic origin arising from soft tissue and bone	Pink to purplish soft nodule
Solitary fibrous tumour	Benign mesenchymal tumour	Clinically shows soft, painless, slowly progressive mass over the axilla, pelvis and thigh
Keloid		Asymptomatic to itchy, painful, firm, solitary or multiple plaques with crab-like extensions at the periphery of plaque at any sites, mostly described in ear lobule, presternal and joint areas
IgG4-related disease		Itchy solitary or multiple erythematous papules, plaque and subcutaneous nodules over head and neck areas, but can involve any region and system

IgG4: Immunoglobulin G4 related disease.

Table 2: Summary of immunohistochemistry positivity and special stains in various dermatoses with storiform pattern

Diseases	Pathological clue	Immunohistochemistry positivity	Immunohistochemistry negativity	Special stains
Dermatofibroma	Circumscribed Grenz zone Collagen trapping Epithelial, follicular and sebaceous induction Hemosiderin	Factor XIIIa, CD68 and CD163	CD34	Masson trichrome stain highlights fibrous tissue as blue
Dermatofibrosarcoma protuberans	Infiltration and expansion of fibrous septa. Interdigitation of fat lobules in a honeycomb pattern Sparing of adnexal structures Herringbone pattern and significant atypia and mitotic figures in sarcomatous variant	CD34	Factor XIIIA, S 100, Melan A and SMA	Pigmented DFSP stains for fontanna masson stain but not Prussian blue Myxoid DFSP stains with alcian blue, colloidal iron
Rosai-Dorfman disease	Emperipolesis	S100 and CD68	CD1a	-
Spindle cell xanthogranulom is a variant of juvenile xanthogranuloma	Touton giant cells with vacuolated histiocytes	Factor XIIIa, Mac 387, lysozyme, CD 68 and vimentin	S100 protein, actin, desmin and keratin AE1.3	Sudan III stain highlights intracytoplasmic fat granules
Sarcomatoid is a variant of anaplastic large cell lymphoma	Large, bizarre-looking, spindle-shaped cells	CD4, CD5, CD30, TIA-1 and ALK while CD3+/–	CD8, CD15, CD20, CD56, CD68, desmin and SMA	-
Angiomyofibroblastoma	Alternating areas of hypercellular and hypocellular region	Desmin, estrogen receptor, progesterone receptor and SMA		Masson trichrome stain smooth muscle cytoplasm as red and collagenous fibrous tissue as blue
Superficial CD34-positive fibroblastic tumour	Neoplastic cells with polymorphic nuclei Granular cytoplasm Intranuclear cytoplasmic pseudoinclusions Extremely low mitotic rate	CD34 and focal positivity for keratin (AE1/AE3)	S-100 protein, EMA, SMA, myosin, desmin, myogenin, CD56 and FLI-1	Masson trichrome stain for fibrous tissue, which highlights as blue
Malignant peripheral nerve sheath tumour	Elongated wavy nuclei and bubblegum or wispy cytoplasm with mitotic activity	CD34 and S100		Silver impregnation (Bodian and Beilschowsky stain) highlights nerve cells
Erythema elevatum diutenum	Leukocytoclastic vasculitis with onion ring fibrosis	-	EMA, CD34 and S100	
Fibrohistiocytic lipoma	Honeycomb fat cells with spindle cells	Vimentin, calponin and CD34		Sudan III stain highlights fat tissue
Superficial acral fibromyxoma	Prominent microvasculature Mast cells Multinucleated stromal cells	EMA, CD34 and CD99		Alcian blue and colloidal iron highlights mucin

(*Contd*...)

Table 1: (*Contd*...)

Diseases	Pathological clue	Immunohistochemistry positivity	Immunohistochemistry negativity	Special stains
Granular cell tumour	Pustulo-ovoid bodies of Milian	S-100, CD31, CD56, CD68, CD117, inhibin, p53, calretinin, EMA and MIB-1		Periodic acid Schiff highlights granules and are resistant to diastase These granules also stain with Sudan black B Trichrome stain shows magenta colouration
Cutaneous histiocytic sarcoma	Signet-ring cell type tumour cells with areas of cellular cannibalism and emperipolesis	CD68, CD163 and lysozyme	S100 and CD1a	-
Neurofibroma	Elongated wavy nuclei and bubblegum or wispy cytoplasm	S100	Glial fibrillary acidic protein	Silver impregnation (Bodian and Beilschowsky stain) highlights nerve cells
Neurothekeoma	Intranuclear pseudo inclusion	Strong positivity of S100A, MiTF, EMA, NSE, NKI/C3 and PGP 9.5 and focal positivity for claudin-1, Glut-1 and CD34		Silver impregnation (Bodian and Beilschowsky stain) highlights nerve cells
Nodular fasciitis	Tissue culture appearance	SMA, calponin, vimentin, KP-1 and HSP47	Desmin, CD34, S100 and cytokeratin	Masson trichrome stain smooth muscle cytoplasm as red and collagenous fibrous tissue as blue Alcian and colloidal iron stain for mucin
Perineuroma	Lamellar-like structures	CD34, EMA, vimentin, S-100 protein, desmoplakin and neurofilament		-
Hybrid schwannoma and perineuroma	Well-circumscribed unencapsulated tumours	Alternating S100, EMA stain with no co-expression; Claudin 1, GFAP and CD34		Silver impregnation (Bodian and Beilschowsky stain) highlights nerve cells
Progressive nodular histiocytosis	Spindle-shaped, vacuolated, stellate, oncocytic (ground glass) and foamy cells	CD68, CD163, vimentin and fascin	S 100 and CD1a	-
Pseudomyogenic (epithelioid sarcoma-like) hemangioendothelioma	Cells with a rhabdomyoblast-like morphology may be seen	ERG with retained INI-1, pancytokeratin AE1/AE3 and CD31	S100, CD34, desmin, EMA, MNF116, SMA, caldesmon, myogenin, MyoD1, HHV-8 and CD163	
Spitz Naevus	Kamino bodies, zonation and absent pagetoid spread	S100, Melan A, HMB45, SOX 10, ALK, NTRK and ROS	SMA, EMA, BRAF and cytokeratin	Masson's fontana stain shows mild positivity in naevus cells Schmorl method stains melanin blue green
Storiform collagenoma	Hypocellular area of abundant collagen with 'plywood-like' clefts	CD34		Masson trichrome stain to highlight collagenous fibrous tissue as blue and nuclei as black
Myofibroma	Biphasic pattern Spindle cells with eosinophilic cytoplasm and elongated nuclei Hemangiopericytoma like vascular pattern	SMA, MSA, vimentin and calponin	P63, desmin and h-caldesmon	Masson trichrome stain smooth muscle cytoplasm as red and collagenous fibrous tissue as blue
Solitary fibrous tumour	Spindle-to-ovoid collagen with inconspicuous cytoplasm	CD 34, STAT 6 and vimentin	CD 99, CD 31, S100, AML, desmin and SOX 10	-
IgG4-related disease	Lymphoid aggregates, plenty of plasma cells and fibroblast in storiform pattern	CD 138 and IgG4		Elastin Van Gieson stain to highlight obliterative venulitis

SMA: Smooth muscle actin, EMA: Epithelial membrane antigen, CD: Cluster of differentiation, SOX: SRY related HMG box 10, NTRK: Neurotrophic tropomyosin-receptor kinase, ROS: Repressor of Silencing, HMB 45: Human Melanoma Black 45, HSP: Heat shock protein, MSA: Muscle-specific actin, GFAP: Glial fibrillary acidic protein, MNF: Cytokeratin pan monoclonal antibody, HHV: Human herpes virus, ERG: Erythroblast transformation specific related gene, PGP: Pglycoprotein, HSP: Heat shock protein, ALK: Anaplastic lymphoma kinase, TIA: T cell intracellular antigen 1, AE: Anionic exchange, STAT: Signal transducer and activator of transcription, AML: acute myeloid leukemia, BRAF: V raf murine sarcoma viral oncogene homolog B, DFSP: Dermatofibrosarcoma protuberans, NKI/C3 doesnot have expansion.

with a storiform pattern. Besides, we provide an overview of pathological characteristics, cellular morphology, and IHC that helps delineate various dermatoses demonstrating storiform patterns.

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