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Patterns of keratin polypeptides in 110 biphasic, monophasic, and poorly differentiated synovial sarcomas

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Abstract Synovial sarcoma is a mesenchymal neoplasm of unknown histogenesis that shows various degrees of epithelial differentiation. It is known to contain simple epithelial keratins, and the possibility of complex epithelial keratin expression has been suggested. In this study, we immunohistochemically examined 110 well-documented synovial sarcomas including 44 biphasic, 48 monophasic, and 18 poorly differentiated (undifferentiated, highly mitotically active) tumors for 11 different keratin (K) polypeptides of the Moll catalogue. The epithelia of biphasic synovial sarcomas showed consistent, extensive reactivity for K7, K8, K14, K18, and K19. Other keratins seen in the epithelia of biphasic tumors included K17 (variable, in 77%), K13 (25%), K16 (23%), and K6 (24%) in the minority of biphasic tumors, predominantly in stratified-appearing epithelia. K10 was detected only focally in one case that showed keratinizing squamous differentiation. Focal expression of K20 was seen in 27% of cases. Monophasic synovial sarcomas had a more limited keratin repertory. Simple epithelial keratin positivity was detected, usually focally for K7 (79%), K19 (60%), K8 (45%), and K18 (46%). Two cases showed more extensive keratin positivity in the spindle cells. The monophasic tumors showed limited positivity for complex epithelial keratins: K14 (28%) and K17 (10%). K20 was detected focally in 6% of the monophasic tumors; other keratins were not detected. The poorly differentiated synovial sarcomas showed limited simple epithelial keratin reactivity, usually limited to scattered cells: K19 (61%), K7 (50%), K18 (47%), K8 (33%), but five cases showed more extensive positivity. Complex epithelial keratins were scant: K14 in one case and K17 in two cases. The immunoreactivity of capillary endothelia seen for K7 and K18 (but not for K8 and K19 with the antibodies used) is a potential diagnostic pitfall, and may cause overdiagnosis of synovial sarcoma if not properly recognized. In summary, we show complex patterns of keratins in synovial sarcoma, especially in the biphasic tumors. Such patterns establish a baseline in differential diagnostic considerations, and give an insight into the complex epithelial differentiation of this enigmatic mesenchymal tumor.

Keywords Complex keratin patterns · Synovial sarcoma

Introduction

Synovial sarcoma is a soft tissue tumor of unknown histogenesis. It typically shows varying degrees of epithelial differentiation that are more extensive and gland-forming in the biphasic tumors. In the monophasic and poorly differentiated tumors, however, the epithelial differentiation is more subtle or histologically unrecognizable [6]; this latter group represents a group of high-grade undifferentiated tumors that often require cytogenetic or molecular genetic documentation for a firm diagnosis unless differentiated areas are present.

Keratin (K) positivity in biphasic and monophasic tumors was initially reported using polyclonal antibodies to plantar callus keratins and subsequently with many antibodies that recognize various combinations of simple epithelial (cyto)keratins [1, 4, 12, 26, 35, 37, 39, 45]. Studies examining individual keratin polypeptides have documented K7, K8, K18, and K19 in the epithelial cells [19, 23], and some studies have also documented high-

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molecular-weight keratins [12, 38], including focal expression of K13 [19]. However, the distribution of the individual keratin polypeptides, as defined by the Moll catalog of (cyto)keratins [30], has not been systematically reported in different types of synovial sarcoma. Vimentin is consistently expressed in the mesenchymal-like spindle cells of synovial sarcoma [26] and also in subsets of epithelial-like cells [19].

In this study, we employed selected antibodies to individual keratin polypeptides, that included members of all keratin pairs (except K3 and K12, the corneal keratins). The complete set of antibodies to simple epithelial keratins was employed. These keratins, K7, K8, K18, and K19 are typically present in non-stratified epithelia [29, 30, 34]. K8, K18, and K19 are widespread and seen in nearly all simple epithelia and many complex non-squamous epithelia, especially in the luminal side, although K19 is not present in hepatocytes and some renal tubular epithelia. K7 shows a slightly narrower distribution and is specifically absent in hepatocytes, some (especially main populations of colorectal) gastrointestinal epithelia, and luminal prostatic epithelia [2, 29, 30, 40, 41].

Among the complex epithelial keratins, K10 is generally restricted to keratinizing squamous epithelia. K14 and K5 are present in many basal cells of stratified epithelia, including myoepithelia, while K13 and K4 are present in all (except basal) squamous and transitional cell epithelia of internal organs, including esophagus, cervix, and urogenital tract [2, 29, 30, 34, 41].

K6, K16, and K17 have a narrower distribution. They are present, for example, in subsets of hair shaft and adnexal, including sweat gland ductal epithelia, and in hyperproliferative epidermis. In addition, K17 is expressed in myoepithelial cells [10, 22, 24, 44]. K20, originally named as protein IT based on its extensive distribution in the gastrointestinal epithelia, is also present in urothelia and epidermal Merkel cells [33].

Although the distribution of keratins follows the above rules in normal epithelia, tumors commonly show deviations including neoexpression of simple epithelial keratins and K17 in squamous cell carcinomas [29] and relative or absolute loss of complex epithelial keratins typical of the differentiated cells in poorly differentiated carcinomas. Aberrant expression of keratins, especially K8 and K18 appears in transformed fibroblasts and various sarcomas with non-epithelial phenotypes [14, 23]. Some adenocarcinomas have complex patterns of keratins including combinations of numerous keratins of simple epithelia and complex epithelia, the latter ones being usually only focally expressed.

In this study, we evaluated 110 synovial sarcomas of different types for 11 individual keratin polypeptides, as defined by the Moll catalog of epithelial keratins [27]. Understanding of the keratin patterns in synovial sarcoma is of pathogenetic and potential diagnostic interest.

Materials and methods

Tumor selection

One hundred and ten previously well-characterized synovial sarcomas were obtained from the files of the Soft Tissue Registry of the Armed Forces Institute of Pathology and from the Medical Academy of Gdansk and Maria Sklodowska-Curie Memorial Institute, Krakow, Poland. There were 44 biphasic, 48 monophasic, and 18 poorly differentiated synovial sarcomas. The cases were entered into the study by means of random selection, while including sufficient numbers of each subtype.

The biphasic tumors were defined as those tumors showing histologically recognizable glandular differentiation. Monophasic spindle-cell synovial sarcomas were defined as synovial sarcomas composed of spindle cells with low mitotic activity, and poorly differentiated synovial sarcomas were defined as synovial sarcomas composed of undifferentiated oval or round cells with mitotic activity exceeding 10/10 high-power fields (HPF). Three of the biphasic, seven monophasic, and five poorly differentiated tumors were verified cytogenetically as t(X;18) translocation positive [18]. Additionally, five biphasic, nine monophasic, and three poorly differentiated tumors were studied molecularly and shown to have the SYT-SSX1 or SSX2 fusion transcript using reverse-transcription polymerase chain reaction (RT-PCR) [16]. Most of the poorly differentiated tumors showed areas more typical of synovial sarcoma elsewhere in the tumor.

The clinical data are summarized in Table 1. The tumors included in this study showed similar clinicopathologic features as generally known for synovial sarcoma [6]. Most of them occurred in young adults, and the tumors typically involved the extremities, with some located in the trunk and head and neck. The median pa-

Table 1 Clinicopathologic characteristics of the synovial sarcomas analyzed for keratins

Median age in years (range)	Biphasic 25 (8–56)	Monophasic 32 (6–69)	Poorly differentiated 26 (16–60)
Male:female*	27:15	24:24	8:8
Location*			
Thigh	4	12	1
Foot	10	9	–
Leg, knee	7	6	3
Inguinal	7	–	2
Trunk	2	2	2
Upper extremity	5	7	3
Axilla	3	2	3
Head and neck	–	2	1
Retroperitoneum	1	–	–
Site unknown	5	8	3
Total	44	48	18

*The total may vary, because some cases have missing data elements

Table 2 Monoclonal antibodies, their source and dilution, and the pretreatment modalities used in this study

Polypeptide	Clone	Pretreatment	Antibody dilution	Commercial source	Reference*
Keratin 6	LHK6B	MW[c]	1:40	Novocastra New Castle, UK	11
Keratin 7	OV-TL 12/30	PrVIII[a]	1:400	Dako, Carpinteria, Ca	42
Keratin 8	Cam5.2	Pepsin[b]	1:40	Beckton-Dickinson, Mt. View, CA	15
Keratin 10	LHP1	MW[c]	1:50	Novocastra	17
Keratin 13	KS-1A3	MW[c]	1:100	Novocastra	39
Keratin 14	LL002	MW[c]	1:100	Novocastra	35
Keratin 16	LL025	MW[c]	1:40	Novocastra	20
Keratin 17	E3	MW[c]	1:40	Novocastra	8
Keratin 18	DC-10	MW[c]	1:40	Novocastra	2
Keratin 19	RCK 108	MW[c]	1:50	Dako	2
Keratin 20	K_s20.8	PrVIII[a]	1:100	Dako	30
EMA	E29	MW[c]	1:50	Dako	

*Refers to the reference that describes the antibody or best characterizes its specificity

[a] PrVIII=0.05% Sigma protease type VIII, 3 min in 0.1 M/l phosphate buffer, pH 7.8 at 37°C

[b] Pepsin=crude pepsin (0.05% in HCl, pH 2.0) for 30 min at 37°C

[c] MW=microwawe heating adjusted to near to boiling in EDTA-buffer (3.2 g sodium EDTA/l), for 20 min at pH 6.0, followed by a 20-min cooling period

tient age of all three groups varied from 25 years to 32 years (age range 6–69 years). There was a male predominance of 2:1 among the patients with biphasic tumors, whereas the other groups showed a 1:1 gender ratio.

The primary antibodies, their dilution and commercial source, and the epitope retrieval procedures used prior to the incubation with the primary antibody are listed in Table 2. The avidin–biotin detection system was used. The primary antibody was incubated for 30 min to 1 h at room temperature followed by biotinylated horse antimouse Ig antiserum (1:200), avidin combined in vitro with biotinylated peroxidase (each 1:500), and color development with diaminobenzidine containing hydrogen peroxide. Appropriate negative and positive controls were also run using sections from a multi-tissue block to verify appropriate negative and positive reactions. This included study of 35 normal tissues and 200 carcinomas of different types with each antibody. Findings that supported accurate antibody specificity and high detection sensitivity in the control tissues were K8 and K18 positivity in a subset of reticulum cells in lymph nodes [9], selective detection of few epidermal Merkel cells in the basal epidermis with antibody to K20 [30], detection of delicate myoepithelial cells and prostatic basal cells with antibodies to K14 and K17, selective expression K13 in urothelia and internal squamous epithelia (esophagus), and essential limitation of K6 and 16 reactivity to squamous carcinomas [10, 44].

Results

The patterns of expression of individual keratin polypeptides in different types of synovial sarcomas are summarized in Table 3 and Table 4.

Biphasic synovial sarcoma

Biphasic synovial sarcomas exhibited various patterns of glandular differentiation with cuboidal, columnar, or pale-staining spindly epithelial cells. The epithelial component typically comprised 30–90% of the total cellular population, but some biphasic tumors had only a focal glandular epithelial component.

These tumors typically showed extensive keratin-positivity with all simple epithelial keratin antibodies including those to K7, K8, K18, and K19. The epithelial, keratin-positive elements often formed solid sheets and strands without lumen, in addition to well-formed glandular lumina (Fig. 1). Keratin-positive areas were typically sharply demarcated from the negative spindle cell areas without any transitional zone. Occasional positive cells in the spindled foci were felt to represent focal tangential cuts of the epithelial areas.

Compared with patterns of simple epithelial keratins, there was K14-positivity in 39 of 44 cases (Fig. 2), although 20% of the positive cases showed less extensive positivity than seen with some antibodies to simple epithelial keratins. Such K14 reactivity was by no means limited to glands with stratified epithelia. K17 was present in the epithelia in 34 of 44 cases (77%). It was seen in more than 10% of the epithelia in 13 of 44 cases (30%), and the positive epithelium often appeared stratified and slightly spindled (Fig. 3). Similar reactivity for K13 was seen to lesser degree (in 25% of the cases).

Focal expression of several other keratins was detected, typically with scattered positive cells among the glandular epithelial cells. Such reactivity was seen for K20 among scattered epithelial cells in the glands (Fig. 4) in 11 of 44 cases each (25%), and K6 and K16 were seen in 9 of 37 and 10 of 44 cases, respectively. The only tumor that had keratinizing squamous differentiation showed focal K10 immunoreactivity in the glandular keratinizing epithelia limited to single cells (Fig. 5).

Epithelial membrane antigen (EMA) was detected nearly globally in the glandular epithelia. Only two cases showed less EMA reactivity (10% and 30% of tumor cells positive).

Table 3 Summary of the keratins in biphasic synovial sarcoma. The percentages of positivity are expressed as percentage of the epithelial component

Biphasic	Positive	Total	% positive	Negative	Focal <10%	Moderate 10–30%	Extensive >30%
K7	42	43	98	1	0	1	41
K8	41	41	100	0	1	5	35
K18	30	30	100	0	3	8	19
K19	44	44	100	0	5	3	36
K10	1	44	2	43	1	0	0
K13	11	44	25	33	11	0	0
K14	39	44	89	5	2	7	30
K6	9	37	24	28	9	0	0
K16	10	44	23	34	9	1	0
K17	34	44	77	10	21	8	5
K20	12	44	27	32	9	3	0

Table 4 Summary of the keratins in monophasic spindle cell and poorly differentiated synovial sarcoma. The percentages of positivity are expressed as percentage of the total cell population

	Positive	Total studied	% of cases with positive cells	Negative	Focal <10%	Moderate 10–30%	Extensive >30%
Monophasic							
K7	33	42	79	9	25	7	1
K8	19	42	45	23	17	1	1
K18	21	46	46	25	14	5	2
K19	27	45	60	18	22	5	0
K10	0	44	0	44			
K13	0	45	0	45			
K14	11	40	28	29	11	0	0
K6	0	24	0	24			
K16	0	42	0	42			
K17	4	41	10	37	4	0	0
K20	3	47	6	44	3	0	0
Poorly differentiated							
K7	9	18	50	9	6	2	1
K8	6	18	33	12	2	4	0
K18	8	17	47	9	3	5	1
K19	11	18	61	7	7	4	0
K10	0	18	0	18			
K13	0	18	0	18			
K14	1	12	9	11	1	0	0
K6	0	9	0	9			
K16	0	18	0	18			
K17	2	18	11	16	2	0	0
K20	0	18	0	18			

Monophasic synovial sarcoma

The 48 monophasic tumors did not show glandular differentiation detectable with hematoxylin and eosin stained sections. They showed sheets of spindle cells with non-collagenous, focally collagenous, or calcified background. Pale clusters of epithelial-like cells were sometimes present.

Simple epithelial keratins were typically detected as focal clusters, strands, or sometimes poorly delineated gland-like structures formed by the tumor cells (Fig. 6). The largest number of cases with any keratin-reactivity was seen for K7 (33 of 42, 79%), while foci of K8-, K18-, and K19-positive tumor cells were detected in 45–60% of tumors. Only two cases showed more than 30% of the spindled tumor cells positive for K7, K8, or K18 (Fig. 7). Compared with biphasic tumors, the expression of K14, K17, and K20 was usually limited to single scattered cells and was seen in only 11 of 40 (28%), 4 of 41 (10%), and 3 of 47 (6%) of cases, respectively. K6, K10, K13, and K16 were not detected.

EMA-positive cells were detected in 29 of 34 cases (85%), and such reactivity was often seen in clusters of cells and patchy areas typically exceeding the positivity seen with any of the keratin antibodies.

Vascular endothelial cells of small capillaries or venules and vascular smooth muscle were often positive for K7 and K18 but not for K8 and K19 with the antibodies used in this study (except vascular smooth muscle, which was occasionally K8 positive).

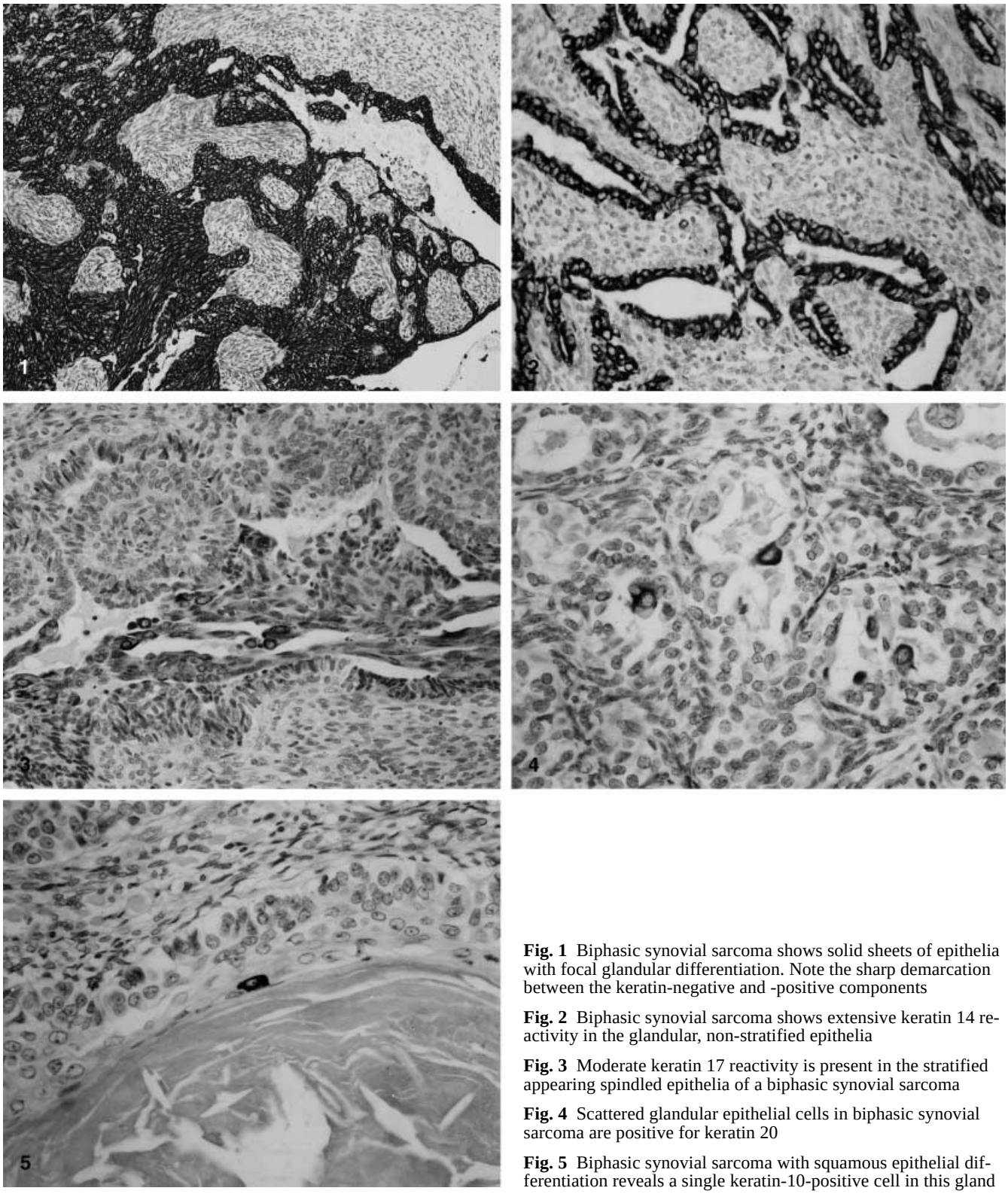


Fig. 1 Biphasic synovial sarcoma shows solid sheets of epithelia with focal glandular differentiation. Note the sharp demarcation between the keratin-negative and -positive components

Fig. 2 Biphasic synovial sarcoma shows extensive keratin 14 reactivity in the glandular, non-stratified epithelia

Fig. 3 Moderate keratin 17 reactivity is present in the stratified appearing spindled epithelia of a biphasic synovial sarcoma

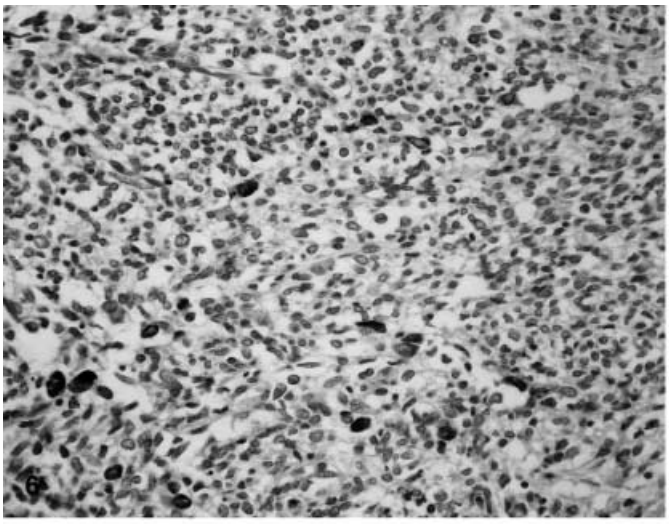
Fig. 4 Scattered glandular epithelial cells in biphasic synovial sarcoma are positive for keratin 20

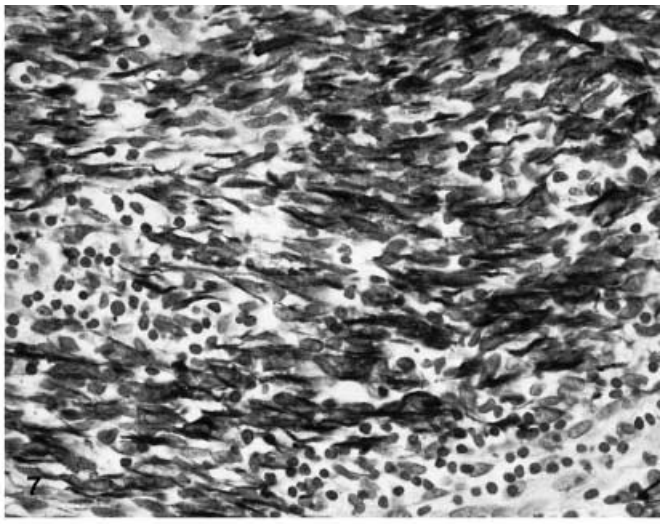
Fig. 5 Biphasic synovial sarcoma with squamous epithelial differentiation reveals a single keratin-10-positive cell in this gland

Poorly differentiated synovial sarcoma

These tumors were high-grade malignant and showed an oval to round cellular pattern, scant extracellular matrix, and high mitotic activity (over 10 mitoses/10 HPF). Seven cases were verified cytogenetically as t(X;18) positive, and three additional cases had been verified as SYT-SSX fusion transcript positive using RT-PCR.

The keratin reactivity, if present, was usually focal in these cases. Simple epithelial keratins were detected for





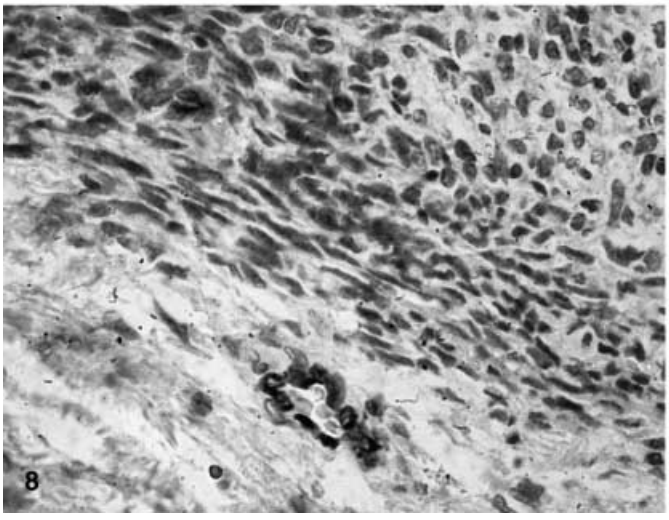


Fig. 6 A typical monophasic synovial sarcoma shows scattered single keratin-19-positive tumor cells

Fig. 7 A rare example of monophasic synovial sarcoma shows nearly global reactivity for keratin 7 in the spindle cells

Fig. 8 Poorly differentiated synovial sarcoma is negative for K18, but some vascular endothelia outside of the tumor are positive. This tumor was verified as t(X;18) positive by cytogenetics

K7 (9 of 18, 50%), K18 (8 of 17, 47%), K8 (6 of 18, 33%), and K19 (11 of 18, 61%) (Fig. 5). In some cases, the keratin positivity was subtle and occurred as cytoplasmic dots or crescents in focal areas of the tumor. Only one case showed more than 30% of K7 or K18-positive cells, while five additional cases showed 10–30% of positive tumor cells with any of these antibodies. Limited stratified epithelial keratin positivity was detected for K17 (2 of 18, 11%) and K14 (1 of 12, 8%). K6, K10, K13, K16, and K20 were not detected. Capillary and venular endothelia were often positive for K7 and K18, similar to that seen in the monophasic tumors (Fig. 8). Such positive endothelial cells were seen more often outside but sometimes also inside of the tumors.

EMA positivity was seen in 10 of 18 cases (56%). Four cases showed more than 10% of tumor cells positive, while three cases showed only scattered cells.

Discussion

In this study, we evaluated the expression of individual keratin polypeptides of the Moll catalog [30], using monoclonal antibodies specific to eleven individual keratins, in order to better understand the patterns of epithelial differentiation in synovial sarcomas of various types. This is important for the delineating the pathogenesis of synovial sarcoma and is of potential interest for differential diagnostic considerations. Based on our findings, synovial sarcomas, especially the biphasic ones, have a highly complex constellation of simple epithelial ("low molecular weight") and complex epithelial ("high molecular weight") keratins. This pattern gives no clue of the histogenetic origin or relationship with normal soft tissue cell types, but is more consistent with the origin of its epithelium from interconversion of mesenchyme.

Simple epithelial keratins K7, K8, K18, and K19 are widely or relatively widely distributed in biphasic synovial sarcoma without much difference in their relative expression. Thus, synovial sarcomas display a complete pattern of simple epithelial keratins similar to many oth-

er glandular epithelia and their tumors that include lung, breast, upper gastrointestinal tract, female genital tract, and their adenocarcinomas [29, 43]. Compared with the biphasic tumors, the expression is more focal in monophasic and poorly differentiated tumors. Previous studies using frozen sections or paraffin sections have obtained similar results with smaller numbers of tumors [19, 23].

The presence of K7 and K18 in subsets of vascular endothelia is noteworthy and represents a diagnostic pitfall by causing potential overdiagnosis of epithelial differentiation. Such keratin positivity of subsets of capillaries has been well documented in the case of K18 [11] and has also been immunohistochemically described for K7 [25]. In lower animal species, endothelial cells can be more prominently keratin positive [11].

K20, typically expressed in gastrointestinal epithelia, urothelia, and epidermal Merkel cells and their neoplasms [33] and sporadically and focally expressed in a wide variety of adenocarcinomas, was focally present in 25% of biphasic synovial sarcomas and occasionally in monophasic tumors. The potential for K20 expression has to be considered in the differential diagnosis of tumors, and specifically does not rule out synovial sarcoma. The histogenetic significance of this finding remains unclear.

The presence of individual keratins of stratified epithelia in synovial sarcoma has remained incompletely characterized. This study reveals unexpected variety and complexity of the expression of stratified epithelial keratins, predominantly seen in the biphasic synovial sarcomas. K14 and K17, keratins of certain basal and other complex epithelia [24, 29, 30, 40], were variably, sometimes prominently expressed in biphasic synovial sarcomas. In fact, the expression of K17 (but not that of K14) was particularly seen in the epithelia with stratified, often spindled appearance. However, their absence was notable in the monophasic and poorly differentiated tumors indicating that these variants essentially display a simple and not complex epithelial type of differentiation.

Keratinizing squamous epithelia in biphasic synovial sarcoma, a rarely documented finding in literature [28, 36], appears to focally express K10, indicating that such morphologic differentiation entails the expression of a typical keratin constituent of keratinizing squamous epithelia as expected [30, 40]. Furthermore, K6 and K16, typical of hyperproliferative squamous epithelia [13, 40, 43] were also focally expressed along with K13 typically present in internal squamous epithelia and their carcinomas [40]. Many adenocarcinomas are also known to have a focal expression of complex epithelial keratins, in addition to simple epithelial keratins [29, 31]. A recent study suggested that such expression of stratified epithelial keratins in ductal carcinomas of the breast may be linked with increased tumor aggressiveness [21].

Monophasic synovial sarcomas are typically composed of morphologically uniform spindle cells, sometimes containing epithelioid clusters but never true glands [6]. These tumors demonstrated a lesser degree of epithelial differentiation than the biphasic ones, and the keratin polypeptide pattern was essentially limited to keratins of simple epithelia. However, equal expression of K7 and K19 to that of K8 and K18 sets monophasic synovial sarcoma apart from those mesenchymal cells and tumors that supposedly express K8 and K18 only [14, 23] as a result of deregulation of K8 and K18 genes in transformed mesenchymal cells [14].

Poorly differentiated synovial sarcomas appear to show only limited keratin positivity, even when antibodies to simple epithelial keratins are used. A minority of such cases that showed more extensive keratin reactivity could actually represent poorly differentiated primarily epithelial synovial sarcomas where the epithelial differentiation is not clearly expressed at the morphologically recognizable level.

The evaluation of the epithelial morphogenesis of synovial sarcoma is an extremely complex task considering the variable morphologic expressions of epithelial differentiation in this tumor and the apparent interconversions between mesenchyme and epithelium. The biphasic tumors consistently display a sharply demarcated keratin-negative spindle cell component of a variable volume supporting the fundamental difference of these components as also suggested by ultrastructural studies [5].

The spindle cell component of the monophasic tumors shows heterogeneity, and a minority of these tumors are globally K7 positive without morphologic hint of epithelial differentiation. The significance of such an extensive keratin expression in monophasic tumors is unclear, but raises the possibility that some of them may actually be more related to biphasic, epithelial components with a spindly appearance and relative lack of stroma.

The differential diagnostic implications of the expression of different keratin polypeptides in synovial sarcoma are complex. However, studies so far suggest that K19 and K7 only rarely occur in other keratin-positive sarcomas, such as Ewing's sarcoma and malignant peripheral nerve sheath tumors [8, 20, 25, 32]. Studies based on paraffin-embedded tumors seem to confirm previous findings made on frozen sections that synovial sarcoma has a more extensive keratin repertory than other sarcomas occasionally expressing keratins: it contains K7 and K19, in addition to K8 and K18 which tend to be the only keratins in transformed fibroblasts and some other sarcomas with non-epithelial morphology [14, 23]. Compared with epithelioid sarcoma, sometimes considered related with synovial sarcoma, biphasic synovial sarcoma has a more complex pattern of keratins with regular versus variable or absent expression of K19 and K17 [27].

Malignant mesothelioma is another tumor with dual epithelial and mesenchymal-like differentiation, with occasional "biphasic" appearance. However, there is usually more gradual transition between the epithelial and spindle cell components, which more commonly appears as a continuum in mesothelioma. The keratin profile of mesothelioma is somewhat similar to that in synovial sarcoma, because both of these tumors typically contain all simple epithelial keratins K7, K8, K18, and K19, and,

in addition, contain higher molecular-weight keratins, such as keratins K5, K6, and K14 [3]. Although most synovial sarcomas occur at sites where mesotheliomas do not occur, the differential diagnosis may be difficult in the case of thoracic or intra-abdominal tumors. The similarities between the keratin profiles of synovial sarcoma and mesothelioma necessitate the use of other differential markers (incompletely known as of yet), or genetic analysis, especially via cytogenetic detection of the t(X;18) translocation, or by demonstration of the SYT-SSX fusion transcript [7, 16].

In summary, we have evaluated keratin expression of 110 synovial sarcomas of the three main types and show a complex pattern of simple and complex epithelial keratins in biphasic tumors, whereas monophasic and poorly differentiated synovial sarcomas predominantly show simple epithelial keratins, and the latter tumors have a greatly reduced keratin expression overall. Understanding the keratin patterns in synovial sarcoma gives baseline information important in the potential diagnostic application of such findings.

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