

---

# Oncologic Imaging: Soft Tissue Tumors

---

Heung Sik Kang • Sung Hwan Hong  
Ja-Young Choi • Hye Jin Yoo

# Oncologic Imaging: Soft Tissue Tumors

 Springer

Heung Sik Kang, MD  
Department of Radiology  
Seoul National University College  
of Medicine  
Seoul National University Bundang  
Hospital  
Seongnam  
Korea, Republic of (South Korea)

Ja-Young Choi, MD  
Department of Radiology  
Seoul National University Hospital  
Seoul  
Korea, Republic of (South Korea)

Sung Hwan Hong, MD  
Department of Radiology  
Seoul National University College  
of Medicine  
Seoul National University Hospital  
Seoul  
Korea, Republic of (South Korea)

Hye Jin Yoo, MD  
Department of Radiology  
Seoul National University Hospital  
Seoul  
Korea, Republic of (South Korea)

ISBN 978-981-287-717-8      ISBN 978-981-287-718-5 (eBook)  
DOI 10.1007/978-981-287-718-5

Library of Congress Control Number: 2017940416

© Springer Science+Business Media Singapore 2017

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature  
The registered company is Springer Nature Singapore Pte Ltd.  
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore  
189721, Singapore

*To my coauthors, Sung Hwan Hong, Ja-Young Choi, and Hye Jin Yoo, for their passion, excellence, and cooperation.*

*And to my three lovely grandsons, wishing them a bright and prosperous future.*

*—Heung Sik Kang, MD*

*To all the teachers and colleagues who have brought me to this point.*

*And to my sweet wife, Yun Kyung, and daughter, Jisu, my buttress and love.*

*—Sung Hwan Hong, MD*

*To my colleagues and family.*

*And finally to my mentor, Professor Kang, for his new start.*

*—Ja-Young Choi, MD*

*To my colleagues without whom I would not be here.*

*To my family for their endless support.*

*And to my cute daughter, whose smile warms my heart with love.*

*—Hye Jin Yoo, MD*

---

## Preface

Diagnostic imaging of soft tissue tumors remains a challenge in musculoskeletal radiology. The difficulty can be attributed to the diversity of soft tissue tumors and the significant overlap in their imaging features. Moreover, confusion persists in the literature regarding the terminology of soft tissue tumors because their taxonomy has evolved over time.

Since the discovery of X-ray, radiologic examination has been widely used to assess bone tumors, whereas soft tissue tumor evaluation was not broadly possible until the introduction of magnetic resonance imaging (MRI) in the early 1980s. Since then, remarkable progress has been made in the imaging of soft tissue tumors. Today, MRI is indispensable in the management of patients with soft tissue tumors, and its utility continues to increase as newly developed technologies become clinically available. As a result, radiology now plays a pivotal role in the detection, diagnosis, and treatment planning of soft tissue tumors.

This book presents a wide range of radiologically illustrated soft tissue tumors classified according to the 2013 WHO classification for soft tissue tumor. Not only radiologists but also other specialists should become well versed in the imaging evaluation of soft tissue tumors, to allow a multidisciplinary approach to treatment. As a radiology textbook, this book aims to familiarize readers with both the imaging findings and pattern analysis of soft tissue tumors. We hope that it will allow readers to improve their understanding of soft tissue tumors and facilitate communication among physicians.

Seongnam, Korea, Republic of (South Korea)  
Seoul, Korea, Republic of (South Korea)  
Seoul, Korea, Republic of (South Korea)  
Seoul, Korea, Republic of (South Korea)

Heung Sik Kang  
Sung Hwan Hong  
Ja-Young Choi  
Hye Jin Yoo

---

# Contents

## Part I General Considerations for the Diagnosis of Soft Tissue Tumors

<b>1 Diagnostic Approach</b> . . . . .	3
1.1 Clinical Consideration . . . . .	3
1.2 Imaging Modalities . . . . .	4
1.2.1 Radiography . . . . .	4
1.2.2 Ultrasonography . . . . .	4
1.2.3 CT . . . . .	4
1.2.4 MR Imaging . . . . .	4
1.3 Benign Versus Malignant . . . . .	5
1.4 Illustrations: Diagnostic Approach . . . . .	6
1.4.1 Location of Soft Tissue Tumors . . . . .	6
1.4.2 Soft Tissue Tumor in Clinical Syndrome . . . . .	8
1.4.3 Radiographic Evaluation . . . . .	9
1.4.4 Sonographic Evaluation . . . . .	13
1.4.5 CT Evaluation . . . . .	14
1.4.6 MR Imaging Evaluation . . . . .	15
References . . . . .	17
<b>2 Diagnostic Procedure</b> . . . . .	19
2.1 Anatomic Compartments . . . . .	19
2.1.1 Upper Extremity . . . . .	19
2.1.2 Pelvis . . . . .	19
2.1.3 Lower Extremity . . . . .	20
2.2 Imaging-Guided Percutaneous Biopsy . . . . .	20
2.3 Illustrations: Diagnostic Procedure . . . . .	21
2.3.1 Anatomic Compartments . . . . .	21
2.3.2 General Principles of Image-Guided Percutaneous Biopsy . . . . .	24
References . . . . .	26
<b>3 Staging of Soft Tissue Sarcoma</b> . . . . .	27
3.1 Tumor (T-Staging) . . . . .	27
3.2 Nodes (N-Stage) . . . . .	28
3.3 Metastasis (M-Stage) . . . . .	29
3.4 Histologic Grade (G-Stage) . . . . .	29
3.5 Proposed Report Format . . . . .	29

3.6	Illustrations: Staging of Soft Tissue Sarcoma . . . . .	29
3.6.1	Stage I . . . . .	29
3.6.2	Stage II . . . . .	32
3.6.3	Stage III . . . . .	33
3.6.4	Stage IV . . . . .	35
	References . . . . .	36

## Part II WHO Classification of Soft Tissue Tumors and Radiologic Illustrations

<b>4</b>	<b>Adipocytic Tumors . . . . .</b>	<b>39</b>
4.1	Lipoma . . . . .	39
4.2	Lipomatosis . . . . .	40
4.3	Lipomatosis of Nerve . . . . .	40
4.4	Lipoblastoma/Lipoblastomatosis . . . . .	40
4.5	Angiolipoma . . . . .	41
4.6	Spindle Cell Lipoma . . . . .	41
4.7	Hibernoma . . . . .	41
4.8	Lipoma Arborescens . . . . .	42
4.9	Atypical Lipomatous Tumor/Well-Differentiated Liposarcoma . . . . .	42
4.10	Dedifferentiated Liposarcoma . . . . .	42
4.11	Myxoid Liposarcoma . . . . .	43
4.12	Pleomorphic Liposarcoma . . . . .	44
4.13	Illustrations: Adipocytic Tumors . . . . .	44
4.13.1	Lipoma . . . . .	44
4.13.2	Lipomatosis . . . . .	46
4.13.3	Lipomatosis of Nerve . . . . .	47
4.13.4	Lipoblastoma . . . . .	48
4.13.5	Angiolipoma . . . . .	49
4.13.6	Spindle Cell Lipoma . . . . .	50
4.13.7	Hibernoma . . . . .	51
4.13.8	Lipoma Arborescens . . . . .	53
4.13.9	Well-Differentiated Liposarcoma . . . . .	54
4.13.10	Dedifferentiated Liposarcoma . . . . .	56
4.13.11	Myxoid Liposarcoma . . . . .	57
4.13.12	Pleomorphic Liposarcoma . . . . .	60
	References . . . . .	61
<b>5</b>	<b>Fibroblastic/Myofibroblastic Tumors . . . . .</b>	<b>63</b>
5.1	Nodular Fasciitis . . . . .	63
5.2	Proliferative Fasciitis . . . . .	63
5.3	Proliferative Myositis . . . . .	64
5.4	Myositis Ossificans . . . . .	64
5.5	Elastofibroma . . . . .	65
5.6	Fibrous Hamartoma of Infancy . . . . .	65
5.7	Fibromatosis Colli . . . . .	65
5.8	Fibroma of Tendon Sheath . . . . .	66
5.9	Desmoplastic Fibroblastoma . . . . .	66

5.10	Calcifying Aponeurotic Fibroma . . . . .	66
5.11	Palmar/Plantar Fibromatosis . . . . .	67
5.12	Desmoid-Type Fibromatosis . . . . .	67
5.13	Dermatofibrosarcoma Protuberans. . . . .	67
5.14	Solitary Fibrous Tumor . . . . .	68
5.15	Inflammatory Myofibroblastic Tumor . . . . .	68
5.16	Myxofibrosarcoma . . . . .	69
5.17	Low-Grade Fibromyxoid Sarcoma . . . . .	69
5.18	Low-Grade Myofibroblastic Sarcoma . . . . .	69
5.19	Sclerosing Epithelioid Fibrosarcoma. . . . .	69
5.20	Illustrations: Fibroblastic/Myofibroblastic Tumors . . . . .	70
5.20.1	Nodular Fasciitis . . . . .	70
5.20.2	Proliferative Fasciitis . . . . .	73
5.20.3	Proliferative Myositis. . . . .	74
5.20.4	Myositis Ossificans . . . . .	76
5.20.5	Elastofibroma Dorsi. . . . .	80
5.20.6	Fibrous Hamartoma of Infancy . . . . .	81
5.20.7	Fibromatosis Colli . . . . .	83
5.20.8	Fibroma of Tendon Sheath. . . . .	84
5.20.9	Desmoplastic Fibroblastoma . . . . .	87
5.20.10	Calcifying Aponeurotic Fibroma. . . . .	89
5.20.11	Palmar/Plantar Fibromatosis . . . . .	90
5.20.12	Desmoid-Type Fibromatosis . . . . .	91
5.20.13	Dermatofibrosarcoma Protuberans. . . . .	94
5.20.14	Solitary Fibrous Tumor . . . . .	96
5.20.15	Inflammatory Myofibroblastic Tumor . . . . .	98
5.20.16	Myxofibrosarcoma. . . . .	99
5.20.17	Low-Grade Fibromyxoid Sarcoma . . . . .	101
5.20.18	Low-Grade Myofibroblastic Sarcoma . . . . .	104
5.20.19	Sclerosing Epithelioid Fibrosarcoma. . . . .	106
	References. . . . .	106
<b>6</b>	<b>So-Called Fibrohistiocytic Tumors . . . . .</b>	<b>109</b>
6.1	Tenosynovial Giant Cell Tumor . . . . .	109
6.2	Deep Benign Fibrous Histiocytoma. . . . .	110
6.3	Giant Cell Tumor of Soft Tissue . . . . .	110
6.4	Illustrations: So-Called Fibrohistiocytic Tumors. . . . .	111
6.4.1	Tenosynovial Giant Cell Tumor, Localized Type . . . . .	111
6.4.2	Tenosynovial Giant Cell Tumor, Diffuse Type . . . . .	115
6.4.3	Giant Cell Tumor of Soft Tissue . . . . .	118
6.4.4	Deep Benign Fibrous Histiocytoma. . . . .	119
	References. . . . .	120
<b>7</b>	<b>Smooth Muscle Tumors . . . . .</b>	<b>121</b>
7.1	Leiomyoma of Deep Soft Tissue . . . . .	121
7.2	Leiomyosarcoma . . . . .	121
7.3	Illustrations: Smooth Muscle Tumors . . . . .	122
7.3.1	Leiomyoma of Deep Soft Tissue . . . . .	122
7.3.2	Leiomyosarcoma . . . . .	126
	References. . . . .	129



<b>8</b>	<b>Pericytic (Perivascular) Tumors</b> .....	131
8.1	Glomus Tumor .....	131
8.2	Myopericytoma, Including Myofibroma .....	132
8.3	Angioleiomyoma .....	132
8.4	Illustrations: Pericytic (Perivascular) Tumors .....	133
8.4.1	Glomus Tumor .....	133
8.4.2	Glomangioma .....	137
8.4.3	Glomangiomatosis .....	138
8.4.4	Myofibroma .....	139
8.4.5	Myopericytoma .....	142
8.4.6	Angioleiomyoma .....	143
	References .....	147
<b>9</b>	<b>Skeletal Muscle Tumors</b> .....	149
9.1	Rhabdomyosarcoma .....	149
9.2	Illustrations: Skeletal Muscle Tumors .....	150
9.2.1	Embryonal Rhabdomyosarcoma .....	150
9.2.2	Alveolar Rhabdomyosarcoma .....	151
9.2.3	Pleomorphic Rhabdomyosarcoma .....	152
9.2.4	Spindle Cell Rhabdomyosarcoma .....	155
	References .....	156
<b>10</b>	<b>Vascular Tumors</b> .....	157
10.1	Hemangiomas .....	157
10.2	Angiomatosis .....	158
10.3	Lymphangioma .....	159
10.4	Kaposiform Hemangioendothelioma .....	159
10.5	Retiform Hemangioendothelioma .....	159
10.6	Kaposi Sarcoma .....	159
10.7	Epithelioid Hemangioendothelioma .....	160
10.8	Angiosarcoma of Soft Tissue .....	160
10.9	Illustrations: Vascular Tumors .....	161
10.9.1	Hemangioma .....	161
10.9.2	Synovial Hemangioma .....	162
10.9.3	Intramuscular Angioma .....	164
10.9.4	Ossifying Intramuscular Angioma .....	168
10.9.5	Venous Hemangioma .....	169
10.9.6	Arteriovenous Malformation/Hemangioma .....	171
10.9.7	Angiomatosis .....	172
10.9.8	Lymphangioma .....	173
10.9.9	Kaposiform Hemangioendothelioma .....	175
10.9.10	Retiform Hemangioendothelioma .....	177
10.9.11	Kaposi Sarcoma .....	178
10.9.12	Epithelioid Hemangioendothelioma .....	179
10.9.13	Angiosarcoma of Soft Tissue .....	182
	References .....	184
<b>11</b>	<b>Chondro-Osseous Tumors</b> .....	185
11.1	Soft Tissue Chondroma .....	185
11.2	Extraskeletal Osteosarcoma .....	185
11.3	Illustrations: Chondro-Osseous Tumors .....	186

11.3.1	Soft Tissue Chondroma . . . . .	186
11.3.2	Extraskelatal Osteosarcoma . . . . .	190
	References . . . . .	191
<b>12</b>	<b>Nerve Sheath Tumors . . . . .</b>	<b>193</b>
12.1	Schwannoma (Including Variants) . . . . .	193
12.2	Neurofibroma (Including Variants) . . . . .	194
12.3	Perineurioma . . . . .	195
12.4	Granular Cell Tumor . . . . .	195
12.5	Malignant Peripheral Nerve Sheath Tumor . . . . .	196
12.6	Illustrations: Nerve Sheath Tumors . . . . .	197
12.6.1	Schwannoma . . . . .	197
12.6.2	Cellular Schwannoma . . . . .	201
12.6.3	Plexiform Schwannoma . . . . .	202
12.6.4	Ancient Schwannoma . . . . .	204
12.6.5	Neurofibroma . . . . .	207
12.6.6	Extraneural Perineurioma . . . . .	211
12.6.7	Intraneural Perineurioma . . . . .	212
12.6.8	Granular Cell Tumor . . . . .	213
12.6.9	Malignant Granular Cell Tumor . . . . .	215
12.6.10	Malignant Peripheral Nerve Sheath Tumor . . . . .	216
	References . . . . .	220
<b>13</b>	<b>Tumors of Uncertain Differentiation . . . . .</b>	<b>221</b>
13.1	Intramuscular Myxoma . . . . .	221
13.2	Synovial Sarcoma . . . . .	222
13.3	Phosphaturic Mesenchymal Tumor . . . . .	222
13.4	Epithelioid Sarcoma . . . . .	223
13.5	Alveolar Soft Part Sarcoma . . . . .	224
13.6	Clear Cell Sarcoma . . . . .	224
13.7	Extraskelatal Myxoid Chondrosarcoma . . . . .	225
13.8	Extraskelatal Ewing Sarcoma . . . . .	225
13.9	Extrarenal Malignant Rhabdoid Tumor . . . . .	226
13.10	Myoepithelioma/Parachordoma . . . . .	226
13.11	Pleomorphic Hyalinizing Angiectatic Tumor . . . . .	226
13.12	Illustrations: Tumors of Uncertain Differentiation . . . . .	227
13.12.1	Intramuscular Myxoma . . . . .	227
13.12.2	Synovial Sarcoma . . . . .	230
13.12.3	Phosphaturic Mesenchymal Tumor . . . . .	234
13.12.4	Epithelioid Sarcoma . . . . .	236
13.12.5	Angiosarcoma . . . . .	239
13.12.6	Clear Cell Sarcoma . . . . .	241
13.12.7	Extraskelatal Myxoid Chondrosarcoma . . . . .	243
13.12.8	Extraskelatal Ewing Sarcoma . . . . .	245
13.12.9	Extrarenal Rhabdoid Tumor . . . . .	247
13.12.10	Myoepithelioma . . . . .	248
13.12.11	Pleomorphic Hyalinizing Angiectatic Tumor of Soft Part . . . . .	249
	References . . . . .	250

<b>14</b>	<b>Undifferentiated/Unclassified Sarcoma</b> .....	253
14.1	Undifferentiated Pleomorphic Sarcoma.....	253
14.2	Undifferentiated Round Cell and Spindle Cell Sarcoma....	254
14.3	Illustrations: Undifferentiated/Unclassified Sarcoma .....	255
14.3.1	Undifferentiated Pleomorphic Sarcoma.....	255
14.3.2	CIC-DUX4 Fusion Positive Undifferentiated Round Cell Sarcoma .....	261
	References.....	262
<b>15</b>	<b>Superficial Soft Tissue Masses</b> .....	263
15.1	Epidermal Inclusion Cyst.....	263
15.2	Pilomatricoma .....	264
15.3	Fat Necrosis .....	264
15.4	Rheumatoid Nodule.....	265
15.5	Morel-Lavallee Lesion.....	265
15.6	Malignant Melanoma.....	266
15.7	Lymphoma (Cutaneous and Subcutaneous).....	266
15.8	Soft Tissue Metastasis .....	268
15.9	Illustrations: Superficial Soft Tissue Masses .....	269
15.9.1	Epidermal Inclusion Cyst.....	269
15.9.2	Pilomatricoma .....	272
15.9.3	Fat Necrosis .....	275
15.9.4	Rheumatoid Nodule.....	276
15.9.5	Morel-Lavallee Lesion.....	278
15.9.6	Malignant Melanoma.....	279
15.9.7	Lymphoma (Cutaneous and Subcutaneous).....	283
15.9.8	Soft Tissue Metastasis .....	286
	References.....	287
<b>16</b>	<b>Masses That May Mimic Soft Tissue Tumors</b> .....	291
16.1	Ganglion.....	291
16.2	Vascular Lesion .....	291
16.3	Gout .....	292
16.4	Sarcoidosis.....	293
16.5	Morton's Neuroma.....	293
16.6	Traumatic Neuroma.....	294
16.7	Xanthoma.....	295
16.8	Illustrations: Masses That May Mimic Soft Tissue Tumors .....	296
16.8.1	Ganglion.....	296
16.8.2	Vascular Lesion .....	299
16.8.3	Gout .....	301
16.8.4	Sarcoidosis.....	303
16.8.5	Morton's Neuroma.....	306
16.8.6	Traumatic Neuroma.....	308
16.8.7	Xanthoma.....	311
	References.....	314

### Part III Practical Pearls in Diagnosis of Soft Tissue Tumors

<b>17</b>	<b>Lesion Characterization Based on MR Signal Intensities</b>	317
17.1	T1 Hyperintense Lesions	319
17.1.1	Lesion Containing Fat	319
17.1.2	Lesion Containing Methemoglobin	322
17.1.3	Lesion Containing Proteinaceous Material	323
17.1.4	Lesion Containing Melanin	324
17.2	T2 Hypointense Lesions	325
17.2.1	Lesion Containing Fibrous Tissue	325
17.2.2	Lesion Containing Mineralization	329
17.2.3	Lesion Containing Free Cholesterol	334
17.2.4	Lesion Containing High-Flow Vessels	334
17.3	T2 Fluid-Equivalent Hyperintense Lesions	337
17.3.1	Lesion Containing Fluid	337
17.3.2	Lesion Containing Myxoid Tissue	339
17.3.3	Vascular Lesion	342
17.3.4	Lesion Containing Cartilage	343
<b>18</b>	<b>Diagnostic Signs</b>	345
18.1	Bowl of Grapes Sign	345
18.2	Bunch of Grapes Appearance	346
18.3	Checkerboard Appearance	347
18.4	Coaxial Cable-Like Appearance	348
18.5	Dark Star Sign	349
18.6	Fascicular Sign	350
18.7	Inverted Target Sign	351
18.8	Gyriform Pattern	352
18.9	Reverse Target Sign	353
18.10	Reverse Zoning Phenomenon	354
18.11	Spaghetti-Like Appearance	355
18.12	Split Fat Sign	356
18.13	String Sign	357
18.14	Stripe Sign	358
18.15	Swiss Cheese Appearance	359
18.16	Tail Sign	360
18.17	Target Sign	361
18.18	Three Stripes Sign	362
18.19	Triple Signal Sign	363
18.20	Zonal Phenomenon	364
<b>19</b>	<b>Syndrome-Associated Soft Tissue Tumors</b>	365
19.1	Kasabach-Merritt Syndrome	366
19.2	Maffucci Syndrome	368
19.3	Klippel-Trenaunay Syndrome	370
19.4	Mazabraud Syndrome	371
19.5	Neurofibromatosis Type 1	372

19.6 Neurofibromatosis Type 2 ..... 376  
19.7 Schwannomatosis..... 379  
19.8 Carney Complex ..... 380  
19.9 Familial Hypercholesterolemia ..... 382

**Part IV Drill and Practice**

**20 Image Interpretation Session** ..... 387  
20.1 Quiz ..... 388  
20.2 Quiz ..... 390  
20.3 Quiz ..... 392  
20.4 Quiz ..... 394  
20.5 Quiz ..... 396  
20.6 Quiz ..... 398  
20.7 Quiz ..... 400  
20.8 Quiz ..... 402  
20.9 Quiz ..... 404  
20.10 Quiz ..... 406  
20.11 Quiz ..... 408  
20.12 Quiz ..... 410  
20.13 Quiz ..... 412  
20.14 Quiz ..... 414  
20.15 Quiz ..... 416  
20.16 Quiz ..... 418  
20.17 Quiz ..... 420  
20.18 Quiz ..... 422  
20.19 Quiz ..... 424  
20.20 Quiz ..... 426  
20.21 Quiz ..... 428  
20.22 Quiz ..... 430  
20.23 Quiz ..... 432  
20.24 Quiz ..... 434  
20.25 Quiz ..... 436  
20.26 Quiz ..... 438  
20.27 Quiz ..... 440  
20.28 Quiz ..... 442  
20.29 Quiz ..... 444  
20.30 Quiz ..... 446  
20.31 Quiz ..... 448  
20.32 Quiz ..... 450  
20.33 Quiz ..... 452