
Combined Scintigraphic and Radiographic Diagnosis of Bone and Joint Diseases

Yong-Whee Bahk

Combined Scintigraphic and Radiographic Diagnosis of Bone and Joint Diseases

Including Gamma Correction Interpretation

Fifth Edition

 Springer

Yong-Whee Bahk
Department of Nuclear Medicine and Radiology
The Catholic University of Korea School of Medicine
Seoul
South Korea

ISBN 978-981-10-2758-1 ISBN 978-981-10-2759-8 (eBook)
DOI 10.1007/978-981-10-2759-8

Library of Congress Control Number: 2017936660

© Springer Nature Singapore Pte Ltd. 2017

This work is subject to copyright. All rights are reserved 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, #22-06/08 Gateway East, Singapore 189721, Singapore

*To those who suffer from skeletal disease and those who heal
and help the sufferers*

Preface to the Fifth Edition



Out of more than a sheer historical curiosity, I tried to trace back the origin of pinhole imaging and surprisingly come across the name of Aristotle (BC 384–322), an eternal scholar, scientist, philosopher, and human being. He saw, observed, meditated, studied, comprehended, and accumulated enormous amounts of knowledge about mankind, animate and inanimate objects, and the universe. Interestingly enough, his records show that he was interested in the imaging effect of the “small hole,” which centuries later realized as the photographic camera. Thirteen centuries passed and Ibn al-Haytham of Cairo (Alhazen; AD 965–1038) described that “An outside object, such as eclipsed sun, could be projected through a *small hole* on the opposite wall of camera obscura as an inverted image.” Chronology further archives that Leonardo da Vinci wrote an instruction book on camera obscura in the fifteenth century which became to be known only toward the end of the eighteenth century. According to the “Histoire de la photographie” of Keim Jean-A in a *Que sais-Je?* No. 1417 (1970), the small hole of the camera obscura gave birth to the modern photographic camera which is today universally used on earth and in the man-made satellites in space. Indeed, almost all kinds of photographic cameras are based on a pinhole.

Gamma correction pinhole bone scan has been lately introduced into *Nuclear Medicine* as an extended use of the camera obscura principle and gamma correction algorithm in order to diagnose trabecular microstructures and endosteal rimming. Thus, this 5th edition additionally discusses gamma correction pinhole scan diagnosis of bone marrow edema and hemorrhage with pathological verification in rat and surgical specimen (Fig. 1). Additionally, gamma correction pinhole bone scan is able to specifically demonstrate tendon insertion site microfractures (Fig. 2).

Seoul, South Korea

Yong-Whee Bahk

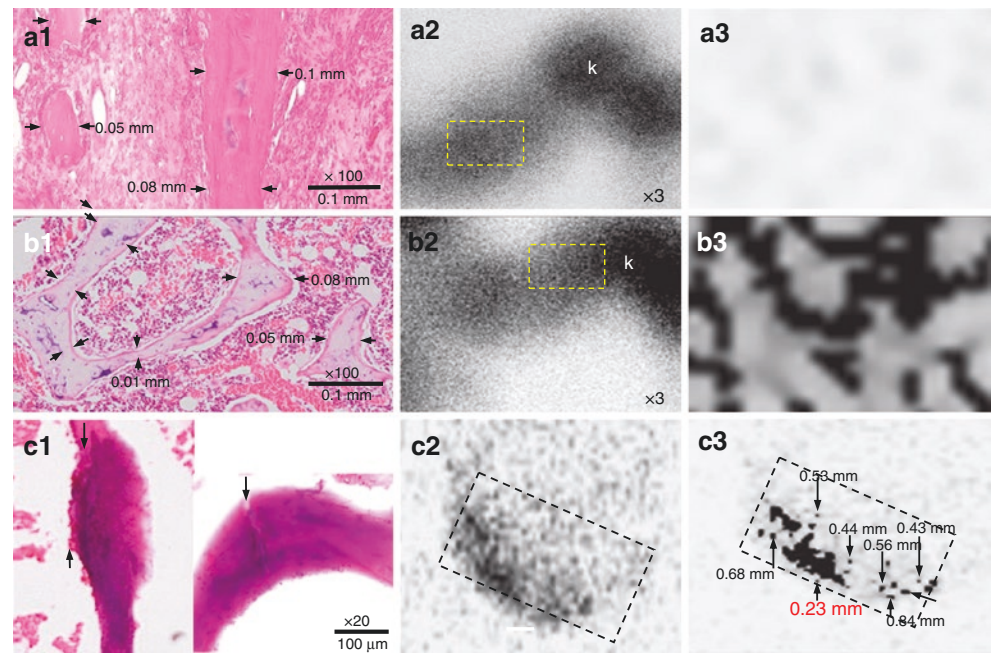


Fig. 1 HE stain of edema and hemorrhage and trabecular microfractures correlated with gamma correction scan changes. (a1) HE stain shows edema dipped trabeculae with intact endosteum in rat (arrows). (a2) $\times 3$ magnified scan shows granular tracer uptake in mid-femoral shaft (frame). k denotes knee. (a3) Uptake cleanly washed out by gamma correction because trabeculae are intact. (b1) HE stain shows trabecular endosteal thickening (arrows) and hemorrhage in rat. (b2) Granular tracer uptake in contusion (frame). (b3) Gamma correction pinhole scan shows endosteal rimming with high unwashed tracer uptake. (c1) HE stain shows two typical calcified calluses with microfractures (arrows) in patient. (c2) Naïve pinhole scan of surgical specimen showing veiled fractures (frame). (c3) Gamma correction highlights microfractures. Size measured by pixelized method. The smallest one is 0.23 mm

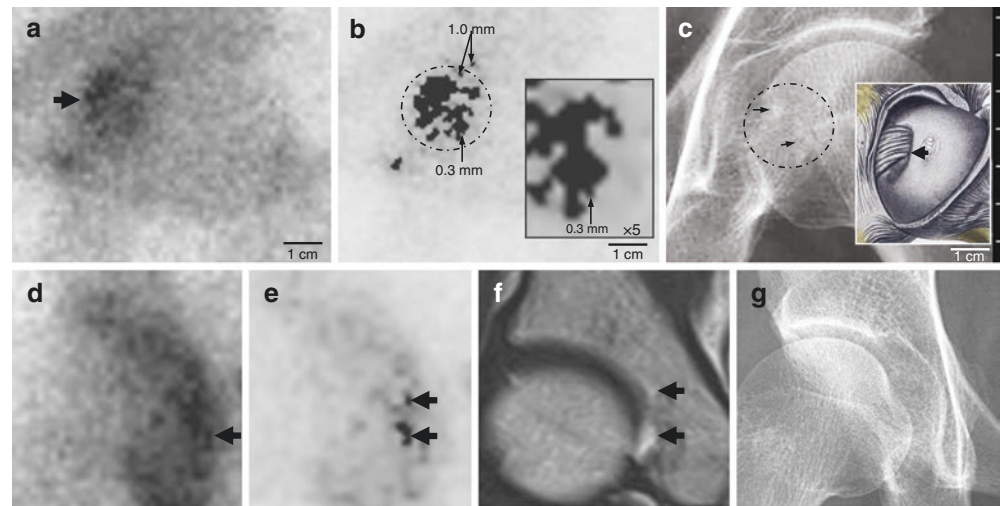


Fig. 2 Pain in the left hip joint incited by motor vehicle accident in a 32-year-old female. (a) Naïve anterior pinhole scan shows blurry tracer uptake in the fovea (arrow). (b) Gamma correction view shows irregular tracer uptake (circle). Inset shows the smallest one measures 0.3 mm in size. (c) Radiograph shows deranged trabeculae with calcification (circle and arrows). Inset shows anatomy of the fovea and ligament (arrow) (Adopted from Clement's Anatomy. Urban & Schwarzenberg, München, 1981). (d) Naïve anterior pinhole scan of the right acetabulum shows diffuse increased tracer uptake in the acetabular fossa (arrow). (e) Gamma correction view shows the washout of blurry uptake highlighting two small fractures at the acetabular terminal of the teres ligament (arrows). (f) Coronal T2-weighted (6120/96) MR image shows two mottled areas of bright signal intensity in the small fractures of acetabular insertion site (arrows). (g) Radiograph is negative

Acknowledgements

Emeritus Professor Henry Nicholas Wagner, Junior, deceased in 2012. He had so gracefully written in continuity all four forewords for the first through fourth editions of this humble book from its cradle to maturity. He convinced the world that Nuclear Medicine will be a science, not just an idea (Hevesy Nuclear Medicine Lecture. *J Nucl Med* 1984;25(8):934–939).

As ever, I am more than deeply appreciative of all readers and friends for their continued encouragement. My thanks are due to Dr. Yoon-Kwang Kim, the Chairman of Sung-Ae General Hospital, Seoul, for his generous support and to Mr. Woo-Jin Chang, Catholic University of Korea Medical School librarian, for his faithful reference work. It is indeed to be sincerely remarked that Dr. Ute Heilmann of Springer-Verlag in Heidelberg deserves our esteem for her superb administration for more than two decades since 1994. We are also thankful to Lauren Kim and Jenny Chun of Springer Korea.

Contents

1	Introduction and Fundamentals of Pinhole Scintigraphy	1
1.1	A History of Nuclear Bone Imaging	4
1.2	Histology and Physiology of Bone	5
1.3	Mechanism of Bone Adsorption of ^{99m} Tc-Radiopharmaceuticals	6
1.4	Bone Imaging Radiopharmaceuticals	6
1.5	Bone Marrow Scan Radiopharmaceuticals	6
1.6	Fundamentals of Pinhole Scintigraphy	7
1.7	Rationale and Techniques of Pinhole Scintigraphy	7
	References.....	12
2	Dual-Head Pinhole Scan, Pinhole SPECT, and Gamma Correction Scan	13
2.1	Dual-Head Planar Pinhole Scintigraphy	13
2.2	Pinhole Single-Photon Emission Computed Tomography of Bone.....	18
2.3	Gamma Correction of Pinhole Bone Scan.....	20
	References.....	27
3	Clinical Applications	29
3.1	Abnormal Bone Scan.....	31
3.2	Altered Biodistribution of Radiopharmaceutical.....	31
	References.....	31
4	Normal Pinhole Scintigraphic Anatomy of Bone and Joint	33
4.1	Skull and Face	33
4.2	Neck.....	37
4.3	Thoracic Cage	39
4.4	Shoulder.....	40
4.5	Thoracic and Lumbar Spine.....	42
4.6	Sacrum and Sacroiliac Joints.....	45
4.7	Pelvis and Hip	47
4.8	Limbs.....	48
4.8.1	Upper Limbs	49
4.8.2	Lower Limbs	51
	References.....	58
5	Normal Variants and Artifacts	59
5.1	Normal Variants.....	59
5.1.1	Skull.....	59
5.1.2	Neck.....	63
5.1.3	Thorax	63
5.1.4	Spine and Abdomen.....	68
5.1.5	Pelvis	68
5.1.6	Limbs.....	71

5.1.7	Accessory Navicular Bone.	72
5.1.8	Urogenital System	72
5.2	Artifacts	75
5.2.1	Radiopharmaceuticals and Altered Body Chemistry and Anatomy . . .	75
5.2.2	Injection and Tourniquet Artifacts	75
5.2.3	Radioactivity Attenuation Artifacts	77
5.2.4	Soiling	81
	References.	82
6	Infective and Inflammatory Diseases of Bone	83
6.1	Acute Osteomyelitis.	83
6.1.1	Pathogenesis.	83
6.1.2	Radiographic Manifestations	84
6.1.3	Pinhole Scintigraphic Manifestations	84
6.2	Subacute and Chronic Osteomyelitis.	92
6.3	Acute and Chronic Infective Osteitis and Cortical Abscess	94
6.4	Acute Infective Periostitis	97
6.5	Special Forms of Osteomyelitis.	98
6.5.1	Neonatal and Infantile Osteomyelitis.	98
6.5.2	Sclerosing Osteomyelitis of Garré.	99
6.5.3	Brodie's Abscess	100
6.5.4	Osteomyelitis in Flat and Irregular Bones	100
6.5.5	Osteomyelitis in the Diabetic Foot	101
6.5.6	Osteomyelitis of the Spine.	104
6.6	Tuberculosis of Bone	106
6.7	¹¹¹ In- and ^{99m} Tc-Leukocyte and ⁶⁷ Ga Citrate Scintigraphy in Skeletal Infections	107
6.8	Tietze's Disease	114
	References.	117
7	Noninfective Osteitides	119
7.1	Osteitis Condensans Ilii	119
7.2	Osteitis Pubis	121
7.3	Condensing Osteitis of the Clavicle.	123
7.4	Sternocostoclavicular Hyperostosis	124
7.5	Infantile Cortical Hyperostosis (Caffey's Disease)	126
7.6	Osteitis Deformans (Paget's Disease of Bone)	128
7.7	Odontogenous Osteitis of the Mandible (Periapical Abscess).	128
7.8	Radiation Osteitis (Osteonecrosis).	129
	References.	131
8	Diseases of Joints and Soft-Tissue Infections	133
8.1	Sterile and Sympathetic Arthritis.	135
8.1.1	Transient Synovitis of the Hip.	135
8.1.2	Sympathetic Synovitis	135
8.1.3	Sterile Traumatic Synovitis	135
8.1.4	Synovitis in Renal Transplantation and Prolonged Hemodialysis.	137
8.2	Infective Arthritis.	140
8.2.1	Pyogenic Arthritis (Pyarthrosis)	140
8.2.2	Pyarthrosis and Abscess of the Sacroiliac Joint.	144
8.2.3	Tuberculous Arthritis of Peripheral Joints	147
8.3	Soft-Tissue Infections	150
8.3.1	Subcutaneous Tissue Infections.	150
8.3.2	Decubitus Ulcer (Bedsore).	153
	References.	154

9 Degenerative Joint Diseases	155
9.1 Osteoarthritis	155
9.2 Pathology	155
9.3 Radiographic Manifestations	155
9.4 Pinhole Scintigraphic Manifestations	156
9.5 Sacroiliac Joint	158
9.6 Hip	161
9.7 Knee	162
9.8 Patella	163
9.8.1 Patellar (Femoropatellar) Osteoarthritis	164
9.8.2 Chondromalacia Patellae	164
9.9 Ankle and Tarsal Joints	167
9.10 Shoulder	169
9.10.1 Acromioclavicular Joint	169
9.10.2 Glenohumeral Joint	170
9.11 Sternum	172
9.11.1 Sternoclavicular Joint	172
9.11.2 Manubriosternal Joint	174
9.12 Elbow	175
9.13 Wrist and Carpal Joints	175
9.14 Spine	178
9.15 Other Common Sites of Osteoarthritis	185
9.15.1 Symphysis Pubis	185
9.15.2 Metatarsosesamoidal Joints	186
9.15.3 Navicular Accessory Joint	186
9.16 Generalized Osteoarthritis	188
9.17 Degeneration-Related Disorders of Spine	189
9.17.1 Diffuse Idiopathic Skeletal Hyperostosis	189
9.17.2 Ossification of the Posterior Longitudinal Ligament	191
9.17.3 Schmorl's Cartilaginous Node	191
9.17.4 Limbus Vertebra	191
9.17.5 Spondylolysis	191
9.17.6 Spondylolisthesis	196
9.17.7 Bastrup's Disease	196
9.18 Degenerative Enthesopathy	198
References	198
10 Rheumatoid Arthritis	201
10.1 Pathology and Laboratory Tests	201
10.2 Radiographic Manifestations	201
10.3 Bone Scintigraphic Manifestations	202
10.4 Hand (Fingers)	206
10.5 Wrist	208
10.6 Elbow	211
10.7 Shoulder	212
10.8 Sternum	215
10.9 Foot	217
10.10 Ankle and Tarsus	218
10.11 Knee	220
10.12 Hip	222
10.13 Sacroiliac Joint	224
10.14 Spine	226
10.15 Temporomandibular Joint	228

10.16	Insufficiency Fracture in Rheumatoid Arthritis	230
10.17	Juvenile Rheumatoid Arthritis	231
10.18	Nuclear Angiography in Rheumatoid Arthritis	232
10.19	Molecular Imaging in Rheumatoid Arthritis	233
10.20	^{99m} Tc-FDG PET/CT in Rheumatoid Arthritis	233
	References	234
11	Seronegative Spondyloarthropathies	237
11.1	Pathology	237
11.2	Radiographic Manifestations	237
11.3	Bone Scintigraphic Manifestations	238
11.4	Ankylosing Spondylitis	239
11.5	Reiter's Syndrome	243
11.6	Psoriatic Arthritis	251
11.7	Enteropathic Arthropathies	254
	References	255
12	Other Rheumatic Osteoarthropathies and Soft-Tissue	
	Rheumatism Syndromes	257
12.1	Sjögren's Syndrome	259
12.2	Behçet's Syndrome	259
12.3	Systemic Lupus Erythematosus	261
12.4	Gouty Arthritis	265
12.5	Charcot's Joint or Neuroarthropathy	269
12.6	Secondary Hypertrophic Osteoarthropathy	270
12.7	Periarticular Soft-Tissue Rheumatism Syndromes	273
	12.7.1 Plantar Fasciitis	279
	12.7.2 Degenerative Rheumatic Enthesopathy	279
12.8	Muscular and Musculotendinous Rheumatism Syndromes	280
	12.8.1 Myositis Ossificans	280
	12.8.2 Rhabdomyolysis	283
	12.8.3 Musculotendinous Unit Strain or Injuries	284
	12.8.4 Distal Femoral Cortical Irregularity	287
	References	292
13	Osteochondroses and Related Diseases	295
13.1	Legg-Calvé-Perthes Disease (Capital Femoral Epiphysis)	297
13.2	Friedrich's Disease (Medial Clavicular End)	298
13.3	Freiberg's Infraction (Metatarsal Head)	299
13.4	Kienböck's Disease (Lunate)	301
13.5	Osteonecrosis of the First Metatarsal Sesamoid (Hallucal Sesamoid)	302
13.6	Osgood-Schlatter Disease (Tibial Tuberosity)	303
13.7	Scheuermann's Disease (Vertebral Secondary Ossification Center)	304
13.8	Sever's Disease (Calcaneal Apophysis)	306
13.9	Slipped Capital Femoral Epiphysis	307
13.10	Osteochondritis Dissecans	309
13.11	Congenital Dislocation of the Hip	310
	References	312
14	Vascular Bone Disorders	313
14.1	Avascular Osteonecrosis and Bone Infarction	313
14.2	Avascular Necrosis in Chronic Alcoholism	318
14.3	Vascularity-Related Osteoporosis	319
14.4	Reflex Sympathetic Dystrophy	322
14.5	Transient Regional Osteoporosis	324

14.6	Transient Osteoporosis with Bone Marrow Edema	326
14.7	Transient Indolent Bone Tracer Uptake	327
14.8	Periostitis in Vascular Insufficiency	329
	References	330
15	Metabolic Bone Diseases and Drug-Induced Osteoporosis	331
15.1	Involitional Osteoporosis	331
15.2	Disuse and Immobilization Osteoporosis	334
15.3	Osteodystrophy Associated with Hyperparathyroidism and Brown Tumor	337
15.4	Drug-Induced Osteoporosis	341
15.5	Rickets and Osteomalacia	343
15.6	Diabetic Neuroarthropathy	345
	References	347
16	Traumatic, Surgical, Sports, and Thermal and Cold Injuries of the Skeleton	349
16.1	Bone Fractures	349
16.2	Joint Sprain	358
16.3	Bone Contusion (Occult Intraosseous Fracture)	361
16.4	Stress Fractures and Related Peri- and Endosteal Reaction	363
16.4.1	Shin Splints	364
16.5	Surgical Bone Injuries	365
16.6	Postreduction Changes of Joint Subluxation and Dislocation	369
16.7	Arthroplasties and Fixation Devices	371
16.8	Healing of Bone Fracture	374
16.9	Assessment of Vascularized Bone Grafts	378
16.10	Complications of Traumatic Bone Injuries	380
16.11	Sports Injuries to Bone	382
16.12	Sports and Traumatic Injuries to Soft-Tissue Structures	385
16.13	Thermal and Cold Injuries to Bone and Muscle	392
16.14	Complex and Special Fractures	395
16.14.1	Comminuted Fracture	397
16.14.2	Open and Compound Fracture	400
16.14.3	Complicated Fracture	401
16.14.4	Lisfranc's Fracture-Dislocation	401
16.14.5	Avulsion Fracture	403
16.14.6	Occult Fractures	403
16.14.7	Pillion Fracture	403
	References	405
17	Malignant Tumors of Bone	407
17.1	Metastasis	407
17.1.1	Bone Marrow Scintigraphy in Metastasis	422
17.2	Primary Malignant Bone Tumors	429
17.2.1	Osteosarcoma (Osteogenic Sarcoma)	429
17.2.2	Chondrosarcoma	436
17.2.3	Ewing's Sarcoma	437
17.2.4	Fibrosarcoma	439
17.2.5	Myeloma (Plasma Cell Myeloma)	440
17.3	Leukemias and Lymphomas	445
17.4	Chordoma	447
17.5	Periosteal Leiomyosarcoma	448
	References	449

18	Benign Tumors and Tumorous Conditions of the Bone	451
18.1	Benign Bone Tumors	451
18.1.1	Osteoma	451
18.1.2	Osteoid Osteoma	452
18.1.3	Osteblastoma	453
18.1.4	Enostosis (Compact Bone Island)	455
18.1.5	Enchondroma	458
18.1.6	Chondroblastoma	458
18.1.7	Fibrous Cortical Defect and Nonossifying Fibroma	461
18.1.8	Osteochondroma (Exostosis)	468
18.1.9	Primary Bone Cysts	470
18.1.10	Aneurysmal Bone Cysts	470
18.1.11	Giant Cell Tumor	472
18.1.12	Vertebral Hemangioma	475
18.1.13	Periosteal Leiomyoma	475
18.2	Tumorous Conditions of the Bone	476
18.2.1	Fibrous (or Fibro-Osseous) Dysplasia	476
18.2.2	Fibro-Osseous Pseudotumor of the Digits	477
18.2.3	Juxtacortical Fibromatosis (Desmoid Tumor of the Soft Tissue)	478
18.2.4	Histiocytosis X (Langerhans Cell Histiocytosis)	478
18.2.5	Paget's Disease of the Bone (Osteitis Deformans)	481
18.2.6	Neurofibromatosis (von Recklinghausen's Disease)	484
18.2.7	Enchondromatosis	488
18.2.8	Hereditary Multiple Exostoses	489
18.2.9	Osteopoikilosis	492
18.2.10	Osteopetrosis	492
	References	495
19	Soft-Tissue Tumors and Tumorlike Conditions	497
	References	506
20	Otorhinological Disorders	507
20.1	Rhinosinusitis and Mucocele	507
20.2	Granulomatous and Similar Diseases	508
20.3	Maxillary Sinus Carcinoma	509
20.4	Malignant Tumors of the Nasal Cavity	512
20.5	Nasopharyngeal Carcinoma	514
20.6	Inflammatory Diseases of the Mastoidal Bones	517
	References	519
21	¹⁸F-FDG PET/CT in Bone and Joint Diseases	521
21.1	Tumors	521
21.1.1	Primary Tumors of the Bone and Soft Tissue	521
21.1.2	Metastatic Bone Tumor	524
21.1.3	Assessment of Therapeutic Response for Bone Metastases	529
21.2	Infectious Diseases	530
21.3	Rheumatoid Arthritis	533
21.4	Fractures	536
	References	536
22	¹⁸F-NaF PET/CT in Bone and Joint Diseases	539
22.1	Benign Bone and Joint Diseases	539
22.1.1	Degenerative or Osteoarthritic Disorder	540
22.1.2	Traumatic Bone Lesion	540
22.1.3	Post-Prosthetic Surgery Evaluation	541

22.1.4	Temporomandibular Joint Disorder	541
22.1.5	Sacroiliitis	541
22.1.6	Knee Pain Evaluation	544
22.1.7	Benign Bone Tumor	544
22.2	Metastatic Bone Diseases	545
22.2.1	Prostate Cancer	546
22.2.2	Breast Cancer	546
22.2.3	Well-Differentiated Thyroid Cancer	547
22.2.4	Renal Cell Carcinoma	548
22.2.5	Hepatocellular Carcinoma	548
22.2.6	Uterine Cervix Cancer	548
22.2.7	Transitional Cell Carcinoma of the Renal Pelvis	551
	References	551
23	A Genetic Consideration of Skeletal Disorders	553
23.1	Essential Bioanatomy of the Musculoskeletal System	555
23.2	^{99m} Tc-MDP Bone Scintigraphic Techniques	555
23.3	^{99m} Tc-MDP Bone Scintigraphy in Autosomal and Polygenic Bone Disorders	557
23.3.1	Autosomal Skeletal Disorders	557
23.3.2	Polygenic Skeletal Disorders	557
23.4	Other HLA-Associated Skeletal Disorders	561
23.4.1	Reactive Arthritis	561
23.4.2	Diffuse Idiopathic Skeletal Hyperostosis (Forestier's Disease)	561
23.4.3	Slipped Capital Femoral Epiphysis	562
23.4.4	Calcific Periartthritis (Hydroxyapatite Crystal Deposition Disease)	563
23.5	Nongenetic Skeletal Disorders	564
	References	564
24	General Gamma Correction Pinhole Bone Scan Diagnosis	567
24.1	Occult Fractures	570
24.1.1	Skull	571
24.1.2	Nasal Bone and Maxilla	572
24.1.3	Ribs and Sternum	574
24.1.4	Coracoid Process and Glenoid	576
24.1.5	Spine	577
24.1.6	Spinous Processes	579
24.1.7	Pelvis	579
24.1.8	Knee	585
24.1.9	Patella	586
24.1.10	Foot	589
24.1.11	Other Bones	593
24.2	Neck Sprain and Whiplash Injury	598
24.2.1	Sprain and Strain of the Neck	598
24.2.2	Whiplash Injury	599
24.3	Bone Marrow Edema and Microfractures of Trabeculae	601
24.3.1	Bone Marrow Edema	601
24.3.2	Pinpoint and Microreticular Fractures of Cancellous Bone	609
24.4	Evident, Gaping, and Stress Fractures	611
24.4.1	Evident Fractures in Small and Irregular Bones	611
24.4.2	Gaping Fractures	613
24.4.3	Stress Fractures	614
24.5	Differential Diagnosis	617

24.5.1	Penumbra Bone Reaction in Avascular Osteonecrosis	617
24.5.2	Bone Formation in Disuse Osteoporosis	619
24.5.3	Fish Vertebrae.	621
24.5.4	Noninfective Osteitides of the Sacroiliac Joint and Pubic Symphysis	621
24.5.5	Nontuberculous Bacterial Bone Infection	623
24.5.6	Benign Bone Tumors and Tumorous Conditions.	627
24.5.7	Primary and Metastatic Malignant Bone Tumors	637
	References.	647
25	Gamma Correction ^{99m}Tc-HDP Pinhole Scan Diagnosis of Trabecular Microfracture and Contusion	649
25.1	Gamma Correction Pinhole ^{99m} Tc-HDP Scan of Contused Trabeculae.	650
25.2	Gamma Correction Pinhole ^{99m} Tc-HDP Scan of Trabecular Fracture.	652
25.2.1	Microfractures in Nasal Bones.	656
25.2.2	Rotator Cuff Injury and Microfractures in Shoulder Girdle Bones . .	657
25.2.3	Spine.	659
25.2.4	Fovea Capitis Femoris, Hip Joint Ligament, and Acetabulum	662
25.2.5	Knee and Patella.	664
25.2.6	Early Degenerative Disease of Knee Joint.	673
	References.	687
26	Miscellanea of Gamma Correction Pinhole Scan.	689
26.1	Hyoid Bone, Cricoid Cartilage, and Sternum	690
26.2	Vascularity of Fractured Bone Fragment	693
26.3	Halation and De-Halation	694
26.4	Applications of Gamma Correction to Bone MRI and CT	694
26.5	Conventional Radiography for Bone Scan: Revisited	695
26.6	Sunburst Sign and Codman's Triangle in Osteosarcoma.	698
	References.	700
	Appendix: Basic Physics of Pinhole Scintigraphy	701
	Index.	711

Contributors

Soo-Kyo Chung, MD, PhD Department of Radiology and Nuclear Medicine, The Catholic University of Korea College of Medicine, Seoul, South Korea

Sung-Hoon Kim, MD, PhD Department of Radiology and Nuclear Medicine, The Catholic University of Korea College of Medicine, Seoul, South Korea

Myung-Hee Sohn, MD, PhD Department of Nuclear Medicine, Jeonbuk National University Medical School Hospital, Jeonju, South Korea

Tae Suk Suh, PhD Department of Medical Engineering, The Catholic University of Korea College of Medicine, Seoul, South Korea

Won-Jong Bahk, MD, PhD Department of Orthopedic Surgery, The Catholic University of Korea College of Medicine, Seoul, South Korea

Yong An Chung, MD, PhD Department of Radiology and Nuclear Medicine, The Catholic University of Korea College of Medicine, Seoul, South Korea

Won Woo Lee, MD, PhD Department of Nuclear Medicine, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seoul, South Korea

Ie Ryung Yoo, MD, PhD Department of Radiology and Nuclear Medicine, The Catholic University of Korea College of Medicine, Seoul, South Korea