Bone densitometry is a fascinating field of medicine. Even in its earliest phases of development, densitometry incorporated aspects of imaging, physics, quantitative analysis, statistics, and computer technology that were applied in the diagnosis and management of multiple disease states. This extraordinary combination of attributes, however, left densitometry without a well-defined niche in clinical medicine. Imaging has traditionally been the purview of the radiologist. Quantitative analysis is more familiar to the pathologist. Metabolic bone disease has been the concern of the internist, rheumatologist, or endocrinologist and occasionally the nephrologist and orthopedist. And of course, physics, statistics, and computer technology have been left to those hardy souls who enjoy such things.

In 1988, when X-ray-based densitometers began to rapidly replace isotope-based densitometers, the door was opened for any medical specialty to perform densitometry. And yet, without a well-defined niche, without a specialty to champion the technology, there were no physicians who, by training, were immediately experts in the utilization of the technology.

In 1983, when I began working with dual-photon absorptiometry, the manufacturers provided a 4-hour inservice at the time of machine installation along with a brief operator’s manual and the promise of technical support whenever it was needed. There were no ongoing programs of continuing education in the performance of densitometry or in the interpretation of the data that it generated. There was no supply of trained densitometry technologists. Conferences on osteoporosis were infrequent and lectures on densitometry were decidedly rare. As a clinical tool, densitometry was viewed with skepticism. None of the notable fracture trials had yet been published. Indeed, these would not come for approximately 10 years. Clinicians, unable to noninvasively measure bone density in the past, saw little need for the ability to do so. The one disease in which densitometry seemed most applicable, osteoporosis, was largely viewed as an unalterable component of aging making the measurement of bone density superfluous.

Certainly much has changed since then, both for good and for ill. With the ability to measure bone density, many disease states are now known to be characterized, at least in part, by demineralization. Suddenly, it is not only osteoporosis for which the technology can provide information crucial to disease management. And osteoporosis itself is certainly no longer viewed as unassailable. The fracture trials are published. Therapeutic and preventive efficacy of many drugs has now been documented. And the disease itself can now be defined based on the measured level of bone density. Although the technology is still properly viewed as a quantitative analytical technique, imaging with densitometry is progressing so rapidly that the time has come when some aspects of plain skeletal radiography are being superseded by imaging densitometry.

But as strange as it may seem, the technology itself is in danger of becoming so devalued that improvements in accessibility and advances in applications may be lost. Although densitometry is still underutilized, the number of devices has steadily increased. The number of individuals involved in the performance of densitometry has
steadily increased. But insistence on quality densitometry has not kept pace. There are those who perform bone densitometry for whom it is ultimately of little importance. There may be no attention to quality control of the devices, no learned supervision of the technologist, and little concern for the ramifications of inaccurate or obsolete reporting of densitometry results. In these circumstances, little value and attention is given to bone densitometry. Not surprisingly then, third party payers, the public, and our non-densitometrist physician colleagues have begun to attach little value to densitometry as well. This is a tragedy, as the advances of the last 20 years may be potentially wasted.

In 1990, Dr. Paul Miller and I independently began teaching courses in bone densitometry for the physician and technologist. The physicians who attended these courses came from all specialties. The technologists were RTs, MRTs, RNs, PAs, and nursing assistants. With the publication of the first edition of Bone Densitometry in Clinical Practice in 1998, I hoped to reach many more physicians and technologists who wished to become proficient in the application and interpretation of bone densitometry. In 2002, my technologist, Lori Lewis, and I published the first edition of Bone Densitometry for Technologists. This volume was intended solely for technologists, regardless of background, who worked in the field of densitometry. Although much of the requisite information and skill in densitometry are common to physicians and technologists alike, the unique demands placed on the densitometry technologist made such a volume both appropriate and necessary. The second edition of Bone Densitometry for Technologists was published in 2006. The second edition of Bone Densitometry in Clinical Practice was published in 2004.

Some, but not all, of our concerns in 2009 are vastly different from 1998. Unlike the situation in 1998, there are few locales in which bone densitometry is not available. Many physicians, clinics, and hospitals own densitometers. The number and types of devices have proliferated at a remarkable rate. It is rare to encounter a physician who does not yet know that fracture risk can be predicted with a single bone mass measurement. Our concerns are no longer access to densitometry and convincing the practicing physician that fracture risk can be predicted. But some concerns remain the same. Should every woman have a bone density measurement and if so, when? Can the World Health Organization criteria for the diagnosis of osteoporosis in postmenopausal Caucasian women be used to diagnose osteoporosis in women of other races or men of any race? Should the diagnosis of osteoporosis be restricted to bone density measurements of the proximal femur? Can peripheral skeletal sites be used to diagnose osteoporosis? How should an individual’s risk of fracture be expressed? Can or should bone densitometry be used to determine efficacy of therapeutic agents in the treatment of osteoporosis? None of these concerns are new or esoteric. They go straight to the heart of how and when we use densitometry and interpret the data in the care of our patients. Whether you are new to the field or have worked in densitometry for 20 years, the issues are the same. All of us must ensure that quality control procedures are instituted and followed, precision studies are done, and data are properly interpreted. In 2009, however, perhaps because we are victims of our own success, the increase in the number of devices and number of individuals involved in densitometry has contributed to occasional misuse of the technology and lapses in quality, which have raised the specter of devaluation.

The third edition of Bone Densitometry in Clinical Practice is substantially larger than the first. New chapters have been added, even since the second edition of the book, which reflect both the new applications for densitometry and the evolving needs of the
Chapter 1 is a review of densitometry technologies that spans the earliest attempts to quantify bone density in the mandible in the late 1800s to the modern technologies of DXA, QCT, and QUS. Chapter 2 looks at the unique aspects of gross skeletal anatomy in densitometry and aspects of bone physiology relevant to the interpretation of bone density data. Chapter 3, which deals with statistics, is intended as an overview only. While most clinicians are familiar with statistical concepts like the mean, standard deviation, and significance, there are few if any areas of clinical medicine in which the application of statistical principles has assumed such a prominent role as in bone densitometry. As the reader will find, an understanding of some basic statistical concepts is imperative in the practice of densitometry. Chapter 3 is not intended to replace a review of more thorough statistical texts, but it is intended to ease the pain that the contemplation of such texts can engender. Chapter 4 reviews issues of machine quality control that are often underappreciated in clinical settings but which profoundly affect the validity of the data generated by the densitometers. Chapter 5 is new to this edition and is a review of radiation safety issues for the non-radiologist. Although radiation safety in clinical practice is not a major concern for the densitometrist, knowledge of radiation safety issues is requisite in the practice of densitometry. Chapter 6 addresses the differences in bone density measurements among the various manufacturers and the attempts at standardization of bone density measurements among manufacturers when bone density is measured at the same skeletal site on devices from different manufacturers.

Two of the last eight chapters in this edition are new to this volume. Chapters 7 and 8 deal with the selection of patients for densitometry measurements. Chapter 7 discusses and compares the guidelines from major organizations as they have evolved over the years. Chapter 8 deals with the various questionnaires and indices that have been developed to help patients identify themselves as candidates for bone mass measurements. These indices are deceptively simple in their final form, belying the very complex development process behind them. Consequently, the initial skepticism with which most of these indices have been met is understandable. Nevertheless, they are extremely useful in many circumstances. Chapters 9, 10, and 11 deal with the specific densitometry applications of diagnosis of osteoporosis, fracture risk prediction, and monitoring changes in bone density. Diagnosis and fracture risk prediction are separate entities and both remain the subject of some controversy, as previously noted. Chapter 11, which deals with monitoring changes in bone density, has been updated and expanded and includes a discussion of the statistical concept of regression to the mean and its relevance, or lack thereof, to monitoring bone density. It is an important concept to understand as it is still incorrectly used to diminish the value of monitoring changes in bone density. Chapter 12, which addresses secondary causes of bone loss, is new to this edition, replacing the chapter in earlier editions in which various articles relating to causes of bone loss were abstracted. When low bone density or osteoporosis is identified, the referring physician may look to the densitometrist for guidance in the evaluation of the patient to exclude secondary causes of bone loss. In this chapter, some of the more common differential diagnoses and the relevant evaluations to exclude each are reviewed. Chapter 12 is intended for the non-metabolic bone disease specialist densitometrist. Chapter 13 is also new to this edition and focuses on the new applications for DXA such as vertebral fracture assessment, aortic calcification scoring, hip structure analysis, and assessment of visceral fat. Finally, the challenge of bringing all this information to bear on the interpretation of the numerical densitometry data is addressed in Chapter 14. Although it is
one of the shorter chapters in the book, its importance should not be underestimated. The reality is that an inadequate or unread report will negate the expertise of the densitometrist and technologist as well as the promise of the technology. Finally, in Chapter 15, the technical specifications of densitometry devices currently approved for use in the United States are listed. These specifications may change without notice; so, the reader is encouraged to contact the manufacturer directly if more information is desired. Contact information for the various manufacturers can be found in Appendix I.

The appendices are an attempt to pull together reference information in a convenient location to enable the physician to refer to the information quickly, without searching the text. An entire appendix, Appendix V, has been devoted to the 2007 ISCD guidelines. The 1998 NHANES III reference database and native databases from the major manufacturers of central DXA devices will be found in Appendices IX-XII. The CD-ROM that accompanies this book contains several files that the densitometrist should find useful in every day practice as well as a study guide that can be completed for continuing education credit. The contents of the CD are described in Appendix XIV.

In a few circumstances in this text, data has been presented from published abstracts, rather than from peer-reviewed, published articles. This was done in the interest of providing information rapidly. The reader should be cautioned that data presented in abstract form might change slightly when it is finally published in a peer-reviewed journal. Some data presented in abstract form is never published in a peer-reviewed journal for a variety of reasons.

As this text has evolved over the years, it has essentially become a text on the use of DXA in clinical practice. Other technologies are discussed and should not be dismissed by the clinician. Some technologies provide measurements that are biologically different from those obtained with DXA. All of the technologies are remarkably accurate and when utilized correctly, very precise. But the evolution of the clinical criteria for the diagnosis of osteoporosis and the prediction of fracture risk have created a circumstance in which DXA measurements of the spine and proximal femur are the measurements that are ultimately clinically useful. It is perhaps unfortunate that this is so, in that truly remarkable technologies consequently have little practical clinical use. Nevertheless, it is the circumstance in which we find ourselves and is reflected in the focus of this book.

Bone densitometry is an extraordinary clinical tool. It provides a safe, non-invasive window to the skeleton. Through that window a physician can obtain vital clinical information that enhances the management of the patient that cannot currently be obtained in any other way. So, to whom in medicine does densitometry belong? To no one specialty in particular and to every specialty in general as long as the physician and technologist are committed to learning the unique aspects of this technology and the proper interpretation of the data that it generates. The technology itself is superb. Bone density can be measured with superior accuracy in virtually every region of the skeleton. The machines are capable of the finest precision of any quantitative technique in use in clinical medicine today. But the machines will perform only to the level of the expertise of those who operate them. And the data that they generate will only be as useful as the clarity of the interpretation that is provided by the densitometrist. It is hoped that this volume will be useful in helping the densitometrist fulfill the potential that the technology holds for contributing to the highest quality of patient care and disease prevention and management.

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