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CAMPBELL'S

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（第9版）

Operative Orthopaedics

Edited by

S.TERRY CANALE

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Operative Orthopaedics

Edited by

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Preface

In the 6 years since the last edition of this text, numerous procedures, techniques, and instruments used in orthopaedic surgery have been developed or modified. Those that we have found beneficial or promising are included in this edition, while older, seldom-used techniques have been omitted. Because of the effect magnetic resonance imaging has had on orthopaedic surgery, a new chapter has been added to this edition, as has a chapter on pediatric cervical spine. Approximately 3000 new illustrations are included in this edition. In an effort to make the text easier to use, chapters have been rearranged in 16 sections in 4 volumes. For the first time a second color has been added to the text to emphasize important elements.

A work of this magnitude required the cooperation and dedication of a large group of people, foremost of which are the contributors, who worked diligently to meet demanding deadlines in the midst of their already busy schedules. I am most appreciative of their efforts.

I wish to especially thank Kay Daugherty, our medical editor at The Campbell Clinic, and Linda Jones, assistant editor, for their assistance with manuscript preparation. Without their help, this edition would not have been possible. I also wish to thank Joan Crowson, our librarian, for her assistance with research and references. My thanks also to Barry Burns, Art Director, and artists Sarah Crenshaw McQueen, Richard Fritzler, Lee Danley, Joel Herring, and Cindy Scott for their artwork in this text. Finally, I wish to thank the staff at Mosby–Year Book—Bob Hurley, Kathy Falk, Robin Sutter, and John Casey—for their expert guidance and encouragement.

S. Terry Canale, M.D.

Preface to First Edition

The title of this book, *Operative Orthopedics*, is not intended to convey the impression that the chief or most important method of treatment of orthopaedic affections is open surgery. Although many orthopaedic affections are best treated by operative measures alone, the majority are successfully treated by more conservative means. Further, such measures are often essential adjuncts either before or after operation.

This volume has been written to meet the current need for a comprehensive work on operative orthopedics, not only for the specialist, but also for many industrial and general surgeons who are doing excellent work in some branches of orthopedic surgery, and are making valuable contributions to this field.

The evolution of orthopedic surgery has been exceedingly slow as compared to that of surgery in general. Not until aseptic technic had been materially refined was surgery of the bones and joints feasible. The statement is often made that the World War afforded the experience which made possible the rapid development or orthopedic surgery during the past two decades. The surgery of the war, however, was chiefly the surgery of sepsis; there was little of the refined asepsis which is required in reconstruction surgery. Undoubtedly, the demonstration during the war of the necessity and importance of this field led many able men to specialize in orthopedics, and to them considerable credit is due for its subsequent progress.

No classification of orthopedic affections is entirely satisfactory; consequently, any arrangement of operative procedures is subject to similar criticism. With the exception of the chapters on Arthroplasty and Arthrodesis, operations described in this text are grouped together according to their applicability to a given affection. This involves less repetition as to generalities of etiology, pathology, and treatment than would be necessary in a classification according to anatomic location. Operative procedures appropriate to two or more affections are described in the discussion of the one wherein they are most commonly employed.

To overcome the too widespread conception of orthopedic surgery as a purely mechanical equation, an effort is made in the first chapter of this book to correlate the mechanical, surgical, and physiologic principles of orthopedic practice, and throughout the book to emphasize the practical application of these physiologic principles. A special chapter has been written on surgical technic, for the purpose of stressing certain details in preparation and aftertreatment which vary to some extent from those described in works on general surgery. A thorough knowledge of these phases of treatment is a requisite to success. To avoid constant repetition, chapters have been included on apparatus and on surgical approaches; repeated reference is made to these chapters. The aftertreatment is given in detail for practically all operative technics. This is a most essential, yet too often neglected, factor in the success of any surgical treatment.

In giving the position or range of motion of a joint, only one system has been followed: with the exception of the ankle and wrist, the joint is in neutral position when parallel with the long axis of the body in the anteroposterior and lateral planes. As the joint proceeds from the neutral position in any direction, the number of degrees in which such movement is recorded decreases progressively from 180 to 170, 160, and so on, to the anatomic limit of motion in that particular direction. To illustrate, complete extension of the knee is 180 degrees; when the joint is flexed 30 degrees, the position is recorded as the angle formed between the component parts of the joint, i.e., the leg and thigh, or 150 degrees. Flexion to a right angle is 90 degrees, and full flexion 30 degrees. In the wrist, the joint is at 180 degrees, or in the neutral position, when midway between supination and pronation, and flexion and extension. In the ankle joint, motion is recorded as follows: the extreme of dorsiflexion, 75 degrees; right angle, 90 degrees; and the extreme of plantar flexion, 140 degrees.

In some instances, the exact end results have been given, to the best of our knowledge. So many factors are involved in any one condition, that a survey of end results can be of only questionable value unless the minute details of each case are considered. Following arthroplasty of the knee, for example, one must consider the etiology, pathology, position of the ankylosed joint, the structure of the bones comprising the joint, the distribution of the ankylosis, and the age of the patient, in estimating the end result in each case. Further, a true survey should include the results of *all* patients treated over a period of *many* years, and should be made by the surgeon himself, rather than by a group of assistants, or by correspondence.

In our private clinic and the hospitals with which we are associated, a sufficient amount of material on every phase of orthopedic surgery has been accumulated during the past twenty years or more to justify an evaluation of the various procedures. From this personal experience, we also feel that definite conclusions may be drawn in regard to the indications, contraindications, complications, and other considerations entering into orthopedic treatment. In all surgical cases, mature judgment is required for the selection of the most appropriate procedure. With this in mind, the technics which have proved most efficient in the author's experience have been given preference in the text. In addition, after a comprehensive search of the literature, operative measures have been selected which in the judgment of the author are most practicable.

Although no attempt has been made to produce an atlas of orthopedic surgery, an effort has been made to describe those procedures which conform to mechanical and physiologic principles and will meet all individual requirements. In any work of this nature, there are sins of omission; also, many surgeons in the same field may arrive independently at the same conclusions and devise identical procedures. We have endeavored, however, to give credit where credit was due. If there are errors, correction will gladly be made. In some of the chapters we have drawn heavily from authoritative articles on special subjects; the author gratefully acknowledges his indebtedness for this material. He also wishes to thank those authors who have so graciously granted permission for the reproduction of original drawings.

In conclusion, I cannot too deeply express my sincere appreciation and gratitude to my associate, Dr. Hugh Smith, who has untiringly and most efficiently devoted practically all of his time during the past two years to collaboration with me in the compilation and preparation of material, which alone has made this work possible. I also desire to express appreciation to Dr. J.S. Speed for his collaboration on the sections on Spastic Cerebral Paralysis and Peripheral Nerve Injuries to Dr. Harold Boyd for anatomic dissections verifying all surgical approaches described, and for his assistance in preparing the chapter on this subject; to Dr. Don Slocum for his aid in the preparation of the chapter on Physiology and Pathology; to Mrs. Allene Jefferson for her efficient editorial services, and to Mr. Ivan Summers and Mr. Charles Ingram for their excellent illustrations.

Willis C. Campbell
1939

Contents

PART

I

General Principles

CHAPTER

1

Magnetic Resonance Imaging in Orthopaedics

Dexter Witte

Aside from routine roentgenography, no imaging modality has had as great an impact on the current practice of orthopaedics as magnetic resonance imaging (MRI). MRI provides unsurpassed soft tissue contrast and multiplanar capability with spatial resolution that approaches that of computed tomography (CT). Consequently, MRI has superseded older imaging modalities such as myelography, arthrography, and even angiography. In some areas, such as the knee and shoulder, MRI has become a powerful new diagnostic tool, helping the surgeon to evaluate structures that were previously invisible to noninvasive techniques. As with any new technology, the final role of MRI in orthopaedics is still uncertain. Improvements in both hardware and software will undoubtedly expand the role of MRI in orthopaedics and in other fields of medicine as well.

MRI is a modality unrelated to any older imaging techniques. Magnetic resonance images are created by placing the patient in a strong magnetic field (approximately 30,000 times stronger than the earth's magnetic field). The magnetic force affects the nuclei within the field, specifically the nuclei of elements with odd numbers of protons or neutrons. The most abundant element satisfying this criterion is hydrogen, plentiful in water and fat. These nuclei, which are essentially protons, possess a quantum spin. While the patient's tissues are subjected to this strong magnetic field, protons align themselves with respect to the field. Since all imaging is performed within this constant magnetic force, this becomes the steady state, or equilibrium. In this steady state a radiofrequency (RF) pulse is applied, which excites the magnetized protons in the field. After application of the pulse, a receiver coil or antenna listens for an emitted RF signal that is generated as these excited protons relax or return to equilibrium. This signal, with the help of localizing gradient fields and Fourier transformation, creates the MR image.

Types of MRI Scans

Although all studies involve magnetization and RF signals, the method and timing of excitation and acquisition of the signal can be varied to affect the contrast of the various tissues in the volume. Most musculoskeletal MRI examinations use the spin-echo technique, which produces T1-weighted, proton (spin) density, and T2-weighted images. T1 and T2 are characteristics of each tissue. These values relate to the rate at which magnetization of a given tissue relaxes or returns to the steady state. By varying the timing of the application of RF pulses (TR, or repetition time) and the timing of acquisition of the returning signal (TE, or echo time), an imaging sequence can accentuate T1 or T2 characteristics. A fairly constant rule is that fat has a high signal (bright) on T1-weighted images, and fluid has a high signal on T2-weighted images. Of course, structures with little water or fat, such as cortical bone, tendons, and ligaments, remain dark in all types of sequences. Faster imaging methods are becoming available. Fast spin-echo technique can reduce the length of T2-weighted sequences by two thirds or more. Unfortunately, some fast spin-echo sequences introduce blurring artifact, which can obscure tiny abnormalities such as meniscal tears. In addition, fat signal in fast spin-echo images remains fairly intense, a problem that can be eliminated by chemical shift fat-suppression techniques. Fat suppression also can be achieved by using an inversion recovery (STIR) sequence. Another fast imaging method, gradient-echo technique, is used selectively for cartilage imaging (such as for the glenoid labrum). Most MR studies are composed of a number of imaging sequences or series, tailored to detect and define a certain pathological process. Because the imaging planes (axial, sagittal, coronal, oblique) and the sequence type (T1, T2, gradient-echo) are chosen at the outset, advance understanding of the clinical problem is required to perform high-quality imaging.

An image can be acquired in the main coil (the hollow tube in which the patient lies during the study). This is satisfactory when studying the chest, abdomen, or pelvis, where a large area is to be evaluated. In the musculoskeletal system, the hips, thighs, or legs often are examined this way. However, when evaluating smaller articular structures, such as the menisci of the knee or the rotator cuff, specialized surface coils are needed. A wide variety of surface coils is commercially available, including coils tailored for specific body parts such as the spine, shoulder, wrist, and temporomandibular joints, as well as versatile flexible coils and a circumferential extremity coil. These coils serve as antennae placed close to the imaging volume, markedly improving signal and resolution. The drawback is that only limited areas can be studied. Nevertheless, these surface coils are mandatory for imaging of joints or small parts.

Contraindications

Some patients are not candidates for MRI. Absolute contraindications to MRI include intracerebral aneurysm clips, cardiac pacemakers, automatic defibrillators, biostimulators, implanted infusion devices, internal hearing aids, and metallic orbital foreign bodies. With the exception of pre-6000 series Starr-Edwards valves, cardiac valve prostheses can be safely scanned. Relative contraindications include first- and second-trimester pregnancy, middle ear prostheses, and penile prostheses. Generally, internal orthopaedic hardware and orthopaedic prostheses are safe to scan, although ferrous metals can create local artifact that can obscure adjacent tissues. Patients with metal external fixation devices should not be scanned.

Foot and Ankle

One of the more complex anatomical regions in the human body is the foot and ankle. The complexity of midfoot and hindfoot articulations and the variety of tendon and ligament pathological conditions make evaluation difficult from a clinical and imaging perspective. The role of MRI in the foot and ankle is less well defined than in the shoulder and knee. Most examinations of the foot and ankle are performed to evaluate tendinopathy, articular disorders, and osseous pathological conditions, often after trauma. MRI can be quite useful when the examination is directed at solving a certain clinical problem, but it should not be used as a screening study for nonspecific pain because the yield will be low. Given the small size of structures to be examined, optimal imaging is achieved on a high field strength (greater than 1.0 Tesla) magnet, and the use of a surface coil, typically an extremity coil, is mandatory. Most studies are directed at the midfoot, hindfoot, or ankle. A small field of view (8 to 10 cm) should be used to obtain appropriate resolution. Images can be prescribed in orthogonal or oblique planes, with combinations of T1-weighted, T2-weighted, and fat-suppressed sequences. The examination should be tailored to best define the clinically suspected problem.

TENDON INJURIES

MRI excels in the evaluation of pathological conditions in the numerous tendons about the ankle joint. Most commonly affected are the calcaneal and tibialis posterior tendons. In chronic tendinitis, the calcaneal tendon thickens and becomes oval or circular in cross section. The enlarged tendon maintains low signal on all sequences. When partially torn, the tendon demonstrates focal or fusiform thickening with interspersed areas of edema or hemorrhage that brighten on T2-weighted series (Fig. 1-1). With complete rupture, there is discontinuity of the tendon fibers. Similarly, tendinitis or rupture of the tibialis posterior tendon can be confidently diagnosed with MRI. Increased fluid in the sheath of the tendon indicates tenosynovitis. Insufficient or ruptured tendons can appear thickened, attenuated, or even discontinuous. Occasionally, similar abnormalities are seen in the other flexor tendons or peroneus tendons (Fig. 1-2).

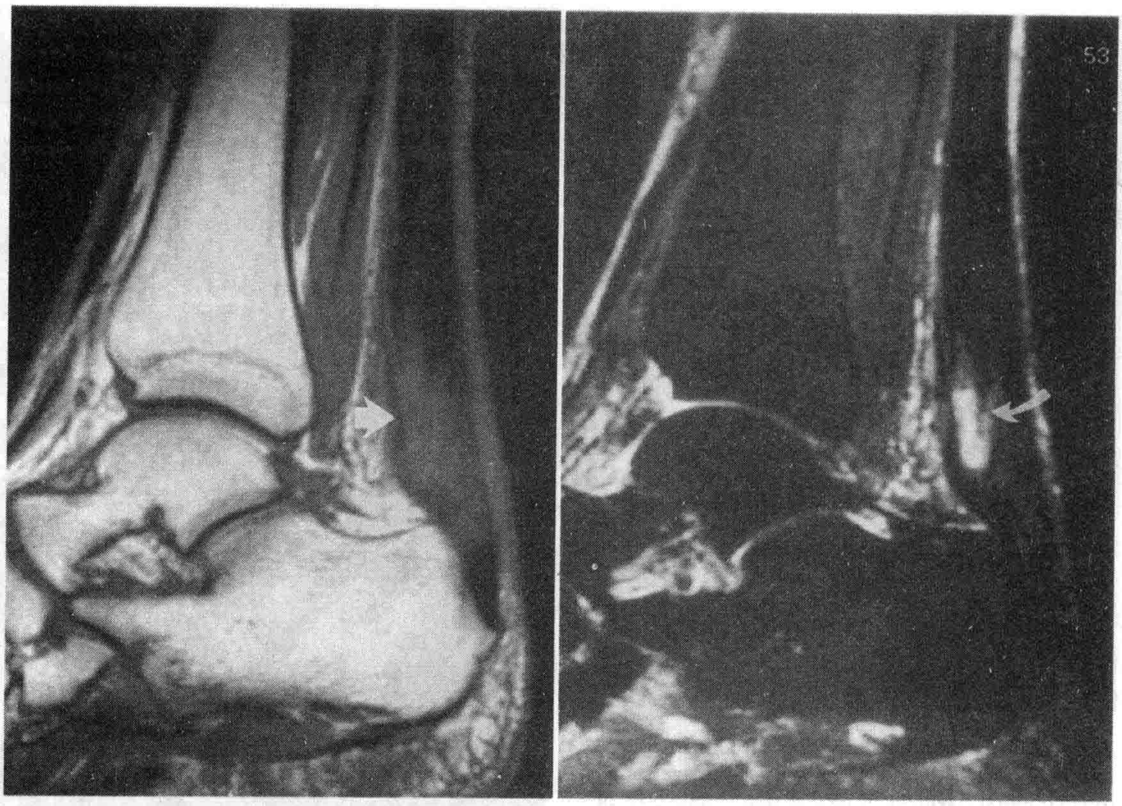
LIGAMENT INJURIES

Although ligamentous injuries about the ankle are common, at this time MRI has a limited role in their evaluation. The medial and lateral stabilizing ligaments of the tibiotalar and talocalcaneal joints, as well as the distal tibiofibular ligaments, usually can be seen with proper positioning of the foot. The imaging status of these ligaments, however, does not change the treatment in most patients.

OTHER DISORDERS OF FOOT AND ANKLE

As elsewhere in the body, bone marrow disorders, avascular necrosis (AVN) or fracture, and osteochondral injuries (Fig. 1-3) are well delineated. The excellent anatomical information provided by MRI allows detection and definition of masses in the foot. One mass unique to the foot is a Morton neuroma.

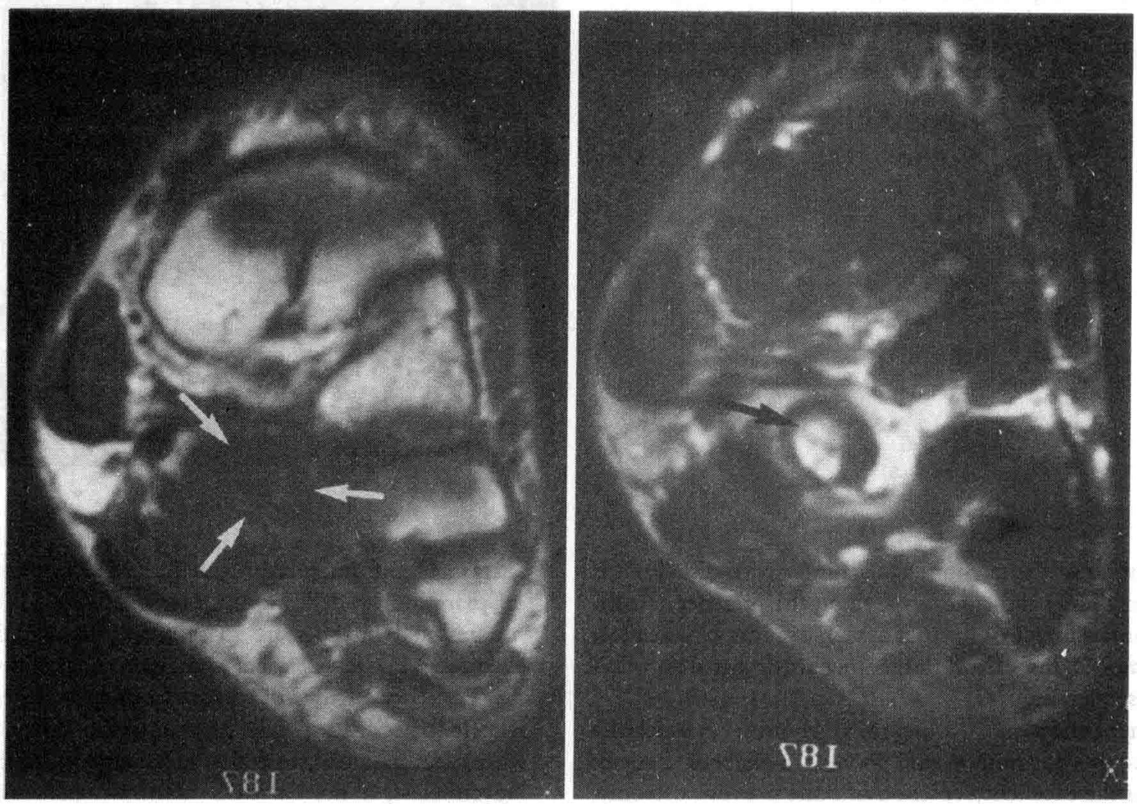
A



B

Fig. 1-1 Partial tear of calcaneal tendon. **A,** Sagittal T1-weighted image demonstrates markedly thickened calcaneal tendon containing areas of intermediate signal (*arrow*). **B,** Sagittal fat-suppressed, T2-weighted image exhibits fluid within tendon substance, indicating partial tear (*curved arrow*).

A



B

Fig. 1-2 Peroneus longus tendon rupture. **A,** Coronal T1-weighted image through midfoot shows increased diameter of peroneus longus tendon (*arrows*). **B,** Coronal fat-suppressed, T2-weighted image reveals fluid signal within ruptured tendon (*arrow*).