IMAGING EDUCATION MANUAL FOR DOCTOR OF PHYSICAL THERAPY PROFESSIONAL DEGREE PROGRAMS

Sponsored by the:
Imaging Special Interest Group, Orthopaedic Section, APTA, Inc.

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PREFACE

The current status of diagnostic and procedural imaging in doctor of physical therapy education and practice is marked by variability and inconsistencies.[1] As such, the enclosed *Imaging Educational Manual for Doctor of Physical Therapy Professional Degree Programs* (*Imaging Education Manual*) has been developed to provide a rich set of resource information that will assist faculty in on-going curriculum assessment and development in this content area. Additional resources can be accessed online at www.orthopt.org. Faculty responsible for teaching imaging content will likely find the evidence review and curriculum resource information useful in course development and other aspects of instruction. Information in the manual will also be useful to faculty members who may be called upon to provide testimony or opinion when regulatory or legislative imaging issues arise in your state. In addition, academic coordinators of clinical education may wish to share materials in the manual with clinical instructors to facilitate further student development of relevant skills during clinical internships.

As physical therapist practice evolves, including patient direct access, the ability to refer patients directly for diagnostic imaging could enhance efficiency and effectiveness of care delivery.[2-4] Doing so is contingent upon doctors of physical therapy having the requisite knowledge and skills of appropriate patient referral for imaging. Published research describing physical therapist use of ultrasound imaging (USI) in patient management has been growing since the 1990s. The practicality of incorporating USI at the point-of-care has been greatly enhanced with improvement in ultrasound technology resulting in smaller machines, higher and improved resolution, and much lower equipment costs.[5]

While imaging as a content area is noted in the *Normative Model of Physical Therapist Professional Education*[6] and the Commission on Accreditation in Physical Therapy Education's (CAPTE) Evaluative Criteria,[7] there is no accepted standard or guidelines for the breadth and depth of this content. As such, the Imaging Special Interest Group of the Orthopaedic Section, APTA, Inc. has created a Steering

Committee (made up of individuals representing practice, academic, and advocacy arenas) to develop an *Imaging Education Manual* for doctor of physical therapy academic and clinical educators. The shared goal of these entities is that all professional educational programs provide appropriate imaging education based on sound evidence, current and future practice models are marked by successful integration of imaging, and that APTA Positions and Guidelines appropriately reflect projected future practice as described by the APTA Vision Statement and societal needs.

Should you have any questions, please do not hesitate to contact any member of the Steering Committee or Imaging Special Interest Group of the Orthopaedic Section, APTA.

LIMITATIONS

The *Imaging Education Manual* is produced by the Imaging Special Interest Group of the Orthopaedic Section, APTA. As such, the content is focused on musculoskeletal imaging. Physical therapists in several other specialties utilize imaging in practice, education, and research including neurologic, sports, women's health, pediatrics, geriatrics, clinical electrophysiology, and cardiovascular and pulmonary. It is hoped that leaders in these practice areas will develop similar resources to promote appropriate utilization and application of diagnostic and procedural imaging.

Medical imaging is constantly evolving with research advances driving new technology, improved health care service delivery models, and reduced equipment costs. This manual reflects expert consensus opinion based on published evidence, current musculoskeletal imaging practice, and the projected future role of imaging and physical therapist practice. Between manual publication and planned revisions in 2020, it is anticipated, and hoped for, that advances in musculoskeletal imaging will coincide with further integration of imaging in doctor of physical therapist practice, education, and research.

ACKNOWLEDGEMENTS

Members of the Steering Committee who contributed to the development of the Imaging Education Manual were: Douglas M. White (Chair), William Boissonnault, Robert Boyles, Charles Hazle, Aimee Klein, Becky Rodda, Rich Souza, and Deydre Teyhen. All members contributed to the concept, design, and content. The Steering Committee members' credentials and contact information are found in the contact list at the end of the manual. The Steering Committee Chair wishes to particularly recognize William Boissonnault and Charles Hazle for the extensive time and expertise they contributed to the development of this manual.

BACKGROUND

Purpose

The purpose of this section is to provide an overview of the activities and information that influenced and supported the development of this manual.

Contents

Introduction

The *Imaging Education Manual* has been created to facilitate the continued development of imaging instruction in physical therapist education and to heighten awareness among academic and clinical faculty of the legislative and regulatory issues the physical therapy profession is facing. The IEM provides resource information to assist faculty in curriculum planning and imaging instruction in both academic and clinical venues. The ultimate goal is that all physical therapist professional educational programs provide appropriate imaging education based on sound evidence, current APTA positions/policies, and projected future practice models as endorsed by the APTA Vision Statement and other association documents.

History: Imaging and Physical Therapist Practice

The ability of Physical Therapists (PTs) to refer for diagnostic imaging is a concept that has been in existence for decades. An obvious example is the U.S. military, where, since 1972, PTs practice as direct access providers with imaging privileges.[4,8] Brought on by an overwhelmed health care system, providers and administrators recognized that PTs were needed as physician extenders to manage patients with nonsurgical, musculoskeletal disorders in a timely fashion. In the 40+ years since, PTs in the military system have been recognized as the musculoskeletal providers of choice and an invaluable asset to the health care team. One aspect of this vital role includes referring patients for appropriate diagnostic imaging evaluations.

Having PTs serve in physician-extender roles has been shown to be an effective method in reducing the number of extraneous images ordered while maintaining high levels of diagnostic accuracy.[9] Physical therapists have been shown to have similar diagnostic accuracy as orthopaedic surgeons and be more accurate than non-orthopaedic providers.[9] Additionally, PTs in this physician-extender role have demonstrated no difference in patient outcomes, a greater than 50% reduction in radiographic examinations, and higher levels of patient satisfaction, as well as increases in access to orthopaedic surgeons and PT job satisfaction.[10] Moore et al[11] conducted a retrospective study over a 40-month period in a military facility and collected data on over 50,000 new patients seen in direct access military physical therapy clinics. Over this period, there were no reported adverse events, no PTs had their credentials or state licenses modified or revoked for disciplinary action, and there were no litigation cases filed against the United States government involving PTs.[11] Boissonnault et al[12] assert the military's long track record of PTs in the physician-extender role dispels concerns among decision-makers who may believe that PTs seek to operate in an allegedly untested practice model. This model is not solely within the military, as other government agencies have adopted this model. Physical therapists in the Public Health Service, Indian Health Service, the Veterans Administration Health System, and the Bureau of Prisons now have imaging privileges.[13]

Positions and Practice Standards Related to Imaging

The APTA Position (HOD P06-12-10-09), *Diagnosis by Physical Therapists* states: "…….*When indicated, PTs order appropriate tests including but not limited to imaging and other studies, that are performed and interpreted by other health professionals. Physical therapists may also perform or interpret selected* *imaging or other studies……*"[14] This would imply PTs have the knowledge base related to appropriate referral of patients for imaging tests and can perform certain imaging procedures. This would encompass knowing when and when not to refer patients and what imaging modality would be most appropriate based on patient examination findings.

The Federation of State Boards of Physical Therapy (FSBPT) model practice act of 2013 does not include affirmative language about the use of imaging for physical therapy.[15] The use of imaging can be considered to fall under the general description of testing in the model practice act.

The FSBPT published a resource paper in 2010 on Rehabilitative Ultrasound Imaging[16] which concludes in part, "…there is a historical basis, available education and training as well as an educational foundation in the CAPTE criteria, and supportive scientific evidence for including rehabilitative ultrasound imaging in the scope of practice of physical therapist, … [T]he appropriate machine settings and the ability to differentiate structures and comprehend the images obtained during rehabilitative ultrasound imaging, at this time, are not entry level skills and should require additional training." The terminology "rehabilitative ultrasound imaging" has been used to describe USI performed by PTs. This terminology is not recommended at this time.

In 2009, the American Academy of Orthopaedic Manual Physical Therapists adopted the position statement, "It is the position of the AAOMPT that ultrasound imaging is within the scope of physical therapist practice."[17]

Legislative and Regulatory Background

A review of all 50 states and the District of Columbia practice acts and rules was performed by Boyles et al.[2] They found 21 states, plus the District of Columbia, have no mention of radiology or the terms roentgen rays or radium in their statutes (Table 1). While 29 state practice acts include language in their definition or limitation of authority sections, the specific wording of the restriction can vary and appears to be specifically focused on restricting PTs from using radioactive materials for therapeutic or diagnostic purposes.[18] A further analysis of the 51 practice acts revealed that the standard language of "the use of roentgen rays and radium for diagnostic and therapeutic purposes” appears in only 16 practice acts. An additional 13 acts have language that may be more or less restrictive with terminology such as, “shall not include radiology” (AL, AS, DE, ID, IL), “not include use of roentgen rays for any purpose” (NY, MS, WI), only include restriction for therapeutic purpose (CO), “excludes the taking of radiologic studies” (NJ), and “excludes the taking of x-rays” (UT). One state (SC) has language that specifically restricts a PT from “ordering lab or other medical tests.” Finally, Colorado further adds as grounds for disciplinary action the ordering or performing, *without clinical justification*, (emphasis added) any service, x-ray, or treatment that is contrary to recognized standards of the practice of physical therapy as interpreted by the director.[19] The Wisconsin Physical Therapist Affiliated Credentialing Board in 2005 ruled the language restricting PTs from using roentgen rays or radium actually meant the “taking of x-rays” (ie, flipping the switch).[20] In many instances, practice acts contain language that is not consistent with present education and practice.

Many state practice acts, as well as various APTA documents, including the *Guide to Physical Therapist Practice,*[21] *A Normative Model of Physical Therapist Professional Education*,[6] APTA House of Delegates Policies, and the APTA Code of Ethics for the Physical Therapist include language that requires a PT to refer to a physician specialist or other health care provider under certain circumstances.[18] Twenty-nine states have specific language requiring a PT to refer to another health care provider if it is determined that symptoms or a condition require services beyond the scope of physical therapy or if physical therapy may be contraindicated, as with the case of a fracture (Table 2). This can either be an affirmative statement as a duty to refer as a part of practice or listed under grounds for disciplinary action. The duty to refer includes referring for imaging if indicated. An example is a recent District of

Columbia Board of Physical Therapy ruling. It was determined that "under section 17 DCMR § 6710.13 the Board believes that a physical therapist may refer a patient for diagnostic imaging to a health care provider who is qualified to perform such testing, provided the other conditions as set forth in the regulation are met." The Wisconsin Physical Therapist Affiliated Credentialing Board, in its 2005 opinion, further stated that "a physical therapist is obligated to refer his/her patient to an appropriate health care professional who is qualified to perform the test and obtain the results of the test."[20] In all jurisdictions, PTs utilize test results, including imaging, which may be performed and/or interpreted by other health care professionals.

The use of imaging in physical therapy practice is complicated by the differences between actual statutory authority (practice act) and payment policy (insurance company and/or third party payer policy). While payment is an important aspect, practice patterns should not be driven exclusively by payment. One should look to the state practice act for authority to refer for imaging with the expectation that payment will follow practice patterns and not the reverse.

Table 1. Practice Act Language Regarding Radiology

Practice Act Language	States
Silent--No mention of radiology	AZ, DC, GA, HI, IA,IN, MD, MA, MI, MN, MO, MT, NV, NM, ND, OR, PA, RI, SD, TN, VT, WY
"Does not include the use of roentgen rays and radioactive materials for diagnosis and therapeutic purposes"	AK, CA, CT, FL, KS, KY, LA, NE, NH, OH, OK, SC, TX, VA, WA, WV
"Use of roentgen rays and radioactive materials for therapeutic purposes"	CO
"Physical therapy does not include the use of roentgen rays and radium for any purpose"	MS, WI, NY
"Physical therapy does not include radiology"	AL, AR, DE, ID, IL
"…and may not use roentgen rays or radium"	ME
"Nothing in P.L…. shall be construed to authorize the taking of radiological studies"	NJ
"Physical therapy does not include the application of roentgen rays or radioactive materials"	NC
"Nothing in this chapter shall be construed to authorize a physical therapist to prescribe medications or order	SC

laboratory or other medical tests”	
“Physical therapy" or "physiotherapy" does not include (iv) taking x-rays”	UT

Table 2. Referral Practice Act Language

Practice Act Language	States
DUTY TO REFER. A physical therapist shall refer a patient to an appropriate health care practitioner if the physical therapist has reasonable cause to believe that symptoms or conditions are present that require services beyond the scope of the practice of physical therapy. **Grounds for disciplinary action.** Failure to refer a patient to the appropriate licensed health care practitioner when the services required by the patient are beyond the level of competence of the physical therapist or beyond the scope of physical therapy practice.	AK, AZ,CO,CT, DC, FL, GA, ID, IN, KS, LA, ME, MA, MN, NH, NJ, ND, NC, OH, OK, OR, RI, SC, TN,TX, VA, WA, WI, WY

Imaging and Entry-level Physical Therapist Education

Diagnostic imaging, specifically related to the musculoskeletal system, has been always been a component of a physical therapist's clinical decision making. The *Guide to Physical Therapist Practice, 3.0*, makes clear the physical therapist should consider the impact of other clinical tests as part of the examination and management of the patient.[21] In addition, content related to diagnostic imaging has been added to physical therapist education since the transition to the Doctor of Physical Therapy (DPT). Domholdt et al[22] reported two separate studies of DPT programs, as well as data collected in the CAPTE's Biennial Accreditation Report. These studies indicated that, in the main, programs converting to offering the DPT are making important, substantial changes, such as increased content in areas such as diagnostics, imaging, and pharmacology. Biologic and clinical sciences, which would include knowledge and skills related to diagnostic imaging, should be part of the curricular outline in professional physical therapist education programs.[23] Finally, in June 2012, the governing body of the American Physical Therapy Association, the House of Delegates, amended the Position on Diagnosis By Physical Therapists to include the following language, “*When indicated, physical therapists order appropriate tests, including* *but not limited to imaging and other studies, that are performed and interpreted by other health professionals. Physical therapists may also perform or interpret selected imaging or other studies."*[14]

A Normative Model of Physical Therapist Professional Education[6] states the graduate of a physical therapy program should use data from the history and systems review to guide selection of specific tests and measures based on best evidence. This would include results of diagnostic imaging studies. Although specific guidelines related to depth and breadth of imaging content are not found in the *Normative Model of Physical Therapist Professional Education*, numerous relevant statements do exist. These statements provide some examples of Terminal Behavioral and Instructional Objectives. Statements directly and indirectly related to imaging include the following:

- collect information from laboratory and diagnostic tests as part of the examination;
- provide a rationale for choice of tests and measures selected;
- determine the need for referral to other health care providers;
- assess health needs and risk factors of different individuals, groups, and communities;
- recognize clusters of symptoms that denote medical emergency;
- identify on a radiograph the components and relationships of the skeletal system;
- explain the laboratory and imaging tests used to differentiate musculoskeletal, neuromuscular, cardiovascular, and cardiopulmonary diagnoses;
- compare the advantages and disadvantages of magnetic resonance imaging (MRI) and computed tomography (CT) scans for diagnosing conditions such as bone tumors and lumbar disk problems;
- define positive MRI findings supporting the diagnosis of multiple sclerosis;
- identify the results of imaging on the practice of physical therapy with respect to the skeletal system;
- identify the needs of various imaging procedures in the examination of the patient/client with skeletal conditions; and
- use results of various imaging procedures for the skeletal system in patient/client management.

There are at least 9 performance criteria in the physical therapist Clinical Performance Instrument that give guidance to the clinical instructor (CI) for the purposes of evaluating the imaging skills of the student across all domains (cognitive, psychomotor, and affective). The list below identifies the criteria that can be used to examine and evaluate the imaging skills of the student. These are the same criteria that are used to evaluate the clinical performance of the student in all areas of the clinical experience.

- Safety (#1)
- Legal practice standards (#5)
- Critical inquiry and the use of logic and evidence in practice (#9)
- Performance of the examination (#11)
- Evaluation of findings (includes diagnosis and prognosis) (#12)
- Design of the plan of care (#13)
- Performance of interventions (#14)
- Education of the patient/client and others (#15)
- Self-directed plan for learning imaging (#23)

It is critical that CIs provide documentation to support the skill (cognitive, psychomotor) level of the student. The *Normative Model of Physical Therapy Professional Education* provides examples of instructional objectives that are appropriate for the clinical education component.

- Perform an examination of a patient/client within a prescribed amount of time.
- Conduct a patient/client, family, or caregiver interview that contributes to the formulation of the differential diagnosis.
- Perform tests and measures efficiently.
- Provide a rationale for the choice of tests and measures selected.
- Collect information from laboratory and diagnostic tests as part of the examination.
- Collect patient/client pharmacological history as part of the examination.
- Ensure the safety of the patient/client throughout the clinical intervention.
- Assess patient/client response to the intervention and modify accordingly.

Although survey results describing diagnostic and procedural imaging curricula in physical therapist entry-level programs revealed a great deal of variability, there are certain areas marked by consistency. For example, regarding assessment of student competence associated with plain film radiography 90.7% of programs tested students on their ability to identify normal anatomy, 87.4% to identify skeletal pathology/injuries, and 86.6% to utilize clinical guidelines for patient referral. For assessment of student competence associated with MRI, 78.8% of programs tested students on their ability to identify soft tissue pathology/injuries, 76.8% to identify normal anatomy, and 72.8% to identify skeletal pathology/injuries.[1] See the Curricular Resource Section of this manual for specific examples of learning objectives and testing strategies.

Foundational Basis for Imaging in Physical Therapist Education

Doctor of physical therapy educational programs are charged with preparing future clinicians for forthcoming practice. Ever changing practice and emerging practice areas are particular challenges for educators. Historically, accreditation criteria have driven curriculum content changes; however, some programs have proactively adopted content for future practice. Recently, manipulation and PTs as primary contact clinicians have become areas in which educational programs have made substantial changes for once emerging, and now routine, practice. These areas were often included as part of preparation for practice by educational programs, their comprehensive inclusion is relatively recent. Similarly, the broader use of imaging by PTs is expected, which challenges educational programs to ensure their content will meet societal demands on future practitioners.

Educational programs have long taught future practitioners to integrate all relevant clinical data as necessary for optimal patient management. This has rationally included the results of imaging, incorporated with findings from the clinical examination, medical history, and other laboratory and testing data into an overall diagnostic framework to guide clinical decision making for patients. Multiple studies have also highlighted the need for PTs to undertake regular medical screening along with detailed clinical examination and assessment of patients presenting for physical therapy management.[24-27] Additionally, most state physical therapy practice acts mandate initial assessments, which inherently include medical screening and recognition of indicators of conditions beyond the scope of physical therapy. The definition of physical therapy, according to the language of the majority of state practice acts, typically includes terminology such as “examination,” “evaluation,” “tests” (or “testing”), and “assessment.” Thus, PTs are legally bound to seek and assimilate into their patient data multiple sources of information to formulate and execute plans of care.[28] Educational curricula have long prepared future professionals for these demands consistent with established accreditation criteria.

Incomplete evaluation of patients for serious pathologies prior to referral for physical therapy[25,26,29] and referral sources with inadequate education and training in musculoskeletal health conditions[31-34] have contributed to the necessity of PTs becoming judicious providers of care.[26] Physical therapists' appropriate use of screening and examination processes, including the recognition of the indications for imaging, has been documented for 40 years.[4,10] While much of this has occurred within the military model of practice, examples also exist in civilian settings in the United States and abroad.[34-36] Since May 2012, registered physiotherapists in the province of Alberta, Canada, once trained and tested as competent in imaging, can order diagnostic imaging to expedite and direct care for their patients as appropriate.[37] Consistently, the utilization of physical therapy in such roles has proven successful in patient satisfaction, reduction in wait time for care, fewer surgical referrals, and decreases in costs of care.[10,34-36] Notably, these studies have demonstrated PTs can utilize imaging appropriately within direct access and diagnostic management contexts.[9,10,34,35] Additionally, a reduction of imaging without compromise of quality care has led to decreases in exposure to medical imaging using ionizing radiation and the associated risks.[10,34] Thus, the use of imaging by PTs has sound foundation for expansion in future practice and the need for commensurate emphasis in physical therapy education.

In 2000, to meet the future physical therapy needs of society, APTA developed a goal of autonomous practice, which included unrestricted direct patient access, the ability to refer to other providers, and the ability to refer for diagnostic tests.[38] The APTA's House of Delegates adopted a new Vision Statement for Physical Therapy in 2013.[39] This Vision Statement proposed that PTs in the future "will embrace best practice standards in examination, diagnosis/classification…," which would logically include diagnostic procedures such as imaging. Further, the APTA proposes the PTs of the future will collaborate with other providers across the continuum of care while serving a larger role in coordination, management, and administration of care. As such, the ability to recognize indications for diagnostic procedures, refer for their completion, and act on their results fundamentally assumes knowledge of imaging.[39] Current CAPTE criteria specifically describes "…changing expectations for graduates resulting from significant changes in practice." To elaborate further, the criteria specifically cites the need for increased curricular content in diagnostics and imaging.[7]

The most comprehensive current set of guidelines for diagnostic imaging in the United States is the American College of Radiology Appropriateness Criteria.[40] The variables and determinants of whether imaging is indicated and what type of imaging is most appropriate for a particular patient are key elements a PT would obtain in routine interactions with patients, including the history and clinical examination findings. Thus, the profession of physical therapy is well-suited to guide the utilization of imaging and the assimilation of imaging results into decision making for optimal patient-centered care. As such, educational programs will prudently include comprehensive imaging content to optimally prepare future practitioners.

CURRICULUM RESOURCES

By design, imaging of the musculoskeletal system is the focus of the curricular content recommendations presented here and are consistent with the purpose of the Imaging Special Interest Group of the Orthopaedic Section and the expertise of the Steering Committee. Imaging has broad applications across most body systems and physical therapy specialties. The Steering Committee hopes the publication of this manual will foster development of additional resources addressing imaging education in other specialties of physical therapy practice.

Imaging is one of many diagnostic tests and adjuncts to interventions PTs may select to optimally manage their patient's care. The emphasis on imaging in the curricular information in this manual does not imply that it is the sole diagnostic test or that imaging is necessary to guide interventions. Imaging has robust evidence to support its judicious use in clinical practice given the appropriate patient presentation. The optimal choices for instructional activities for PT students are those that offer them the opportunity to develop clinical decision-making skills in the judicious integration of imaging in patient management, as well as to develop technical skill in the application of imaging.

Purpose

The purpose of this section is to provide resources to assist academic and clinical faculty in the development of imaging content within the curricula, courses, and instructional activities related to imaging. Specifically, the resources will provide a rich background of information on imaging, focusing on radiology and USI and touching on magnetic resonance and other imaging studies. Radiology and USI are the focus as these are the two imaging modalities most likely to be ordered or utilized by a PT in day-to-day patient management.

An overview of the regulatory and legislative issues relevant to imaging, as well as curricular content, is provided elsewhere in this manual. Recommended curricular content related to imaging in didactic, practical, and clinical education is outlined. Sample instructional materials and an instructional resource list are provided. Also incorporated in these materials are faculty qualifications, opportunities for faculty development, and resources for identifying qualified faculty.

As the profession of physical therapy continues to advance and evolve to meet the needs of society, particularly with first contact patient access to PTs, knowledge and expertise has grown to include imaging. The emphasis of this manual will be to recognize normal anatomy on an imaging study and to be able to view common studies such as radiographs and sonograms. Physical therapists need to know when to refer for or perform imaging studies, and which modality would optimally benefit the patient. This manual will assist in the development of these skills.

Contents

Legislative and Regulatory Considerations
Curricular Content

Legislative and Regulatory Considerations

Purpose

The purpose of this section is to provide an overview of legislative and regulatory considerations relevant to academic and clinical instruction in imaging in professional PT education.

Contents

Scope of Practice Regulation
Classroom and Clinical Physical Therapist Laboratory Instruction
Clinical Internship Considerations
Summary

The primary regulatory consideration in teaching imaging in PT professional education programs is language related to the use of imaging by PTs in state physical therapy practice acts and in PT licensing board's rules and regulations. Other standards to be considered are CAPTE's evaluative criteria,[7] the accepted physical therapy scope of practice as defined in APTA documents including the *Guide to Physical Therapist Practice (Guide)*[21] and *A Normative Model of Physical Therapist Professional Education.*[6]

State Practice Regulation

The physical therapist legal scope of practice is regulated by each United States jurisdiction through the passage and regulation of the jurisdictional physical therapy practice act. Typically, each practice act includes language that requires the individuals licensed under the physical therapy practice act to be of good moral character, to have graduated from a program accredited by a nationally recognized agency or an agency approved by the state board, and to pass the physical therapy licensure examination.

Classroom and Clinical Physical Therapist Laboratory Instruction

The focus of classroom and clinical physical therapist laboratory instruction is in accordance with meeting CAPTE's evaluative criteria[7] that includes teaching the scope of physical therapy practice as described in the *Guide to Physical Therapist Practice 3.0.* The terminology used and defined in the *Guide*[21] is taught and used in physical therapist professional education programs. Consultation with university legal counsel is advisable if there are any concerns regarding freedom to include certain aspects of the scope of PT practice in the curriculum due to language in state laws and/or regulations.

Clinical Internship Considerations

Clinical internships of student PTs are under the direct supervision of PTs who are CIs. Clinical instructors and students must adhere to the rules and regulations of the physical therapy practice act regarding both scope of practice and use of accepted terminology to describe that practice in the jurisdiction where they practice.

Summary

The CAPTE's evaluative criteria and the *Guide's* description of PT practice, support the premise for imaging to be taught in all doctor of physical therapy education programs; however, faculty must consider any restrictions placed on academic and/or clinical instruction by existing state law. Academic faculty members have latitude to meet CAPTE's evaluative criteria and be consistent with the *Guide* in curriculum development and level of instruction, but are encouraged to consider the contents of this manual. Clinical instructors and student PTs must comply with state practice acts regarding both scope of practice and accepted terminology during instructional activities conducted at clinical internship sites. Further clarification of regulatory issues can be sought by consulting with legal counsel.

Curricular Content

Purpose

The purpose of this section is to outline the essential elements of a curriculum in imaging instruction appropriate for doctor of physical therapy education programs. Recommended didactic content includes:

(1) Theory and principles of imaging.

(2) Practical instruction in utilizing imaging is a necessary component of a curriculum in imaging instruction for PTs, as is practice of imaging procedures (in most situations ultrasound) during clinical education experiences. Guiding commentary related to both practical instruction and clinical education are presented in this section.

Contents

Imaging Theory and Principles

Theory and principles of imaging effects, effectiveness, safety, and technical application are described and examined in a multitude of texts and articles. The reader is encouraged to select current instructional materials from the list of resources provided elsewhere in this manual and on the Orthopaedic Section, APTA website available at: www.orthopt.org.

The principles of imaging through common modalities are important for the doctor of physical therapy student to understand and are available in a number of imaging textbooks, including several focused on imaging in rehabilitation.

Other Resources:

Additionally, there are several websites that offer high quality images and information for independent study or enhancement of formal study. Most notably, examples of images demonstrating normal anatomy, anatomical variants, and results consistent with clinical syndromes are readily available. Those websites directly associated with professional organizations and accredited educational institutions are likely to be the resources having undergone peer review with resultant valid and reliable information.

The American College of Radiology Appropriateness Criteria is one resource of critical value for educators, students, and clinicians. This concise compilation of regularly reviewed and updated imaging guidelines offers valuable information essential for evidence informed decision making and is available at: http://www.acr.org/quality-safety/appropriateness-criteria.

Expected Learning Outcomes:

While a thorough understanding regarding the physics of imaging and the parameters that govern imaging prescription are possibly beyond the scope of what should be expected of a DPT student, the basic principles of each of the most common imaging modalities should be expected so that the DPT can make informed decisions regarding the indications, contraindications, advantages, and disadvantages of each modality. The expected learning outcomes include a basic understanding of principles of the following modalities be taught in all DPT programs: CT, MRI, radiography, scintigraphy, ultrasound (US), and duel energy x-ray absorptiometry (DEXA or DXA) imaging.

I. **Normative Model of DPT Physical Therapist Professional Education**
   - **Statements related to imaging include:**
     - Collect information from laboratory and diagnostic tests as part of the examination.

- Provide a rationale for choice of tests and measures selected.
- Determine the need for referral to other health care providers.
- Assess health needs and risk factors of different individuals, groups and communities.
- Recognize clusters of symptoms that denote medical emergency.
- Identify on a radiograph the components and relationships of the skeletal system.
- Explain the laboratory and imaging tests used to differentiate musculoskeletal, neuromuscular, cardiovascular, and cardiopulmonary diagnoses.
- Compare the advantages and disadvantages of MRI, CT scan for diagnosing conditions such as bone tumors and lumbar disk problems.
- Define positive MRI findings supporting the diagnosis of multiple sclerosis.
- Identify the results of imaging on the practice of physical therapy with respect to the skeletal system.
- Identify the needs of various imaging procedures in the examination of the patient/client with skeletal conditions.
- Use results of various imaging procedures for the skeletal system in patient/client management.

Section 1. General Instructional Concepts

1. The properties of commonly used imaging modalities with particular reference to:
   a. their capabilities and limitations in identifying anatomy and patho-anatomy;
   b. the basic physics of their operation;
   c. relative risk, complications, and contraindications of commonly used imaging modalities including life-time cumulative radiation exposure and age-related radiation exposure;
   d. the rationale for applications of each in common clinical scenarios; and
   e. the performance and interpretation of ultrasound.
2. Imaging for appropriate medical screening of patients including the specific history and clinical examination findings, and where relevant clinical guidelines, indicating the need for imaging.
3. Recognition of normal musculoskeletal anatomy, common anatomical variants, and developmental/lifespan changes, including the imaging modality best demonstrating the anatomy.
4. Specific history elements and clinical examination findings consistent with indications for imaging, including:
   a. age, sex, and race;
   b. individual health history;
   c. chief presenting complaint;
   d. palpatory examination;
   e. joint/ligament stability testing;
   f. passive mobility testing;
   g. neuromuscular examination;
   h. special tests; and
   i. other observations.

5. The appropriate application of established imaging decision guidelines, such as the applicable *American College of Radiology Appropriateness Criteria, American Institute of Ultrasound in Medicine,* and body region specific decision guides.
6. Integrating imaging results with the clinical presentation, particularly relating to clinical reasoning and decision making in patient management.
7. Understanding the radiologist's report and communications with other providers relating to imaging.
8. The role of the physical therapist in patient education of imaging results and its impact on PT care.

Safety:

While the depth of understanding of the principles of imaging for each imaging modality will undoubtedly vary across programs, a clear understanding of safety should be a required component of all curricula. Examples of information that should be provided and tested include: radiation-based imaging—the effective radiation dose of a chest radiograph vs a multiphase abdominal CT vs a head CT; MRI–no radiation involved; however, the MRI environment is potentially very dangerous if ferromagnetic items are introduced (pace-makers, etc). For all imaging, including US imaging, the principle of "as low as reasonably achievable"[41] should be paramount.

Computed Tomography Radiation Dosages[42]		
Computed Tomography Image/Region	Effective Dose (mSv)	Equivalent Number of Chest Radiographs
Head	2	30
Neck	4	55
Suspected Stroke	14	199
Chest	8	117
Coronary Angiogram	22	309
Abdomen	15	220
Multiphase Abdomen/Pelvis	31	442

Particular attention is to be directed at the Image Wisely™ (http://www.imagewisely.org/)[43] for adult patients and Image Gently® (http://www.imagegently.org/Home.aspx)[44] for pediatric patients. These resources focus on quality of imaging as a contributor to diagnosis and decision making, while maintaining high standards for minimizing risks of radiation exposure.

Example Objectives:

The following example objectives are derived from CAPTE Evaluative Criteria[7]:

1. Use and understand imaging terminology appropriately, expressively, and receptively with imaging professionals, and discuss the differences between various imaging modality terminologies. (CC-5.17; CC-5.31)

2. Understand the basic physics of MRI, its advantages and limitations, and be able to discuss briefly how MR images are acquired and how key parameters such as repetition time (TR) and echo time (TE) influence image weighting. (CC-3)

3. Understand the uses and capabilities of ultrasound imaging and discuss its uses in the physical therapy setting. (CC-5.30 b, e, f, k)

Basic Imaging Modality Properties

Imaging Modality	Mechanism	Assets	Limitations/ Concerns	Relative Radiation Dosages*
Radiography	Imaging obtained by detection of x-rays projected through human tissues with varying degrees of radiolucency and radio-opacity demonstrated.	Allows good appreciation of basic bony anatomy.	Complex bony anatomy superimposition. Limited capacity for soft tissue demonstration.	Low
Computed Tomography (CT)	Computerized image reconstruction of multiple slices of tissues through which x-rays have been passed and detected.	Excellent demonstration of cortical bone anatomy. High sensitivity to variances in density of tissues. Multiplanar views of anatomy; 3-D images possible.	Soft tissue demonstration dependent on CT unit. Expensive.	High
Magnetic Resonance Imaging (MRI)	A method of exposing tissues to magnetic fields and radiofrequency waves to detect properties of tissues and thereby produce images.	Excellent demonstration of soft tissues and bone marrow. Multiplanar views of anatomy; 3-D images possible. Multiple sequences allowing various tissue characteristics.	Lack of signal in cortical bone. Expensive.	None
Scintigraphy (Bone Scan)	Imaging obtained by introduction of radio-isotopes into the body that are subsequently concentrated in areas of increased metabolic activity and recorded by tracer sensitive detection.	Good sensitivity to increased metabolic activity/bone turnover.	Lack of diagnostic specificity with increased radio-isotope uptake.	Moderate
Sonography (Ultrasound)	A method of passing high frequency sound waves through tissues that are reflected or absorbed at varying levels depending on tissue properties. The reflected sound waves are detected and serve as a basis for the image.	Good demonstration of soft tissues. Allows real time, dynamic imaging. Convenience and cost.	Image yield highly dependent on operator.	None
Dual Energy X-Ray Absorptiometry (DEXA or DXA)	Measurement of relative x-ray attenuation as a function of tissue density.	Simple, quick, accurate, modest cost. Suited to serial testing, if same device.	Inconsistent performance between devices from different manufacturers.	Low
**Actual dosages dependent on body region imaged and exam specifics.*				

Didactic Instruction

The recent survey[1] of accredited PT education curricula revealed imaging content is typically introduced in the first or second year of the curriculum. Approximately half of the responding programs included a stand-alone required course, with 58% of these programs also integrating imaging content throughout the remainder of the curriculum. Irrespective of a stand-alone imaging course, the recommendation is to introduce the content as early as possible and then integrate where appropriate in the clinical science tracks. Opportunities for early introduction exist in the basic science track; including imaging in the human anatomy and neuroanatomy courses, providing a great example of how students will incorporate imaging and apply anatomy in the clinic. Once students understand the properties of various imaging modalities, a better understanding will develop of when particular modalities are indicated based on initial patient presentation and ongoing management. Last, utilizing imaging to evaluate pathological processes will promote optimal patient care. The following are provided as suggestions, as a guide for introducing and integrating imaging content into the curriculum. Specific instructional and student assessment content are included.

Section 1. General Instructional Concepts (continued from page 22)

9. The properties of commonly used imaging modalities with particular reference to:
    a. their capabilities and limitations in identifying anatomy and patho-anatomy;
    b. the basic physics of their operation;
    c. relative risk, complications, and contraindications of commonly used imaging modalities including life-time cumulative radiation exposure and age-related radiation exposure;
    d. the rationale for applications of each in common clinical scenarios; and
    e. the performance and interpretation of ultrasound.

10. Imaging for appropriate patient medical screening includes the specific history and clinical examination findings, and where relevant, clinical guidelines, indicate the need for imaging.

11. Recognition of normal musculoskeletal anatomy, common anatomical variants, and developmental/lifespan changes, including the imaging modality, best demonstrates the anatomy.

12. Specific history elements and clinical examination findings consistent with indications for imaging, includes:
    a. age, sex, and race;

b. individual health history;
c. chief presenting complaint;
d. palpatory examination;
e. joint/ligament stability testing;
f. passive mobility testing;
g. neuromuscular examination;
h. special tests; and
i. other observations.

13. Appropriate application of established imaging decision guidelines, such as the applicable *American College of Radiology Appropriateness Criteria, American Institute of Ultrasound in Medicine,* and body region specific decision guides.

14. Integrating imaging results with the clinical presentation, particularly relating to clinical reasoning and decision making in patient management.

15. Understanding the radiologist's report and communications with other providers relating to imaging.

16. The role of the physical therapist in patient education of imaging results and its impact on physical therapist care.

<u>Example Student Assessment/Competency Items:</u> (answers italicized)

1. In any patient having sustained a fracture, physical therapists often want to know if the fracture is "adequately" healed to safely accept increases of exercise or functional loads. To determine if a fracture is healed "clinically," the orthopaedist typically considers two practical criteria. One is radiographic evidence of healing; the other is often based on clinical examination.
   a) Briefly describe the basic radiographic evidence of healing.
      blunting, widening, callus, sclerosis, bridging, remodeling
   b) What is the practical, clinical evidence that the fracture is healing?
      painfree at rest and with activity; subjective reports of stability

2. Arrange the biologic and non-biologic samples in order of most radiolucent to most radiopaque.

_*B*_ 1.	A. Bone
_*C*_ 2.	B. Air
_*E*_ 3.	C. Fat
_*A*_ 4.	D. Metal
_*D*_ 5.	E. Water

3. For the imaging modalities listed in the first row of the table below, in each box describe what the appearance of the structure will be on a gray scale.

	CT	T1-W MRI	T2-W MRI
Swelling/Effusion	Gray/dark/hypodense	Low signal intensity Dark	High signal intensity Bright
Fat	Dark/gray/black	High signal intensity Bright	Intermediate signal intensity Gray
Bone Cortex	White	Low signal intensity Dark	Low signal intensity Dark
Bone Marrow	Dark/gray	High to intermediate signal intensity Bright/Gray to white (depends on marrow type)	Intermediate signal intensity Gray

4. Which imaging modality uses markers to measure metabolism and blood flow and is used in early detection of stress fractures and skeletal metastases?
   a. *bone scan.*
   b. radiographs.
   c. magnetic resonance imaging.
   d. computed tomography scan.

5. Place the imaging modality in order of lowest to highest radiation dose to the patient.
   a. magnetic resonance imaging, computed tomography scan, radiography.
   b. radiography, magnetic resonance imaging, computed tomography scan.
   c. *magnetic resonance imaging, radiography, computed tomography scan.*
   d. ultrasound, radiography, computed tomography scan, magnetic resonance imaging.

6. The imaging modality that most accurately depicts the location, size, and orientation of fracture fragments is:
   a. three-dimensional ultrasound.
   b. radiography.
   c. computed tomography.
   d. magnetic resonance imaging.

Section 2. Body Region Not Defined

Recommended Instructional Content

Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Initial screening of suspected primary bone tumors. Possible tumor. "Incidental" finding on magnetic resonance imaging. Not clearly benign. No radiographs. Soft-tissue mass. Clinically suspicious for superficial lipoma or nonspecific clinical assessment. Initial imaging study. Juxta-articular soft-tissue mass. Clinically suspicious for ganglion or popliteal cyst. Initial imaging study. Suspicion for stress fracture (fatigue/insufficiency): 1. First study. 2. Follow-up study 10-14 days later (not hip or sacrum) and initial radiographs normal.	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/Magnetic resonance arthrography	Positive localized or regional symptoms suspicious for bone lesion. Radiographs negative or findings do not explain symptoms. Bone lesion on radiographs. Next study most clinical scenarios. "Incidental" bone finding on CT. Not clearly benign. No radiographs. Soft-tissue mass, next study following radiographs: 1. nondiagnostic, or 2. with prominent calcification. Suspicion for stress fracture (fatigue/insufficiency).	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.

Computed tomography	Bone lesion demonstrated on radiographs. Radiographic and/or clinical pattern suspicious for osteoid osteoma.	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Ultrasound	Soft-tissue mass. Clinically suspect superficial lipoma. Initial imaging study. Suspected deep vein thrombosis (Doppler). Superficial soft tissue foreign body evaluation. Muscle integrity, contraction ability, volume, and degenerative changes. Soft tissue and joint swelling evaluation.	Particular operator and equipment considerations in conducting the examination for specific suspected pathologies or anatomical concerns.

Example Student Assessment/Competency Items: (answers italicized)

1. Which imaging modality is typically the best option to allow differentiation of a benign versus a pathological fracture?
   a. bone scan.
   b. computed tomography.
   c. conventional radiography.
   d. *magnetic resonance imaging.*

2. A limitation of radiographs that in some cases determines the use of computed tomography to be preferable to detect or rule out fractures is:
   a. insensitivity to bone mass loss.
   b. *overlapping bony layers.*
   c. inability to demonstrate surrounding edema.
   d. difficulty with allowing visualization of ligaments.

3. The imaging modality that generally best reveals non-displaced fractures is:
   a. *magnetic resonance imaging.*
   b. computed tomography.
   c. radiography.
   d. ultrasound.

4. In the ABCs approach of identifying content of images, the “A” represents:
    a. air.
    b. *alignment.*
    c. adjacent structures.
    d. asymmetry.

Section 3. Cervical Spine Region

Recommended Instructional Content

Typical Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Investigation of suspected or further study of: 1. Follow-up for cervical spine trauma 2. Chronic neck pain a. with or without prior trauma b. with prior history of malignancy c. with prior cervical spine surgery	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/Magnetic resonance arthrography	Investigation of suspected or further study of: 1. Acute cervical spine trauma with a. neurological involvement b. mechanical instability 2. Chronic neck pain, neurological signs or symptoms present 3. Infection or malignancy	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Computed tomography	Investigation of suspected or further study of: 1. Acute cervical spine trauma 2. Chronic neck pain with prior cervical spine surgery 3. Posterior longitudinal ligament ossification	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Specific Imaging Decision Guides: Canadian Cervical Spine Rule National Emergency X-Ray Rule (NEXUS)		

Example Student Assessment/Competency Items: (answers italicized)

1. Which are common criteria for both the Canadian Cervical Spine Rule and the NEXUS Low Risk Rule?
   a. *cervical spine tenderness to palpation; neurological signs or symptoms.*
   b. age 65 years or greater; evidence of intoxication.
   c. distraction from other injury; ambulatory status.
   d. age 65 years or greater; range of motion limitation.

2. You are observing a lateral view radiograph of the cervical spine in a patient with rheumatoid arthritis who is currently at your facility. You observe an anterior atlantodental interval of 6.0 mm, consistent with that reported by the radiologist. Your response to this as a physical therapist is understanding _____________________ and you determine to __________________.
   a. Normative values have not been established; proceed with care as previously planned.

b. *3.5 mm is considered the upper normative limit; conduct a detailed neurological exam.*
c. 4.5 mm is considered the upper normative limit; do a reductive mobilization technique.
d. 5.0 mm is considered the upper normative limit; begin stabilization exercise.

3. You are seeing a 71-year-old woman following rotator cuff repair. At two months postsurgery, she enters today for her 6th visit and tells you of a fall she had at home yesterday. She says she extended both arms to protect herself during the fall. She now reports increased pain in her involved shoulder and neck. You note her neck motions are significantly limited and she has midline posterior neck tenderness. Her active shoulder motion was 100° of flexion in sitting last week and is now pain limited at 60°. Upon considering her presentation today, your greatest concern is:
   a. whether she reinjured her shoulder and if MRI of her shoulder is needed to evaluate her status for continuing rehabilitation.
   b. whether she reinjured her shoulder and how you will modify her program today to be reduced for a few days before progressing again to higher level exercise.
   c. whether she has a significant cervical spine injury and to stabilize her neck until imaging of her neck can be completed.
   d. whether she now has a cervical radiculopathy and how you will address that problem in addition to her shoulder.

4. An otherwise healthy 32-year-old female was in a motor vehicle accident two days ago. She was rear-ended while stopped at a busy intersection during rush hour traffic. She states she is surprised "my neck is this sore because my back bumper had only a small dent in it." Shortly after the accident and in the ensuing hours, she reports that she experienced gradually increasing left posterolateral neck stiffness and pain. The next morning, she awoke with a dull ache in the left deltoid muscle area, and after washing her hair she noted the ache moved down to her elbow. The physical examination reveals pain limited cervical active range of motion with extension at 25°, left rotation limited to 55°, and left lateral flexion to 20°. Her other cervical active ranges are with end-range pain at normal limits for her age. The neurological examination, including myotome and dermatome testing along with reflexes, is without deficits or abnormal findings.
   Based on this much information, would you refer this patient for imaging?
   No, imaging is not currently indicated.

   Give a rationale for your response.
   Her presentation is not consistent with an elevated fracture risk being negative on the Canadian Cervical Spine Rule and NEXUS Low Risk Rules criteria within the American College of Radiology Appropriateness Criteria. Specifically, the mechanism of injury is not consistent with a "dangerous mechanism," her range of motion limitations are not severe, and her neurological exam is negative. She also has no other personal risk factors to elevate the risk of bone compromise, instability, or other related problems.

5. A 55-year-old male enters your clinic with his right upper extremity elevated and his wrist resting on the top of his head. He states this is the only position of relief for him and it has been this way for 3 weeks. His specific description of symptoms is of right neck, periscapular, and proximal arm pain, accompanied by intermittent distal paresthesia. On clinical examination, you find grossly limited cervical range of motion in all planes, and cervical compression and Spurling's maneuver are both provocative of the upper extremity symptoms. Traction is equivocal for reduction of symptoms. Sensory testing suggests a decrement in light touch, but the area is poorly defined. Manual muscle testing is difficult to interpret as exertion at the shoulder and elbow are both pain limited. Grip strength on his affected dominant side is 38 pounds and 95 pounds on the left. Based on this information, your best course of action today is:
    a. seek an MRI to assist in physical therapy decision making.
    b. refer back to the physician as he clearly has a problem beyond your scope of care.
    c. *defer imaging, begin conservative care, and monitor his status closely.*
    d. obtain radiographs before beginning conservative care.

Section 4. Shoulder Region

Recommended Instructional Content

Typical Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Investigation of suspected or further study of: 1. Acute shoulder pain of any etiology 2. Septic arthritis 3. Thoracic outlet syndrome (chest radiograph)	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/Magnetic resonance arthrography	Investigation of suspected or further study of: 1. Persistent significant pain 2. Labral injury, with or without indications of instability on examination, age prior to anticipated degenerative changes 3. Bursitis or long head of biceps tenosynovitis 4. Impingement, age after which degenerative changes anticipated, and radiographs normal or demonstrating coracoacromial arch osteophytes/ syndesmophytes 5. Re-tear status post prior rotator cuff tear 6. Thoracic outlet syndrome (chest MRA)	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Computed tomography	Investigation of suspected or further study of: 1. Scapular fracture[45-49] 2. Osseous glenoid fossa lesions[50-54]	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.

Ultrasound	Investigation of suspected or further study of: 1. Bursitis 2. Long head of biceps tendinopathy or displacement 3. Impingement, age after which degenerative changes anticipated, and radiographs normal or demonstrating coracoacromial arch osteophytes/ syndesmophytes 4. Rotator cuff tendinopathy with/or without prior shoulder arthroplasty 5. Re-tear status post prior rotator cuff repair 6. Acromioclavicular joint integrity, degeneration of effusion	Particular operator and equipment considerations in conducting the examination for specific suspected pathologies or anatomical concerns.

Example Student Assessment/Competency Items: (answers italicized)

1. Your 56-year-old male patient experienced a fall on his back a week ago while cleaning leaves from his house gutters. He went to the emergency room and had radiographs completed of his shoulder. These were interpreted as negative, but also with the comment of being underexposed. He presents to you now with shoulder and left upper back pain severely limiting his motion actively and passively. Manual muscle testing of his left shoulder from a neutral position reveals 4/5 pain limited weakness of the shoulder in all planes. On palpation, his left upper back is exquisitely tender. The neurological screen is negative. You have an increased suspicion of what injury and seek to have what diagnostic test performed to allow better decision making?
   a. rotator cuff tear; magnetic resonance imaging.
   b. suprascapular nerve injury; electroneuromyography.
   c. capsulolabral injury; magnetic resonance imaging.
   d. scapular fracture; computerized tomography scan.

2. Match the MRI finding of the rotator cuff with the likely interpretation:

__*C*__ Complete tear	A. Heterogenous signal intensity
__*A*__ Tendinopathy	B. Fiber fraying
__*B*__ Partial tear	C. Interposed fluid signal

3. For imaging of the rotator cuff, which statement is most accurate?
   a. *ultrasound and magnetic resonance imaging are equivalent in allowing appreciation of focal tendon abnormalities. The selection of which is most appropriate depends on potential for degenerative changes and other suspected pathology.*
   b. ultrasound is superior to magnetic resonance imaging in that it performs as well as magnetic resonance imaging overall and is much less expensive. Thus, ultrasound is preferable in most situations.

c. magnetic resonance imaging is superior to ultrasound, even considering the greater cost. As such, ultrasound should be considered a secondary exam procedure after magnetic resonance imaging.
d. magnetic resonance arthrogram is indicated in most suspected rotator cuff pathologies.

4. The imaging modality which best identifies and discriminates labral lesions in the shoulder is:
   a. magnetic resonance imaging.
   b. *magnetic resonance arthrography.*
   c. computed tomography with contrast.
   d. single photon emission computed tomography.
   e. high resolution ultrasound.

Section 5. Elbow Region

Recommended Instructional Content

Typical Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Investigation of suspected or further study of: 1. Acute injury, initial screening for fracture 2. Chronic elbow pain	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/magnetic resonance arthrography	Investigation of suspected or further study of: 1. Intraarticular osteocartilaginous body/osteochondral injury 2. Soft-tissue mass 3. Chronic epicondylitis 4. Collateral ligament tear 5. Tendon lesion or bursitis 6. Nerve abnormality 7. Osseous tumor	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Computed tomography	Investigation of suspected or further study of: 1. Heterotopic ossification 2. Osteophytosis	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Ultrasound	Investigation of suspected or further study of: 1. Chronic epicondylosis 2. Tendon lesion or bursitis 3. Collateral ligament tear 4. Nerve abnormality	Particular operator and equipment considerations in conducting the examination for specific suspected pathologies or anatomical concerns.

Example Student Assessment/Competency Items: (answers italicized)

1. Please describe the significance of a so-called "fat pad sign" or "sail sign" at the elbow.
   The "fat pad sign" or "sail sign" is consistent with effusion displacing the joint fat pads and indicating possible intraarticular injury or fracture. The fracture may be radiographically occult and, if so, may warrant additional imaging.

2. A parent brings the start youth league pitcher for consultation. The 12-year-old is describing pitching arm medial elbow pain that began during practice last evening. He describes trying a new pitch and immediately sensed the pain. He applied cold all night, which helped modestly. You observe moderate effusion of the elbow with range of motion being painful throughout and limited to 30° to

100°. There is exquisite tenderness medially and laxity upon valgus testing. The first step for this patient is:

a. *radiographs to investigate for medial epicondyle fracture.*
b. magnetic resonance imaging to evaluate for ligament injury.
c. computed tomography angiography to evaluate for vascular compromise.
d. bone scan to investigate for a Salter-Harris fracture.

3. Your patient sustained right elbow trauma in a motor vehicle accident. She was the front seat passenger and extended her arms to protect herself from an anticipated front impact, but her vehicle was first struck from the side before the front impact, triggering the airbag. Her primary description is now of medial elbow pain and upper extremity weakness. On clinical examination, your most notable finding is pain and laxity with valgus stress testing of the joint. The imaging to best reveal the pathology you suspect and the hallmark finding on this imaging would be:
   a. magnetic resonance imaging; increased signal intensity at the medial epicondyle.
   b. *magnetic resonance arthrography; "T-sign."*
   c. computed tomography; intraarticular fracture.
   d. radiography; radial head fracture.

4. Which of the following radiographic views would give the most information about the carrying angle of the elbow joint?
   a. lateral view.
   b. oblique: internal rotation view.
   c. oblique: external rotation view.
   d. *anterior-posterior view.*

Section 6. Wrist and Hand Region

Recommended Instructional Content		
Typical Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Investigation of suspected or further study of: 1. Wrist, hand, and distal forearm trauma including suspected fractures and dislocations 2. Chronic wrist pain 3. Carpal tunnel syndrome	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/Magnetic resonance arthrography	Investigation of suspected or further study of: 1. Occult or stress fractures, including scaphoid 2. Non-union, malunion, osteonecrosis, and/or posttraumatic arthritis 3. Ligamentous injury, including thumb ulnar collateral ligament 4. Ganglion cyst or other palpable wrist mass 5. Inflammatory arthritis 6. Chronic wrist pain 7. Possible infection	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Computed tomography	Investigation of suspected or further study of: 1. Occult fracture, including hook of hamate and scaphoid 2. Non-union, malunion, osteonecrosis, and/or posttraumatic arthritis 3. Distal radio-ulnar joint dislocation 4. Intraarticular fracture	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Ultrasound	Investigation of suspected or further study of: 1. Tendon injury[55-59] 2. Nerve lesion 3. Ganglion cyst and soft tissue masses	Particular operator and equipment considerations in conducting the examination for specific suspected pathologies or anatomical concerns.

<u>Example Student Assessment/Competency Items</u>: (answers italicized)

1. Your 38-year-old male patient who fell off scaffolding 3 weeks ago has persistent radial aspect wrist pain without improvement over the past two weeks along with tenderness in the anatomical snuffbox, pain with longitudinal thumb compression, and prior negative radiographs of the hand and wrist. Your next step is:
   a. *seek repeat radiographs or magnetic resonance imaging of the wrist.*
   b. seek computed tomography with intraarticular contrast.
   c. allow two more weeks of conservative care, but less aggressively with plans to contact the physician as the patient returns for the next follow-up to the physician at the end of the two-week period.
   d. immobilize the wrist, use therapeutic ultrasound and electrical stimulation to promote healing and re-evaluate in 10 days.

2. Your patient with distal radial forearm and thumb pain who has continued working and has been slow to respond to interventions is now scheduled to undergo an MRI of the involved extremity. Based on isolated swelling in the area, exquisite tenderness, and pain with ulnar deviation, you expect the radiologist's report to include language consistent with increased signal intensity circumferentially enveloping the straight fibrilinear pattern of tendons on the T2-weighted sequence and that result is most likely consistent with:
   a. an intrasubstance partial tear.
   b. a complete tendon rupture.
   c. fatty infiltration.
   d. *tenosynovitis.*

3. You are seeing a 36-year-old female driver for a package delivery service who reports wrist pain. She had a similar bout of symptoms one year ago that reduced, but did not completely resolve. During this prior episode of increased symptoms, a positive ulnar variance was identified on radiographs. Given this background, what type of pathology would you suspect?
   a. *excessive loading on the lunate and potentially Kienböck's disease.*
   b. ulnar neuropathy.
   c. ganglion cysts and tenosynovitis.
   d. proximal scaphoid fracture and avascular necrosis.

4. Your 62-year-old patient, who is right hand dominant, is a recreational golfer of less than average skill. One particular day, he attempts a difficult shot and strikes the ground firmly with his club. He describes this as causing an immediate onset of pain at the proximal, ulnar aspect of his left hand. Upon presenting to you two days later, his symptoms are still present with wrist motion moderately limited by pain, a significant reduction in grip strength, and tenderness throughout the hypothenar eminence. He has particular worsening of symptoms with resisted flexion of the 4th and 5th digits. Match the pathology for which you are most suspicious and the two best imaging options to detect this.
   a. pisiform fracture: magnetic resonance imaging or posterior-anterior radiograph.

b. ulnar styloid process fracture: magnetic resonance imaging or lateral view radiograph.
c. hook of hamate fracture: carpal tunnel view radiograph or computed tomography.
d. shaft of 5th metacarpal fracture: oblique view radiograph or computed tomography.

5. Your patient has a longstanding history of painful popping and clicking in the wrist with activities requiring use of her dominant right hand. She also has pain-limited wrist motion, decreased grip strength, and well-localized tenderness at the proximal dorsal aspect of the wrist.

a. What is the most probable pathology?
Scapholunate dissociation.

b. What radiographic view would best reveal this pathology?
A clenched fist stress view.

c. What specific result would indicate the presence of this instability?
An interval between the scaphoid and lunate of 5 mm or more.

Section 7. Thoracolumbar Spine Region

Recommended Instructional Content

Typical Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Investigation of suspected or further study of: 1. Thoracic or lumbar spine in child (< 14 yrs) with known cervical, thoracic, or lumbar fracture 2. Rib fracture	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/Magnetic resonance arthrography	Investigation of suspected or further study of: 1. Back pain with, a. Low velocity trauma b. Osteoporosis c. Focal and/or progressive neurological deficit d. Prolonged symptom duration e. Age > 70 years f. Cancer g. Infection h. Immunosuppression 2. Back pain and/or radiculopathy 3. Back pain with prior lumbar surgery 4. Cauda equina syndrome, multifocal or progressive neurological deficit 5. Blunt trauma of thoracic or lumbar spine with neurological abnormalities	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Computed tomography	Investigation of suspected or further study of: 1. Blunt trauma to the thoracic or lumbar spine with neurological abnormalities 2. Thoracic or lumbar spine in child (<14 yrs) with known cervical fracture 3. Abdominal aortic aneurysm	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Dual energy x-ray absorptiometry	Investigation of suspected or further study of: 1. Low bone density and fracture risk identification (DXA of spine & hip) 2. Suspected fracture (DXA vertebral fracture assessment of spine)	
Ultrasound	Initial screening for abdominal aortic aneurysm	Particular operator and equipment considerations in conducting the examination for specific suspected pathologies or anatomical concerns.

Example Student Assessment/Competency Items: (answers italicized)

1. When considering imaging studies for lumbar pain, research shows the modality that offers the highest sensitivity and specificity for detecting cancer, infections, and intervertebral disk changes is:
   a. *magnetic resonance imaging.*
   b. radiographs.
   c. bone scan.
   d. computed tomography.

2. You are seeing a 15-year-old female gymnast and cheerleader for low back and bilateral buttock pain. Given her history of pain for 6 months, you base your examination on the suspicion that she could potentially have a pars interarticularis injury. As such, you select the clinical examination procedures found to have very good psychometric values in comparison to imaging evidence in those with spondylolysis/spondylolisthesis in order to rule out that problem. Those specific procedures are:
   a. palpation for presence of a step sign at the probable level.
   b. palpation of passive intervertebral motion at the suspected segment.
   c. one leg hyperextension test looking for posterior pain provocation.
   d. *no exam, procedure has good correlation to image findings.*

3. You are treating a 60-year-old woman with back pain. Your examination and assessment yields findings that suggest manual therapy may be indicated. Before you determine that she is safe for the application of end-range manual techniques, you would like to have more definitive, objective data. To be confident in your clinical decision-making to proceed with manual techniques, you would like to have a:
   a. magnetic resonance imaging to rule out overt radiculopathy.
   b. dual energy x-ray absorptiometry scan with values greater than -1.0 on the t-score.
   c. dual energy x-ray absorptiometry scan with values less than -2.5 on the t-score.
   d. computed tomography scan to rule out fracture in her remote past.

4. The most accurate early diagnostic combination matched with the implicated disorder is which of the below:
   a. elevated sedimentation rate, radiography; rheumatoid arthritis.
   b. *Short Tau Inversion Recovery (STIR)-MRI, presence of a specific leukocyte antigen; ankylosing spondylitis.*
   c. radiography, venogram; abdominal aortic aneurysm.
   d. computed tomography, McMurray's test; tibial chondral lesion.

Section 8. Hip/Pelvis Region

Recommended Instructional Content

Typical Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Investigation of suspected or further study of: 1. Fracture 2. Avascular necrosis 3. Chronic pain 4. Possible referred pain to exclude hip 5. Stress (fatigue/insufficiency) fracture	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/Magnetic resonance arthrography	Investigation of suspected or further study of: 1. Fracture 2. Avascular necrosis 3. Osseous or surrounding soft tissue abnormality 4. Labral tear or femoroacetabular impingement 5. Pigmented villonodular synovitis 6. Osteochondromatosis	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Computed tomography	Investigation of suspected or further study of: 1. Osteoid osteoma 2. Acetabular fracture	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Dual energy x-ray absorptiometry	Identification and follow-up of low bone density and fracture risk assessment in absence of symptoms but elevated risk	
Ultrasound	Investigation or further study of: 1. Developmental dysplasia in infants	Particular operator and equipment considerations in conducting the examination for specific suspected pathologies or anatomical concerns.

Example Student Assessment/Competency Items: (answers italicized)

1. A frequently overlooked cause of low back pain that may escape radiographic detection in older women is:
   a. occult femoral neck fracture.
   b. *sacral insufficiency fracture.*
   c. pubic ramus fracture.
   d. lumbar disk herniation.

2. The imaging method of screening the hips of infants for developmental dysplasia, which is typically chosen based on accuracy, convenience, and minimizing risk is:
    a. radiography.
    b. magnetic resonance imaging.
    c. computed tomography.
    d. bone scan.
    e. *ultrasound.*

3. Which of the following statements is FALSE regarding pelvic fractures?
    a. with pelvic trauma, an anterior-posterior view radiograph is usually sufficient.
    b. widening of the symphysis pubis > 1 cm is abnormal.
    c. *the pelvis is a ring and fractures usually occur in only one area.*
    d. “open book” injuries refer to a loss of osseoligamentous stability.

4. Your 70-year-old female patient is complaining of intense inguinal pain with no prior history of trauma, especially with weight bearing, but relieved with rest and sleep. Her family practice physician has completed radiography noting “mild degenerative changes” in the painful hip along with osteopenic appearance. Your greatest immediate concern at the time of her initial evaluation is:
    a. if the degeneration might be more than indicated on the radiograph.
    b. *if a proximal femur fracture has been adequately ruled out.*
    c. if she might have septic arthritis of the hip.
    d. if a neoplasm might be the cause of her complaint.

Section 9. Knee Region

Recommended Instructional Content

Typical Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Investigation of suspected or further study of: 1. Fracture or dislocation 2. Routine monitoring after arthroplasty 3. Suspected periprosthetic infection 4. Atraumatic knee pain	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/Magnetic resonance arthrography	Investigation of suspected or further study of: 1. Persistent pain 2. Osteochondral lesion, internal derangement, or joint effusion 3. Avascular necrosis 4. Posterior dislocation following significant trauma	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Computed tomography	Investigation of suspected or further study of: 1. Tibial plateau fracture 2. Periprosthetic infection or prosthesis loosening	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Ultrasound	Investigation of suspected or further study of: 1. Tendon lesion 2. Popliteal cyst 3. Superficial ligament lesion	Particular operator and equipment considerations in conducting the examination for specific suspected pathologies or anatomical concerns.
Specific Imaging Decision Guides: Ottawa Knee Rule		

Example Student Assessment/Competency Items: (answers italicized)

1. The most common site for osteochondritis dissecans along with the best imaging modality to identify it is:
   a. *medial femoral condyle; magnetic resonance imaging.*
   b. capitulum; computed tomography.
   c. dome of the talus; magnetic resonance imaging.
   d. femoral head; radiograph.
   e. radius at radiocarpal joint; computed tomography.

2. A 48-year-old school teacher presents to you with right knee pain, which she describes as "a dull ache—like a tooth ache." She reports the pain started 4 to 5 months ago and denies any incident or accident. She further describes her symptoms being worse, and walking more difficult early in the morning with improvement over the morning, but worsening again by day's end. At the end of the day, she reports sitting for 30 minutes with improvement in her knee symptoms. You observe her gait lacks extension at terminal swing on the right along with an abbreviated stance period. The overall pattern of knee pain has remained relatively consistent over the past 3 months and she states, "just finally I am sick of it and it's why I came to PT." She also tells you of a severe right knee injury in high school, resulting in ligament and meniscus tears. She reports having had surgery, but is vague on the details. You note a faded surgical scar approximating the medial joint line. The current right knee active range of motion is 3° to 110°. Palpation reveals that the knee is generally tender with a modest increase along the joint lines. The only medication she lists is acetaminophen for pain. She denies significant illnesses.
    a. Would you refer this patient for imaging?
       No.
    b. Please provide a rationale for this decision.
       It is very likely that she has degenerative changes in her knee and that is the source of her problem. The overall course of her knee condition is proposed to be stable with no suggestions of serious pathology. Similarly, there are no elements in her overall presentation indicating systemic or medical issues beyond the scope of physical therapy. Because imaging findings are unlikely to change her course of care, imaging before beginning intervention is not warranted. This decision can be reviewed at any time, particularly if she fails to progress after a reasonable time/number of visits for a favorable response.

3. A 27-year-old, who happens to be a weekend rugby player, stops by your clinic unscheduled after having had radiographs made of his knee. He was injured one week ago in a match and he wants you to look at his knee images and then examine his knee. He explains that he was on crutches the first 4 days after the injury because of swelling and difficulty weight bearing. He has since stopped using the crutches as he has returned to full weight bearing although with an antalgic gait pattern. He said the swelling reduced a couple of days ago. He asks you what he should do next as no further follow-up is planned. He was told by his physician to ride a bike and then gradually return to activity as tolerated. Upon looking at the images and seeing the radiologist's report, you note the equivocal presence of a small bone fragment immediately lateral to the proximal tibial rim on the A-P radiograph. He asks you. "what does this mean?" Upon seeing this, your next step is answer his question and undertake what specific procedures?
    a. explain that he should not have had the radiographs made because he did not meet the criteria of the Ottawa Knee Rule. Examine his crutch walking on various surfaces and undertake gait training.
    b. explain the tiny bone fragment is inconsequential as an anatomical variant and is an incidental finding. Instruct him in a home program and plan follow-up in one week.
    c. *explain that he may have a significant intraarticular injury yet to be adequately described. Complete ligamentous stability testing with particular attention to Lachman's test.*

d. explain that he does not need to see an orthopaedist for further follow-up and simply needs to start rehabilitation. Further standard exam of motion, strength, and functional mobility are needed.

4. A woman, 35 years of age, reports to you with knee pain after stumbling and losing control of a piece of furniture she was carrying with another person last weekend. She says her pain is essentially unchanged from the onset 5 days ago and the swelling that gradually accumulated has also not changed. She says her pain is focused on the inside (medial aspect) of her knee and is at its worst when she is trying to climb or descend stairs. On clinical examination, you find mild joint effusion, range of motion at 10° to 110°, mild effusion, and joint line tenderness, medial greater than lateral. Her gait is noteworthy for a decreased stance period as limited by pain on her affected side. You are hypothesizing what pathology is most likely to be present, and would be detected with what further clinical examination procedure, and potentially confirmed by what imaging?
   a. medial collateral ligament injury; valgus stress test; computed tomography.
   b. *medial meniscus injury; Thessaly test; magnetic resonance imaging.*
   c. tibial plateau fracture; Apley's compression and distraction; computed tomography.
   d. patellar medial subluxation; apprehension test; lateral view radiograph.

Section 10. Ankle and Foot Region

Recommended Instructional Content

Typical Imaging Modality Applications		
Modality	Clinical Presentations	Application Specific Information
Radiography	Investigation of suspected or further study of: 1. Acute injury imaging for suspected fracture, instability, or penetrating trauma 2. Osteonecrosis 3. Degenerative joint disease 4. Chronic pain 5. Osteomyelitis in presence of diabetes mellitus	The assorted radiographic views and the value of each in the anatomy demonstrated. Views of particular interest for specific suspected pathologies.
Magnetic resonance imaging/Magnetic resonance arthrography	Investigation of suspected or further study of: 1. Ankle impingement syndrome 2. Osteochondral lesion 3. Musculotendinous disruption 4. Ligamentous injury or instability, including syndesmotic injury 5. Stress injury or occult fracture 6. Rheumatoid arthritis, inflammatory arthropathy, or other inflammatory disorder 7. Neuroma or local neuropathy, including tarsal tunnel syndrome 8. Chronic heel pain or plantar fasciitis 9. Osteomyelitis in presence of diabetes mellitus	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Computed tomography	Investigation of suspected or further study of: 1. Talus[60-62] or calcaneal fracture[63-65] 2. Tarsal coalition or bony anomaly	The addition of contrast intra-articularly and intravenously as applicable and what supplemental information is revealed by the added contrast along with its accompanying diagnostic importance. Planes of particular interest for specific suspected pathologies.
Ultrasound	Investigation of suspected or further study of: 1. Muscle or tendon lesion 2. Penetrating trauma/foreign body 3. Neuroma or local neuropathy, including tarsal tunnel syndrome 4. Plantar fascia lesion 5. Ligament lesion	Particular operator and equipment considerations in conducting the examination for specific suspected pathologies or anatomical concerns.
Scintigraphy	Investigation of suspected or further study of: 1. Complex regional pain syndrome	Information provided by phases and variations of nuclear imaging procedure.

Specific Imaging Decision Guides:
Ottawa Ankle & Foot Rules

<u>Example Student Assessment/Competency Items</u>: (answers italicized)

1. Which of the following criteria is NOT a criterion of the Ottawa Ankle & Foot Rules?
   a. incapable of standing or walking on the affected limb shortly after the injury and at present.
   b. bone tenderness of the distal posterior 2.5 inches of the fibula.
   c. bone tenderness at the attachment point of the fibularis brevis.
   d. tenderness at the dome of the calcaneus.

2. Your patient had an ankle injury in a pick-up basketball game 4 weeks ago. He was referred to you 3weeks ago with negative radiographs having been completed immediately prior to his first visit. After 6 visits with you, he is still struggling to make progress and requires crutches to ambulate because of ankle pain with weight bearing. He has persistent ankle effusion, worsened with ambulation more than short distances. His anterior drawer test is mildly positive, but your impression is this may not be consistent with the severity of his complaints. For which condition are you having increased suspicion and how would it be detected or ruled out?
   a. stress fracture; magnetic resonance imaging.
   b. *osteochondral lesion; magnetic resonance imaging.*
   c. pathologic fracture; bone scan.
   d. Jones fracture; computed tomography scan.

3. A 24-year-old female using crutches hopped into your clinic using crutches and not weight bearing on her left lower extremity. She described falling the night before while walking on ice and injured her left foot in the accident. She has not had any emergent care prior to visiting you. She just now borrowed the crutches from her neighbor and does not know how to use them. You observe mild swelling across the middle of the foot and palpation of her foot provokes pain over the mid-shaft of the 3rd metatarsal.
   Would you recommend radiographs for this patient?
   Yes.
   Give a rationale for your answer.
   Bone tenderness and impaired weight bearing elevate suspicion of fracture.

4. A 17-year-old male cross country runner presents to your clinic with a description of pain in his right anterior-medial tibia just below the knee. He reports an insidious onset about 4 weeks ago. The pain is mostly present when he runs but sometimes hurts just walking around school. There is no soft tissue swelling. Local tenderness to palpation is not especially impressive.
   a. list 2 or 3 possible diagnoses and rank from the most likely diagnosis to the least likely diagnosis.
   Stress fracture/reaction, pes anserine bursitis, meniscus tear, patellofemoral, etc.
   b. what imaging studies would you recommend be performed to rule in/out the diagnosis you listed first? Briefly provide a rationale for your choice.

MRI: stress reaction/swelling/fracture/soft tissue. MRI will allow for earlier presentation of fluid or fracture, whereas a radiograph/plain film will not demonstrate any change.

The recommended imaging content as previously described is based on the American College of Radiology Appropriateness Criteria by the American College of Radiology (ACR Appropriateness Criteria®. Available at www.acr.org/ac. Accessed November 28, 2014) and supplemented by the evidence cited below.

Practical Instruction – Ultrasound Imaging Procedures

Recent advances in USI technology have made it increasingly practical to incorporate instruction of USI into doctor of physical therapy education curriculum. The cost of USI equipment has decreased considerably in recent years while the quality of images has steadily improved. Image quality of lower cost portable USI equipment is comparable to hospital radiology department USI.

Teaching USI is time intensive and somewhat resource intensive. Programs can understandably be reluctant to add to an already full curriculum. By incorporating USI in a longitudinal fashion to their programs, academic programs will see the benefits outweigh the challenges of adding USI as it is ideally suited to teaching anatomy and movement. The advantage to USI is real-time imaging of live subjects. No other practical tool offers this ability in the laboratory and classroom. The most obvious indications for US are instruction in normal and abnormal anatomic variability, pathology, kinesiology, pathokinesiology, physiology, and pathophysiology. Once the fundamentals of USI physics, acquiring images, and understanding morphology is learned, USI can be incorporated throughout the curriculum in didactic and laboratory instruction. As faculty become skilled at using and incorporating USI, other less effective teaching tools and methods can be discontinued allowing for minimal overall impact to teaching time and resources. Ultrasound imaging can also be readily employed in student self-directed learning.

Ultrasound imaging is rapidly being adopted by PTs in clinical practice. Using USI in examination and management is commonly referred to as point-of-care application. There is an increasing body of research of USI and physical therapy. Growing point-of-care and research activity strengthen the case for PT student education in USI.

Faculty Resources

Prior to incorporating the practical instruction of US into PT curriculum, faculty must be trained in USI. The predominant method for non-radiologist health care practitioners to learn USI is by continuing education, self-study, colleague mentoring, and instruction. A listing of continuing education and self-study resources is provided at www.orthopt.org. The most common multi-disciplinary credential for musculoskeletal USI is offered by the American Registry of Diagnostic Medical Sonography. There is no PT specific credential offered by a United States professional society.

Fundamentals of Ultrasound Imaging

Ultrasound imaging can be introduced early in the curriculum for students to gain fundamental knowledge of the use of USI, equipment, and applications. Some of the fundamentals of USI overlap with the fundamentals of other imaging modalities and can be covered as part of an overall imaging curriculum. Broad topic areas that should be covered in learning the fundamentals of USI are adapted from the National Ultrasound Curriculum for Medical Students[66]:

- Basic principles of the physics of ultrasound
- Image acquisition: sound transmission and reflection, scatter, acoustic window
- Image optimization: depth, focal zone, time-gain compensation, gain, field of view
- Posterior acoustic properties: posterior enhancement (increased sound transmission), sound attenuation, acoustical shadowing
- Artifacts: near field, reverberation, edge refraction, mirror image
- Terminology: echogenic, hyperechoic, hypoechoic, anechoic, isoechoic
- Characteristics of simple fluid, complex fluid, soft tissue/solid, air/gas, bone/calcium
- Imaging modes: B-mode, Doppler, M-mode
- Knowledge of instrumentation
- Describe advantages of ultrasound
- Describe limitations of ultrasound
- Correlate patient safety and ultrasound
- Identify classic appearances of normal structures on ultrasound

Overview of Clinical Applications of Ultrasound Imaging

The PT point-of-care application of USI can be described in two broad categories, diagnostic and procedural. Diagnostic USI in point-of-care applications are using USI as one component of the diagnostic process. The PT utilizes information gained from USI combined with patient history and physical examination findings along with other relevant data to arrive at a diagnosis. Point-of-care diagnostic USI is distinct from USI examinations performed by a consultant who does not participate in patient care beyond the USI examination and rendering a report to the treating clinician.

Procedural US in PT practice encompasses many interventions that include but are not limited to patient biofeedback, neuromuscular re-education, monitoring real-time changes in morphology and movement during interventions, documenting change in clinical conditions, using US localize to target areas for manual interventions and physical agents, and using US to guide needle placement in interventions such as dry needling, electromyography, and nerve conduction velocity.

Ultrasound Imaging Equipment

Ultrasound imaging equipment is available from many manufacturers. Elsewhere in this manual are resources that provide guidance on equipment selection. In particular, the Royal College of Radiologists: *Standards for Ultrasound Equipment*[67] and the American Institute of Ultrasound in Medicine: *Practice Guideline for the Performance of a Musculoskeletal Ultrasound Examination*[68] are particularly informative.

Ultrasound Imaging Teaching Models

Teaching the practical aspect of USI at a minimum requires a student, an instructor, an ultrasound machine, and a live or simulated model. Commonly, PT students use their classmates as models for other content areas and the same approach can be used in teaching USI. Consideration can also be given for using USI on human and animal cadavers. There are artificial USI simulators available but generally they are not optimal for physical therapy education. Individuals solicited from the community can be excellent models. Community models have an advantage of generally providing greater anatomic and age variation than classmates. When utilizing human models, one needs to consider developing a policy to address the disclosure of incidental findings obtained during USI and to limit pressure on models to expose sensitive body areas. A valuable resource in multiple aspects of teaching ultrasound is the Alliance of Medical Student Educators in Radiology (AMSER) Curriculum, Competencies, and Objectives.[69]

Clinical Education

Clinical instructors are a contracted extension of the academic institution. Therefore Cis are expected to provide opportunities for the student to learn and apply judicious use of imaging in patient management, as allowed and appropriate for the patient population at the facility, the skills of the CI, and state regulations. Adequate instruction from a properly qualified CI is a continuum of the academic program's instruction and is essential in students' development of skill in the utilization of imaging. Given the appropriate academic background and guided practice, students can be expected to incorporate imaging safely and effectively in patient management.

Clinical Instruction and Documentation of Student Performance

The CI should use progressive student questioning on the safety, theory, indications, and contraindications for imaging. In settings where US is available with appropriately trained CIs in USI, the student should practice the application of US in a safe and progressive fashion, and offer feedback on the skill performance and critical thinking process.

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CONTACT LIST

This section includes a contact list for physical therapists searching for information to assist with the development and implementation of curricula and courses covering imaging. Organizations and individuals are listed that can be utilized to answer questions, gain guidance, and/or other forms of assistance.

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