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**American College of Radiology  
ACR Appropriateness Criteria®**

**Clinical Condition:**      **Limping Child — Ages 0-5 Years**

**Variant 1:**                      **Nonlocalizable pathology by clinical evaluation (no concern for infection).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray lower leg	8	Tibia/fibula only.	⊕
US hip	6	Toxic synovitis and septic arthritis usually present with localizing symptoms.	0
X-ray pelvis and leg and foot	5	May be considered as secondary investigation after negative tibia/fibula examination.	⊕⊕
X-ray lumbar spine	5	Frontal and lateral views.	⊕⊕
Tc-99m 3-phase bone scan lower thoracic spine to distal lower extremities	5		⊕⊕⊕⊕
MRI lower thoracic spine to lower extremities without IV contrast	5	Superior to bone scan for soft-tissue pathology. Data for contrast administration in this scenario are limited. Sedation risks should be considered.	0
MRI lower thoracic spine to lower extremities without and with IV contrast	5	Superior to bone scan for soft-tissue pathology. Data for contrast administration in this scenario is limited. Use contrast if needed based on evaluation of noncontrast MRI findings. Sedation risks should be considered.	0
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Variant 2:**                      **Localized pathology by clinical evaluation (no concern for infection).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
MRI area of interest without IV contrast	6	Sedation risks should be considered.	0
MRI area of interest without and with IV contrast	6	Use contrast if needed based on evaluation of noncontrast MRI findings. Sedation risks should be considered.	0
US area of interest	5	Consider for palpable soft-tissue mass or suspected joint effusion. Provides only limited data for evaluation of osseous abnormalities.	0
CT area of interest without IV contrast	3		Varies
CT area of interest with IV contrast	2		Varies
CT area of interest without and with IV contrast	1		Varies
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Clinical Condition:** Limping Child — Ages 0-5 Years

**Variant 3:** Concern for infection, including septic arthritis.

Radiologic Procedure	Rating	Comments	RRL*
US hips	9		O
X-ray pelvis	8		☼☼
MRI pelvis without IV contrast	7	Sedation risks should be considered.	O
MRI pelvis without and with IV contrast	7	Use contrast if needed based on evaluation of noncontrast MRI findings. Sedation risks should be considered.	O
X-ray lumbar spine	5		☼☼
Tc-99m 3-phase bone scan area of interest	5	If MRI is not available or contraindicated.	☼☼☼☼
CT area of interest with IV contrast	4	If MRI is not available or contraindicated.	Varies
CT area of interest without IV contrast	2		Varies
CT area of interest without and with IV contrast	1		Varies
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

## LIMPING CHILD — AGES 0-5 YEARS

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### **Summary of Literature Review**

The limping child can be a diagnostic dilemma for clinicians [1-10]. The role of radiology in the evaluation varies depending on the clinical presentation, signs, and symptoms. In general, the differential diagnosis of limping depends on the patient's age, presence of signs of infection, any localization of pain, and history of trauma [11]. The presence of fever, elevated white blood count, elevated erythrocyte sedimentation rate (ESR) or elevated C-reactive protein may suggest infection. Increased heart rate may be a sign of infection but may also be explained by the presence of pain. The presence of erythema, swelling, or maximal tenderness may help localization. Physical maneuvers and signs such as the Trendelenburg test, Galeazzi sign, Patrick/FABER test, pelvic compression test, or psoas sign may also help localize pain [12]. A detailed analysis of gait can also suggest the diagnosis [11].

Many articles discussing clinical evaluation and differential diagnoses have been written, with several clinical algorithms proposed [1,10,13-15]; however, there are no prospective studies using imaging algorithms for evaluation of the limping child.

In order to provide clear and helpful recommendations, the radiologic algorithm can be narrowed down by clinical scenarios:

Scenario 1: Trauma.

Scenario 2: No trauma, no signs of infection.

Scenario 3: Possible presence of infection.

#### **Scenario 1: Trauma**

The most common etiology of acute limping in children is traumatic injury [1]. Clinical examination and history may allow localization of the pain or injury to a specific area, which can target the radiologic examination. Targeted radiographs in two or three planes of the area of concern are appropriate in this scenario. Unfortunately, particularly in small children, it is common that the pain cannot be accurately localized to one focal area.

#### *Radiographs*

In children <4 years of age, it is common for clinicians to order plain radiographs from the pelvis to feet, due to the patient's typical lack of verbalization and the inability to localize symptoms [14,16]. Radiographs of the lower extremities are often normal [17,18], with reports of fracture incidence ranging from 4%-20%. Tibial fractures are one of the most common diagnoses in this scenario [19]. Recently, Baron et al [20] retrospectively evaluated the use of total-extremity radiographs (133 patients) versus tibia films alone (128 patients) in children <4 years of age presenting with non-weight-bearing and nonfocal examination. Of these 261 patients, 36 (14%) had tibial fractures on initial radiographic imaging. The study found one nontibial fracture (metatarsal) in total-extremity imaging over tibial films, and suggests limited imaging focused to the tibia in patients in this age range with nonfocal clinical examinations. The concept of fracture diagnosis with decreased radiography and improved clinical criteria has been documented even in the broader pediatric age range [21,22]. McConnochie et al [21]

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utilized logit analysis and statistical modeling to determine that using the most predictive clinical signs and symptoms would avoid 25.8% of lower-extremity radiographs. Rivara et al [22] found that gross deformity and point tenderness detected 97% of lower-extremity fractures in children 1-15 years of age and suggest that, in the absence of these findings, diagnosing a fracture by radiographs is low.

If initial imaging is normal, but symptoms persist, follow-up imaging may be useful. In the Baron study [20], follow-up radiographs in a portion of patients with continued symptoms yielded four additional missed tibial fractures, shown to be subtle toddler's fractures with interval development of periosteal reaction. One patient who was discharged later returned with worsening symptoms and signs of infection and was found to have spinal discitis and epidural abscess. As these examples demonstrate, if initial evaluation is negative, follow-up instructions and evaluation may be necessary.

#### *Nuclear Medicine*

Radionuclide bone scans have shown some efficacy in evaluating limping children younger than 5 years of age, particularly when the examination is nonfocal [23,24]. The bone scan provides a total-body screen and is sensitive in detecting bone or soft-tissue abnormality. Englaro et al [18] studied patients without radiographic abnormalities of the lower extremities and no history of fever or infection, child abuse, or malignancy, and found that 30 out of 56 patients had abnormal bone scans, with the dominant finding of tarsal uptake (16 patients) thought to be due to stress injury. Aronson et al [17] studied a group of 50 children and showed similar findings of localization of abnormal uptake in 54% of patients. It is rare for bone scan to be the first study in a child with trauma. There are instances where bone scintigraphy may be helpful in detecting injury, particularly in nonverbal neurodevelopmentally delayed children [25]. Toddler's fractures are well visualized by bone scan [26]; however, given the additional cost and radiation exposure, this is not usually the preferred modality of diagnosing toddler's fractures.

#### *Computed Tomography*

The role of computed tomography (CT) is limited in the early workup of a child with a limp, due to the ionizing radiation and the efficacy of other imaging modalities. It can be useful in preoperative evaluation of known fractures [27], in diagnosing osteoid osteoma, and in detecting osteopenia in early tibial stress fractures [28].

#### *Magnetic Resonance Imaging*

Magnetic resonance imaging (MRI) is a costly examination and, in this age range, often requires sedation due to the length of the examination. MRI is sensitive for soft-tissue and bony injury, with particular use in detection of stress fractures [28,29]. It may be performed in selected younger children, when complications, alternate diagnoses, or subtle injuries need to be diagnosed or excluded.

### **Scenario 2: No Trauma, No Signs of Infection**

In this scenario, patients may be presenting with nonacute development of limping or possibly unwitnessed acute trauma. The differential diagnosis in this scenario is broader and encompasses other entities such as toxic synovitis, Legg-Calve-Perthes (LCP) disease, juvenile idiopathic arthritis, developmental dysplasia of the hip (DDH), child abuse, and neoplasm.

Transient synovitis of the hip, also known as toxic synovitis, affects approximately 3% of children, typically during the ages of 3-10 years. Although the etiology is not completely elucidated, many of the children who present with transient synovitis will have had an upper respiratory illness in the preceding 2 weeks, suggesting an inflammatory postviral response. Nearly all children recover with rest and anti-inflammatory medication within 2 weeks [30]. In a prospective study of 243 children under 14 years of age presenting with an atraumatic limp [31], the most common diagnosis was transient synovitis. Radiographs may demonstrate subtle signs of toxic synovitis, such as hip joint space widening, loss of soft-tissue planes around the hip joint, or slight demineralization of the bone of the proximal femoral metaphysis. However, the sensitivity and specificity of radiographs for this diagnosis are low. Making an accurate and specific diagnosis based on a bone scan may be difficult, as the scan may show decreased uptake early in the disease process and increased uptake later due to hyperemic response.

Ultrasound (US) of the hip is a fast, radiation-free examination that has high sensitivity for detecting hip effusions [32]. Given the frequency of diagnosis, Fischer and Beattie [31] routinely use US as the primary imaging modality, reserving radiographs for cases where the US was negative. Terjesen and Osthus [33] also suggest US as the primary imaging technique in transient synovitis, with radiography being unnecessary in uncomplicated cases. False negatives can occur with US, with a reported rate of 5%, due to inadequate examinations or very

early scanning [34]. One study showed that radionuclide bone scan in the irritable hip workup had limited diagnostic value when findings on US were negative [35]. As transient synovitis may have overlap clinically with septic arthritis, laboratory values and fluid aspiration are key in differentiating the two entities [36]. MRI has been shown to be helpful in differentiating transient synovitis from septic arthritis [37,38].

LCP is an idiopathic avascular necrosis of the proximal femoral epiphysis. LCP is a rare condition affecting 0.005%-0.016% of the population, with a predisposition towards boys (5:1). It is typically diagnosed between 2-14 years of age, with peak incidence at 5-6 years of age. Typically unilateral, LCP can occur in both hips in 15% of patients. Evaluation traditionally begins with radiographs (anteroposterior [AP] and frog leg lateral positions). Early in the disease process, subcortical lucency may be seen, with progression to femoral head cortical collapse, fragmentation, sclerosis, and widening and shortening of the femoral head/neck.

There are definite roles for contrast-enhanced MRI and/or bone scintigraphy, particularly in the classification and outcome prediction in patients with Langerhans cell histiocytosis (LCH) [39-47]. Postcontrast MRI can show its avascular appearance within the proximal femoral epiphysis and better delineates its extent and severity to allow a more accurate prognosis [40].

Juvenile idiopathic arthritis (JIA) is a diagnosis that applies to any arthritis of unknown origin that occurs before the age of 16 years and persists for more than 6 weeks. The classification of JIA is recent (2000) and encompasses many subgroups (and previous classifications) of arthritides, including juvenile chronic arthritis and juvenile rheumatoid arthritis. Its overall incidence is not well reported; however, it is thought to be a rare cause of limping in children, and can present even in the preschool years. Initial radiographs can be normal or show minor nonspecific changes such as soft-tissue swelling, joint effusion, or osteopenia. Progressive radiographic changes such as joint space narrowing, erosive changes, and joint ankylosis are seen later in the disease course [48]. US has been shown to be an excellent tool in the evaluation and follow-up of JIA and more sensitive than radiography or clinical examination in detecting effusions, synovial hypertrophy, and synovial cysts. MRI is superior to both US and radiography in detecting inflammatory changes in the joint and cartilage damage. Subtle erosions, loss of joint space, cartilage damage, and ligamentous involvement are also better detected and delineated with MRI [49]. While US and MRI are the best modalities for detection and follow-up of JIA, limited use of bone scan is reported. Actively inflamed joints can be demonstrated. However, increased uptake is also seen in normal growth plates, which may be very close to the adjacent joints, thus limiting the evaluation [50].

DDH is often diagnosed within the first year of life by physical examination and/or by radiologic screening in predisposed populations. Specific ACR Appropriateness Criteria<sup>®</sup> have been constructed for this scenario (See the ACR Appropriateness Criteria<sup>®</sup> on “[Developmental Dysplasia of the Hip — Child](#).”) If clinical history suggests undiagnosed DDH in the older infant or child, AP radiograph of the hips will confirm the diagnosis.

Child abuse should be considered a possibility if soft-tissue or skeletal injuries are identified without the appropriate traumatic clinical history. As this is an extremely important topic, separate ACR Appropriateness Criteria<sup>®</sup> have been constructed for guidance in imaging (See the ACR Appropriateness Criteria<sup>®</sup> on “[Suspected Physical Abuse — Child](#).”).

Neoplasm may present in scenario 2 or 3 and is discussed below.

### **Scenario 3: Possible Infection**

Limping in the presence of one or more of the following clinical/laboratory signs should suggest the possibility of infection: fever, elevated white blood count, elevated ESR, or elevated C-reactive protein. The differential diagnoses in this scenario most commonly include septic arthritis, transient synovitis, osteomyelitis, diskitis, and psoas abscess. Neoplastic entities, such as leukemia, osteosarcoma, Ewing’s sarcoma, LCH, and osseous metastatic disease may present in either scenario 2 or 3.

Septic arthritis is the most common cause of acute severe monoarticular pain in children. It typically results from hematogenous and subsequent intra-articular *Staphylococcus aureus*, with the hip being the most common site of involvement [51,52]. Septic arthritis requires rapid diagnosis to prevent or limit adverse outcomes [53].

Osteomyelitis is most common in young children, peaking around 3 years of age, with approximately half of the cases occurring in children <5 years of age. Hematogenous spread of disease is the most common source, and *Staphylococcus aureus* is the most common organism isolated. One-third of children presenting with

osteomyelitis will have a history of recent trauma at the site, and involvement is most common at the metaphyseal region of the long bones of the lower extremities [6,54].

Diskitis is a rare inflammatory and/or infectious process of the intervertebral disc, which may involve the adjacent vertebral bodies (osteomyelitis) and may extend into the adjacent soft-tissues and epidural space. An incidence of 1/100,000 is reported with a bimodal distribution, with a peak incidence at ages 1–4 years and less commonly at 10–14 years. A recent study and review of cases suggests it can be a difficult diagnosis to make, particularly because of the lack of early radiographic and definitive bone scan findings [55].

Neoplasm should be included in the differential diagnosis, as the laboratory findings and presentation may overlap with osteomyelitis. Diffuse marrow abnormalities may suggest leukemia or metastatic disease, particularly in neuroblastoma. Soft-tissue masses and associated calcification should raise concern for osteosarcoma and Ewing's sarcoma, although they are less common in the 1-5-year-old population.

LCH is an aggressive marrow-replacing histiocytic disorder thought to be either inflammatory or neoplastic, with a reported incidence of 8-9/1 million. Involvement can be at a single site or can involve multiple organs. Imaging appearance may be benign, as with a well-circumscribed lytic lesion, or can be aggressive with associated soft-tissue mass, overlapping in appearance with osteomyelitis and tumor.

Myositis and soft-tissue abscesses are less common but have been reported in all ages of children, including infants and toddlers, but the largest clustering in children appears to be in children 6-17 years of age [56-58].

Given the spectrum of these differential diagnoses, imaging guidelines can be further classified by the clinical examination: localized pain (hip or nonhip) or nonlocalizable pain.

### **Scenario 3A: Localized Pain to the Hip**

Localization is important in the radiologic evaluation of the patient. If the pain appears localized to the hip, the diagnosis of exclusion is septic arthritis. As mentioned in the transient synovitis discussion above, US of the hip allows the quick and accurate diagnosis of a joint effusion. Aspiration is the gold standard in differentiating septic arthritis from transient synovitis [32,59,60]. There are studies that suggest clinical data can help determine which effusions need to be aspirated [53,61,62]. The presence of fever, an elevated C-reactive protein level, an elevated ESR, lack of weight-bearing, and an elevated serum white-blood-cell count have been shown to be indicators of septic arthritis, with the presence of several of these factors and documented joint indicated a >90% probability of septic arthritis [53,61]. However, this clinical protocol has proven less specific in other researchers' studies [60]. MRI of the pelvis in cases of septic arthritis may demonstrate associated osteomyelitis or associated soft-tissue abscess [63] and may be considered following sonography if clinical history suggests a longstanding infection.

In the absence of a hip effusion and with signs of infection and hip localization, a diagnosis of pelvic osteomyelitis or pyomyositis should be considered. A study by Karmazyn et al [64] concluded that plain radiographs of the pelvis may be somewhat useful but their sensitivity for detecting abnormality may be as low as 11%-30%. MRI, given its sensitivity to musculoskeletal injury and inflammation, is extremely useful in diagnosing infection, specifically osteomyelitis and pyomyositis [65-68]. Findings of infection on MRI include abnormal bone marrow signal, soft-tissue inflammation, abnormal enhancement and intraosseous, subperiosteal, and/or soft-tissue abscess formation. Contrast administration in the MR evaluation of suspected soft-tissue or osseous infection does not increase sensitivity or specificity but may increase reader confidence and better delineate abscesses [69,70]. As stated earlier, a benefit of MRI is its lack of ionizing radiation; however, the need for sedation in young patients may complicate its use in diagnosis. While bone scan has been shown to detect osteomyelitis in radiographically silent cases, in Karmazyn et al's study, bone scan was found to have only 70% sensitivity in their 33 patients as compared to MRI. Consequently the study recommends pelvic MRI in pediatric patients with acute hip pain, ESR of >30 mm/h, and no evidence of septic hip.

### **Scenario 3B: Localized Pain, Nonhip/Lower Extremity**

Plain radiographs of the localized area of pain should be obtained. Irregular or mottled lucencies reflect marrow abnormality, and periosteal elevation demonstrates inflammatory reaction and chronicity, as in infection or neoplasm. Soft-tissue mass and calcification without a history of trauma suggest neoplasm. MRI, given its sensitivity to musculoskeletal injury and inflammation, is extremely useful in diagnosing infection, specifically osteomyelitis and pyomyositis [65-68]. Findings of infection on MRI include abnormal bone marrow signal, soft-tissue inflammation, abnormal enhancement, and intraosseous, subperiosteal and/or soft-tissue abscess formation. Contrast administration in the MR evaluation of suspected soft-tissue or osseous infection does not increase

sensitivity or specificity but may increase reader confidence and better delineate abscesses [69,70]. As stated earlier, a benefit of MRI is the lack of ionizing radiation; however, the need for sedation in young patients may complicate its use in diagnosis. Due to the severity of late diagnosis of infection, the presence of signs and symptoms of infection often outweigh the risks of sedation in this scenario. While bone scan has been reported to have a high sensitivity for the diagnosis of osteomyelitis [71], MRI has been advocated as the imaging technique of choice for evaluation of pelvic osteomyelitis because of its lack of ionizing radiation and better ability to detect abscesses [72]. While no prospective study of MRI versus bone scan has been performed in this scenario, review of recent literature suggests that MRI is commonly used in the evaluation. A recent retrospective study examining bone scan and MRI demonstrated a much higher sensitivity of MRI (99%) compared to bone scan (53%) and suggested that the imaging algorithm of plain radiographs be followed by MRI [73]. Even after a positive bone scan, MRI is often obtained for further evaluation of soft-tissues to detect any abscess formation [74].

### **Scenario 3C: Nonlocalized Pain**

In nonlocalizable limping with possible infection, radiographs of the spine, pelvis, and lower extremities may help localize an abnormality. However, low sensitivities have been reported [64,73]. As stated above, in the acute presentation of osteomyelitis, plain radiographs are typically normal. MRI or bone scan can be considered in this scenario. While there have been no prospective studies comparing MRI and bone scan in the evaluation for osteomyelitis, both imaging techniques have reported high sensitivity for the diagnosis. Positives for performing MRI include lack of ionizing radiation and better resolution and soft-tissue evaluation, with the dominant negative being the need for sedation in this age group. Contrast administration during MRI has not been shown to be necessary in the evaluation for soft-tissue or osseous infection, particularly in the absence of signs of edema [69,70]. Positives for bone scan include cost-effective diagnosis and whole-body imaging for site localization, with the dominant negative being the lack of soft-tissue detail and abscess detection [71] and slightly decreased sensitivity [73,74]. As stated above, review of the literature suggests that more centers may be using MRI in the evaluation for osteomyelitis; however, no prospective study has fully evaluated the scenario of a limping child without a localizable site.

Fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET) imaging and leukocyte scintigraphy can be useful in evaluating chronic osteomyelitis, outperforming MRI and radiographs in a study by Termaat et al [75]. Whole-body MRI may also be helpful in children with multifocal abnormalities [76].

### **Summary**

- The type of imaging evaluation to be used for a limping child can be determined after a thorough clinical evaluation. Eliciting a history of trauma and/or signs of infection can help focus the imaging pathway to diagnosis.
- Imaging pathways for the above-described three scenarios (trauma, no trauma/no signs of infection, and possible presence of infection) vary due to the diverse differential diagnoses in these subgroups.
- In a post-traumatic setting, localized radiographs or tibial radiographs are most appropriate.
- In an atraumatic and noninfectious history, hip US may be the initial study of choice, with radiography to follow if the US finding is negative. If there is a suggestion of infection, MRI is the study of choice, with radiography a low-sensitivity but commonly obtained initial imaging modality. Bone scan may also be considered in this setting, particularly if the site of tenderness or pain cannot be determined.

### **Relative Radiation Level Information**

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.



Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊕	<0.1 mSv	<0.03 mSv
⊕⊕	0.1-1 mSv	0.03-0.3 mSv
⊕⊕⊕	1-10 mSv	0.3-3 mSv
⊕⊕⊕⊕	10-30 mSv	3-10 mSv
⊕⊕⊕⊕⊕	30-100 mSv	10-30 mSv

\*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies”.

### Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to [www.acr.org/ac](http://www.acr.org/ac).

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.