Several postoperative complications associated with pain may develop in the stump of an amputated lower limb. Clinical findings are often nonspecific; however, radiologic evaluation, especially with magnetic resonance (MR) imaging, is useful in the early diagnosis of these complications, thereby helping minimize physical disability with its psychological and socioeconomic implications. Conventional radiography can demonstrate evidence of osseous origins of pain (eg, aggressive bone edge, heterotopic ossification, osteomyelitis) and should be the first imaging study performed after clinical examination. Videofluoroscopy can help evaluate improper prosthetic fit by demonstrating abnormal residual limb motion, piston action, rolling of soft tissues, and abnormal angle between the limb axis and the prosthesis during gait. Ultrasonography can demonstrate inflammatory changes in the stump as well as soft-tissue fluid collections. However, MR imaging is the modality of choice when clinical and other imaging findings are indeterminate. Because of its high spatial and contrast resolution, MR imaging can demonstrate subtle inflammatory changes, fluid collections, cancers, neuromas, and subtle traumatic bone lesions. Knowledge of various surgical and rehabilitation techniques is required for accurate diagnosis of complications associated with stump pain. Correct diagnosis allows choice of the most appropriate therapy, which may involve treating the stump, remodeling the prosthesis, or both.
Introduction
Amputation is one of the oldest types of surgery and the most commonly performed. It is indicated in a variety of pathologic conditions including major limb trauma, posttraumatic gangrenous infections, ischemia, noncontrollable infected pseudarthrosis, and tumors with neurovascular invasion. An estimated 400,000 persons with amputated limbs live in the United States, with approximately 60,000 lower limb amputations performed in the U.S. each year. Appropriate treatment and prosthetic rehabilitation can often improve the quality of life for these patients.

Diagnosis of the various causes of stump pain is difficult because clinical manifestations are often nonspecific. Very little data regarding imaging for stump pain have been published in the radiology literature, and most of these data deal with neuroma. However, radiologic evaluation has proved to be helpful in many cases in conjunction with physical examination. Such evaluation can help make an early determination of the cause of pain and disability in a patient who has undergone lower limb amputation, thereby helping limit the psychologic and socioeconomic difficulties associated with this condition.

In this article, we discuss surgical considerations in lower limb amputation as well as prosthetic rehabilitation and classification of lower limb stump pain. In addition, we discuss and illustrate the utility of various imaging modalities in the setting of a painful stump and the radiologic appearances of a variety of causes of non–prosthesis-induced stump pain (aggressive bone edge, heterotopic ossification, osteomyelitis, cancer and tumor recurrence, neuroma, phantom pain) and prosthesis-induced stump pain (bursitis and soft-tissue inflammation, stress fractures and bone bruises, cutaneous lesions).

Surgical Considerations in Lower Limb Amputation
Amputation is performed in different clinical situations by surgeons practicing different subspecialties. In the oncologic setting, amputation is planned and performed according to the rules of surgical oncology. In cases of major multiple trauma that is life-threatening, it can be performed by a general surgeon.

Three main principles can be applied in lower limb amputation. First, it is necessary to consider prosthetic management before performing surgery. The level of amputation has strong implications for postoperative rehabilitation. To ensure the best possible results for ambulation, the knee should be preserved as much as possible. The length of the stump is another main consideration in ensuring successful rehabilitation. In cases of above-knee amputation, it is recommended that at least 10 cm below the ischium be preserved to prevent the lameness and perineal skin damage that can be caused by the socket edge. In cases of below-knee amputation, it is recommended that at least 8 cm below the tibial plateau be retained to allow optimal control of the socket and reduce end-bearing. Prosthetic management tends to be problematic if amputation is performed 4 cm or less below the tibial plateau (1).

The incision is usually cuneiform to keep enough muscle tissue to adequately pad the stump. The stump should not be too thin or contain redundant soft tissue. The periosteum should be resected below the site of osseous amputation to hermetically cover the end of the amputated bone, which should be blunted (1). In cases of below-knee amputation, the Farabeuf angle should be maintained by cutting the fibula 2 cm above the tibia. The anterior tibial tuberosity should also be rounded off (1). The vascular structures are ligated, and the nerves should be resected by moderately pulling them to induce retraction of the nerve endings away from the muscular-cutaneous scar (3). The muscles are sutured to give sufficient volume to the stump and to pad the bones. The cutaneous scar is usually localized posteriorly in the coronal plane out of the weight-bearing area. Postoperatively, the stump should be kept elevated to minimize edema, and tightly bound bandaging is left in place for 2–3 weeks.

Any of the surgical steps may generate complications with varying degrees of severity leading to early or late disability. These complications are summarized in Table 1.

Prosthetic Rehabilitation
Cicatrization is mostly complete within 2–3 weeks, at which time a temporary prosthesis is designed. The shape of the socket is continuously modeled to correct the decrease of edema, and the definitive prosthesis is designed 2–3 months after surgery (3).

Conventional prosthetic sockets usually rely on osseous protuberances like the ischium or the greater trochanter in cases of above-knee amputation. They rely on the patellar tendon and the anterior tibial tuberosity in cases of below-knee amputation. The most common type of prosthesis for below-knee amputation is the patellar tendon–bearing transtibial prosthesis. This prosthesis is easy to fit; however, it is difficult to control and leaves the patient vulnerable to cutaneous trophic lesions in the weight-bearing areas. Nevertheless,
Table 1
Clinical Manifestations and Treatment of Postoperative Complications of Lower Limb Amputation

<table>
<thead>
<tr>
<th>Surgical Procedure</th>
<th>Potential Complications</th>
<th>Clinical Features Associated with Pain</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuneiform incision</td>
<td>Thin stump, redundant</td>
<td>Telescoping or pistonning</td>
<td>Prosthesis fitting</td>
</tr>
<tr>
<td></td>
<td>soft tissue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periosteal coverage</td>
<td>Heterotopic ossification</td>
<td>Soft-tissue damage, ulceration</td>
<td>Prosthesis reshaping,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>stump revision</td>
</tr>
<tr>
<td>Bone edge blunting</td>
<td>Aggressive bone edge</td>
<td>Soft-tissue damage, ulceration</td>
<td>Prosthesis reshaping,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>stump revision</td>
</tr>
<tr>
<td>Farabef angle maintenance</td>
<td>Aggressive bone edge</td>
<td>Soft-tissue damage, ulceration</td>
<td>Prosthesis reshaping,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>stump revision</td>
</tr>
<tr>
<td>Vascular suturing</td>
<td>Hematoma</td>
<td>Swelling</td>
<td>Survey, drainage</td>
</tr>
<tr>
<td>Nerve cutting</td>
<td>Neuroma</td>
<td>Mass, Tinel sign</td>
<td>Conservative therapy,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>resection</td>
</tr>
<tr>
<td>Muscular suturing</td>
<td>Thin stump, redundant</td>
<td>Telescoping or pistonning</td>
<td>Prosthesis fitting</td>
</tr>
<tr>
<td></td>
<td>soft tissue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutaneous suturing</td>
<td>Scar in the weight-bearing area, keloids</td>
<td>Calluses, abrasion, ulceration</td>
<td>Prosthesis fitting, excision with plastic repair</td>
</tr>
<tr>
<td>Postoperative contention</td>
<td>Lymphedema</td>
<td>Edema</td>
<td>Tightly bound bandaging</td>
</tr>
<tr>
<td>Preventive anticoagulation</td>
<td>Deep venous thrombosis</td>
<td>Swelling</td>
<td>Anticoagulation therapy</td>
</tr>
</tbody>
</table>

They are known as total surface–bearing prostheses (Fig 1) and are most often designed with plaster cast molding to ensure adequate encasement of the stump. These prostheses optimally distribute the mechanical load to avoid steep pressure gradients at the lower end, piston action of the stump in the socket, and stretching of the skin (5), thereby minimizing soft-tissue damage (1,4).

Additional silicone soft inserts of varying thickness are usually positioned at the residuum-socket interface to ensure stability, load absorption, and comfort. These soft inserts adhere directly to the prosthesis and to the residuum by vacuum action (Fig 1).

In all cases, rehabilitation must be started as soon as possible because the level of mobility achieved is related to time elapsed since amputation (6). It should include posture and coordination exercises to avoid stump shrinkage, which can lead to complications such as muscular atrophy, contracture, retraction, and ankylosis.

Prosthetic fit can be evaluated with both subjective and objective criteria. Subjective criteria evaluate patient comfort level at rest and during gait. Discomfort can be estimated with visual analogic scales. Objective criteria include residual limb motion, piston action of the stump, rolling of soft tissues, and angle between the axis of the limb and the prosthesis during gait. These criteria can be assessed with clinical and videofluoroscopic examination (5,7). Volumetric assessment of the

Figure 1. Diagram illustrates a total surface–bearing transtibial prosthesis. a = lower limb, b = stump covering, c = soft insert, d = hard socket, e = joint with prosthetic foot.

it constitutes the only prosthetic solution when the stump is too thin (1,4).

Recently developed prosthetic sockets are preferable when the stump volume is satisfactory.
stump with and without weight-bearing views can be performed with optical surface scanning and three-dimensional spiral computed tomography (CT) (8,9).

**Classification of Lower Limb Stump Pain**

In cases of a painful stump, the first question to consider is whether the pain is intrinsic or extrinsic. Extrinsically, pain could be the result of a conflict between the stump and the prosthesis due to improper fit or alignment. Extrinsic pain can be relieved mostly by reshaping the socket without specific therapy for the stump.

Intrinsic pain is related to numerous pathologic processes with different origins. Some of these processes may be related to improper or unsuccessful surgical techniques. Intrinsic pain may at times develop at a distance from the stump without a well-defined anatomic substratum (phantom limb pain). Management of intrinsic pain often requires specific therapy for the stump. Transcutaneous nerve stimulation of a neuroma, surgical resection of heterotopic ossification, or abscess drainage...
may be sufficient to relieve the pain. Sometimes, systemic therapy (antibiotic therapy, analgesia) is needed. In these situations, the prosthesis might not be responsible for the onset of pain; however, modification of a socket or placement of soft inserts within the prosthesis to correct uneven loading can relieve pain and should be attempted before surgery.

Causes of Non–Prosthesis-induced Stump Pain

Aggressive Bone Edge

When the Farabeuf angle in below-knee amputation is not maintained or when the bone end of a stump is not blunted, the bone edge can cause soft-tissue stress or ulceration, particularly at the anterior tibial tuberosity or at the end of the fibula if it is left too long (1).

These disease entities can be accurately assessed with conventional radiography (Fig 2). Anteroposterior and lateral radiography with weight-bearing views can demonstrate soft-tissue compression associated with piston action of the stump in the socket (Fig 3). Inflammatory changes are usually better depicted with magnetic resonance (MR) imaging.

Heterotopic Ossification

Heterotopic ossification is frequently encountered at the stump end. During amputation, the surgeon should consider resecting the periosteum longer than the bone to adequately cover the bone end. When the end is not well covered with periosteum, spike-shaped heterotopic ossification might develop in the soft tissue, generating pain, inflammation, or ulceration (1).

Conventional radiography is the method of choice in diagnosing heterotopic ossification, especially with anteroposterior and lateral weight-bearing views (Fig 4). Soft-tissue damage with
inflammatory changes are usually best seen at MR imaging (Fig 5).

**Osteomyelitis**

Bone infection can occur many years after amputation from late recurrence of a quiescent septic focus, spread from a contiguous soft-tissue infection, or hematogenous spread of infection.

Conventional radiography is particularly useful for comparative studies, but changes including osteolysis and osteosclerosis with periosteal reaction are often neither specific nor sensitive for osteomyelitis (Fig 6a). MR imaging and radionuclide bone scintigraphy are the methods of choice in detecting and localizing inflammatory changes. MR imaging is more sensitive in demonstrating related soft-tissue inflammation and mapping fluid collections prior to drainage (Fig 6b, 6c). It can also be used to exclude the diagnosis of osseous spread of a soft-tissue infection (10). CT is particularly useful in detecting sequestra that could not be seen at MR imaging (Fig 6d). In cases of fluid discharge, fistulography can show evidence of a sinus tract between the bone and the skin. Ultrasonography (US) can facilitate drainage of a soft-tissue fluid collection (11).

**Cancer and Tumor Recurrence**

Local tumor recurrence may occur many years after amputation for neoplasm. Microscopic skip metastases may be present in the initial stage or may develop later. Implantation of tumor cells in the soft tissue at the time of surgery is another possibility. Periodic clinical and imaging evaluation can help detect local recurrence prior to dissemination. Conventional radiography is particularly useful for comparative studies, but MR imaging is the method of choice in detecting and localizing recurrence (10).

Rarely, malignant transformation into squamous cell carcinoma may develop in a sinus tract of chronic osteomyelitis (12). A less common occurrence is malignant degeneration following

**Figure 5.** Heterotopic ossification in a patient with pain and disability who had undergone above-knee amputation. (a) Coronal T1-weighted MR image shows a spur on the lower end of the femur as well as heterotopic ossification associated with soft-tissue inflammation (bottom arrow). Osteonecrosis of the femoral head is also present (top arrow). (b) Axial T1-weighted MR image shows evidence of soft-tissue inflammation around the femoral spur (white arrow). Sciatic neuroma is also depicted (black arrow).
Figure 6. Osteomyelitis in a patient who had undergone below-knee amputation for trauma. (a) Anteroposterior radiograph shows osseous abnormalities including osteolytic and condensed zones with periosteal reaction. (b) Coronal T1-weighted MR image shows a large, intraosseous area of low signal intensity at the lower end of the tibia (arrow). (c) Axial gadolinium-enhanced fat-saturated T1-weighted MR image shows an intraosseous abscess (white arrow) extending to the skin through a sinus tract (black arrow). (d) Coronal reconstructed CT scan shows periosteal reaction (open arrow), an intramedullar sequestrum (small solid arrow), and an opening in the cortical wall (large solid arrow).
chronic lymphedema of the stump (Fig 7). Stewart-Treves syndrome involves the occurrence of angiosarcoma following lymphedema after mastectomy. Angiosarcoma is seen in 0.07%–0.45% of patients 10–25 years after surgery. This tumor has also been associated with chronic lymphedema, which is related to other congenital and acquired disorders including parasitic infestations (eg, filariasis), trauma, and, rarely, complications of limb amputation (13,14).

Neuroma

Neuroma is a nonneoplastic proliferation that occurs at the end of an injured nerve and is usually seen 1–12 months after amputation (15,16). Two types of postamputation neuromas are encountered (15–17). Terminal neuroma originates at the end of the severed nerve. It is usually due to the proliferation of axons in any direction without the support of the Schwann cells in an abortive attempt to repair the nerve. Terminal neuroma represents a normal pattern of healing of the nerve and is often asymptomatic (2). Spindle neuroma is localized in the nerve away from the severed nerve ending and represents the response of a peripheral nerve subjected to microtrauma due to stretching or compression by the localized scar tissue. Pain associated with a neuroma does not always have a precise topography and is often difficult to distinguish from phantom limb pain.

Clinical findings may be normal or may include a soft-tissue mass or pain related to percussion of the stump (Tinel sign). Pain relief with injection of lidocaine in the painful area may help confirm the diagnosis.

Imaging is useful for confirmation and localization of a painful neuroma. Detection is usually difficult when the neuroma is less than 1 cm;
most radiologically detected neuromas have been reported to measure 1.0–3.5 cm (16–20). Sciatic neuromas are easier to detect than those arising on the smaller nerve branches of the thigh. MR imaging is considered optimal for detection of a neuroma, which has low signal intensity on T1-weighted images and intermediate to high signal intensity on T2-weighted images and demonstrates variable enhancement after administration of gadopentetate dimeglumine (Figs 8, 9). A low-signal-intensity ring on T1- and T2-weighted images is sometimes reported (15,17–19). An important limitation of MR imaging is that surgical clips or metallic fragments can cause artifacts. Some authors have evaluated the efficacy of US in the depiction of a neuroma. At US, neuromas appear as a pseudocystic, hypoechoic mass with irregular or poorly defined margins (15,17,20).

To prevent neuromas from developing following amputation, the surgeon should cut the nerve and pull it moderately to induce retraction of the nerve ending away from the muscular-cutaneous scar (1,2). During the postoperative period, it is also important to mobilize the surgical scar to prevent the scar from adhering to underlying tissues (1).

Conservative therapy has been reported to be successful in more than half of affected patients (15,21). Corticosteroid therapy, nerve stimulation, or reshaping of the socket may help relieve pain. Resection of a neuroma should not be undertaken lightly because it can induce extension of the scar area with the potential of generating a new symptomatic neuroma (21).

**Figure 8.** Sciatic neuroma in a patient who had undergone above-knee amputation and presented with pain in the lower end of the stump. (a) Axial T1-weighted MR image demonstrates a low-signal-intensity mass (arrow). (b) Axial fat-saturated T2-weighted MR image reveals a high-signal-intensity mass in the area of the sciatic nerve (arrow). (c) Coronal contrast-enhanced fat-saturated T1-weighted MR image shows diffuse enhancement of the mass (arrow). (d) Intraoperative photograph depicts the sciatic neuroma before resection.
Figure 9. Peroneal neuroma in a patient who had undergone below-knee amputation and presented with lateral stump pain. (a) Anteroposterior radiograph does not show any abnormality. (b) Axial T1-weighted MR image shows a low-signal-intensity nodular lesion in the lateral portion of the stump (arrow). (c) Coronal T1-weighted MR image shows a low-signal-intensity nodular lesion in contact with the end of the fibula (arrow). (d) Coronal contrast-enhanced fat-saturated T1-weighted MR image shows the nodular lesion with increased signal intensity associated with soft-tissue inflammation (arrow). (e) Intraoperative photograph depicts the neuroma in the distribution of the peroneal nerve.

Phantom Pain
Phantom pain should be distinguished from phantom limb sensation, which is present in almost all amputees, mostly during the initial phase after amputation. Phantom limb sensation is mostly present at the end of the stump and is a normal, painless sensation. It can be intense in the initial postsurgical phase, becoming less so after months or years.

In contrast, phantom pain is a pathologic condition that develops following amputation. It has been reported to occur in 1.5%–5.0% of amputees.
in several studies, but its true prevalence may be higher (22,23). No relationship is reported between reasons for amputation, use of prosthesis, pain sensitivity, age, years since amputation, and presence or severity of phantom limb pain (22). The only predisposing factor related to phantom pain is the presence of stump pain (23). Patients describe phantom limb pain as a burning or crushing sensation or paresthesia. The evolution of this condition varies depending on physical energy level and mood. In cases of traumatic amputation, phantom pain sometimes replicates the pain felt at the time of trauma. No abnormality is detected with current imaging methods. The primary purpose of imaging is to exclude a stump neuroma, which may simulate phantom limb pain.

**Causes of Prosthesis-induced Stump Pain**

**Bursitis and Soft-Tissue Inflammation**
Uneven loading leading to steep pressure gradients causes repeated microtrauma, resulting in inflammation of the soft tissues or bursitis in the area of weight-bearing. Adventitious bursae are cystic formations that appear de novo in the soft tissues of the stump between the skin and muscle or bone and between bones and tendons (10). They represent mucoid and myxomatous degeneration of connective tissue rather than synovial bursae. Unlike with synovial bursae, no endothelial synovial lining has been reported at pathologic examination with adventitious bursae (24,25). The latter tend to reduce friction at certain locations, including the head of the fibula, the patella, the anterior tibial tuberosity, and the end of the stump (Figs 10, 11). Adventitious bursae may remain asymptomatic and may represent a physiologic process in the amputation stump (26).
Figure 11. Bursitis of the lower end of the stump in a patient with pain and inflammation who had undergone below-knee amputation. (a) Lateral radiograph shows a soft-tissue area of increased opacity in the distal part of the stump (arrow). (b) Coronal T1-weighted MR image demonstrates low signal intensity in the soft tissues of the lower end of the stump (arrow). (c) On a coronal T2-weighted MR image, the soft tissues of the lower end of the stump demonstrate a high signal intensity similar to that of fluid (arrow). (d) Axial contrast-enhanced fat-saturated T1-weighted MR image shows a fluid collection in the lower end of the stump (arrow).
The repetition of friction and microtrauma causes inflammation of the soft tissues at the pressure points accompanied by inflammation of the bursae, resulting in pain with simple touch or with weight-bearing (10,26). Pain associated with soft-tissue inflammation or bursitis leads to restricted socket tolerance and physical disability.

Clinical findings include swollen skin with erythema and cutaneous hyperthermia. US depicts superficial bursitis as a hypoechoic area that appears similar to fluid. MR imaging better depicts a deep-seated bursa as a localized area of low signal intensity on T1-weighted images and of high signal intensity on T2-weighted images, with peripheral enhancement and progressive intrabursal diffusion of gadopentetate dimeglumine (Figs 10, 11) (10). Soft-tissue inflammation without bursitis demonstrates diffuse low signal intensity on T1-weighted MR images and diffuse high signal intensity on T2-weighted images with diffuse accumulation of contrast material after injection of gadopentetate dimeglumine (Figs 12, 13).
**Figure 13.** Soft-tissue inflammation in a patient who had undergone above-knee amputation and presented with pain at the anterior stump end. (a) Sagittal T1-weighted MR image shows low-signal-intensity infiltration of the soft tissue between the end of the femur and the socket (arrow). (b) Axial fat-saturated T2-weighted MR image demonstrates high-signal-intensity subcutaneous fat with inflammation in the area of pressure on the socket (arrow). No fluid collection is seen.

**Figure 14.** Bone bruise in a patient with pain on the inside of the knee who had undergone below-knee amputation. The bone bruise developed after the patient had participated in a sporting event. (a) Axial T1-weighted MR image depicts the internal tibial plate with low signal intensity (arrow). (b) On a coronal T2-weighted MR image, the proximal tibial marrow demonstrates high signal intensity (arrow). (c) Axial T2-weighted MR image shows bone marrow with high signal intensity (arrow), a finding that indicates edema associated with a bone bruise.
Load reduction is the treatment of choice and involves reshaping the socket to limit the pressure gradients (26,27). Replacement of a silicone soft insert with one of a different thickness may prove beneficial.

**Figure 15.** Bone bruise in a patient with pain on the posterior side of the knee and physical disability who had undergone above-knee amputation. (a) Lateral radiograph of the stump does not show any significant abnormality. (b) Sagittal T1-weighted MR image shows low-signal-intensity bone marrow in the lateral femoral condyle accompanied by edema (arrow). (c) Sagittal T2-weighted MR image shows bone marrow with high signal intensity (arrow), a finding that indicates edema associated with a bone bruise (cf Fig 14c).

**Stress Fractures and Bone Bruises**
Uneven loading on the socket or improper alignment of the prosthesis may lead to stress fractures. Diagnosis is frequently delayed because radiographic findings are still normal after 2–3 weeks. The appearance of a callus may help confirm the diagnosis (28). Earlier diagnosis is possible with MR imaging and scintigraphy. MR imaging may depict medullar bone edema with low signal intensity on T1-weighted images and with high signal intensity on T2-weighted images (Figs 14, 15) and may depict the fracture as a low-signal-intensity line with both sequences (28). In addition, MR imaging can help localize the fracture more precisely than scintigraphy and is helpful in correcting the shape of the socket.
Table 2
Suggested MR Imaging Protocol for Work-up of Patients with a Painful Stump

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type of Amputation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Above-knee</td>
</tr>
<tr>
<td><strong>Coil</strong></td>
<td>Surface or knee coil</td>
</tr>
<tr>
<td><strong>Extent of exploration</strong></td>
<td>Acetabulum to lower end of stump</td>
</tr>
<tr>
<td><strong>Section thickness</strong></td>
<td>4–5 mm</td>
</tr>
<tr>
<td><strong>Sequence and plane</strong></td>
<td>Unenhanced</td>
</tr>
<tr>
<td></td>
<td>Coronal T1-weighted; axial T1-weighted (optional); axial fat-saturated T2-weighted</td>
</tr>
<tr>
<td></td>
<td>Fat-saturated T1-weighted in two orthogonal planes</td>
</tr>
</tbody>
</table>

**Cutaneous Lesions**

Cutaneous lesions are often associated with muscular atrophy or with redundant soft tissue at the end of the stump. Scar lesions may occur as keloids, which may cause uncomfortable prosthetic fit, stretching of the skin with abrasion, and ulceration. Confinement of the stump in the socket and friction can cause skin maceration leading to folliculitis, eczema, or mycosis. Epidermoid cysts may develop in the subcutaneous tissue as a consequence of the implantation of keratin islets during surgery (26,29). Aggressive bone edge and heterotopic ossification may lead to ulceration.

Imaging can help differentiate between soft-tissue infection and osteomyelitis. US is helpful in identifying a superficial fluid collection, a finding that is suggestive of bursitis and abscess. MR imaging is more efficient in detecting a deeper soft-tissue fluid collection or in diagnosing osteomyelitis (10).

**Conclusions**

Several postoperative complications associated with pain may develop in the stump of an amputated lower limb. Conventional radiography is essential in the work-up of patients with a painful stump and should be the first imaging study performed after clinical examination. Conventional radiography can demonstrate evidence of osseous origins of pain such as aggressive bone edge, heterotopic ossification, and osteomyelitis. It can be performed with the prosthesis in a weight-bearing position to evaluate piston action of the stump. Videofluoroscopy may be performed to objectively evaluate improper prosthetic fit. It can show abnormal residual limb motion, piston action, rolling of soft tissues, and abnormal angle between the axis of the limb and the prosthesis during gait. US may be useful in cases of inflammatory changes in the stump. It can demonstrate soft-tissue fluid collections, a finding that suggests the presence of bursitis and abscess when the collection is not too deep. MR imaging is the modality of choice when physical examination and previous imaging modalities do not help identify the origin of pain. Because of its high spatial and contrast resolution, MR imaging can demonstrate subtle inflammatory changes, fluid collections, cancers, neuromas, and subtle traumatic bone lesions. Suggested MR imaging protocol for the work-up of patients with a painful stump is summarized in Table 2. Radiologic evaluation plays a major role in the early diagnosis of complications associated with a painful stump and allows proper management and treatment, which may consist of treating the stump, remodeling the prosthesis, or both.
References