MR imaging manifestations of skin tumors

Abstract In this study, we evaluated MR imaging findings of skin tumors and categorized them into four types: (1) discrete mass lesions of the dermis and epidermis, (2) mass lesions of the subcutis with or without abutment to the skin, (3) diffuse or localized skin thickening without a true mass, and (4) a skin mass with bone destruction. The categorization of MR images may be useful in the differential diagnosis of skin tumors.

Keywords MR · Skin neoplasm · Image manifestation

Introduction

Skin tumors are readily noticeable and usually diagnosed easily by gross examination. Therefore, radiological examination is not frequently needed for skin lesions compared to lesions located in other parts of the body. MR imaging has proven to be clinically useful in patients with skin tumors for preoperative evaluation of the depth and extent of primary and recurrent skin tumors. The common indications for MR imaging of skin tumors include the following: (1) the evaluation of specific imaging findings of skin tumors, (2) the evaluation of the extent of known skin tumors, (3) the evaluation of recurrence of a known skin tumor, (4) the detection of occurrence of long-term malignant complications in underlying chronic skin lesions such as burn or “Marjolin’s ulcer,” and (5) to differentiate skin tumors from skin involvement of subcutis soft tissue tumors. Thus, there is a general need to be aware of the radiological appearance of skin tumors. However, there currently is a paucity of imaging literature regarding the imaging findings of skin tumors. This article discusses the MR manifestations of a variety of benign and malignant skin tumors, as well as normal skin anatomy.

Evaluation of MR manifestations may prove helpful in the diagnosis of skin tumors and the differentiation of these tumors from other lesions of the skin. Therefore, we divided skin tumors into four types, according to their MR manifestations: (1) discrete mass lesions of the dermis and
epidermis, (2) mass lesions of the subcutis with or without abutment to the skin, (3) diffuse or localized skin thickening without a true mass, and (4) a skin mass with bone destruction. We then categorized skin tumors based on these four types.

**Normal anatomy**

The skin is composed of two layers, the epidermis and dermis; the epidermal layer is composed of keratinized stratified squamous epithelium, and the dermal layer is composed of moderately dense connective tissue. Skin has appendage structures of specialized adnexa, including the hair follicles, sweat glands and sebaceous glands, which descend into the underlying dermis from the epidermis (Fig. 1) [1]. The MR imaging of normal skin appears as a linear line with intermediate signal intensity on T1-weighted spin echo images (Fig. 2), but it is indiscernible on the T2-weighted spin echo images.

**Skin tumors**

1. **Discrete mass lesions of the dermis and epidermis**

The mass formation type of skin tumor is usually described in cases of malignant skin cancer. This type of lesion appears as a focal mass formation of the skin that protrudes outward over the skin layer. Although the imaging findings of most skin tumors are nonspecific on the MR images, a few tumors show characteristic findings. In these cases, correlation with the clinical manifestations may be helpful in differentiation from other skin tumors.

**Squamous cell carcinoma** Squamous cell carcinoma accounts for a large proportion of non-melanoma skin cancers. The most frequent predisposing factor is ultraviolet radiation, normally as the result of chronic sun exposure. These tumors have a peak incidence at 60 years of age and affect women more frequently than men [1]. The majority of mass-forming tumors have a nonspecific signal intensity pattern of low signal intensity on T1-weighted images and moderate to high signal intensity on T2-weighted images, with relatively homogeneous enhancement on contrast-enhanced images (Fig. 3). When the tumor grows and cystic necrosis develops within the tumor, it generates a heterogeneous signal intensity, including a non-enhanced region, on the contrast-enhanced images [2].

**Malignant melanoma** Most melanomas apparently arise de novo, but some develop in association with a preexisting benign nevus [1]. Melanomas have a variety of MR patterns, depending on several factors. Stable free radicals within the melanin pigment are paramagnetic and induce a shortening of T1 and T2 relaxation times. Unpaired electrons in the free radicals or, more likely, chelated metal ions present in melanin pigment, may be a secondary cause of proton relaxation enhancement after dipole-dipole interactions. Therefore, the expected signal pattern for melanotic melanoma is hyperintensity on T1-weighted images and hypointensity on T2-weighted images. In the amelanotic pattern, the lesion is hypointense or isointense on the T1-weighted images and hyperintense or isointense on T2-weighted images (Fig. 4) [3].

Amelanotic melanomas also contain melanin. However, these tumors have less than 10% of melanin-containing
Fig. 3 A 73-year-old woman with squamous cell cancer on the left wrist. 

a Coronal T1-weighted spin echo image shows a focal mass formation with low intensity (arrow).  
b Coronal T2-weighted spin echo image reveals intermediate intensity in this lesion (arrow).  
c Axial contrast-enhanced T1-weighted spin echo image shows moderate enhancement in this lesion (arrow).

Fig. 4 A 77-year-old woman with malignant melanoma in the left foot. This tumor is originated from preexisting nevus.  
a Sagittal T1-weighted spin echo image shows a focal mass formation (arrow) with hypointensity in the skin.  
This mass has a small intermediate intense nodule, suggesting melanin pigment.  
b Axial T2-weighted spin echo image reveals intermediate intensity (arrow) in this mass.  
c Sagittal contrast-enhanced T1-weighted spin echo image shows heterogeneous enhancement (arrow) in this mass.
cells on histological analysis. Intralesional hemorrhage may have a significant influence on the MR imaging appearance because such blood products also produce paramagnetic effects. The appearance of hemorrhagic lesions on the MR images is dependent on the age of the hematoma and the type of pulse sequences employed. Contrast enhancement reveals relatively homogeneous enhancement in small lesions, but the larger the mass is, the more heterogeneous the enhancement pattern tends to be [4, 5].

Dermatofibrosarcoma protuberans Dermatofibrosarcoma protuberans is an uncommon spindle cell tumor that typically develops in the dermis as an outward protruding mass. Males are slightly more commonly affected with this type of tumor than females. These tumors occur in patients of all ages, with the highest frequency of incidence between the 2nd and the 5th decades. The trunk is the most common site of involvement for dermatofibrosarcoma protuberans, accounting for almost half of all cases [1].

On MR imaging, the tumor appears as a well-defined lesion with a low signal on T1-weighted images and a signal higher than or equal to fat on T2-weighted images. This tumor usually is enhanced more strongly than other skin tumors on contrast-enhanced images (Fig. 5). Occasionally hemorrhages occur in this tumor, which give the tumor a heterogeneous appearance in the signal intensity on MR images [4, 6, 7].

Cutaneous lymphoma Cutaneous lymphomas are a heterogeneous group of non-Hodgkin’s lymphomas of T- or B-cell origin; the skin is the primary organ of involvement. The skin lesions progress from the patch stage to the plaque stage and finally become tumors [1]. The cutaneous lesions, including patches, plaques or erythroderma, are usually very difficult to discern on imaging studies. However, once a mass is clinically detected, MR can be helpful in the diagnosis of the mass. The signal intensity of this tumor is isointense on T1- and T2-weighted images, probably due to the high cellular composition of this tumor. The margin has a tendency of thorny appearance into the subcutaneous fat, suggesting lymphatic spread (Fig. 6). In addition, this mass may be associated with
reticular infiltration and/or lymphadenopathy in the subcutaneous fat layer. Cutaneous lymphomas have homogeneous enhancement on contrast-enhanced images [2, 8].

2. Mass lesions of the subcutis with or without abutment to the skin

The majority of skin tumors that develop from the skin appendage apparatus are this type [9–14]. These masses are located within the subcutaneous fat layer; however, the borders of the tumors, focally or widely, abut against the skin. Some tumors of this type reveal characteristic image findings and correlation with clinical findings may be helpful for the specific diagnosis of these tumors.

**Pilomatricoma** Pilomatricoma is an unusual benign cutaneous tumor, originating from hair cortex cells. These lesions are common in childhood, although they have occasionally been observed in elderly individuals. These tumors normally develop in males (M:F = 5:1). The majority occur in the head, neck and chest regions. The typical pilomatricoma is a firm, solitary, calcified, dermal nodule [1].

MR imaging findings of a pilomatricoma include bands of hyperintense signals radiating away from a low signal-intense center towards the periphery on T2-weighted images with or without fat suppression (Fig. 7). Enhancement at the periphery can be detected, but no enhancement is noted at the center of the lesion on contrast-enhanced images. Homogeneous intermediate signal intensity is observed on T1-weighted images. Amorphous calcification accounts for the nonhomogeneous appearance in 81–88% [9]. Low intense centers noted on T2-weighted images indicate the presence of basaloid cells and sheets of avascular epithelial cells. High signal intensity reticulations are indicative of surrounding edematous stroma [9–12].

**Epidermal cyst** Epidermal cysts are the most common type of simple epithelial cysts and are likely formed by remnant ectodermal tissues that are misplaced during embryogenesis, occlusion of the pilosebaceous unit or by the traumatic or surgical implantation of epithelial elements. These cysts are filled with keratin and variable amounts of lipid-containing debris derived from sebaceous secretions [1]. Typically, unruptured epidermal cysts are well-defined round or ovoid lesions, with characteristically low signal intensity on T1W images and high signal intensity on T2W images (Fig. 8) [13]. However, MR images show a variety of signal intensities on T1W and T2W images, depending on the chemical composition of cholesterol and keratin;
high lipid concentration leads to short T1 or T2 values; acrystalline forms of cholesterol, keratin and microcalcification lead to reductions of relaxation time values. This results in no enhancement or thin peripheral rim enhancement on contrast-enhanced images. In cases where the cyst wall ruptures, a secondary foreign body-type reaction, a granulomatous reaction or abscess formation may occur. Ruptured epidermal cysts have not only the characteristic image findings of unruptured epidermal cysts, but also septa and thick and irregular rim enhancement, as well as fuzzy adjacent soft-tissue enhancement on contrast-enhanced images (Fig. 9) [14].

**Granuloma annulare**

Granuloma annulare is an uncommon, benign group of dermatoses that develop anytime from infancy to young adulthood. Granuloma annulare occurs in the lower extremities as single or multiple lesions, but solitary lesions tend to be somewhat more common. These lesions are nonscaly, annular plaques with indurated borders, and present as rapidly growing, painless nodules. These lesions normally regress spontaneously over months or years, even if they prove to be locally or distally recurrent [1].

MR imaging findings of this lesion show a subcutaneous mass with indistinct margins; the signal intensity abnormalities extend into the adjacent subcutaneous fat. The signal intensity of this lesion is equal to or slightly greater than that of muscle on T1-weighted images, and heterogeneous but predominantly high signal intensity is noted on T2-weighted images. The enhancement pattern is variable, from homogeneous to heterogeneous, and this reflects the inflammatory nature and increased vascularity of the granuloma annulare (Fig. 10) [15, 16].

**Dermatofibrosarcoma protuberans**

Dermatofibrosarcoma protuberans occasionally spreads into the subcutaneous tissues and muscle when it grows to be large. These tumors occur principally in the deep tissues. The skin may be thickened in the adjacent and adjoining areas. Enhancement studies are also informative in this regard, in that the skin area is enhanced as well as the tumor (Fig. 11) [4, 6, 7].

### 3. Diffuse or localized skin thickening without a true mass

This type of skin tumor is characterized by a thickening of the skin, in a localized or diffuse pattern. The signal intensity and enhancement pattern of thickened skin is important for a diagnosis, but associated image findings in the subcutaneous fat layer, including lymphadenopathy, panniculitis-like infiltration or increased blood vessels, also provide useful information for differentiation.

**Fig. 9** A 30-year-old woman with ruptured epidermal cyst in back axial fat-suppressed contrast-enhanced T1-weighted spin echo image shows thick wall enhancement with irregular enhancement in adjacent subcutaneous fat (arrow)

**Fig. 10** A 5-year-old boy with granuloma annulare in right foot. **a** Axial T1-weighted spin echo image shows an oval shaped, hypointense mass with irregular margin in the subcutaneous fat layer (arrow). This mass abuts against skin. **b** Axial fat-suppressed contrast-enhanced T1-weighted spin echo image shows heterogeneous enhancement in the mass, with focally deep involvement through extensor digitorum tendons (arrow)
Superficial neurofibroma

Plexiform neurofibromas occur superficially and can be either cutaneous or subcutaneous. Cutaneous and subcutaneous involvement is common in type 1 neurofibromatosis. Superficial neurofibromas are normally unilateral, asymmetrical, with ill-defined margins, and increased vascularity [17]. MR imaging shows a diffusely infiltrative lesion with a poorly defined margin, but not the target-like appearance often observed in cases of deep neurofibromas.

Although the signal intensity is homogeneous or heterogeneous, these lesions normally generate high signal intensity on STIR or T2-weighted images, and are well enhanced as the result of the increased vascularity (Fig. 12) [17, 18].

Cutaneous lymphoma

Skin is commonly involved in peripheral T-cell lymphomas. A cutaneous T-cell lymphoma can be subcategorized into a subcutaneous panniculitis-like T-cell lymphoma, mycosis fungoides/Sézary syndrome and primary cutaneous type anaplastic large cell lymphoma [1]. Subcutaneous panniculitis-like T-cell lymphomas preferentially infiltrate the subcutaneous tissue without overt lymph node involvement. It manifests as multiple-enhancing subcutaneous nodules or plaques, and infiltrates either the subcutis only, or both the subcutis and skin (Fig. 13). Mycosis fungoides is an indolent lymphoma, which normally progresses through three stages: a pre-mycotic phase resembling psoriasis or eczema, an infiltrative plaque phase and a final tumor phase. In its later stages, mycosis fungoides can cause peripheral lymphadenopathy. Anaplastic large cell lymphoma manifests as a single or multiple nodules or as tumors and ulceration in some cases; it infiltrates the dermis, sometimes extending to the subcutis. The imaging features of mycosis fungoides

Fig. 11 An 89-year-old woman with dermatofibrosarcoma protuberans in right leg. a Axial T2-weighted spin echo image shows an oval shaped, heterogeneous signal intense mass (arrow) in the subcutaneous fat layer, which is abutting against skin. Adjacent skin is thickened and surrounding vessels are engorged. b Axial fat-suppressed contrast-enhanced T1-weighted spin echo image shows homogeneously enhancement in this mass, with enhancement in adjacent thickened skin (arrow)

Fig. 12 A 42-year-old woman with superficial neurofibroma in back. She is a neurofibromatosis type 1 patient. a Axial T1-weighted spin echo image shows marked skin thickening with intermediate intensity (arrow). This lesion deeply infiltrates into the subcutaneous fat layer, with poorly defined margin. b Axial contrast-enhanced T1-weighted spin echo image shows heterogeneous enhancement with intense enhancement in the skin, contrary to non-enhanced deep portion (arrow)
and anaplastic large cell lymphoma are similar; they both manifest as a thickening of the skin or a mass formation of the skin [8, 19, 20].

Kaposi sarcoma Kaposi sarcoma (KS) is a low-grade vascular tumor, which typically manifests as one of four variants: classic, endemic, iatrogenic (organ transplant-related) or acquired immunodeficiency syndrome (AIDS)-related Kaposi sarcoma. Iatrogenic KS and AIDS-related KS are the most commonly observed forms of this disease and are characterized by multiple hypervascular lesions, which eventually progress to form tumors [1]. When
Kaposi sarcoma involves the skin, the common imaging findings are thickened skin, sometimes coupled with nodules or mass formation. The lower limbs are the most commonly affected sites, followed by the upper limbs and rarely the face and chest. When this tumor occurs in the musculoskeletal system, it is associated with erosions of the bones and soft-tissue masses [21]. The MR imaging findings of Kaposi sarcoma are high signal intensity on T2-weighted and low signal intensity on T1-weighted images with a marked enhancement on contrast-enhanced images due to the rich vascularization (Fig. 14).

Other skin cancers Other skin cancers often appear as skin thickening. In squamous cell cancer, this is the result of malignant degeneration of untreated chronic wounds, which is referred to as Marjolin’s ulcers, and this appears as a thickening of the skin. On MR images, this thickened skin may show focal heterogeneity on T2-weighted images and heterogeneous enhancement on gadolinium-enhanced images, due to fibrosis in the tumor due to chronic inflammation (Fig. 15) [22]. Other malignant skin cancers may also appear as skin thickening; however, the involved skin tends to be localized. When the tumor is small, it tends to be enhanced in a relatively homogeneous pattern.

4. Skin mass with bone destruction

Bony destruction is uncommon with skin tumors. However, when bone destruction is noted on the MR images, malignant melanoma should be considered. When malignant melanoma develops in a distal extremity, especially in the acral area, it is occasionally associated with bone destruction. This type of malignant melanoma frequently develops extensive vertical growth phases, thereby inducing the bone destruction. Thus, it tends to appear as a soft tissue mass with bone destruction in the tips of the fingers or toes. On the MR images, these tumors normally show
the imaging findings characteristic of melanoma (Fig. 16) [4, 5].

**Conclusion**

The MR images of the majority of skin tumors cause changes in the skin. The skin tumors were located in the subcutis without any change in the skin usually attached to the skin, with narrow or wide bases. Therefore, identification of skin changes on MR imaging is useful for the diagnosis of skin tumors. This review is an initial attempt at categorizing the MR imaging findings of skin tumors. This is not an exhaustive review of the topic. However, we present an approach to defining and categorizing skin tumors that can be applied to other lesions and thereby improve diagnosis.

**References**