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ORIGINAL ARTICLE

Grading and characterization of soft tissue tumors on magnetic resonance imaging: the value of an expert second opinion report

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Abstract
Objective To retrospectively compare the accuracy of the initial MRI (magnetic resonance imaging) report of referring radiologists and the second opinion report.
Material and methods MRI of 155 patients presenting with a soft tissue tumor (STT) in a single large community center were referred for inclusion in the Belgian Soft Tissue Neoplasm Registry (BSTNR). The initial report and the second opinion report were made independently. Histopathology (gold standard) was obtained in 90 patients (group 1). In 65 patients, the diagnosis was made by the combination of clinical findings and/or follow-up (group 2). In group 1, the concordance in grading and tissue-specific (TS) diagnosis between the referring center (RC) and expert center (EC) was reviewed.
Results In group 1, MR grading yields a sensitivity of 100% and a specificity of 89% in the EC. The sensitivity was 88% and the specificity 81% in the RC. The accuracy was significantly higher in the EC (92%) compared to the RC (83%) (p=0.039). The TS diagnosis was correct in 50% versus 38.5% of malignant tumors and in 71.8% versus 51.6% of benign tumors in the EC and RC respectively.
Conclusion A second opinion report increases the accuracy in the diagnosis of STT on MRI.
Main Messages
- *A second opinion MRI report increases the overall accuracy in the diagnosis of soft tissue tumors.*
- *There is a good overall agreement in MR grading between the referring and expert institution.*
- *In the expert center, there were fewer false-negative and false-positive diagnoses.*
- *MRI performs better in the tissue-specific diagnosis of benign versus malignant STT.*

Keywords Soft tissue tumors · Magnetic resonance imaging · Histopathology · Second opinion · Retrospective study

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Introduction

Soft tissue tumors (STT) consist of a heterogeneous group of tumors with a variable biological behavior and prognosis. Correct diagnosis is essential for accurate determination of prognosis and to guide appropriate treatment strategy. The added value of an expert second opinion report of soft tissue tumor specimens has been emphasized previously in the pathology and orthopedic literature[1–4]. Although magnetic resonance imaging (MRI) is considered to be a useful technique for local staging, grading and characterization of STT [5, 6], previous studies regarding the value of MRI in

characterization and grading have primarily focused on the accuracy based on the analysis of different parameters in one single institution with large expertise in the subject [5, 7–9]. The Belgian Soft Tissue Neoplasm Registry (BSTNR) is a multi-institutional database project involving the cooperation of a large number of MRI centers in Belgium. The initiative started back in 2001 and had two main goals: firstly, to provide a second opinion report within 48 h as a professional courtesy toward the cooperating radiologists; secondly, to serve as a scientific database of STTs, which are rare lesions in daily radiological practice [10]. Currently, 2,377 cases have been included in the database. The purpose of the current study is to compare the diagnostic accuracy of MR imaging in grading and characterization of soft tissue tumors (STT) of the initial report made by the referring radiologist in a large community hospital and the second opinion report made by the experts of the BSTNR.

Materials and methods

During a 10-year period (April 2001-April 2011), MR imaging examinations of 155 patients presenting with a STT in a single large community center were referred for inclusion in the Belgian Soft Tissue Neoplasm Registry (BSTNR) and a subsequent second opinion MR report. All examinations were performed on a 1.5-T MR scanner (General Electric, Signa, Milwaukee, WI, USA). The MR study protocol consisted of axial T1-weighted images (WI), axial T2-WI, axial fat suppressed (FS) T1-WI, coronal or sagittal FS T2-WI depending on the lesion location, axial FS contrast-enhanced (CE) T1-WI, coronal or sagittal FS CE T1-WI, and subtraction of axial pre- and post-CE FS T1-WI. Intravenous administration of gadolinium contrast was not performed in cases where the imaging diagnosis was already made on the noncontrast-enhanced MRI scan. The report from the referring radiologist was made by a single general radiologist (either K.T. or J.D.), both having experience in MRI (12 and 14 years, respectively). The expert report was made in consensus by a panel of at least two musculoskeletal radiologists experienced in imaging of STT (A.D.S., 25 years of experience; J.G. and F.V., each 20 years of experience). Age, gender and clinical information were available, but the experts were blinded to the initial

Table 1 Parameter analysis in the second opinion report

Second opinion report parameters
• Age
• Gender
• Location
• Volume
• Margins
• Intra- versus extracompartmental extension
• Multiplicity
• Presence of intralesional calcifications
• Morphological signs (fluid-fluid levels, target sign, fascicular sign, bunch of grapes, etc.)
• Signal intensity on different pulse sequences
• Inhomogeneity
• Intralesional hemorraghe
• Intralesional necrosis
• Degree (none, moderate or marked?) and pattern of enhancement (central versus peripheral with papillary projections?) on static contrast examination
• Contrast kinetics (if available) on dynamic contrast examination
• Invasion of adjacent bones and neurovascular bundles

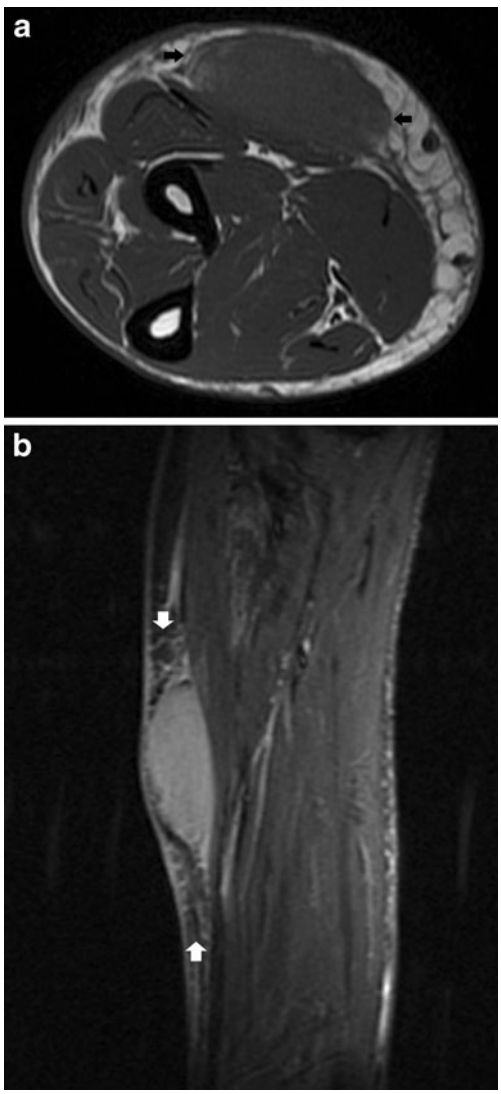

Fig. 1 **a-b** B-cell non-Hodgkin's lymphoma of the forearm abutting the fascia. **a** Axial spin-echo T1-WI. Fusiform subcutaneous mass (black arrows) extending along the superficial fascia. The lesion is of slightly higher SI compared to the SI of muscle. **b** Sagittal STIR image. The lesion is of intermediate signal intensity. Note surrounding stranding (white arrows) of the subcutaneous fat (lymphangitis)

imaging report. The second opinion report was based on analysis of individual parameters described in the literature (Table 1)[5, 6]. The revised nomenclature proposed by the World Health Organization was used [11]. MR grading is defined as differentiation between benign and malignant lesions, whereas characterization on MR consists of prediction of the exact histology (tissue-specific diagnosis). The age of the patients ranged between 6 months and 88 years. Histopathology, which was used as the gold standard, was obtained in 90 cases (group 1). In 65 patients, the diagnosis was made by the combination of clinical findings and/or follow-up (group 2). In group 1, the concordance in differentiation between benign and malignant tumors and tissue-specific (TS) imaging diagnosis between the referring center and expert center was determined. Four categories were distinguished on MRI:

- correct diagnosis both by the referring center and second opinion report
- incorrect diagnosis by the referring center; correct second opinion report
- correct diagnosis by the referring center; incorrect second opinion report
- incorrect diagnosis by both the referring center and second opinion report

If multiple differential diagnoses were suggested in the radiological reports, only the first (most probable) diagnosis was taken into account. Indeterminate lesions with high suspicion of malignancy were considered as malignant.

Group 2 was divided into two categories:

- Concordant diagnosis between the referring center and second opinion report
- Discordant diagnosis between the referring center and second opinion report

For group 1, sensitivity, specificity and accuracy of MR grading were calculated for the referring center reports and second opinion reports. The performance of the referring center reports and second opinion reports were compared by means of McNemar tests. To assess the agreement between the referring center and second opinion reports on all 155 lesions (with or without histological proof), Cohen's kappa coefficient was calculated. All statistical analyses were performed by the Statistical Package for the Social Sciences (SPSS) 19 software (IBM, New York, USA)

Results

Group 1

Group 1 revealed 26 malignant lesions and 64 benign lesions.

Malignant lesions

In 23 cases, the lesion was scored as malignant by the referring center (RC) and the expert center (EC). In three cases, the imaging diagnosis of a benign lesion was made by the RC, whereas the EC made the imaging diagnosis of a malignant lesion (correct grading of 100% versus 88.5% in EC versus RC respectively). One lesion consisted of a soft tissue lymphoma (Fig. 1), incorrectly diagnosed by the referring center as a schwannoma. The other lesions with discordant imaging diagnosis were myxofibrosarcoma (vs. rhabdomyoma) and leiomyosarcoma (vs. nodular fasciitis).

A correct tissue-specific (TS) diagnosis was made by both the RC and the EC in eight cases. In eight cases, there was disagreement in the TS diagnosis between the referring center and the expert center (5 cases of correct diagnosis in an expert center and 3 cases of correct diagnosis in the referring center). TS diagnosis was incorrect in both centers in ten cases (Table 2). The TS diagnosis was correct in 13/26

Table 2 Categories of tissue-specific MR diagnosis of histologically proven malignant tumors (n=26)

Histology	Number
a. Correct diagnosis both by referring center and second opinion report	
Lymphoma	2
Well-differentiated liposarcoma	2
Soft tissue metastasis	2
Sarcoma NOS	1
Pleiomorphic liposarcoma	1
Total	8
b. Incorrect diagnosis by referring center; correct second opinion report	
Lymphoma	1
Myxoid sarcoma	1
Sarcoma NOS	1
Chondrosarcoma	1
Low-grade myxofibrosarcoma	1
Total	5
c. Correct diagnosis by referring center; incorrect second opinion report	
Leiomyosarcoma	1
Chondrosarcoma	1
Pleiomorphic sarcoma	1
Total	3
d. Incorrect diagnosis both by referring center and second opinion report	
Sarcoma NOS	4
Myxoid liposarcoma	2
Leiomyosarcoma	2
Spinocellular leiomyosarcoma	1
Synovial sarcoma	1
Total	10

malignant lesions (50%) in the expert center versus 10/26 (38.5%) in the referring institution.

Benign lesions

In 50 cases, the lesion was scored as benign by both centers. In seven cases, a correct diagnosis of a benign lesion was made by the expert center, whereas the referring center made the diagnosis of a malignant lesion. In two cases, an incorrect diagnosis of a malignant lesion was made by the expert center, whereas the referring center made the diagnosis of a benign lesion. In five benign lesions, the imaging diagnosis was malignant in both centers.

A correct TS diagnosis was made by both the referring center and the expert center in 31 cases (48.4%). In 17 cases, there was discordance in the TS diagnosis (Figs. 2 and 3) between the referring center and the expert center (15 cases of correct diagnosis in the expert center and two cases of correct diagnosis in the referring center). The TS diagnosis was incorrect in both centers in 16 cases (Table 3). The TS diagnosis was correct in 46/64 benign lesions (71.8%) in the expert center versus 33/64 (51.6%) in the referring institution.

For histologically proven lesions (group 1), a sensitivity of 100% vs. 88% (p=0.250), a specificity of 89% vs. 81% (p=0.180) and accuracy of 92 vs. 83% (p=0.039) (McNemar test) were obtained for grading in the expert center vs. the referring institution respectively (Table 4).

Group 2

Group 2 comprised 65 lesions in which the diagnosis was made by the combination of clinical findings and/or follow-up without histopathological proof as the gold standard. Most lesions were considered as benign, and therefore a wait-and-see policy was preferred by the referring clinicians. In 51 cases, there was concordance in the TS diagnosis between the referring center and the expert center. These cases are summarized in Table 5. There was disagreement about the diagnosis in 14 cases. Twelve of the latter cases were scored as benign by both institutions, whereas suspicion of malignancy was raised by the referring center in one case and by the expert center in another

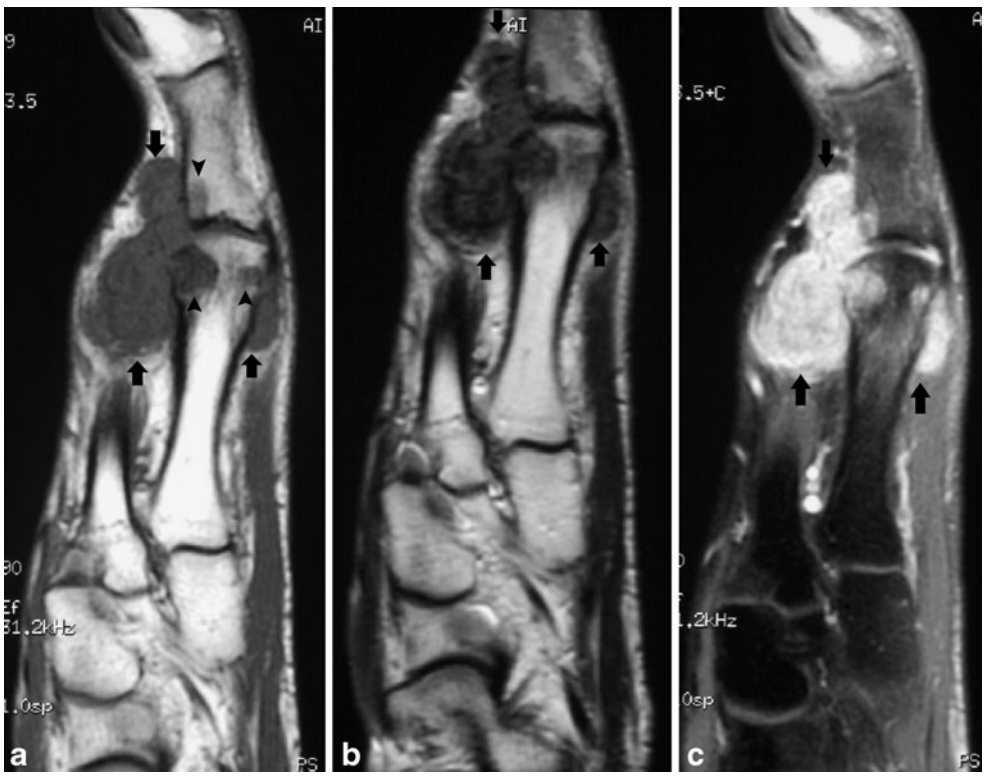

Fig. 2 **a-c** Pigmented villonodular synovitis in a 31-year-old man, misdiagnosed as a malignant lesion by the referring institution. **a** Axial SE T1-WI. Lobulated intra-articular lesion at the left metatarsophalangeal joint of the hallux (black arrows). Note the presence of erosions on both sides of the joint (black arrowheads). The lesion is of overall low signal. **b** Axial TSE T2-WI. The lesion is still of very low signal (black arrows). **c** Axial fat suppressed SE T1-WI after IV administration of gadolinium contrast. Marked enhancement of the lesion (black arrows). Despite the aggressive behavior of the lesion (erosions), the low signal of the lesion on both pulse sequences (in keeping with hemosiderin deposition), the articular location of the lesion, the marked enhancement and the relatively young age of the patient allowed a correct tissue-specific diagnosis by the expert center

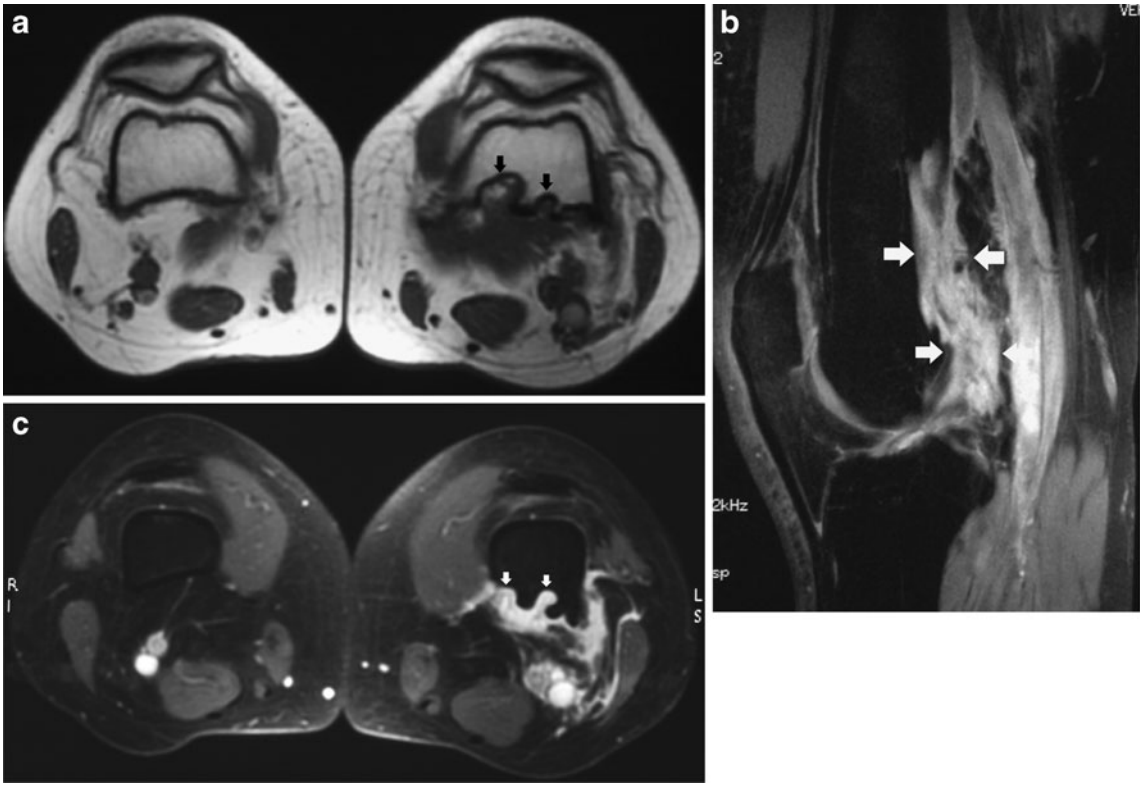

Fig. 3 **a**-**c** Diffuse plexiform neurofibroma of the thigh. **a** Axial SE T1-WI. Diffuse infiltrating mass lesion in the popliteal fossa causing scalloping (black arrows) of the posterior cortex of the left femur. **b** Sagittal fat-suppressed TSE proton density WI. The lesion is of high signal (white arrows). **c** Axial fat-suppressed SE T1-WI after IV administration of gadolinium contrast. Diffuse enhancement of the lesion (white arrows). Although a rare occurrence, a plexiform neurofibroma may present as a diffuse infiltrating mass causing pressure erosion of the adjacent bone. Experience with a large series of rare pathology allowed the expert center to suggest a correct tissue-specific diagnosis

case. Because of the clinical evidence of benignity, no further diagnostic or therapeutic action was undertaken by the referring clinician.

All lesions

As far as the differentiation between benign and malignant STT is concerned, there is good overall agreement (Table 6) between both institutions (Cohen's kappa=0.742).

Discussion

Since its introduction to clinical imaging more than 2 decades ago, MRI has radically modified the practice of preoperative assessment of STT. The accuracy of this technique in grading and characterization was studied in many previous papers [5–9]. The reported results were however based on analysis of MRI examinations by groups of dedicated musculoskeletal (MSK) radiologists in single institutions with a great deal of expertise in the subject. As MRI has become a widespread technique, performed in many general hospitals, the current study aimed to compare the accuracy of MRI reports made by radiologists in community hospitals and second opinion reports made by experts in MSK radiology.

In our series, the overall agreement in MR grading of STT (including both histological and nonhistological confirmed cases) between EC and RC is good. This may reflect adequate core knowledge of the referring radiologists regarding MR diagnosis of STT. On the one hand, this may be due to the high level of general radiological education in our country. On the other hand, continuing education and evaluation of feedback by reading the second opinion report may have contributed to this good overall agreement. Furthermore, evolving experience in the imaging diagnosis of STT may also have resulted in an improved diagnosis in the EC. Unfortunately, because of the relatively low number of referred cases/year, quantification and statistical analysis of the learning curves of both institutions are not possible.

However, despite the good overall agreement, there were some significant differences in grading between the RC and EC.

In the EC, there were no false negatives (misdiagnosis of a malignant tumor as a benign lesion), compared to a minority of malignant tumors misdiagnosed on MRI as benign tumors in the RC.

Table 3 Categories of tissue-specific MR diagnosis of histologically proven benign tumors (n=64)

Histology	Number
a. Correct diagnosis both by referring center and second opinion report	
Lipoma	7
Neurogenic tumor	5
Giant cell tumor	4
Morton's fibroma	4
Hemangioma	4
Tumor-like lesion	3
Lipoma arborescens	1
Elastofibroma dorsi	1
Glomus tumor	1
Desmoid	1
Total	31
b. Incorrect diagnosis by referring center; correct second opinion report	
Tumor-like lesion	5
PVNS	2
Neurogenic tumor	1
Hemangioma	1
Nora's lesion	1
Desmoid	1
Myxoma	1
Angioleiomyoma	1
Lipoma	1
Fibrous hamartoma	1
Total	15
c. Correct diagnosis by referring center; incorrect second opinion report	
Fibroma tendon sheath	1
Schwannoma	1
Total	2
d. Incorrect diagnosis by both referring center and second opinion report	
Lipoma	4
Tumor-like lesion	2
Neurogenic tumor	2
Desmoid	2
Chondroma	1
Hibernoma	1
Fibrous histiocytoma	1
Granular cell tumor	1
Lymphangioma	1
Hemangioma	1
Total	16

More systematic and meticulous analysis of a combination of multiple parameters, experience with a larger series of STT and knowledge of sometimes subtle imaging signs may have contributed to this better prediction of malignancy in the EC. A typical example consisted of a soft tissue lymphoma, incorrectly diagnosed by the referring center as a schwannoma, mainly because of its fusiform morphology. Although the MR appearance of soft tissue lymphoma may be nonspecific in most cases [12], certain useful signs have been reported previously. Most ST lymphomas are of hyperintense signal on T2-weighted images, but a relatively low to intermediate signal on T2-weighted images may be seen as well [13, 14]. Other potential useful signs in the MR diagnosis of ST lymphoma are the homogeneity of the lesion on all pulse sequences and the absence of central necrosis in relatively large tumors [14], the growth pattern along the fascia [15], surrounding lymphangitis and the "wrapped-around" sign of lymphoma surrounding bony structures [16, 17]. False negatives may have a major impact on patient management and the ultimate prognosis. This underscores the value of a second opinion MR report. In our series, false-positive diagnoses (misdiagnosis of a benign tumor as a malignant lesion) were less frequent in the EC compared to the RC, which may reduce the number of unnecessary biopsies. The impact of a false-positive imaging diagnosis is less pronounced as this will not result in radical modification of the treatment strategy. However,

Table 4 Results of grading on MRI in group 1

	Malignant	Benign	Total
a. Results of grading on MRI by expert center			
MRI malignant	26	7	33
MRI benign	0	57	57
Total	26	64	90
b. Results of grading on MRI by referring center			
MRI malignant	23	12	35
MRI benign	3	52	55
Total	26	64	90

a: Sensitivity 100%; specificity 89%; accuracy 92%

b Sensitivity 88%; specificity 81%; accuracy 83%

Table 5 List of lesions without histopathological proof but with concordant MR diagnosis (N=51)

Histology	Number
Hemangioma	16
Lipoma	11
Tumor-like lesion	8
Plantar fibromatosis	4
Neurogenic tumor	3
Elastofibroma	3
Morton's fibroma	2
Ganglion cyst	2
Soft tissue metastasis	1
Giant cell tumor tendon sheath	1
Total	51

Table 6 Overall agreement in MR grading between the expert center (EC) and referring center (RC)

	Malignant EC	Benign EC
Malignant RC	28	8
Benign RC	6	113

There is good agreement between the expert center and referring center (kappa=0.742)

since biopsy is recommended in all cases where imaging remains "indeterminate" [18], a number of unnecessary biopsies are unavoidable. Typical lesions that may be misinterpreted as a malignant tumor are desmoid tumors because of their aggressive growth pattern on imaging [19–21]. A number of lipomatous tumors may be misinterpreted as potential malignant lesions because they contain nonlipomatous components. Gaskin et al. already stated that when an extremity or body wall lesion is considered suggestive of well-differentiated liposarcoma, 64% of these lesions will turn out to represent benign lipoma variants containing nonlipomatous elements [22]. In our series, four histopathologically proven lipomas and one hibernoma were initially interpreted as well-differentiated liposarcoma, because of lesion inhomogeneity and intralesional nonlipomatous components. Recently, Toirkens et al. confirmed that subcutaneous lipoma variants and liposarcoma variants may show overlapping MR characteristics [23]. Even in retrospect, these false-positive diagnoses may be unavoidable, but when a lipoma has to be differentiated from a well-differentiated liposarcoma, there is no change in the treatment regime, as both tumors are treated by simple a shell-out procedure. In the group of histopathologically proven tumors (group 1 of our series), the EC performed better than the RC in suggesting a correct TS diagnosis. This is also attributed to the increased knowledge and experience with rare phenotypes of STT in the EC, which were previously studied in case reports, review articles and small series [19, 24–27].

Our study also confirms previous published data showing that prediction of the TS diagnosis on MRI is more accurate for benign than malignant STTs. In 2004, Gielen et al. reported that a correct tissue-specific diagnosis of benign STT could be predicted on MRI in 50% of cases [5]. A slightly higher percentage (58%) was reported by Berquist et al. [7]. In our series, the TS diagnosis was correct in 50% of malignant lesions in the EC versus 38.5% in the RC. The TS diagnosis was correct in 71.8% in the EC versus 51.6% in the RC.

Among the 65 soft tissue lesions without histopathological proof (Table 6), a concordant tissue-specific MR diagnosis was made by both centers in the majority of cases (78.5%). These cases presented with a typical MRI appearance such as hemangioma, lipoma, etc. Concordance in the MR diagnosis was extremely valuable for the referring physician, as it allowed a more confident diagnosis based on the combination of clinical findings and imaging. Aggressive diagnostic procedures and treatment regimes could be avoided in these patients, and a reliable wait-and see policy could be implemented.

We acknowledge the limitations of our study.

First, there was a relatively high number of malignant STTs in our series (n=26, 16.8%) compared to the estimated prevalence between 5.1 and 15.5% in the literature [28]. This may be due to a selection bias caused by the referral policy by the clinician for an MR examination. A second limitation is the potential pathology bias. The pathologist was aware of the imaging diagnosis of both centers when making his final histopathological diagnosis, which might bias the pathologist in the diagnosis of STT [29]. A third limitation is the high number of non-histologically proven STTs (N=65). However, because of the evidence of benignity based on a combination of imaging, clinical findings and follow-up, it would have not been considered good medical practice if these patients had undergone invasive diagnostic procedures. The last limitation is due to the fact that the MR protocol was not completely uniform as intravenous administration of gadolinium chelates was not performed in all patients.

In conclusion, a second opinion imaging report by an expert center is useful to enhance the overall accuracy in diagnosis.

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