Synovial Sarcoma on Magnetic Resonance Imaging: a Retrospective Study on Tumor Configuration and Postoperative Surveillance

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Abstract

Background: To assess the configuration of primary and recurrent synovial sarcoma on MRI. Additionally, to evaluate postoperative MRI regarding diagnostic performance and locoregional post-treatment changes.

Methods: Twenty-five patients with histologically proven synovial sarcomas underwent 1.5-T MRI follow-up between 2012 and 2018. In all, 258 pre- and postoperative MRIs with available radiological and pathological were screened for primary/recurrent synovial sarcoma, diagnostic performance (false-positive/-negative and true-positive/-negative values) and post-treatment changes.

Results: The median age of the patients was 40±15.2 years. The median volumes of primary and recurrent synovial sarcomas were 603 cm^3 and 806 cm^3, respectively. Of the patients 24% presented recurrences (n=6). In two patients false-positive diagnosis was made . There was one false-negative diagnosis of synovial sarcoma. Primary synovial sarcomas were significantly most often polycyclic/multilobulated (p=0.01) and heterogeneous in appearance with marked contrast enhancement. Recurrent synovial sarcomas showed two appearances: ovoid/nodular/homogeneous and polycyclic/multilobulated/heterogeneous, both with marked contrast enhancement. The most common post-treatment changes were subcutaneous (92%; p<0.001) and muscular edema (72%; p<0.001-0.003).

Conclusion: While the configuration of primary synovial sarcomas was mainly polycyclic/multilobulated/heterogeneous, recurrent synovial sarcomas showed two shapes: ovoid/homogeneous and polycyclic/multilobulated/heterogeneous. MRI is still a highly valuable imaging modality for the postoperative surveillance of synovial sarcomas. Subcutaneous and muscular edema are common post-treatment changes.

Background

Synovial sarcoma is a relatively rare malignancy, accounting for about 2.5 to 10% of all soft-tissue sarcomas [1–3]. Both genders are affected equally. The mean age at first diagnosis is 32 years [2]. Synovial sarcoma occurs in a variety of locations, but the majority of cases are reported in the extremities (80–95%), mostly in the lower limbs [2, 4]. Numerous studies have reported that synovial sarcoma is a high-grade malignancy with a high rate of metastasis, particularly to the lungs [5–7]. Therefore, precise pre- and postoperative diagnosis is essential. Postoperative surveillance should meet the requirements of detecting recurrences early. MRI is the imaging modality of choice for the follow-up of synovial sarcoma [8]. Nevertheless, synovial sarcoma is often misdiagnosed, especially in small lesions due to the lack of characteristic clinical manifestations and specific imaging features [4, 9]. A new and simple approach is to classify soft-tissue sarcomas by characterizing their configurations on MRI [10, 11]. Therefore, our study investigated the configuration of primary and recurrent synovial sarcoma on MRI. Additionally, we evaluated postoperative MRI regarding diagnostic performance and locoregional post-treatment changes.

Patients And Methods

Thirty consecutive patients with histologically proven synovial sarcomas received post-treatment MRI follow-up examinations between 2012 and 2018. In 5 patients imaging data were not sufficient and therefore excluded. Ultimately, 258 MRI follow-up scans with radiological reports of 25 patients were systematically reviewed. From the dataset, primary and recurrent tumor localization, age of the patients at primary diagnosis, and recurrence-free MRI follow-up intervals were analyzed. Additionally, the MRI follow-up scans were systematically screened for locoregional post-treatment changes, which showed 7 main post-treatment changes: subcutaneous edema, muscular edema, postoperative seroma, synovitis, bone edema, neuritis, and reactive lymphadenopathy. Furthermore, all available pathological reports were reviewed. Primary and recurrent STS were examined for configuration, contrast enhancement (heterogeneity/homogeneity and intensity), limitation (well- or ill-defined borders), and volume on MRI. Information on false-positive, false-negative, true-positive, and true-negative diagnosis of synovial sarcomas was derived from our data by correlating the radiological reports with pathological findings.

MRI was performed with a 1.5-Tesla MRI system (MAGNETOM Symphony, Siemens Healthineers), using the following MRI sequences: T2-weighted (T2w) TSE (TE: 64–114 ms, TR: 3010–5840 ms, FOV: 22–44 cm²), T1-weighted (T1w) SE (TE: 10–14 ms, TR: 587–868 ms, FOV: 22–44 cm²), proton density-weighted (PDw) FS (TE: 26–36 ms, TR: 2740–4610 ms, FOV: 22–40 cm²) or turbo-inversion recovery magnitude (TIRM) (TE: 68–77 ms, TR: 4410–6980 ms, FOV: 37–45 cm²), and contrast-enhanced T1w SE FS (10–13 ms, TR: 533–1440 ms, FOV: 22–45 cm²). Two dedicated musculoskeletal radiologists with a minimum of 5 years of experience in sarcoma diagnostics reviewed each MRI, with findings reached by consensus.

Statistical data: Data are given as median values with range (minimum to maximum) or mean and standard deviation (SD). Parametric and nonparametric tests to compare group values (χ2-test, Mann-Whitney U-test, ANOVA) were performed as indicated. Relative risks were determined by using relative risk ratios (RR). The statistical significance for all tests was set at a level of $p < 0.05$. Statistical analysis was done using the IBM-SPSS, version 26.0, software package (IBM, Armonk, NY, USA).

Results

The median age of the patients was 40 years (SD: 15.2; Min.: 18, Max.: 71). Synovial sarcomas recurred 14 months after primary tumor resection in the median (SD: 12.2, Min.: 3, Max.: 31). The median volumes of primary and recurrent synovial sarcomas were 603 cm^3 (Min.: 3, Max.: 4573, SD: 1384) and 806 cm^3 (Min.: 1, Max.: 4350, SD: 1741), respectively. Synovial sarcomas significantly most often occurred in the leg and groin ($p = 0.02$; Fig. 1). From 12 patients we extracted imaging data on the configuration of the primary synovial sarcoma. Of these patients, 24% presented recurrences (n = 6). In the observation period, two patients were given a false-positive diagnosis. There was only one false-negative diagnosis of synovial sarcoma in our study (table 1). Primary synovial sarcomas were significantly most often polycyclic/multilobulated ($p = 0.01$) and heterogeneous in appearance and showed marked contrast

enhancement, especially in the thigh, where all primary tumors appeared in this shape (Fig. 2). Additionally, some primary synovial sarcomas showed an ovoid (Fig. 3) or fascicular (Fig. 4) configuration (table 2). Recurrent synovial sarcomas showed two appearances: ovoid and homogeneous, with marked contrast enhancement (Fig. 3) and polycyclic/multilobulated and heterogeneous, with marked contrast enhancement (Fig. 2; table 3). There was no significant difference between the volume of primary and recurrent synovial sarcoma. The most common locoregional post-treatment changes were subcutaneous (92%; $p < 0.001$) and muscular edema (72%; $p < 0.001–0.003$). Of the patients, 36% presented with postoperative seroma (table 4).

Discussion

In this study we investigated the role of pre- and postoperative MRI in the surveillance of synovial sarcoma. To this end, we addressed the questions of primary and recurrent synovial sarcoma configuration and the diagnostic performance of MRI during postoperative follow-up and evaluated the occurrence of locoregional post-treatment changes.

Synovial sarcomas are reported to be a high-grade malignancy that develop most often in the extremities, accounting for approximately 70% of the cases [1, 12–14]. They show 5- and 10-year survival rates between 24–68% and 11–56%, respectively, and have a high rate of metastasis [5–7]. Therefore, precise and reliable diagnosis is necessary. For optimal radiological surveillance, MRI is the imaging modality of choice for the detection and follow-up of soft-tissue tumors, as it best characterizes intratumoral architecture, perilesional edema, and involvement of other structures [1, 8]. Nevertheless, for accurate MRI follow-up of sarcomas experienced radiologists are needed. Therefore, postoperative MRI is usually performed at multidisciplinary sarcoma centers.

Previous data have described synovial sarcoma as a prominent, heterogeneously enhancing solid tumor, with no enhancement in the areas containing cysts, necrosis, or septation and mostly well-defined borders, although a few cases of unclearly defined borders have also been described [2, 4, 8, 15, 16]. Other studies, in contrast, have characterized synovial sarcoma with infiltrative tumor margins [16]. A contrast-enhanced imaging study revealed that the enhancement of large tumors is often significantly heterogeneous in MRI images, while tumors of a smaller size often show homogeneous enhancement, especially those smaller than 5 cm [4, 17, 18]. Furthermore, synovial sarcomas are reported to have a multilobulated/polycyclic appearance [16, 17, 19–22]. Homogeneous contrast enhancement was associated with a nonmultilobulated configuration, while multilobulated lesions mostly showed heterogeneous contrast enhancement in our study. Furthermore, we could confirm that primary synovial sarcomas are significantly most often polycyclic/multilobulated in appearance ($p = 0.01$), especially in the thigh, where all primary tumors appeared in this shape. Primary tumors may also appear ovoid or fascicular. However, recurrent synovial sarcomas showed two appearances: ovoid/homogeneous and polycyclic/multilobulated/heterogeneous, both with marked contrast enhancement. Our data suggest that by knowing the possible configurations of synovial sarcomas, not only radiologists, but also

clinicians can quickly get an impression of the presence of recurring tumors. This may lead to faster and more precise diagnosis on MRI.

Of our patients synovial sarcomas recurred in 24% during MRI follow-up. Scheer M. et al. describe a local recurrence rate of 42% in young adults [23]. Krieg AH et al. even determined a local recurrence rate of 47% in patients with synovial sarcoma, with 28% of the recurrences presenting after more than 5 years [24].

Furthermore, 83% of the recurrences were correctly detected during MRI follow-up. In two patients the radiologist made a false-positive and in another a false-negative diagnosis. Of course, false-positive results usually require core-needle biopsy, which is annoying, but false-negative results lead to progression of sarcoma, which worsens the prognosis. Our findings emphasize the role of MRI in the postoperative surveillance of synovial sarcoma patients, but the question of post-treatment surveillance duration has not been answered yet. In the standard clinical setting, observational periods of up to 5 years with MRI are foreseen, but in our experience it is unusual for patients to present for MRI follow-up for the duration of five years at one and the same radiological department [25]. Indeed, in our study all recurrences developed in fewer than 5 years, but Krieg AH et al. reported that 28% of the recurrences were observed after more than 5 years [24]. Therefore, it should be carefully examined in individual cases whether it would be wise to continue follow-up after 5 postoperative years.

Previous studies showed a mean size of primary synovial sarcomas of 8.5 cm, ranging from 6.2 to 15 cm [4, 8], which mainly coincides with our data.

Another task of MRI is to distinguish between post-treatment soft-tissue changes and tumor recurrences, which is often problematic [26]. In accordance with studies on soft-tissue sarcomas, studies of locoregional post-operative soft-tissue changes are also rare and the rate of postoperative changes has only rarely been investigated. In our study, 92% and 72% of our patients developed post-treatment subcutaneous and muscular edema, respectively. This high rate of edema can pose a challenge for less experienced radiologists and clinicians since the distinction between postoperative changes and small recurrences can be difficult. In our study, postoperative seroma developed in 36% of the patients. This rate is higher than described previously. Postoperative seromas have been reported to occur in approximately 17–19% after resection of soft-tissue sarcomas [26–28].

Our study has some limitations, mainly the single-center approach and the retrospective design of the current study. Although 25 patients were included in this study, only 12 primary and 6 recurrent synovial sarcomas could be extracted. Due to the rarity of imaging data on soft-tissue sarcomas, a multicenter study could offer an advantage, especially in evaluating the configuration of synovial sarcoma recurrences and postoperative changes.

Conclusion

While primary synovial sarcomas were most often polycyclic/multilobulated and heterogeneous in appearance, recurrent synovial sarcomas showed two main shapes: ovoid/homogeneous and

polycyclic/multilobulated/heterogeneous. For the detection of local recurrences, MRI is still a highly valuable imaging modality with low false-positive and false-negative rates. Subcutaneous and muscular edema are common post-treatment changes, which can make postoperative surveillance more difficult.

List Of Abbreviations

MRI
Magnetic resonance imaging

Declarations

Ethics approval and consent to participate

This study was approved by the responsible ethics committee of the Ruhr-University Bochum, Germany.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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None.

Authors' contributions

SS has made substantial contributions to the conception/design of the work, acquisition, analysis, interpretation of data and have drafted the work.

FS has made substantial contributions to the conception/design of the work, analysis, interpretation of data and substantively revised the draft.

JB has made substantial contributions to the analysis and interpretation of data, and substantively revised the draft.

CB has made substantial contributions to the analysis and interpretation of data, and substantively revised the draft.

MS has made substantial contributions to the conception/design of the work, acquisition, analysis, interpretation of data and have drafted the work.

All authors approved the submitted version and have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Tables

Due to technical limitations, table 1 to 4 is only available as a download in the Supplemental Files section.

Figures

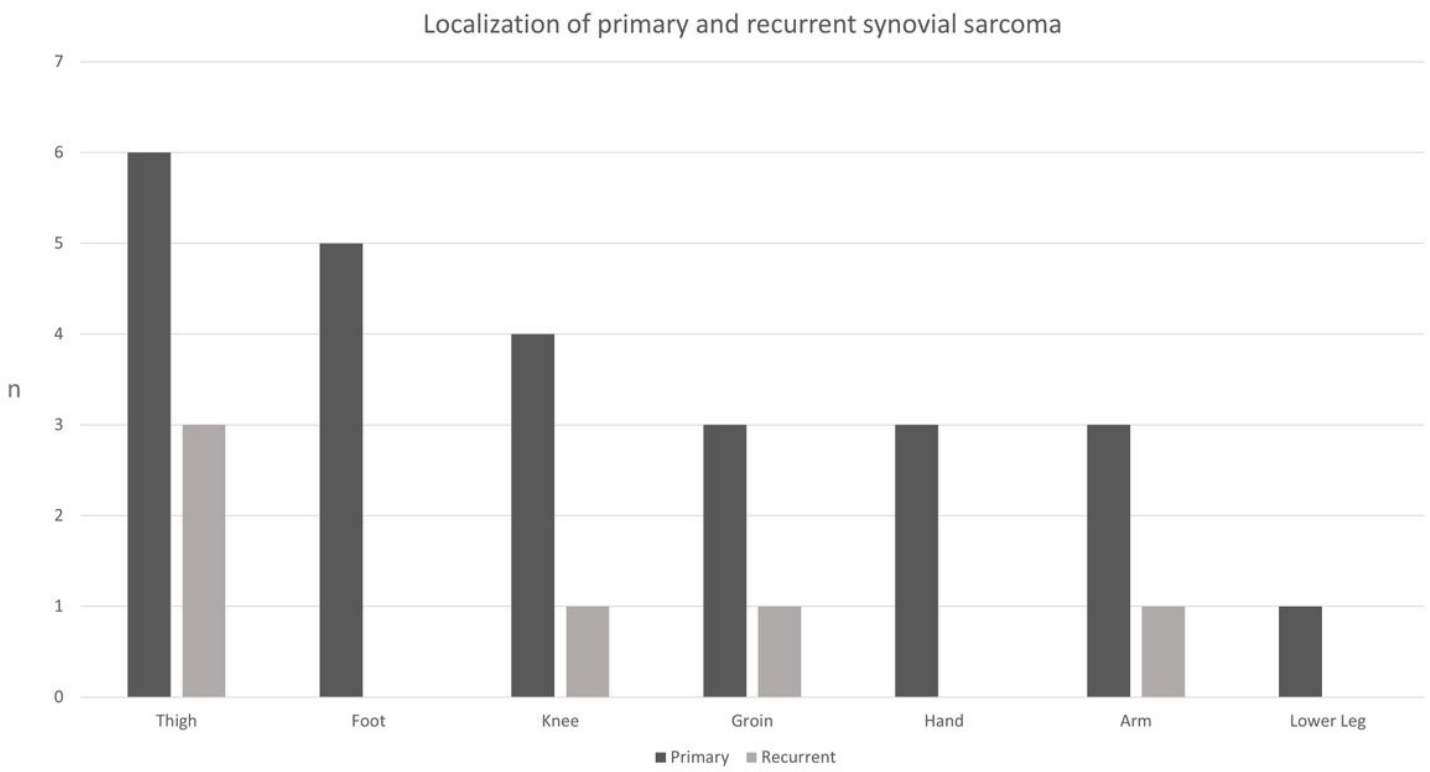

Figure 1

Main localizations of primary and recurrent synovial sarcoma, shown as number of patients “n”.

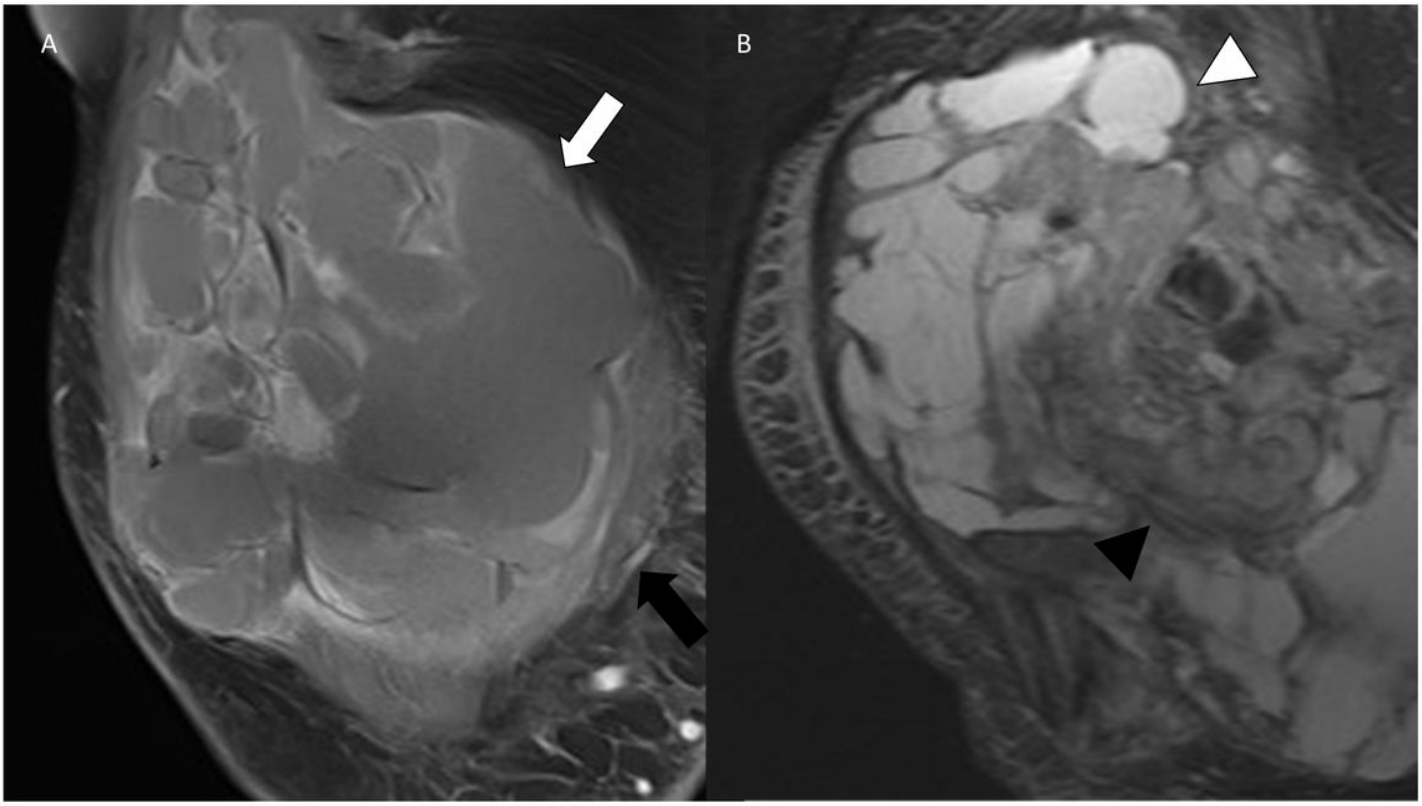

Figure 2

1.5-T MRI (T1w FS after application of IV gadolinium) of the thigh of a 41-year-old patient. (A) shows a primary synovial sarcoma, while (B) shows the recurrent synovial sarcoma after resection of the primary tumor. Both tumors have a multilobulated and heterogeneous appearance with polycystic (white arrow heads) and solid (black arrow head) parts, and with both infiltrative (black arrow) and well-defined borders (white arrow).

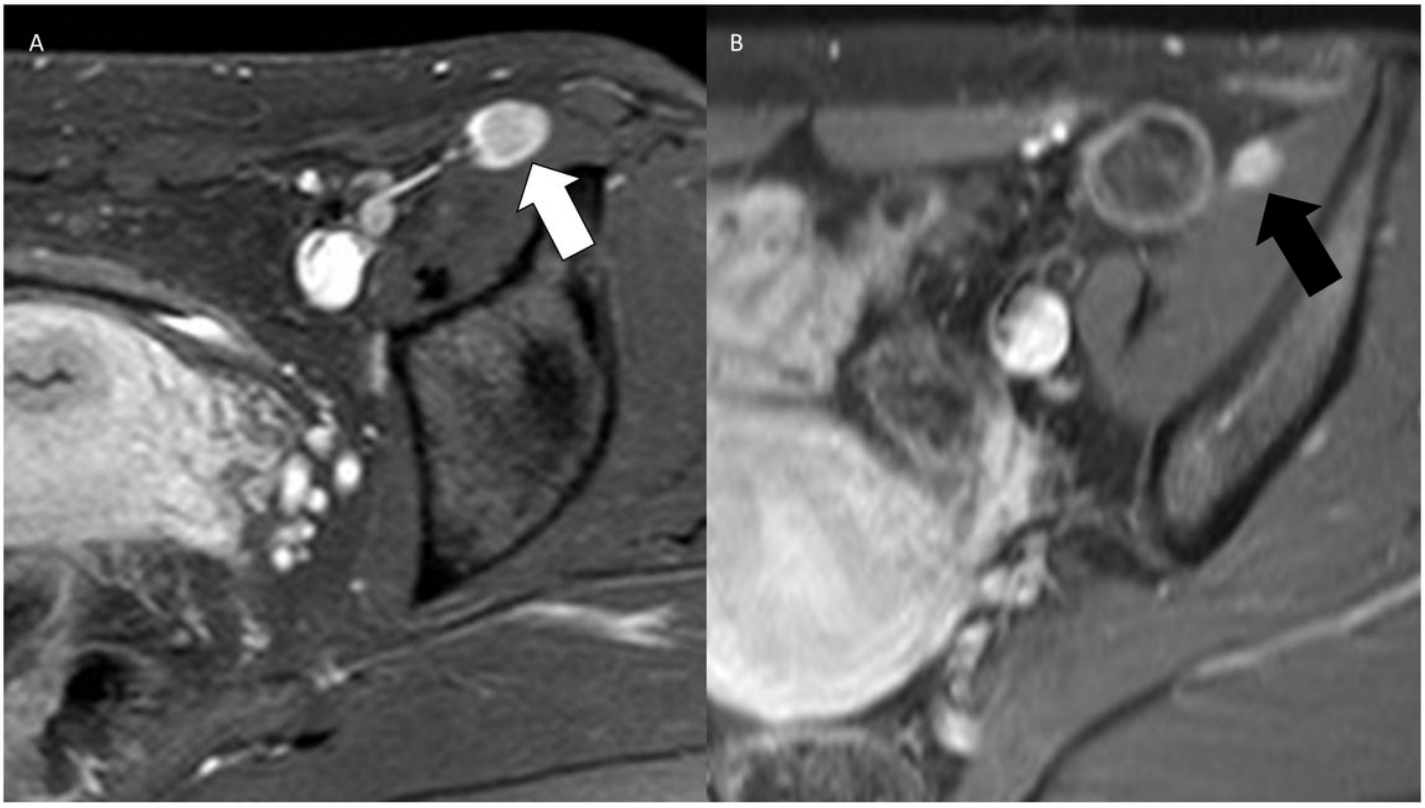

Figure 3

1.5-T MRI (T1w FS after administering IV gadolinium) of the left iliac region of a 31-year-old patient. (A) shows a primary synovial sarcoma, while (B) shows a recurrent synovial sarcoma. Both tumors have an ovoid/nodular appearance with homogeneous contrast enhancement (white arrows) and well-defined borders.

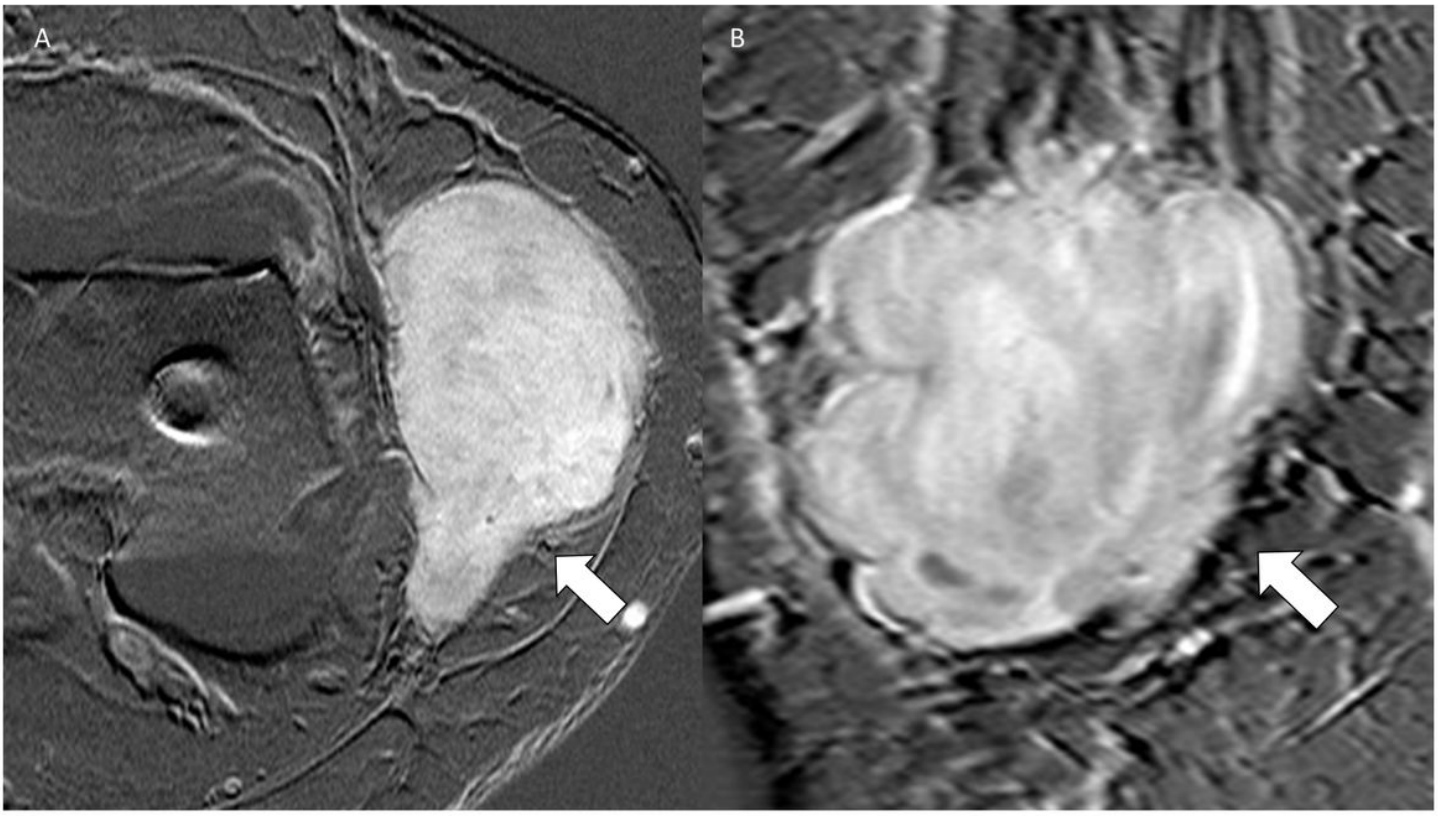

Figure 4

1.5-T MRI (Subtraction after administering IV gadolinium) of the knee of a 61-year-old patient. (A) and (B) show a primary synovial sarcoma in axial (A) and coronal (B) view. The tumor appears homogeneous and fascicular (white arrow) with well-defined borders (arrowheads).

Supplementary Files

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