Low-grade myofibroblastic sarcoma of the levator scapulae muscle: a case report and literature review

Hirotaka Yonezawa, Norio Yamamoto, Katsuhiro Hayashi, Akihiko Takeuchi, Shinji Miwa, Kentaro Igarashi, Mickhael Bang Langit, Hiroaki Kimura, Shingo Shimozaki, Takashi Kato, Sei Morinaga, Yoshihiro Araki, Yohei Asano, Hiroko Ikeda, Takayuki Nojima, and Hiroyuki Tsuchiya

Abstract

Background: Low-grade myofibroblastic sarcoma (LGMS) is described as a distinct atypical myofibroblastic tumor often with fibromatosis-like features and predilection for the head and neck, especially the oral cavity and larynx. LGMS arising in the levator scapulae muscle is extremely rare.

Case presentation: A 69-year-old woman was admitted to our hospital because she noticed a hard mass in her left neck six months prior. Magnetic resonance images (MRI) showed a soft tissue tumor of the left levator scapulae muscle. A core needle biopsy showed cellular fascicles or a storiform growth pattern of spindle-shaped tumor cells with minimally atypia. Immunohistochemistry revealed focally positive for α-smooth muscle actin (α-SMA), negative for S-100, and a low-grade spindle cell sarcoma was suspected. Following a biopsy, the tumor was resected with a wide surgical margin. Immunohistochemical staining was positive for vimentin and α-SMA and negative for desmin, CD34, nuclear β-catenin, and h-caldesmon. LGMS diagnosis was determined based on the histopathological findings. The patient was alive without evidence of disease eight years after the surgery.

Conclusions: To the best of our knowledge, this is the first case report of LGMS arising in the levator scapulae muscle. In addition to the case report, 48 reports with 103 LGMS cases are reviewed and discussed. In previous reports of LGMS, there were 43 females and 60 males, with a mean age of 43.0 years (range, 2–75). There were 13 (12.6%) patients aged < 18 years, 67 (65.1%) patients aged 18 to 59 years, and 23 (22.3%) patients aged ≥ 60 years. The average tumor size was 4.4 cm (range: 0.4–22.0). The commonest sites of LGMS was the tongue. Tumor growth patterns were evaluated in 52 cases, and 44 cases (84.6%) showed infiltrative growth patterns. Local recurrence was 26.7%, and distant metastasis was 4.4%. Because of the locally aggressive feature, it is important to diagnose LGMS with biopsy and to excise the tumor with an adequately wide margin.

Keywords: Low-grade myofibroblastic sarcoma, Levator scapulae muscle, Infiltrative pattern, Intramuscular, Wide excision
**Background**
Low-grade myofibroblastic sarcoma (LGMS) is a rare and relatively new entity that was recently recognized as such and described by Mentzel et al. [1] in 1998. LGMS is described as a distinct atypical myofibroblastic tumor, often with fibromatosis-like features and predilection for the head and neck [2]. Oral cavity [1, 3–16] and larynx [17–20] cases are common, but a variety of tissues, including skin [21–23], breast [24, 25], vulva [26, 27], parapharyngeal space [28], jaw [1, 10], nasal cavity [29], paranasal sinus [29], soft tissue of the cheek [7, 23], and palate [3, 30] have also been reported. LGMS has been characterized as having a low-grade malignant potential, the propensity to recur locally, and a low likelihood of distant metastases [1, 6, 31]. Treatment primarily involves surgical resection with clear margins [32]. We encountered a case of LGMS of the levator scapulae muscle. To the best of our knowledge, this is the first case report of LGMS arising in the levator scapulae muscle. The present study details the case of a patient with LGMS and reviews 103 relevant LGMS cases.

**Case presentation**
A 69-year-old female was admitted to our hospital because of a hard mass in her left neck six months prior (Fig. 1). On physical examination a palpable mass about the size of a quail egg was found to be located at the left neck. The mass had unclear boundaries, and was not tender. Magnetic resonance images (MRI) showed a soft tissue tumor of the left levator scapulae muscle with a size of 2.5 × 3.5 cm (Fig. 2). The mass appears isointense in T1-weighted image (WI) and heterogenously hyperintence in T2WI and short TI inversion recovery (STIR) image. Contrast-enhanced T1WI revealed marked enhancement with gadolinium. She had no medical, family, or surgical history. Needle biopsy specimens were obtained, and histological examination showed spindle cells with minimally atypia arranged with fascicular or storiform growth patterns in the fibrous stroma, suggestive of low-grade spindle cell sarcoma. Immunohistochemistry revealed focally positive for α-smooth muscle actin (αSMA), and negative for S-100. Based on the diagnosis of low-grade spindle cell sarcoma, tumor excision with a wide surgical margin was performed (Fig. 3). The cut surface of the surgically resected tumor was grayish-white (Fig. 4). The histological features comprised a proliferation of spindle-shaped tumor cells in the fibrous stroma with partially infiltrative growth into the surrounding muscle tissues. There was no pseudocapsule but the tumor boundary was nevertheless well-delineated. Inflammatory cells, atypia, and mitosis was rarely seen. Immunohistochemically, the tumor cells were positive for vimentin, αSMA (focally), and negative for HHF-35, desmin, H-caldesmon, CD34, and nuclear β-catenin. S-100 protein was focally positive. An ultrastructural analysis could not be performed because we had only paraffin-embedded material, unsuitable for electron microscope analysis. The lesion was diagnosed as LGMS.

The postoperative course was uneventful. The patient was alive with no evidence of local recurrence or metastasis eight years after the surgery without any additional therapy. She had no functional deficit and the shoulder range of motion was 150° in abduction, 150° in flexion, and 45° in extension at the final follow up. The patient had provided informed consent for publication of the case, and the study protocol was approved by Medical Ethics Committee of Kanazawa University.
Discussion and conclusions

Literature reports published between 1998 and 2019 were identified using the search terms in PubMed and Google Scholar, excluding non-English language reports. We searched for synonyms of “low-grade myofibroblastic sarcoma” and “myofibroblastic sarcoma”. We checked reference lists of all included studies for additional sources. Our case was included in this review as well. A total of 103 cases from 48 reports were analyzed (Table 1) [1, 3, 4, 6–31, 33–51]. Age, location, symptoms, tumor size, infiltrative pattern, treatment method, local recurrence and outcomes were evaluated.

Reported LGMS included 43 females and 60 males aged 2–75 years (median, 43). The number of patients
aged <18 years were 13 (12.6%), those aged 18 to 60 years were 67 (65.1%), and those aged ≥60 years were 23 (22.3%). The average tumor size was 4.4 cm (range: 0.4–22.0). As presented in Table 2, LGMS was located in the head and neck in 53 cases (51.5%); soft tissue 41 cases vs. bone 6 cases, trunk in 26 cases (25.2%); soft tissue 11 cases vs. bone 1 cases, and extremity in 24 cases (23.3%); soft tissue 12 cases vs. bone 7 cases. In the head and neck region, the most common site was the tongue [1, 6–10, 13, 14], followed by the larynx [17–20, 47], and gingiva [3, 12, 15, 16]. LGMS was also observed in the mandible [10, 23], face [23], skull [9], acoustic meatus [9], and deep tissue spaces, including the parapharyngeal space [28] as well as throughout the head and neck region. Some authors have reported LGMS of bone [3, 9, 23, 36, 42, 43, 45]. LGMS of the bone was a total of 14 cases (13.6%) and were located in the femur in five cases (4.9%), mandible in three cases (2.9%), maxilla in two cases (1.9%), tibia in two cases (1.9%), hard palate in one case (1.0%), and sacrum in one case (1.0%). In this series, the most common site of LGMS in the extremities was the femur, followed by groin in four cases, and thigh in three cases. There was another large case series reported by Chan et al. [52] They reported 49 cases of LGMS in the USA, and the most common sites were the extremities in 40.8% of cases, followed by the head and neck region with 26.5% of cases [52]. In contrast to their study, these 103 cases revealed that LGMS was commonly located in the head and neck, especially in the oral cavity.

In most cases, patients present with a painless swelling or an enlarged mass, and pain or related symptoms are rarely reported. In these 103 cases, 33 out of 50 patients had swelling, and 16 out of 50 patients had pain. Chan et al. [52] reported non-head and neck LGMS with a significantly higher number of cases with tumor size > 4 cm. They reported that the mean tumor size in the head and neck region was 3.2 cm (range, 1.0–7.7); in the non-head and neck region tumors, the mean size was 7.1 cm (range, 2.4–24.0). In these 103 cases, the tumor size located in head and neck, trunk, and extremity averaged 2.7 cm (range, 1.0–22.0), and the border of the tumor on the MRI was varied; some authors reported well demarcated tumor [7, 13, 44], but the others were ill-defined [10, 41, 42]. Morii et al. [41] and Niu et al. [50] reported the usefulness of 18F-Fluorodeoxyglucose-positron emission tomography (FDG-PET)/computed tomography (CT) for diagnosing LGMS. They reported abnormally increased FDG metabolism and the
### Table 1 Summary of the clinical features of previously reported 102 LGMS cases and the present case

| Authors               | Case | Age      | Sex (M:F) | Size (cm) | Infiltrative pattern | EM         | Treatment                  | FU (months) | LR          | Oncological outcome |
|-----------------------|------|----------|-----------|-----------|----------------------|------------|----------------------------|--------------|-------------|---------------------|
| Mentzel et al. [1]    | 18   | 42       | 1:7       | 4.0       | Yes (12)             | Yes (4)    | E (10) WE (2) E + RT (2)   | 35.9 (10–151)| Yes (3)     | CDF (8) NED (2) AWD (1) N/A (7) |
| Montgomery et al. [3] | 10   | 54.4     | 8:2       | 4.7       | Yes (6) Mostly       | Yes (6)    | E (6) WE (1) E + RT (1) WE + RT (1) N/A (1) | 48.1 (4–172)| Yes (4)     | CDF (4) NED (2) N/A (4) |
| Meng et al. [29]      | 3    | 34       | 3:0       | 4.2       | Yes (3)              | Yes (1)    | E (3) E + RT (3)           | 21.3 (16–27)| Yes (3)     | NED (3) |
| Meng et al. [9]       | 14   | 30.5     | 9:5       | 4.6       | Yes (1) No (13)      | Yes (8)    | E (8) E + CTX (4) E + RT (2) | 28.3 (20–46)| Yes (5)     | CDF (8) NED (5) N/A (1) |
| Cai et al. [23]       | 9    | 43.9     | 6:3       | 2.7       | No (9)               | No (9)     | Scrapped (1) E (3) E + RT (1) WE + RT (3) Lobectomy (1) | 28.6 (11–44)| Yes (1)     | CDF (7) NED (1) N/A (1) |
| Others [4, 6–8, 10–22, 24–28, 30, 31, 32–51] | 48   | 43.8     | 6:3       | 4.1       | Yes (28) No (2)      | Yes (10)   | E (18) E + RT (1) WE (21) WE + CTX (2) WE + RT (2) CRT (1) Others (2) N/A (1) | 21.3 (6–72)| Yes (8)     | CDF (36) NED (6) DOD (5) N/A (1) |
| Present case          | 1    | 69       | female    | 3.5       | Yes                  | No         | WE                         | 96           | No          | CDF                 |

LGMS Low-grade myofibroblastic sarcoma, M Male, F Female, N/A Not applicable, EM Electron microscopy, E Excision, WE Wide excision, CTX Chemotherapy, RT Radiotherapy, CRT Chemo-radiotherapy, LR Local recurrence, CDF Continuous disease free, NED No evidence of disease, AWD Alive with disease, DOD Death of disease

### Table 2 Comparisons of clinical features according to location of previously reported 102 LGMS cases and the present case

| Location       | Head and neck | Trunk | Extremity | Total |
|----------------|---------------|-------|-----------|-------|
| Number of cases | 53 (51.5%)    | 26 (25.2%) | 24 (23.3%) | 103   |
| Size (cm)      | 2.7 cm (0.4–5.9) | 7.5 cm (1.2–22.0) | 4.9 cm (1.5–11.0) | 4.4 cm (0.4–22.0) |
| LGMS of soft tissue | 41/47 (87.2%) | 11/12 (91.6%) | 12/19 (63.3%) | 64/78 (82.0%) |
| SC (+D)        | 7/47 (14.9%)  | 4/12 (33.3%) | 4/19 (21.1%) | 15/78 (19.2%) |
| SM (+Mu)       | 21/47 (44.7%) | 1/12 (8.4%)  | 0/19 (0%)    | 22/78 (28.2%) |
| IM             | 11/47 (23.4%) | 2/12 (16.6%) | 4/19 (21.1%) | 17/78 (21.8%) |
| Others         | 2/47 (4.2%)   | 4/12 (33.3%) | 4/19 (21.1%) | 10/78 (12.8%) |
| LGMS of bone   | 6/47 (12.8%)  | 1/12 (8.4%)  | 7/19 (36.7%) | 14/78 (18.0%) |
| Infiltrative pattern | 28/29 (96.6%) | 10/14 (71.4%) | 6/9 (66.7%) | 44/52 (84.6%) |
| No             | 1/29 (3.4%)   | 4/14 (28.6%) | 3/9 (33.3%) | 8/52 (15.4%) |

LGMS Low-grade myofibroblastic sarcoma, D Dermis, SC Subcutaneous, Mu Mucosa, SM Submucosa, IM Intramuscular
maximum standard uptake value (SUV max) of the tumor. In previous reports, SUVmax of LGMS were 2.8–9.8 [41, 50]. They suggested that the high capacity of glucose utilization is a possible reflection of LGMS. Differential diagnoses for this tumor include leiomyosarcoma, low-grade fibrosarcoma, well-differentiated osteosarcoma, desmoplastic fibroma, inflammatory myofibroblastic tumor, nodular fasciitis, and fibromatosis. Leiomyosarcoma is a tumor that needs to be most carefully differentiated among them [3, 4, 6, 38, 41, 48]. In these 103 cases, the preoperative histologic assessment was performed in 21 patients. Thirteen out of 21 patients had a record of the details (fine needle aspiration cytology; FNAC, core needle biopsy; CNB, or open incisional biopsy; OIB). A FNAC was performed in three lesions, a CNB was performed in six lesions, and an OIB was performed for six lesions. Both the CNB and OIB were performed in two lesions. Two out of six lesions evaluated by CNB were diagnosed as benign lesions (benign fibrohistiocytoma and myofibroblastoma). The other four lesions were diagnosed as malignant lesions (atypical spindle cell with numerous mitotic figures, synovial sarcoma, malignant mesenchymal tumor, and low grade spindle cell sarcoma) However, the lesions evaluated by OIB were diagnosed as LGMS in three cases, myofibroblastic sarcoma in one case, low grade fibrosarcoma in one case, and low grade sarcoma in one case. There were no malignant cells in three lesions evaluated by FNAC. The positive margin ratios in the biopsy group (12 cases) and non-biopsy group (26 cases) were 16.7 and 38.4%, respectively. Two out of 12 patients in biopsy group was positive surgical margin. Both cases had infiltrative growth pattern and the tumor locations were deep (larynx and left maxillary sinus) [18, 47]. Regarding to the LGMS in the upper aerodigestive tract, Meng et al. [29] reported that owing to the diverse histologic appearance in the same tumor of myofibroblastic sarcoma; misdiagnosis may occur in small and superficial biopsy samples. Montebugnoli et al. [12] also reported that an OIB must be performed, reaching an adequate submucosal depth because a misinterpretation can result from the specimen being sampled from the tumor surface, which contains mainly the granulation tissue-like and hypocellular areas but not the atypia hypercellular area. However, if the tumor location is trunk or extremity, CNB are sometimes preferable because of its convenience, which can be performed as day surgery under local anesthesia at the outpatient clinic [54]. In the present case, the histological grade was accurate by CNB, and wide excision was performed. If the tumor is not sampled by CNB, OIB is recommended to prevent inadequate excision. If the tumor size is less than 3 cm, an excisional biopsy can be indicated [55].

Recently, LGMS has been defined as a distinct entity under a new classification of soft tissue tumors [2]. In the 2002 WHO classification of soft tissue and bone tumor pathology and genetics, LGMS was for the first time classified as a distinct entity. In the subsequent versions, it is still referred to as LGMS and classified as part of the fibroblastic/myofibroblastic tumor category. LGMS is classified as an intermediate (rarely metastasizing) type of myofibroblastic tumor [2]. Myofibroblasts have been characterized as mesenchymal spindle cells that share features of both fibroblasts and smooth muscle cells. Some authors consider that electron microscopy is the gold standard for diagnosis of the presence of myofibroblasts. However, only 22 (21.4%) of 103 cases were reviewed by electron microscopy in this series. Ultrastructurally, myofibroblasts are characterized by myofilaments with focal density (stress fiber) and prominent rough endoplasmic reticulum (RER) [56–58]. In contrast, it is controversial whether fibronexus, occasionally observed in reactive myofibroblasts and myofibroblastic tumors, is a specific and essential feature of myofibroblasts [56–59]. Some authors reported that recognizing purely myofibroblastic differentiation is difficult without electron microscopic examination, but agree that neoplastic cells have poorly developed ultrastructural features that may not identifiable in all cases [4, 60]. Although electron microscopic examinations were not available in the present case, the extensive vimentin- and actin-positive and h-caldesmon-negative immunohistochemical staining, and their eosinophilic wavy cellular features, supports their myofibroblastic differentiation.

Surgery is the primary treatment modality for LGMS [6, 10, 32, 39]. Adjuvant therapies such as chemotherapy and radiotherapy have also been used in some cases [1, 3, 29, 33, 61], although the optimal treatment of LGMS remains ill-defined. Peng et al. [33] reported no recurrence five years after surgery and adjuvant chemotherapy for LGMS of the pancreas. However, Humphries et al. [43] reported that chemotherapy does not seem to be effective. About radiotherapy, Khosla et al. [18] reported that the patient underwent postoperative radiotherapy because of margin involvement, and the patient was alive and disease-free 14 months after surgery. Because LGMS is extremely rare, the standardization of its treatments, including surgery, chemotherapy, and radiotherapy, requires further investigation. Chan et al. [52] reported a 5-year overall survival of 71.6% and disease-specific survival of 76.3%.

LGMS usually affects deep soft tissue sites and is often poorly circumscribed with fascicles and individual cells infiltrating between muscle fibers, although focal circumscription is not unusual [4]. Forty-four (84.6%) out of 52 cases had infiltrative growth patterns in these 103
Table 3 Comparisons of oncological outcomes according to location of previously reported 102 LGMS cases and the present case

| Oncological outcome | Head and neck | Trunk | Extremity | Total |
|---------------------|---------------|-------|-----------|-------|
| CDF                 | 35/48 (72.9%) | 15/23 (65.2%) | 14/18 (77.8%) | 64/89 (71.9%) |
| NED                 | 11/48 (22.9%) | 5/23 (21.7%)  | 3/18 (16.7%)  | 19/89 (21.4%)  |
| AWD                 | 0/48 (0%)     | 1/23 (4.4%)   | 0/18 (0%)     | 1/89 (1.1%)    |
| DOD                 | 2/48 (4.2%)   | 2/23 (8.7%)   | 1/18 (5.5%)   | 5/89 (5.6%)    |

Local recurrence
Yes 13/49 (26.5%) 6/22 (27.3%) 5/19 (26.3%) 24/90 (26.7%)
No 36/49 (73.5%) 16/22 (72.7%) 14/19 (73.7%) 66/90 (73.3%)

Distant metastasis
Yes 1/49 (2.0%) 2/23 (8.7%) 1/19 (5.3%) 4/91 (4.4%)
No 48/49 (98.0%) 21/23 (91.3%) 18/19 (94.7%) 87/91 (95.6%)

LGMS: Low-grade myofibroblastic sarcoma, CDF: Continuous disease free, NED: No evidence of disease, AWD: Alive with disease, DOD: Death of disease

Received: 8 October 2020 Accepted: 3 December 2020

References
1. Mentzel T, Dry S, Katenkamp D, Fletcher CD. Low-grade myofibroblastic sarcoma: analysis of 18 cases in the spectrum of myofibroblastic tumors. Am J Surg Pathol. 1998;22(10):1228–38.
2. Mentzel TDW. Low grade myofibroblastic sarcoma. In: WHO classification of tumors: Soft Tissue and Bone Tumors. Lyon: IARC Press; 2020. p. 112–3.
3. Montgomery E, Goldblum JR, Fisher C. Myofibrosarcoma: a clinicopathologic study. Am J Surg Pathol. 2001;25(2):219–28.
4. Jay A, Piper K, Farthing PM, Carter J, Diwakar A. Low grade myofibroblastic sarcoma of the tongue. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104(5):515–20.
5. Takácsi-Nagy Z, Murakeyboard G, Bogány P, Fodor J, Orozzi Z. Myofibroblastic sarcoma of the base of tongue. Case report and review of the literature. Strahlenther Onkol. 2009;185(3):198–201.
6. Cai C, Dehner LP, El-Mofty SK. In myofibroblastic sarcomas of the head and neck, mimics benign lesions: a case report and literature review. Virchows Arch. 2013;463(6):827–36.
7. Maruyama T, Nakasone T, Nimura F, Matayoshi A, Kawanoto T, Nishihara K, et al. Indolent growth of low-grade myofibroblastic sarcoma of the cheek mimics benign lesions: a case report and literature review. Oncol Lett. 2017;13(6):4307–14.
8. Laco J, Simíková E, Slezáří R, Tucek L, Mottl R, Spacek J, et al. Low grade myofibroblastic sarcoma of tongue: a case report. Cesk Patol. 2006;42(3):150–3.
9. Meng GZ, Zhang HY, Bu H, Zhang XL, Pang ZG, Ke Q, et al. Myofibroblastic sarcomas: a clinicopathological study of 20 cases. Chin Med J. 2007;120(5):363–9.
10. Damarosi F, Bay A, Moneghini L, Carassì A. Low-grade myofibroblastic sarcoma of the oral cavity. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;108(2):248–54.
11. Niedzielska I, Janic T, Mrowiec B. Low-grade myofibroblastic sarcoma of the mandible: a case report. J Med Case Rep. 2009;10(3):458.
12. Montebuggioni L, Venturi M, Gissi DB, Flammini F, Focchiini MP. Low-grade myofibroblastic sarcoma of the gingiva. BMJ Case Rep. 2010;2010: bcr02702013166.
13. Mori T, Shimane T, Hayashi T, Uzuki A, Ikegaya Y, Akiyama R, et al. Low-grade myofibroblastic sarcoma at the base of the tongue. Showa Univ J Med Sci. 2010;22(4):239–43.

Abbreviations
LGMS: Low-grade myofibroblastic sarcoma; MRI: Magnetic resonance imaging; α-SMA: α-smooth muscle actin; FDG-PET: Fluorodeoxyglucose-positron emission tomography; CT: Computed tomography

Acknowledgments
The authors thank Editage (www.editage.com) for English language editing and publication support.

Authors’ contributions
HY, NY, KH, AT, SM, KI, M-B L, HK, SS, TK, SM, YA, YA and HT designed the study. HY and SM collected the data. HY, SM, HI and TN analyzed the data and developed the methodology. HY was a major contributor in writing the manuscript. HY and SM analyzed and interpreted the patient data. HT oversaw the study. All authors read and approved the final manuscript.

Funding
Not applicable.

Availability of data and materials
All data generated or analyzed during this study are included in this article.

Ethics approval and consent to participate
This study was approved by Medical Ethics Committee of Kanazawa University. Participation outcomes were collected independently from the participant with written informed consent.

Consent for publication
Written consent to publish was obtained from the study participant, and a copy is available to the journal. All the authors read the final manuscript and approved for publication.

Competing interests
The authors declare that they have no competing interests.

Author details
1Department of Orthopaedic Surgery, Graduate School of Medical Sciences, Kanazawa University, 13-1 Takara-machi, Kanazawa, Ishikawa 920-8640, Japan.
2Department of Orthopedics, Philippine Orthopedic Center, Quezon City, Manila, Philippines.
3Department of Diagnostic Pathology, Kanazawa University Hospital, Kanazawa, Japan.
Low-grade myofibroblastic sarcoma of the scalp. J Hand Surg Am. 2004;29(6):1196–9.

24. Han SR, Yee GT. Low grade myofibroblastic sarcoma occurred in the scalp. J Int Med Res. 2013;41(4):1050–4.

25. Myong NH, Min JW. Low-grade myofibroblastic sarcoma arising in the scalp. Int J Oral Sci. 2012;4(3):170.

26. Roth TM, Fratkin J, Woodring TC, McGehee RP. Low-grade myofibroblastic sarcoma of the scalp in a child. J Craniofac Surg. 2005;16(6):1614–7.

27. Park JS, Park SM, Park CH, Kim HJ, Kim HJ, Lee JY, et al. Low-grade myofibroblastic sarcoma of the scalp: a clinicopathologic study. Am J Surg Pathol. 2000;24(12):1617–22.

28. Yonezawa S, Kondo T, Kono Y, Komatsu T, Takeda Y, Aoki K, et al. Low-grade myofibroblastic sarcoma of the scalp in a child. J PEDIatr. 2004;144(3):451–2.

29. Nishigaki S, Yoneda M, Aoki K, Komatsu T, Takeda Y, Aoki K, et al. Low-grade myofibroblastic sarcoma of the scalp: a clinicopathologic study. J Jpn Soc Pathol. 2005;39(1):21–5.

30. Yamada T, Yoshimura T, Kitamura N, Sasabe E, Ohno S, Yamamoto T. Low-grade myofibroblastic sarcoma of the scalp. J Cutan Pathol. 2005;32(8):460–3.

31. Qiu JY, Liu P, Shi C, Han B. Low-grade myofibroblastic sarcomas of the scalp. J Dermatol. 2001;28(7):383–90.

32. Fujimoto M, Cawaja A, Fujimoto M, Cawaja A, Fujimoto M, Cawaja A, et al. Low-grade myofibroblastic sarcoma of the scalp. J Cutan Pathol. 2003;30(9):465–70.

33. Takahama A Jr, Nascimento AG, Brum MC, Vargas PA, Lopes MA. Low-grade myofibroblastic sarcoma of the scalp: a clinicopathologic study. Am J Surg Pathol. 2000;24(12):1617–22.

34. Park JS, Park SM, Park CH, Kim HJ, Kim HJ, Lee JY, et al. Low-grade myofibroblastic sarcoma of the scalp: a clinicopathologic study. Am J Surg Pathol. 2000;24(12):1617–22.

35. San Miguel P, Fernández G, Ortiz-Rey JA, Larrauri P. Low-grade myofibroblastic sarcoma of the scalp: a clinicopathologic study. Am J Surg Pathol. 2000;24(12):1617–22.

36. Fernández-Aceñero M, Sanz-Laguna A, Carrascoso-Aran J, López-Criado P. Low-grade myofibroblastic sarcoma of the scalp: a clinicopathologic study. J Int Med Res. 2013;41(4):1050–4.

37. Tajima Y, Yonezawa S, Kondo T, Kono Y, Komatsu T, Takeda Y, et al. Low-grade myofibroblastic sarcoma of the scalp: a clinicopathologic study. J Jpn Soc Pathol. 2005;39(1):21–5.

38. Fratkin J, Woodring TC, McGehee RP. Low-grade myofibroblastic sarcoma of the scalp: a clinicopathologic study. J PEDIatr. 2004;144(3):451–2.

39. Nishigaki S, Yoneda M, Aoki K, Komatsu T, Takeda Y, Aoki K, et al. Low-grade myofibroblastic sarcoma of the scalp. J Cutan Pathol. 2005;32(8):460–3.

40. Kamata T, Mochizuki K, Sano H, Fujino T, Harasawa A, Satomi K, Occult myofibroblastic sarcoma detected on FDG-PET performed for cancer screening. Ann Nucl Med. 2008;22(9):811–5.

41. Arai R, Gupta R, Sharma A, Dinda AK. A rare case of low-grade myofibroblastic sarcoma of the femur in a 38-year-old woman: a case report. J Med Case Rep. 2010;28(4):412.

42. Humphries WE 3rd, Satyan KB, Relayea K, Kim ES, Adesina AM, Chintagumpala M, et al. Low-grade myofibroblastic sarcoma of the sacrum. J Neurosurg Pediatr. 2010;6(3):86–90.

43. Miyazawa M, Naitaka Y, Miyaki A, Asaka S, Isohata N, Yamauchi K, et al. A low-grade myofibroblastic sarcoma in the abdominal cavity. Anticancer Res. 2011;31(9):3089–94.

44. Saito T, Mitomi H, Kurisaki A, Torigoe T, Takagi T, Suehara Y, et al. Low-grade myofibroblastic sarcoma of the distal femur. Int J Surg Case Rep. 2013;4(2):195–9.

45. Olyumlu M, Yildiz A, Ercan S, Olyumlu M, Dervisoglu V. Cardiac metastasis of a low-grade myofibroblastic sarcoma. Echocardiography. 2014;31(3):E1–4.

46. Gómez-Oliveira G, Ambás-García I, Álvarez-Builla A, Sánchez-Burgos R, Martínez-Pérez F, Alvarez-Flores M. Low-grade myofibroblastic sarcoma. Two rare tumors in two rare locations. Rev Esp Cir Oral Maxilofacial. 2015;37(2):108–12.

47. Hadjiapetroiu GF, Samaras V, Varios V. Low-grade myofibroblastic sarcoma of the thoracic spine: report of an extreme rare case. Br J Neurosurg. 2017;31(6):731–3.

48. Zhao S, Ma Y, Ma T, Wang Z. Low-grade myofibroblastic sarcoma of the orbit: a case report and literature review. Medicine (Baltimore). 2017;96(51):e9720.

49. Niu R, Wang JF, Zhang DC, Shao XL, Qu C, Wang YT. Low-grade myofibroblastic sarcoma of gastric cardia on 18F-FDG positron emission tomography/computed tomography: an extremely rare case report. Medicine (Baltimore). 2018;97(4):e9720.

50. Taiwvesit M, Thorner PS. Distinctive features of low-grade myofibroblastic sarcoma on aspiration cytology: a case report. Cytopathology. 2018;29(6):578–81.

51. Chan YJ, Gooi Z, Wong EW, Ng SK, Tong MC, Vlantis AC. Low-grade myofibroblastic sarcoma: a population-based study. Laryngoscope. 2017;127(1):116–21.

52. Shipzin BA, Holliday RA. Levator scapulae muscle asymmetry presenting as a palpable neck mass: CT evaluation. AJNR Am J Neuroradiol. 1993;14(2):363–70.

53. Watanabe K, Ogura G, Tajino T, Hoshi N, Suzuki T. Myofibrosarcoma of the scalp. J Cutan Pathol. 2000;27(9):533–6.

54. Eyden B. The myofibroblast: an assessment of controversial issues and a definition useful in diagnosis and research. Ultrastruct Pathol. 2001;25(3):193–202.

55. Okada K. Points to notice during the diagnosis of soft tissue tumors with a literature review. J Clin Pathol. 2008;61(3):301–6.

56. Fisher C. Myofibrosarcoma. Pathol Case Rev. 2002;7:153–6.

57. Martínez-Pérez F, Alvarez-Flores M. Low-grade myofibroblastic sarcoma of the scalp: a clinical, immunohistochemical, molecular genetic and ultrastructural study of two cases with literature review. J Clin Pathol. 2008;61(3):301–6.

58. Eisenstat J, Gilson T, Reimann J, Sampson B. Low-grade myofibroblastic sarcoma of the heart causing sudden death. Cardiovasc Pathol. 2008;17(1):55–9.

59. Toki T, Mochizuki K, Sano H, Fujino T, Harasawa A, Satomi K, Occult myofibroblastic sarcoma detected on FDG-PET performed for cancer screening. Ann Nucl Med. 2008;22(9):811–5.

60. Arah R, Gupta R, Sharma A, Dinda AK. A rare case of low-grade myofibroblastic sarcoma of the femur in a 38-year-old woman: a case report. J Med Case Rep. 2010;28(4):412.

61. Kortmann B, Reimer T, Gerber B, Klautke G, Fietkau R. Concurrent low-grade myofibroblastic sarcoma presentation: an unusual finding. Int J Clin Exp Pathol. 2016;9:1568–77.

Publisher's Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.