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Use of radiologic imaging to differentiate lipoma from atypical lipomatous tumor/ well-differentiated liposarcoma: Systematic review

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Abstract

Background: Lipomas and atypical lipomatous tumors or well-differentiated liposarcomas (ALTs/WDLs), pose a diagnostic challenge due to their overlapping clinical and imaging features. Accurate differentiation is crucial as treatment strategies differ significantly between benign lipomas and malignant ALTs/WDLs. In recent years, medical imaging techniques have shown promise in distinguishing lipomas from ALTs/WDLs by providing enhanced visualization and assessment of various imaging parameters.

Objective: This systematic review aimed to investigate the use of magnetic resonance (MR) imaging and computed tomography (CT) scan to differentiate lipomas from ALTs/WDLs.

Methods: A systematic review was conducted by using MEDLINE, PubMed, PubMed Central, Cochrane Library, Google Scholar, and clinical trail.gov to identify imaging studies published between 2001 and 2022. Two independent reviewers reviewed 221 record to scrutinize the studies. The methodological quality of each included studies was assessed the using Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) tool.

Results: Thirteen retrospective cohort studies included 1,390 of total patients. Among them, 11 studies used MR imaging, 2 studies used CT scan and MR imaging both to differentiate lipoma from ALTs/WDLs. The significant diagnostic variables identified in the included studies were age, size, texture, mean intensity, contrast enhancement, location, septation, and nodularity. The overall, sensitivity, specificity, and accuracy of the included studies for diagnosis of lesions range from 66% to 100%, 37% to 100%, and 76% to 95%, respectively. The positive and negative predictive values range from 46.9% to 90% and 86% to 100%, respectively.

Conclusion: The most frequent diagnostic features of ALTs/ WDLs include tumors $\geqslant$110 mm in size, often in patients over 60, predominantly in the lower extremities, with an irregular shape, incomplete fat suppression, contrast enhancement, nodularity, septation $>$2 mm, and predictive markers such as lactate dehydrogenase $>$220 and a short tau inversion recovery-signal intensity ratio $>$1.18.

Keywords

lipoma, atypical lipomatous tumor, well-differentiated liposarcoma, diagnostic imaging, CT scan, MR imaging

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Introduction

Lipomatous tumors account for the majority of soft tissue tumors.[1,2] Belonging to a mesenchymal origin, they are either benign in nature, such as lipoma, or malignant, such as liposarcoma.[2] Following Undifferentiated pleomorphic sarcoma, liposarcoma ranks as the second most prevalent soft tissue tumor in adults, with an estimated prevalence of 15%.[3,4] An atypical lipomatous tumor (ALT), also known as

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well-differentiated liposarcoma (WDL), is one of the most common subtypes of liposarcomas.[1,4,5] As the therapeutic strategies for lipoma and ALTs/WDLs vastly differ, accurate diagnosis is required before the initiation of treatment, which is usually challenging as many diagnostic parameters coincide between the two tumors.[4,6,7] Traditional histological diagnosis of ALTs/WDLs relies on the presence of atypical hyperchromatic nuclei in the examined tissue sample. However, observing these cells is often ambitious because of their paucity and scattered appearance throughout the lesion.[8] Furthermore, biopsy is a surgically invasive procedure that carries the risk of seeding tumor cells into neighboring tissues or in the bloodstream.[9] While the likelihood of such seeding is low, it is not negligible and remains a critical factor in clinical decision-making.[9] Fluorescence in situ hybridization (FISH) to identify murine double minute 2 (MDM2) gene amplification is an effective pathological technique and is considered the gold standard tool for diagnosing ALTs. In particular, MDM2 is a sensitive biomarker for ALTs.[10]

In recent decades, medical imaging has stepped forward to provide the best visualization, which aids in distinguishing lipoma from ALTs/WDLs by virtue of soft tissue contrast, echogenicity, high resolution, and capability of simultaneously imaging functional parameters.[11,12] Multiple imaging and clinical parameters, for example, tumor size, intensity, location, depth, fat content, and age assessed in previous diagnostic imaging studies were reported to be significant for diagnosing ALTs/WDLs.[13] However, owing to the complexity and discrepancy in the clinical presentation of these parameters, it may be unclear what specific combinations of certain parameters indicate tumors and often make it difficult to incorporate these parameters for clinical diagnosis. To prevent dubiety in the diagnosis of lipoma and ALTs/WDLs, several approaches have been described including the use of various image sequences, extraction, and filtration of features by magnetic resonance (MR) textural analysis, followed by grading of features by deep machine learning modal and radiomics model.[12–14]

Therefore, the aim of this study was to conduct a systematic review of the literature to investigate the different studies that used MR imaging and computed tomography (CT) scans to differentiate benign lipomas from ALTs/WDLs.

Method

The systematic review was performed according to guidelines from the preferred reporting items for systematic reviews and meta-analyses (PRISMA).[15] PubMed, PubMed Central, MEDLINE, Clinical Trial.gov, and Google Scholar databases were searched. Articles published between 2002 and 2022 were retrieved and the last search was performed on July 15, 2023. The search strategy for Google Scholar was, "lipoma" AND ("Atypical lipomatous tumor" OR "well-differentiate liposarcoma") AND ("diagnosis" OR "diagnostic imaging" OR "MR Imaging" OR "CT scan" OR "sonography" OR "medical imaging") The MeSH term strategy was developed for the remaining databases ("Lipoma/diagnosis"[Mesh] OR "Lipoma/diagnostic imaging"[Mesh]) AND ("Liposarcoma/diagnosis"[Mesh] OR "Liposarcoma/diagnostic imaging"[Mesh]). Two reviewers independently screened the abstracts and full text of the studies. Disagreements and non-agreements were resolved by an independent third party who acted as an arbiter. The reference list of the included studies was also examined to identify any articles relevant to the study inclusion criteria.

The study inclusion and exclusion criteria were as follows:

- All relevant retrospective studies, prospective cohort studies, observational studies, and randomized control trials that compared and differentiated a lipoma from ALTs/WDLs were included.
- Studies with more than ⩾20 patients participants were included (this number was chosen to avoid papers that form part of a series of case studies and to exclude studies with low statistical power, yet allow a good breadth of studies to be included).
- The study uses MR imaging or CT scan or both as index tests in study.
- The study used histopathological identification, and MDM2 TEST as Reference standard was included.
- Studies published in languages other than English were excluded.
- Literature search, case report, case series, and case-control studies were excluded.
- Any composite (scoring) or nomogram model study that combined histopathology or MDM2 (FISH) results with diagnostic imaging to develop a grading system for tumors was excluded.

Methodological quality assessment of the included studies was independently performed by two reviewers (M.M. and U.A.) using the Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) tool for diagnostic accuracy studies.[16] Interobserver agreement was analyzed using Cohen's *k* coefficient. Disagreements were resolved using census building. The following data were extracted for the table building: year and type of study; number of patients with lipoma, ALTs/WDLs, and total; mean or median age; reference test; index test; image sequence; significant predictive variables; number of observers; sensitivity; specificity; accuracy; positive predictive and negative predictive values. All these data were represented in three different.

Results

Study selection

A comprehensive systematic literature search yielded a total of 199 unique citations. Subsequently, title and abstract screening of the retrieved records yielded 36 potentially eligible studies that employed medical imaging for tumor

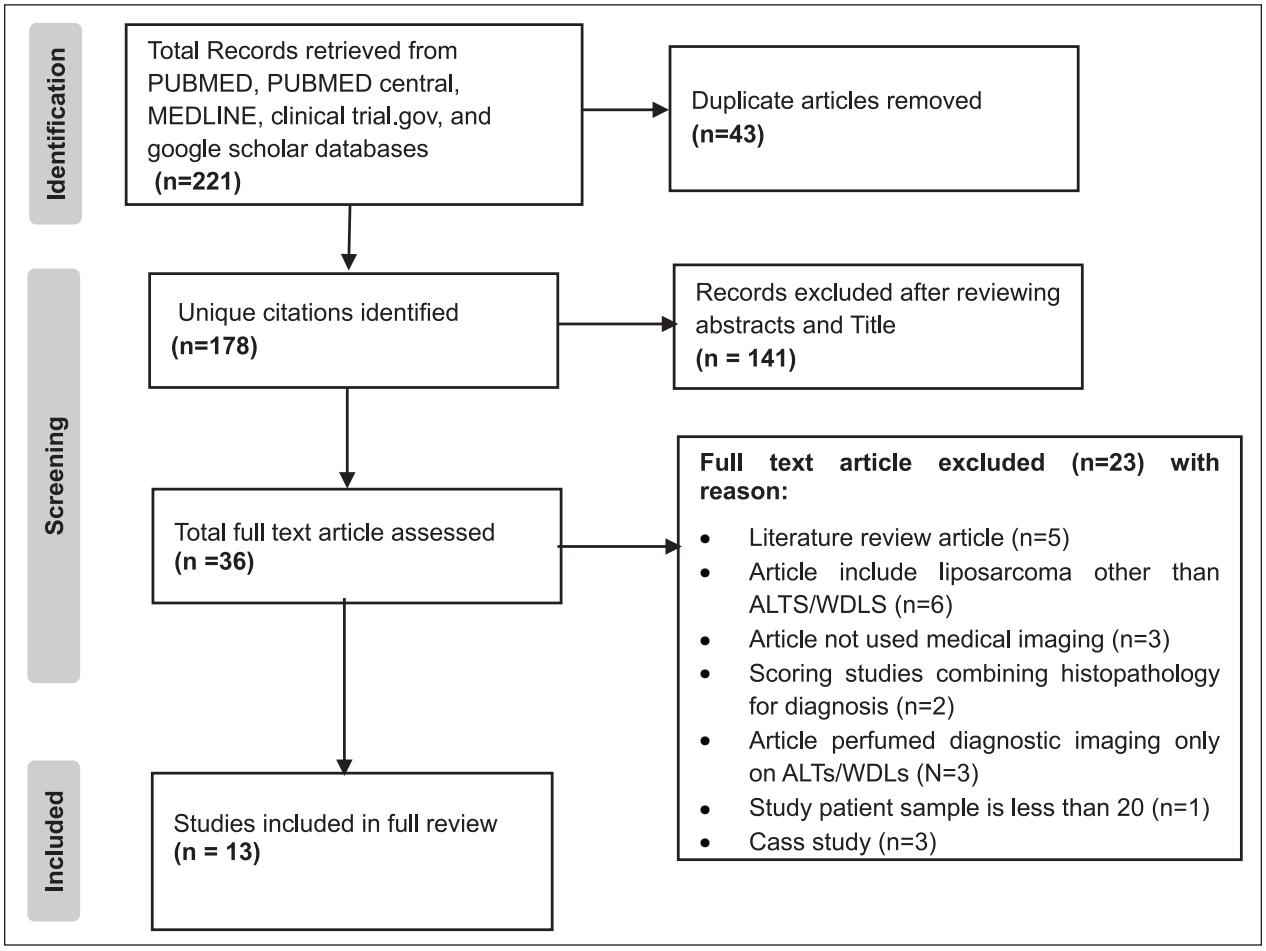

Figure 1. Summary of literature search.

classification. An additional 22 studies were excluded during the key-question applicability screening because they did not meet one or more of the study inclusion criteria (see Figure 1). Consequently, 13 studies were included in this systematic review for a comprehensive analysis.

Quality assessment and characteristics of included studies

In the methodological quality assessment, five studies demonstrated a low risk of bias regarding patient selection,[12,14,17–19] whereas eight studies exhibited a high risk of bias.[13,20–26] The primary reason for the high risk of bias in patient selection, as noted across these studies, was the exclusion of patients who met the study criteria due to the unavailability of their data. The risk of bias remained unclear in three studies related to index tests[17,19,21] and in four studies concerning the reference standard,[19,23,25] mainly due to insufficient reporting on blinding procedures. All studies demonstrated a low risk of bias in terms of flow and timing (Figure 2).

All 14 studies included in this review were retrospective cohort studies conducted between 2001 and 2022, encompassing a total of 1,390 patients. Among these patients, 899 were diagnosed with lipoma and 491 with ALT/WDL. The median age of patients with lipoma was 52 years (range 48–56.4), while patients with ALTs/WDLs had a median age of 61.3 years (range 59–67). Five of the included studies used a combination of histopathology and MDM2 (FISH) testing as a reference standard, whereas the remaining studies relied solely on histopathology or MDM2 (FISH) (see Table 1). Eleven studies exclusively employed MR imaging, while two studies used both CT scan and MR imaging as index tests (see Table 1). Notably, there was variability in the MR imaging sequences used to define the target lesions in the included studies, in terms of fat suppression, contrast enhancement, spin echo types, and fluid-sensitive sequences. However, most studies have preferred T1-weighted, T2-weighted, and short tau inversion recovery (STIR) sequences. In four studies, radiological findings were independently interpreted by readers, while the remaining four studies reported a consensus-building approach (see Table 2).

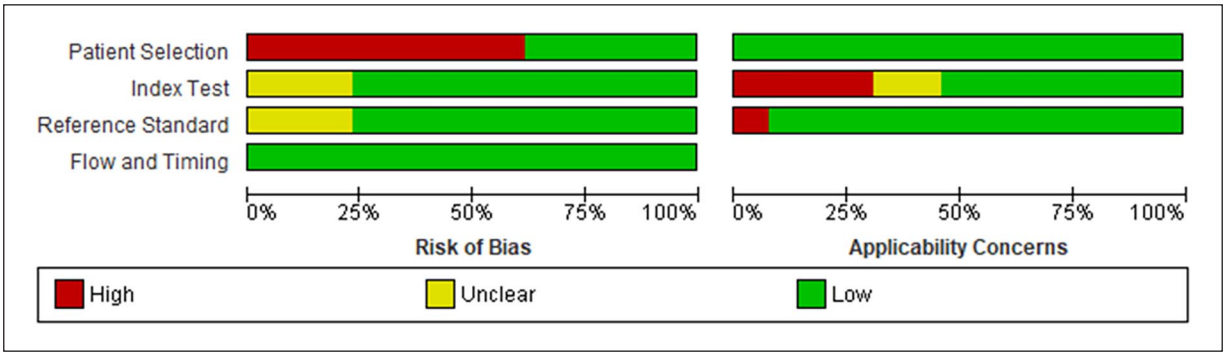

Figure 2. Graph of assessment of risk of bias and applicability concern.

Effectiveness of imaging techniques and sequences

Regarding the effectiveness of imaging techniques and sequences for classifying target lesions, MR imaging alone was reported to be superior to CT scans or a combination of both modalities, as demonstrated by Yang et al.[12] Only two studies reported the use of CT scans, primarily due to CT being reserved for cases where magnetic resonance imaging is contraindicated, such as in patients with pacemakers.[12,19] All included studies recommended using at least two or more MR image sequences for radiographic assessment of lesions. Vos et al, in their study, further strengthened the fact of using two or more imaging sequences by evaluating the accuracy of the T1 imaging model and T1 + T2 imaging model.[26] Their study observed significantly higher accuracy, sensitivity, and specificity for T1 + T2 imaging model than for the T1 imaging model. Nine studies applied contrast enhancement to imaging sequences to improve visual assessment and image sharpness (see Table 1). However, three studies reported similar accuracies in tumor diagnosis with and without contrast enhancement.[17,22,26] In the remaining six studies, the presence of contrast enhancement was consistently associated with ALTs/WDLs, with enhancement patterns typically appearing nodular, thick septal (>2 mm), hazy, or solid in nature.

Models implemented by included studies

To extract quantitative imaging parameters and classify lipomas from ALTs/WDLs, four studies implemented deep machine learning algorithms and radiomics models.[12,14,25,26] Among these, Yang et al. and Leporq et al. in their employed a gray-level discretization method in their radiomics models, which involves grouping image pixels based on their intensity levels to facilitate texture feature extraction and calculation.[12,14] Yang et al. in their study also integrated six deep learning extracted features with handcrafted radiomics to develop a nomogram model.[12] Shim et al. in their study constructed a decision tree model from potential predictor variables by using classification and regression tree analysis, a non-parametric method employing binary recursive partitioning.[25] Additionally, four studies applied logistic regression models or receiver operating characteristic analysis to assess the multivariable contributions of observed imaging and non-imaging variables in predicting lipoma and ALTs/WDLs by determining the appropriate thresholds.[13,18,20,22] Furthermore, four studies independently analyzed and reported significant variables for predicting the diagnosis of lipoma from ALTs/WDLs.[17,19,23,24] Only one study developed a composite (risk) score by combining the most significant imaging parameters analyzed through magnetic resonance textural analysis (MRTA).[24] This study applied histogram filtration techniques to MRTA to eliminate heterogeneity in MR images, enhance imaging features, and extract coarse textural parameters with the highest degree of discernibility.

Diagnostic parameters

The studies demonstrated moderate homogeneity concerning significant clinical and imaging variables for predicting malignant tumors from lipomas. Commonly identified significant predictive variables included age, size, location, contrast enhancement, intensity, and texture (see Table 1). Additionally, some unique predictive variables were observed, including lactate dehydrogenase, STIR-SI ratio, gray-level texture metrics, and the texture parameter axial proton density MRTA (see Table 1). Leporq et al. introduced four texture metrics for each gray discretization, from which characteristics were extracted and averaged (see Table 1).[14] These four matrices appeared to be the most effective algorithm-based variables for identifying lipomas and ALTs/WDLs, as they exhibited high sensitivity, specificity, and accuracy in Leporq et al.'s study. Another textural parameter was developed by Pressney et al. in their study,[24] who quantified the texture level of axial proton density MR images at three different spatial scales of the filter (SSF; fine, SSF = 2 mm; medium SSF = 3, 4, and 5 mm; and coarse, SSF = 6 mm) using histogram-based parameters. The mean texture intensity at coarse-filtered texture (SSF = 6) was identified as the best univariate texture marker for differentiating ALTs/WDLs from lipomas, with a cutoff value of <304.

Table 1. Patient and studies characteristics and significant parameters reported by studies.

First author (year)	Type of study	No of patient	Age (years)		Reference standard	Imaging technique	Sequence used to define target condition	Predictive variables
			Mean (m) or median (M)	Range				
Yang (2022)[12]	Retrospective study	Total; 127 Lipoma; 69 ALT; 58	48 M ⩽60 M >60 M		MDM2 (FISH)	CT and MRI	Contrast enhanced CT T1WI and T2 with fat suppression MRI images	Age, lactate dehydrogenase
Knebel (2019)[18]	Retrospective study	Total; 113 Lipoma; 66 ALT; 47	N/A 53 M 60 M	 13–82 28–88	MDM2 (FISH)	MRI	Contrast enhanced T2 FSE, T1WI with fat suppression and STIR	Age, tumor size, location, contrast enhancement, and nodularity
Leporq (2022)[14]	Retrospective study	Total; 81 Lipoma; 40 ALT; 41	N/A N/A N/A		Histopathology	MRI	Gadolinium-contrast enhanced T1WI,FSE	Size, shape, four texture features extracted by gray discretization Level: (gray-level co-occurrence matrix, gray-level run length matrix, gray-level size zone matrix , and neighborhood gray-tone difference matrix)
Pressney (2020)[24]	Retrospective study	Total; 60 Lipoma; 30 ALT; 30	N/A 51 M 60 M	 29–76 27–89	Histopathology and MDM2 (FISH)	MRI	T1W TSE, STIR, T2W FSE, PDW FSE, SPAIR	Tumor location, depth of tumor, fat content, texture parameter on axial PD MRTA (mean intensity at coarse-filtered texture scales)
Shim (2020)[25]	Retrospective study	Total; 231 Lipoma; 186 ALT; 45	N/A 50.74 m 59.42 m	N/A ±11.95 ±11.30	N/A	MRI	T1W FSE and T2WI FSE with and without fat suppression	Age, tumor location, Enhancement pattern (thick/ nodular/thin)
Donners (2020)[20]	Retrospective study	Total; 94 Lipoma; 68 ALT; 26	58 m 56.4 m 62.6 m	21–84 21–83 40–84	Histopathology and MDM2 (FISH)	MRI	T1WI and STIR	Size, STIR-SI ratio
Nardo (2020)[22]	Retrospective study	Total; 246 Lipoma; 176 ALT; 70	59 M	23–89	Histopathology and MDM2 (FISH)	MRI	T1WI FSE, T2WI with fat suppression, and STIR	Pain, size, tumor location, depth, margin, texture
Vos (2019)[26]	Retrospective study	Total; 116 Lipoma; 58 ALT; 58	64 M N/A N/A	54–71 N/A N/A	Histopathology and MDM2 (FISH)	MRI	T1 and T2 with fat suppression, STIR, SPIR, SPAIR, TIRM, T1 With gadolinium, T2WI FFE	Shape, texture, and intensity features
Brisson (2013)[13]	Retrospective study	Total; 87 Lipoma; 54 ALT; 33	N/A 53.5 M 65 M	N/A 10–79 40–83	Histopathology and MDM2 (FISH)	MRI	T1WI SE, T1WI FSE with fat suppression, and STIR	Age, size, tumor location, fat content
Doyle (2008)[17]	Retrospective study	Total; 51 Lipoma; 33 ALT; 18	N/A 53 m 59 m	N/A N/A N/A	Histopathology	MRI	T1WI and fluid-sensitive sequence	Age, size
Panzarella (2005)[23]	Retrospective study	Total; 32 Lipoma; 24 ALT; 8	N/A N/A N/A	N/A N/A N/A	Biopsy and histopathology	MRI	T1WI SE, T2WI with and without fat suppression, T1 with gadolinium	Size, presence, or absence of gadolinium enhancement
Galant (2001)[21]	Retrospective study	Total; 92 Lipoma; 60 ALT; 32	N/A N/A N/A	N/A N/A N/A	Histopathology	MRI	T2WI with fat suppression and STIR Gadolinium contrast (five patient)	Septation, nodules, intensity, gadolinium enhancement
Kransdorf (2002)[19]	Retrospective study	Total; 60 Lipoma; 35 ALT; 25	N/A 56 M 67 M	N/A 1–88 30–87	Histopathology	CT and MRI	Images with contrast enhancement	Sex, age, septation, fat content, and nodularity

ALT: atypical lipomatous tumor; FISH: fluorescence in situ hybridization; MDM2: murine double minute 2; MRI: magnetic resonance imaging; CT: computed tomography; STIR: short tau inversion recovery; SI: signal intensity; PD: proton density; MRTA: magnetic resonance textural analysis;
FSE: Fast spin echo; PDW: proton density weighted; SPAIR: Spectral Attenuated Inversion Recovery; SPIR: Spectral Presaturation with Inversion Recovery.

Table 2. Observer and diagnostic performance characteristics of imaging studies for detection of lipoma and ALTs/WDLs.

First author (year)	Number of observers n (ind OR con)	Sensitivity (%)	Specificity (%)	Negative predictive value (%)	Positive predictive value (%)	AUC cutoff (95% CI)	Accuracy (%)
Yang (2022)[12]	2	95	77.78	93.33	82.61	0.942	86.84
Knebel (2019)[18]	2 (ind)	85.10	86.40	89.10	81.60	N/A	N/A
Leporq (2022)[14]	2 (ind)	100	90	100	90.90	0.96	95
Pressney (2020)[24]	1	90	60	N/A	N/A	0.8	N/A
Shim (2020)[25]	2 (con)	66.67	95.59	N/A	N/A	N/A	91.72
Donners (2020)[20]	2	65	100	N/A	N/A	N/A	76
Nardo (2020)[22]	3	89	78	94	61	0.83	N/A
Vos (2019)[26]	3	66	84	72	81	0.75	N/A
Brisson (2013)[13]	2 (ind)	90.90	37.00	86.90	46.90	N/A	N/A
Doyle (2008)[17]	2 (ind)	N/A	N/A	N/A	N/A	N/A	N/A
Panzarella (2005)[23]	4 (con)	100	71	100	53	N/A	N/A
Galant (2001)[21]	2 (con)	100	88.30	100	82.10	N/A	N/A
Kransdorf (2002)[19]	N/A (con)	N/A	N/A	N/A	N/A	N/A	N/A

ALT: atypical lipomatous tumor; WDL: well-differentiated liposarcoma; AUC: area under curve; ind: independently reading; con: consensus reading; CI: confidence interval.

Donners et al. in their study introduced the STIR-SI ratio, calculated as the mean signal intensity (SI) of tumors divided by the mean SI of adjacent fat assessed on STIR sequences of MR imaging. A cutoff value of 1.18 for the STIR-SI ratio yielded 93% specificity, 74% sensitivity, and 79% accuracy for diagnosing lipoma. Furthermore, the study observed a maximum accuracy of 85%, along with a specificity and sensitivity of 85%, when a STIR-SI ratio cutoff of 1.27 was combined with a tumor diameter greater than 15.5 cm. The overall sensitivity, specificity, and accuracy of the included studies are summarized in Table 2. The criteria proposed by the included studies to rule out clinically significant ALT/WDL from lipomas are detailed in Table 3. Among the significant variables, tumor diameter or size emerged as the most relevant feature contributing to the detection of clinically significant disease in all studies. However, the cutoff values for tumor size to rule out ALT/WDL varied among studies, with a minimum cutoff of >100 mm (see Table 3). Furthermore, nearly all studies identified age as a significant predictive variable, although only three studies specified the cutoff age, with a consistent value of >60 years.

Limitation

This study has some limitations. The significant diversity in diagnostic tools, techniques, and parameters across the reviewed studies hindered the ability to perform a meta-analysis. Additionally, although most studies reported sensitivity, specificity, and positive and negative predictive values, a substantial number did not calculate accuracy. This variability in reporting further complicates the direct comparison of diagnostic effectiveness across the studies, highlighting the need for more standardized methodologies in future research.

Discussion

This systematic review represents the summation of 14 studies evaluating the reliability and diagnostic significance of MR imaging and CT scans in distinguishing lipomas and ALTs/WDLs. Our findings suggest that the methodology executed by retrieved studies to address our research question can be broadly classified into two categories.

The diagnostic results in the first category of studies were derived from the analysis of clinical and imaging variables that can be manually interpreted by radiologists, independently of computer-aided assistance. These variables included shape, age enhancement, vascularity, fat suppression, region, location, septation, and nodularity. Despite their significance, all these variables documented modest accuracy for predicting final diagnosis compared to the amplification of MDM2 detected by FISH which reported 100% sensitivity and specificity.[9] The main reason for this low accuracy is that all the conventional variables are subjective and qualitative. The diagnostic outcomes produced by combining these variables may be strongly susceptible to interobserver variability and may depend on the radiologist's experience. Several factors influence interobserver variability, primarily tumor heterogeneity, which results in a wide range of imaging appearances and reduces the ability of these conventional imaging variables to distinguish lipoma from ALTs/WDLs efficiently. For example, in a study by Brisson M et al.[13], 15% of ALTs/WDLs were located in the upper extremities rather than the lower extremities, and only 45% of overall ALTs/WDLs displayed thick/nodular septation.Also, the various imaging variables between lipoma and ALT/WDL overlap, which leads to a certain degree of resemblance in the visual appearance of both tumors, resulting in a high threshold of false positives and poor sensitivity. Numerous measures have been

Table 3. Criteria used to differentiate clinically significant ALTs/WDLs from Lipoma.

First author (year)	Clinically significant ALTs/WDLs
Yang (2022)[12]	Age >60 and lactate dehydrogenase level >220, DL signature
Knebel (2019)[18]	Tumor diameter of ⩾130.0 mm/presence of contrast enhancement and nodularity/thick septa >2 mm/commonly located in lower limb/intramuscularly
Leporq (2022)[14]	Gray-level co-occurrence matrix, gray-level run length matrix, gray-level size zone matrix, and neighborhood gray-tone difference matrix
Pressney (2020)[24]	Located in lower limb and retroperitoneum/intensity cutoff value of <304 at coarse-filtered texture scale (SSF = 6)/deep to fascia/septation/non-fat signal components
Shim (2020)[25]	Thick septa >2 mm/nodularity/solid enhancement/tumor diameter of ⩾127.5 mm/deep/located in lower limb/irregular shape/absence of intermingled muscle fiber
Donners (2020)[20]	STIR-SI ratio a cutoff value of >1.27 and tumor diameter of ⩾155.0 mm OR STIR-SI ratio a cutoff value of 1.18
Nardo (2020)[22]	Tumor diameter of 18 ± 7 cm/age 61 ± 13 years/located in lower limb/deep to fascia/irregular margin/thick septa >2 mm/incomplete fat suppression/contrast enhancement/complex architecture
Vos (2019)[26]	Located in lower limb/volume >70 centiliter
Brisson (2013)[13]	Age >60/tumor diameter of >100 mm/located in lower limb/deep to fascia/amorphous fat content
Doyle (2008)[17]	Septation/nodularity/incomplete fat suppression
Panzarella (2005)[23]	Presence of gadolinium enhancement
Galant (2001)[21]	Thich septa/nodularity/hyperintensity/gadolinium enhancement
Kransdorf (2002)[19]	Tumor diameter of >100 mm/thick septa/fat percentage <75%/nodularity and globular areas/located in lower limb/non-adipose mass

ALT: atypical lipomatous tumor; WDL: well-differentiated liposarcoma; STIR: short tau inversion recovery; SI: signal intensity; SSF: scale of the filter.

taken by first-category studies to cope with high interobserver variability issues, such as excluding patients with complex MR images and not using a prespecified threshold. However, these measures lead to spectrum and information biases noticed in most first-category studies.[26]

The second category of studies is exclusively based on computer-aided diagnosis (CAD) techniques, such as algorithm-based deep learning and radiomics models. The radiomics model is a feature-based strategy that can generate diagnosis by extracting large-scale quantitative variables through manual segregation and grading them to correlate each feature with their respective tumor characteristics.[27] The algorithm-based deep learning model is a feature learning-based strategy that uses a similar approach for diagnosis as the radiomic model. However, image feature segregation and grading are performed by algorithm-based machine learning rather than manually.[28] Although employing various approaches for tumor evaluation, All CAD model studies classify lipomas and ALTs/WDLs based only on quantitative variables such as mean intensity, texture, size, and contrast level. As a result, the investigated outcomes of CAD studies are much higher than those of other studies and are nearly the closest to the diagnostic outcome of MDM2 detected by FISH.[9,14] However, some limitations are noted in these studies. For instance, all studies are small sample retrospective extract data from limited databases that might create a possibility of referral bias as patients with lack exposure to the database are not included in studies. The database also holds multicenter and multivendor aspects, which could be favored in acquisition data heterogenicity and, subsequently will facilitate in attaining good applicability. However, the effect of the multivendor aspect on MR imaging features is not demonstrated by any included article except Leporq et al., who observed a significant variation in contrast, dissimilarity, and different variance of ALTs/WDLs MR images concerning different MR vendors.[14]

Overall quantitative variables are far more reliable and validated for distinguishing lipoma for ALT than qualitative variables. CAD techniques could be good tools for diagnosing lipoma and ALTs/WDLs. However, questions arise on their implementation in clinical settings as these models are executed by experienced healthcare workers and researchers on small patient samples in a controlled study. In the future, a prospective or randomized controlled study on a large sample size is required to address applicability concerns regarding CAD studies. Nonetheless, the majority of studies used MR imaging as an index test. There was a considerable inconsistency among studies in terms of methodology, significant variables, and diagnostic outcome. Regardless, we still considered medical imaging an important diagnostic method as MDM2 by FISH. Medical studies are instrumental in informing surgical decisions regarding the management of lipomatous tumors. In surgical settings, tumors are subjected to marginal resection without a comprehensive evaluation of their type or are treated based solely on histopathological findings.[29] This approach can lead to increased recurrence rates for ALTs/WDLs.[30] Previous study indicates that the recurrence rate for ALTs/WDLs is significantly influenced by the surgical technique employed. Specifically, when ALTs/WDLs are marginally resected, the local recurrence rate is approximately 15.3%. In contrast, wide excision reduces the local recurrence rate to 3.3%.[19,30] Furthermore,

Additionally, relying only on histopathology can lead to an increased chance of overdiagnosing lipomas, as many ALTs/WDLs, which present features similar to lipomas, show positive MDM2 status.[31] MDM2 is highly sensitive for detecting ALTs/WDLs. Besides suggesting that a lesion may be benign or malignant, radiological imaging also describes local tumor margins, distinct spreads to neighboring tissue, and the prognosis of the given treatment.[32,33] Hence, enabling the operating surgeon to make the preoperative decision for the likelihood of margin-negative resection and to anticipate the possible loss of adjacent structures during surgery.[34,35]

Conclusions

According to our review findings, the most frequent diagnostic features of ALTs and WDLs include tumors with a diameter of ⩾110 mm, typically observed in patients over 60 years old, primarily located in the lower extremities, and presenting with irregular shape, incomplete fat suppression, contrast enhancement, nodularity, and septation thicker than 2 mm. Additionally, unique predictive markers such as lactate dehydrogenase levels above 220 and an STIR-SI ratio exceeding 1.18 were noted. The studies reviewed reported overall sensitivity, specificity, and accuracy for diagnosing these lesions ranging from 66% to 100%, 37% to 100%, and 76% to 95%, respectively. Positive predictive values ranged from 46.9% to 90%, while negative predictive values ranged from 86% to 100%. Notably, machine learning models showed sensitivity and specificity closest to the diagnostic accuracy of MDM2 amplification detected by FISH, underscoring their potential in improving diagnostic precision in clinical practice.

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None.

Author contributions

Muhammad Muhib: conceptualization, study design, literature search, manuscript writing, perform risk of bias assessment, interpretation of data of article; Syeda Labiba Fatima Abidi: study design, manuscript writing, literature search, interpretation of data of article; Uzair Ahmed: study design, literature search, interpretation of article data, perform risk of bias assessment; Ahson Afzal: table and figure designing, manuscript writing and editing, proofreading; Anoosh Farooqui: literature search, data extraction, and interpretation, proofreading; Omer bin Khalid Jamil: literature search, data extraction and interpretation, proofreading, supervision; Shayan Ahmed: data extraction and interpretation, proofreading; Hifza Agha: data extraction and interpretation, proofreading.

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Ethics approval

As study type is a systematic review, ethical approval is not taken.

Informed consent

Not applicable.

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