REVIEW ARTICLE

Diagnostic errors in musculoskeletal oncology and possible mitigation strategies

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Abstract

The objective of this paper is to explore sources of diagnostic error in musculoskeletal oncology and potential strategies for mitigating them using case examples. As musculoskeletal tumors are often obvious, the diagnostic errors in musculoskeletal oncology are frequently cognitive. In our experience, the most encountered cognitive biases in musculoskeletal oncologic imaging are as follows: (1) anchoring bias, (2) premature closure, (3) hindsight bias, (4) availability bias, and (5) alliterative bias. Anchoring bias results from failing to adjust an early impression despite receiving additional contrary information. Premature closure is the cognitive equivalent of "satisfaction of search." Hindsight bias occurs when we retrospectively overestimate the likelihood of correctly interpreting the examination prospectively. In availability bias, the radiologist judges the probability of a diagnosis based on which diagnosis is most easily recalled. Finally, alliterative bias occurs when a prior radiologist's impression overly influences the diagnostic thinking of another radiologist on a subsequent exam. In addition to cognitive biases, it is also important for radiologists to acknowledge their feelings when making a diagnosis to recognize positive and negative impact of affect on decision making. While errors decrease with radiologist experience, the lack of application of medical knowledge is often the primary source of error rather than a deficiency of knowledge, emphasizing the need to foster clinical reasoning skills and assist cognition. Possible solutions for reducing error exist at both the individual and the system level and include (1) improvement in knowledge and experience, (2) improvement in clinical reasoning and decision-making skills, and (3) improvement in assisting cognition.

Keywords Diagnostic error · Musculoskeletal oncology · Musculoskeletal oncologic imaging

Key points
- Diagnostic errors are more likely to be cognitive than perceptual in oncologic imaging.
- Knowledge and experience reduce the likelihood of errors.
- Multidisciplinary diagnostic teams may reduce errors if group interactions are optimized.
- Individuals and groups should learn to recognize impact of cognitive bias and adopt strategies such as force functions to mitigate their impact.

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Introduction

The challenges of an accurate diagnosis in musculoskeletal oncology are numerous and affect radiologists, pathologists, or surgical oncologists alike. Diagnostic errors are defined as mistakes that lead to a missed, incorrect, and/or delayed diagnosis [1]. Sources of diagnostic error are numerous and can occur at individual, group, and system levels. The two most common for an individual practitioner are perceptual (do not see it) and cognitive (see it but do not process it correctly). For an individual practitioner, reported interpretation errors across the broad spectrum of radiology occur at an estimated rate of 3–5% in real-time practice and most of these are perceptual (60–80%) [2] such as a missed fracture or unrecognized lesion. Cognitive errors including overcall (e.g., normal structure interpreted as a tumor), under call (e.g., seeing an abnormality but incorrectly attributing it to a normal structure and not including it in the report), and misdiagnosis (e.g., interpreting a lesion as a tumor when

in retrospect it is infection). Because the manifestations of musculoskeletal tumors are frequently obvious, errors in cognition are more common [3, 4] in musculoskeletal oncology compared to everyday perceptual errors in general practice. The purpose of this paper is to discuss sources of cognitive diagnostic errors in musculoskeletal oncology and potential strategies for mitigating them.

Diagnostic error and cognitive bias

A broadly accepted model of human decision making is the dual process theory of reasoning defined by Kahneman and Tversky [5] that separates cognitive judgment into type 1 (fast) and type 2 (deliberate). Type 1 processing is a short-cut in reasoning that is either "hard wired" or a learned "intuition," also known as a heuristic, that offers the advantage of quick decision making. Type 2 thinking is more deliberate and is more likely to occur when an abnormality is detected but cannot be quickly categorized using a heuristic. Both type 1 and type 2 thinking can produce correct diagnoses. However, type 1 thinking is more prone to cognitive bias and resultant error and therefore has received more attention in the medical literature [1, 2, 6–10]. It is incorrect to assume that heuristic thinking is "bad" [8, 11, 12]. While more deliberative type 2 thinking is less prone to faults introduced by type 1 processes, it is not immune to error [8]. Moving back and forth between these two types of processing may produce optimum decision-making performance [8].

The concept of cognitive bias was first introduced by Tversky and Kahneman [13]. Cognitive biases are mechanisms used by humans to manage probability decision making in complex, uncertain, and/or time constrained situations [14]. A cognitive bias has been defined as an involuntary systematic phenomenon that reliably deviates from reality and is distinct from normal information processing [15]. At least 174 cognitive biases have been described and no widely recognized taxonomy for them has been defined to date [16]. In our experience, the most encountered well described cognitive biases in musculoskeletal oncologic imaging are anchoring bias, premature closure, hindsight bias, availability bias, and alliterative bias.

Anchoring bias

Anchoring bias is defined as failing to adjust to an early impression despite receiving additional information. Anchoring bias is a common source for diagnostic error in musculoskeletal oncologic imaging and is more common in the setting of an unusual presentation of a common diagnosis in our experience. One potential source of this cognitive

bias includes over emphasis on described classic radiologic signs that provide a prototypical template for heuristic-based errors. Another source for error is ignoring clinical/laboratory data or discordant radiologic findings from other modalities.

Case example #1—Anchoring bias (Fig. 1)

A 14-year-old female developed acute onset of left distal thigh pain. MRI showed a high T2 signal lesion with T1 Penumbra sign, rim enhancement following contrast enhancement and adjacent bone marrow edema like signal. Radiography revealed a lesion in the distal femur with features of a non-ossifying fibroma. Final preoperative radiologic diagnosis of Brodie's abscess was rendered based on the MRI findings despite discordance with radiologic presentation. Final pathologic diagnosis was infarcted non-ossifying fibroma. In retrospect, the discordance between the radiographic findings of non-ossifying fibroma and MRI findings of Brodie's abscess were not resolved by the interpreting radiologist.

Premature closure

Premature closure is defined as failure to consider other possibilities after initial diagnosis is made. Both individual and groups are at risk for this bias. It is similar to anchoring bias in that over-reliance of "classic" signs on a modality without considering the broader picture can contribute to diagnostic error but it differs from anchoring bias in that additional information is not sought or pursued.

Case example #2—Premature closure (Fig. 2)

A 69-year-old man presented for evaluation of a painless mass that he had he noticed for years. The mass was mobile and non-tender but hard to palpation. MRI revealed a lobular T1 intermediate and heterogeneous but predominantly high T2 signal intermuscular mass in the upper arm. Interdigitating fat signal was appreciated in the upper portion of the mass and central peripheral enhancement was seen in lobular components of it. Ultrasound obtained at time of fine needle aspiration revealed flow in the periphery of the tumor and pathologically bland spindle cells in a myxoid background were retrieved from this procedure. Based on imaging findings, cytologic results and discussion at a multiple disciplinary conference, the patient was diagnosed as having a vascular malformation and was placed in an interval follow-up clinic. The mass had enlarged on subsequent follow-up and was becoming painful. The concerned surgical oncologist reviewed the imaging with a senior radiologist who thought that the

Fig. 1 Infarcted non-ossifying fibroma, initially misdiagnosed as a Brodie's abscess. AP (**A**) and lateral (**B**) radiographs demonstrating an eccentric lucent lesion with a sclerotic border in the distal femoral metaphysis, consistent with a non-ossifying fibroma. Axial T1-weighted (**C**), axial post-contrast T1-weighted with fat saturation (**D**), and sagittal T2-weighted with fat saturation (**E**) images show marked surrounding marrow edema and periosteal reaction. Peripheral T1-hypointensity (arrow in C) was misinterpreted as a "penumbra sign," seen in an intraosseous abscess

imaging findings still fit best with a vascular malformation. He was referred to an interventional radiologist with experience in vascular malformations who thought it had the clinical and imaging features of a vascular malformation but the potential treatments were outweighed by possible complications of an intervention. The patient was referred back to orthropedic oncology. On subsequent oncologic follow-up, the mass continued to enlarge. The patient was reevaluated by interventional radiology and a core biopsy was then performed with a final pathologic diagnosis of a rare extraskeletal chondrosarcoma. An earlier diagnosis may have been achieved if clinical and imaging features of the lesion including presentation at an older age and its physical exam features had been considered at time of initial diagnosis. In this case, premature closure from initial imaging and cytologic findings led to later anchoring bias by multiple physicians involved in the patient's care.

Hindsight bias

Hindsight bias is defined as retrospectively overestimating the likelihood of interpreting the examination prospectively. It is more common in retrospective interpretation of cases because of the advantage of additional imaging, further clinical information, and/or subsequent histologic diagnosis.
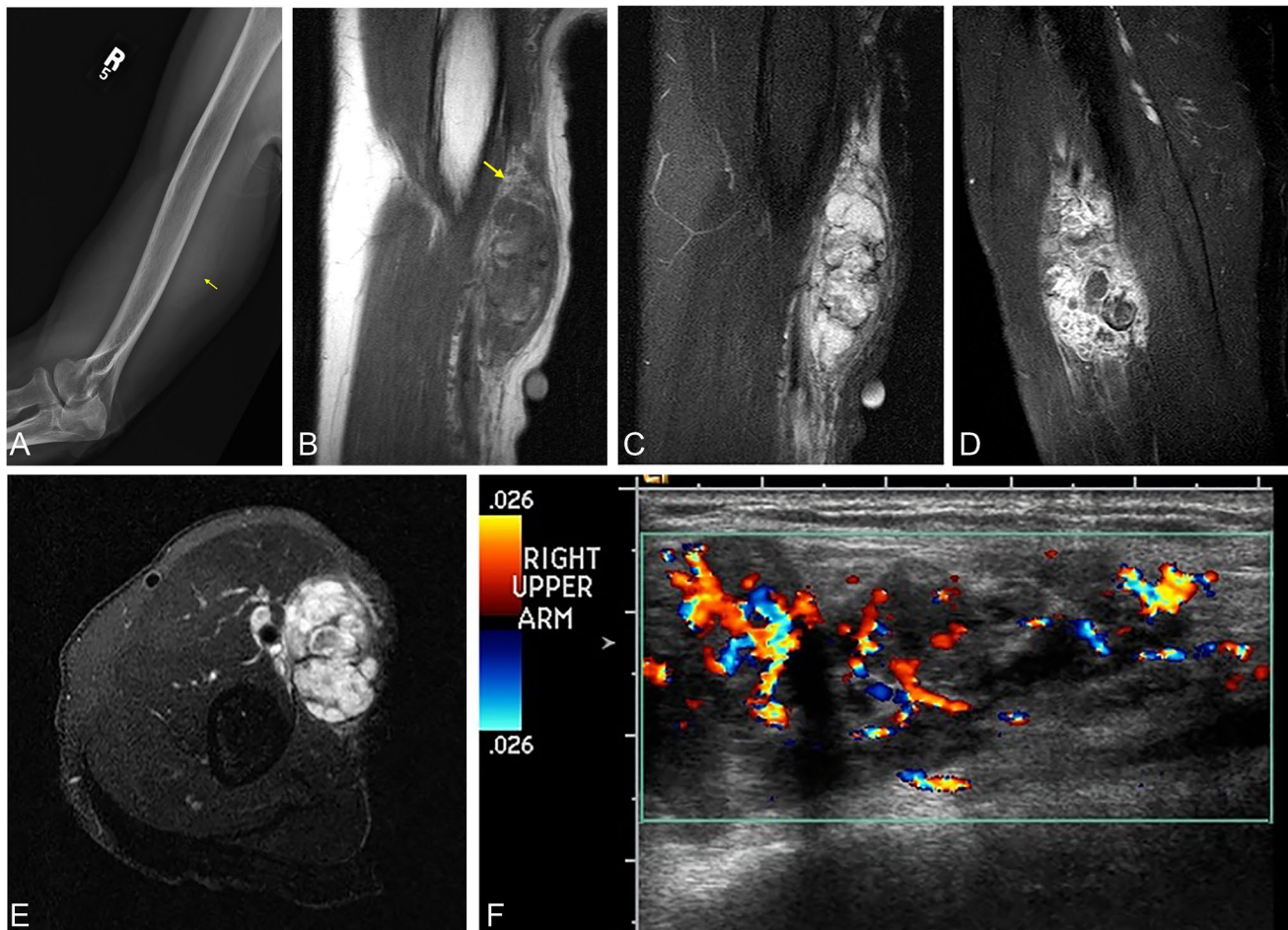
Fig. 2 Extraskeletal chondrosarcoma, initially misdiagnosed as a vascular malformation. Radiograph (**A**) of the right arm demonstrated few punctate calcifications in the mass (arrow in A); however, no phleboliths were seen. Sagittal T1-weighted (**B**) and sagittal (**C**) and axial T2-weighted (**E**) images demonstrate a lobulated T2-hyperintense mass with mild surrounding soft tissue edema. Perceived inter-digitating fat (arrows in B) led the interpreting radiologist to suggest a vascular malformation. However, note the classic peripheral and lobular cartilage enhancement pattern seen on the coronal post-contrast fat-saturated T1-weighted image (**D**). Color Doppler ultrasound (**F**) prior to the biopsy demonstrated solid hypervascular tissue

Case example #3—Hindsight bias (Fig. 3)

A 17-year-old male experienced posterior knee pain after playing American football. The patient was afebrile with normal CBC, ESR, and C-reactive protein. Radiograph showed an eccentric lucent lesion in posterior distal femur with geographic margination, destruction of the posterior cortex and focal interrupted periosteal reaction. MRI showed an eccentric, high T2 signal lesion with thin peripheral enhancement and adjacent bone marrow edema like signal. The lesion was contained by periosteum despite subperiosteal extension. The final MR interpretation favored subperiosteal abscess. At surgery, the lesion was clearly not an abscess. The final histologic diagnosis was cystic Ewing tumor. In retrospect, there was no soft tissue edema adjacent to the posterior femur and a small focus of enhancing tissue was visible in the lower lateral aspect of this lesion (Fig. 3d)

that was almost entirely necrotic. A peer review committee later suggesting that a diagnosis of neoplasm should have been favored over infection in this case would be an example of hindsight bias in this challenging case.

Availability bias

Availability bias is defined by judging the probability of a diagnosis based on which diagnosis is most easily recalled. This is different than anchoring bias although it seems similar at first glance. Availability bias is a probability estimate derived from memorable experiences. This heuristic will likely be correctly applied if the interpretation comes from memories of common experiences. Alternatively, this heuristic can result in diagnostic error if the most memorable diagnosis is derived from a recent rare presentation or

Fig. 3 Cystic Ewing tumor, initially misdiagnosed as a subperiosteal abscess. Lateral radiograph (**A**) demonstrates a lytic lesion in the posterior distal femoral metaphysis. Note the aggressive periosteal reaction superiorly (arrow in **A**). Sagittal T2-weighted image with fat saturation (**B**) demonstrates a heterogeneously T2 hyperintense lesion with surrounding marrow edema, but importantly, no periosteal or adjacent soft tissue edema as would be expected for a subperiosteal abscess. Sagittal (**C**) and axial (**D**) post-contrast and fat-saturated T1-weighted images demonstrate predominantly peripheral enhancement in this necrotic lesion, with only a small area of solid enhancement in the distal lateral portion of the lesion (arrow in **D**)

haunting case by ignoring what is most likely. An inexperienced radiologist or a radiologist who experiences a recent missed case is at particular risk for this cognitive bias.

Case example #—Availability bias (Fig. 4)

A 6-year-old female with myelomeningocele presented with thigh swelling and insensitivity to pain below the waist. MRI of right femur showed widening of distal physis, periosteal stripping and dramatic high T2 signal abnormality in the adjacent soft tissues. Diagnosis of osteosarcoma was made by musculoskeletal radiology fellow on call who had seen two cases of osteosarcoma that month. In retrospect, no marrow replacement was present on T1-weighted images.

Alliterative bias (satisfaction of report)

Alliterative bias is defined as the effect of a person's prior impression on the subsequent diagnostic thinking of another individual [17].

Case example #5—Alliterative bias (Fig. 5)

A 17-year-old male was referred for evaluation of a painless palpable mass in his buttock. The mass was partially mineralized on radiography. MRI showed a mass demonstrating heterogeneous signal on T1 (low and intermediate) and T2 (low, intermediate and high) signal. Heterogeneous enhancement was demonstrated following contrast administration. An FNA was performed showing bland spindle cells. Final diagnosis rendered by the pathologist after consultation with the radiologist that interpreted the MRI was myositis ossificans. The patient returned two years later because of increasing discomfort. A repeat MRI showed that the mass had only slightly increased in size but was primarily unchanged. Based on the prior MRI and pathology report, the musculoskeletal radiology fellow generated a preliminary report of stable findings of myositis ossificans. The final impression in the radiology report signed by the attending after providing feedback for the fellow reflected primary concern for synovial sarcoma. A subsequent core biopsy confirmed diagnosis of synovial sarcoma. In this case, cognitive and system errors on the original assessment led to an alliterative error committed by inexperienced radiologist on a subsequent report.

Affective influences

Research in cognitive neuroscience has shown that decisions result from the interaction between thinking and feeling [18], and it is important that we acknowledge our feelings when making decisions. It has been shown that people that are more aware of their heart rate or "gut feelings" make better decisions in high-risk financial situations than people who are not attuned to such somatic markers [19]. Positive feelings are signals that we are making correct decisions and are correlated with certainty. Negative feelings such anxiety and sadness are clues that we might be making poorer decisions and may need to change to a different mode of thinking or consider alternative decisions. Positive affect is associated with more flexible thinking. Negative affect has the opposite influence of restricting processing scope. Additionally, an individual's negative affect has been shown to have an adverse effect on clinical reasoning in teams [20]. Experienced radiologists may benefit from being attuned to their instincts in challenging cases.

Fig. 4 Salter I neuropathic fracture, initially misdiagnosed as an osteosarcoma. AP (**A**) and lateral (**B**) radiographs of the femur demonstrating exuberant periosteal reaction with irregularity of the distal femoral physis. Sagittal T1-weighted (**D**), sagittal T2-weighted with fat saturation (**E**), and coronal post-contrast and fat-saturated T1-weighted (**F**) images demonstrate diffuse marrow, physeal, periosteal, and soft tissue edema, as well as a knee joint effusion. There is preserved fatty marrow signal on the T1-weighted image (arrow in D), indicating no marrow replacement. Follow-up AP radiograph 2 months later (**C**) demonstrates expected maturation of bony callus

Defining various sources of cognitive and affective bias suggests that errors occur in one discrete domain. Retrospective review of errors in an emergency department using a technique of purposeful introspection and reflection, coined a "cognitive autopsy," suggests that one bias can trigger future biases producing a snowball effect [21]. Case examples #2 and #5 above seem to support this notion. Interestingly, lack of application of medical knowledge was the primary source of error rather lack of knowledge in most cases in this particular paper. The notion that the primary cause of error is cognitive bias rather than lack of knowledge has been challenged by Norman et al. [22] since errors decrease with experience. Case example #1 and case example #5 support that knowledge is very important in musculoskeletal oncologic imaging.

How to reduce errors?

A concerted effort to reduce error in medicine began following the 1999 Institute of Medicine report, *To Err is Human: Building a Safer Health System*. This seminal publication led to extensive effort to develop measurement tools, identify sources of error, and create effective solutions to reduce unnecessary death and suffering caused by errors. Much progress has been made in other facets of health care, but diagnostic errors remain a significant source of increased cost and patient harm despite improved understanding of possible sources for it. Appropriately, the negative consequence of diagnostic errors has primarily focused on patients but the high cost of significant errors on physician well-being has only recently been acknowledged.
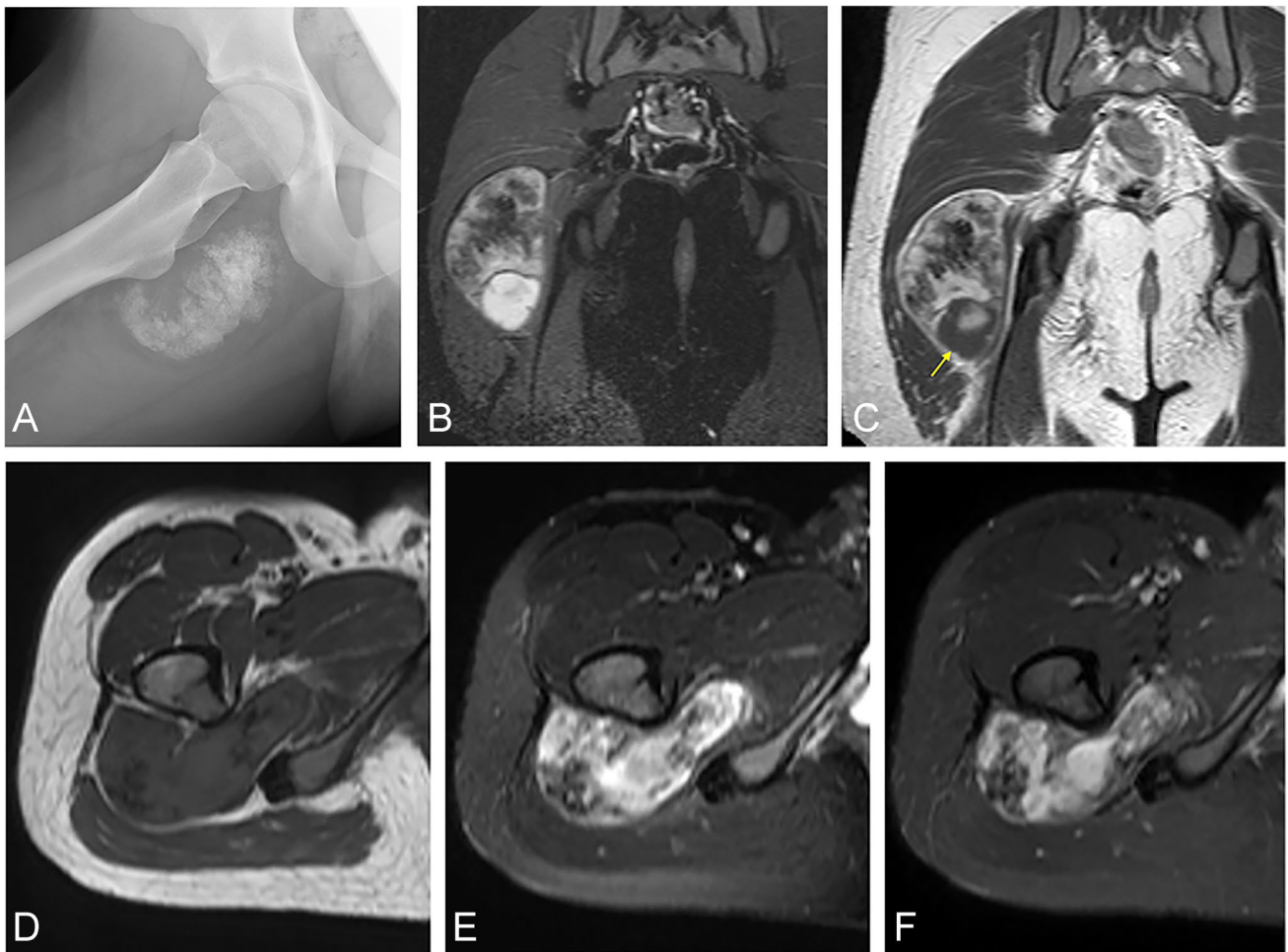
Fig. 5 Synovial sarcoma, initially misdiagnosed as myositis ossificans. Radiograph (**A**) demonstrating a calcified mass in the proximal thigh, without the zonal ossification necessary to diagnose myositis ossificans. Coronal T2-weighted with fat saturation (**B**), coronal post-contrast T1-weighted (**C**) and axial T1-weighted (**D**), T2-weighted with fat saturation (**E**), and post-contrast fat-saturated T1-weighted images (**F**) demonstrate a heterogeneously T2 hyperintense mass with solid enhancement and necrosis (arrow in C). T1 and T2 hypointense signal in the mass corresponds to calcifications

Possible solutions for reducing error can be directed at individuals or a system. Research on improving clinical reasoning in individuals has focused on three categories: (1) improvement in knowledge and experience; (2) improvement in clinical reasoning and decision-making skills; and (3) improvement in assisting cognition [23].

Improvement in education

Experience has a significant impact in musculoskeletal oncology and it has a substantial effect on establishing the correct final diagnosis in this domain [3, 4, 24–26]. The rare nature of sarcomas and inexperience with pathologic and radiologic assessment of extremity masses contributes to discrepancies in interpretation that result in a clinically significant change in diagnosis in 22–38% of cases when a second opinion is sought at a center with more experience [3, 4, 27, 28]. Lack of confidence and the implications of missing a tumor result in non-neoplastic conditions being erroneously reported as sarcomas [25]. These overcalls result in patient anxiety, expense associated with needless additional imaging and unnecessary referral to a surgical oncologist. Unnecessary oncologic referral can be reduced by 82%, as reported in one study, through the development and implementation of a diagnostic triage system [29].

While advanced training can reduce the likelihood of an interpretative error [24], errors still occur regardless of experience, in part because of the rarity of specific diagnoses and in part because of unusual presentations of more common tumors. Regardless, a significant component of error in musculoskeletal oncology is due to faults in human cognition [6] and/or breakdown in team function including, for example, poor communication, over-reliance

on pathology results, or one person's opinion blocking effective group discussion.

The rarity of musculoskeletal neoplasms requires educators to create opportunities to experience the challenges of diagnosis in this domain. Fortunately, "simulation" of image interpretation of patients with benign and malignant masses is relatively easily achieved by creating standardized case sets. The case sets can be constructed to allow learners to recognize common mimics for neoplasm such as hematoma, Paget disease and stress fracture and juxtapose these cases with soft tissue sarcoma, metastatic disease, and primary bone tumor. The challenge with this effort is finding the time for learners and educators to discuss the cases in detail, to probe knowledge, to identify knowledge deficits and to provide the quality feedback that is necessary for efficient learning. Simply providing an answer or a passive lecture/electronic module is not sufficient to refine the decision-making process.

Post-graduate education of practicing physicians is also challenging. Continuing medical education through reading articles and attending lectures are important activities but, when passive, are less effective at changing practice patterns [30]. Active learning pursuits and workplace activities yield more meaningful and durable results [6, 31] (Table 1).

Improvement in clinical reasoning

Efforts to improve clinical reasoning have centered on the concept of "cognitive debiasing" [32]. Changing how a person thinks and reasons is extremely challenging given that many cognitive biases are "hard wired" and therefore are not a conscious act. Education strategies may help increase awareness of the possibility of bias but are not sufficient to ensure that debiasing will occur in the future. Other education approaches may address "in the moment" events including teaching of mindfulness, reflection, recalibration and "slowing down" tactics [32] to reduce errors.

Implementing cognitive forcing functions are rules that require decision makers to consciously apply a metacognitive step to force consideration of different alternatives. One of the most useful forcing functions in the experience of the authors is considering the opposite or asking oneself, "why is it not that"? Looking at an initial impression from the perspective of deconstructing it rather than defending it is a strategy that produces more accurate results [23]. Use of metacognitive scaffolds [33] or lesion differential checklists [31] may also reduce errors.

While improving clinical reasoning is challenging for multiple reasons, recent literature has shown that there are promising interventions, particularly in techniques using guided reflection and cognitive forcing functions, that can produce a measurable positive change in cognitive reasoning [34]. The emphasis on learning "cognitive balance" seems to be a useful goal which is acknowledging the potential positive and negative results of both heuristic and deliberate approaches to diagnosis. While heuristic thinking is acknowledged by many to be a major source of cognitive error, it is one of the primarily and successfully used modes of reasoning employed by experts.

Improvement in assisting cognition

Though technology such as artificial intelligence may someday augment diagnostic decision making in musculoskeletal oncology, the most used and currently practical methods to assist cognition are multidisciplinary groups and second opinion.

It is widely accepted that solutions derived by groups are generally superior to those from a single person. The general principle is that collective decision making through discussion will yield more accurate diagnoses. We have created a multidisciplinary diagnostic team (MDT) that consists of faculty and learners from the disciplines of orthopedic oncology, musculoskeletal pathology, and musculoskeletal radiology to leverage this belief. This team meets twice a month to discuss the diagnostic challenges in both routine and difficult cases outside of a tumor board that primarily focuses on therapeutic and surgical management of patients with known tumors. The musculoskeletal MDT allows for discussion of both neoplastic and non-neoplastic conditions that mimic tumor to include infection, metabolic bone disease and other disorders [35].

Table 1 Education interventions

Activity	Learning opportunity
Active participation in tumor board	Feedback from peers and patient outcomes
Peer learning conferences	Nonjudgmental discussion of errors in the department
Sharing cases with peers in PACS	Increased exposure to tumor and tumor mimics
Discuss difficult cases with peers	Exposure to different ideas and knowledge
Follow-up biopsy results	Feedback from success and failure
Follow-up future imaging results	Feedback from new data may add new insight
Continuous certification assessment	Feedback from assessment of knowledge

Fig. 6 Erdheim-Chester disease, almost misdiagnosed as metastatic neuroendocrine tumor after biopsy sample contamination. AP radiograph of both knees (**A**) demonstrating symmetric and bilateral sclerosis of the metadiaphyses. Coronal T1-weighted (**B**) and T2-weighted images of the knee (**C**) show heterogeneous marrow infiltration. Whole-body Tc99 m scintigraphy (**D**) demonstrates intense uptake in the ends of the long bones which is bilateral and symmetric in the lower leg. All of these findings are characteristic of Erdheim-Chester disease and were discrepant with the initial pathology diagnosis

A high-functioning MDT is dependent on many of the characteristics of individuals. For example, experience, adaptability, and performance monitoring and feedback are shared skills of successful groups and individuals. To avoid being just a collection of individual traits, high-performing groups rely on additional abilities including shared mental models, respectful and trusting interpersonal relations, and open communication to create high-quality collaboration [36].

Groups tend to make better diagnostic decisions but are not immune to errors. A cognitive autopsy following group error can reveal that MDT's may experience the same cognitive biases as individuals to include anchoring bias, premature closure, and alliterative bias (see case example #2). Recognizing when the group should slow down and be more cautious is critical. The learned experience of the authors is that radiological and pathological result discordance and subsequent cognitive dissonance should not be ignored. Mismatch between clinical, radiologic, and/or pathologic interpretations should be considered a group cognitive force function and result in a thorough reassessment of the discordant case. The discussion should include consideration of other diagnoses, need for additional imaging, review of

biopsy approach, need for additional tissue, potential gene sequencing, and possibility of second opinion of radiologic and/or pathologic findings. This additional effort can have a significant impact on patient outcome (case example #6).

case example #6—discordant imaging and Pathology Results (Fig. 6)

A 68-year-old man presented with bilateral knee pain. Musculoskeletal imaging features led to leading differential diagnosis of Erdheim-Chester disease. CT guided biopsy of the distal femur yielded initial pathologic diagnosis of metastatic neuroendocrine tumor. A vigorous discussion ensued at a multidisciplinary diagnostic team meeting because the imaging findings did not fit with the pathologic diagnosis. Based on prior experience, the surgical oncologist asked if another patient had been biopsied that day with a final diagnosis of neuroendocrine tumor. Subsequent investigation confirmed that a patient with small cell lung cancer had been biopsied immediately prior to the patient with presumed Erdheim-Chester. Tissue from the patient with small cell lung cancer had inadvertently been introduced during tissue processing into the pathologic material from

the patient with later confirmed Erdheim-Chester disease. The cognitive dissonance created by the unexpected initial pathologic diagnosis led to a search for another explanation and allowed a catastrophic error to be avoided.

A second opinion should be considered when the radiologic and pathologic findings are unusual or are outside the experience of the members of the MDT. The literature on the benefit of second opinion tends to compare non-expert and expert diagnoses [3, 4, 37–39]. While at least one article has suggested that collective intelligence outperforms individual expert interpretation in the setting of screening mammography [40], there is no literature on the efficacy of second opinion between two expert organizations in the setting of musculoskeletal oncology. In the authors' experience, cases that are challenging for an expert group are likely to be challenging for the expert second-opinion group. The major benefit of seeking a peer expert opinion is in building consensus.

Summary

Diagnostic decision making in the setting of musculoskeletal oncology is challenging even at a tertiary care center. The experience of individuals and multidisciplinary teams involved in diagnosis clearly has a positive impact on the opportunity to arrive at a presumed correct diagnosis. Both individuals and groups must be aware of cognitive biases and the importance of prospectively recognizing situations that require a reappraisal of any case. Words or thoughts such as, "this doesn't fit," and/or uneasy feelings should trigger a deliberate reassessment of all features of the case to avoid anchoring bias and premature closure. MDT's may help reduce diagnostic errors through collective reasoning but we also need to recognize moments when group reconsideration of a case is necessary. A cognitive autopsy when errors occur may help both individuals and groups recognize opportunities for improvement. Finally, more dedicated research is needed in the function and optimization of musculoskeletal diagnostic teams to reduce diagnostic errors in oncologic imaging.

Declarations

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