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Research Article

Proximal radial pseudotumour: magnetic resonance imaging appearances and prevalence

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Abstract

Introduction: Cases have been referred to our tertiary referral sarcoma service where marrow abnormalities have been identified in the proximal radius. We believe this to be a normal variant, likely representing residual red marrow. The purpose of this study is to describe the features and determine the prevalence of such a finding on elbow magnetic resonance imaging (MRI) in an unselected group of patients imaged at our institution.

Materials and methods: Retrospective review of the last 100 elbow MRI studies performed at our institution. Patient age, sex, side imaged and reason for MRI were recorded. The proximal radial pseudotumour, was defined as a region of marrow signal abnormality with intermediate T1W SE/ T2W FSE/PDW FSE signal intensity between medullary fat and skeletal muscle with hyperintense STIR/PDW FS signal compared to medullary fat, but hypointense to joint fluid. For positive cases, the length and distance from the proximal radial articular surface was measured. Also, local changes, including cortical abnormality, active periostitis, surrounding soft tissue abnormality and similar change in distal humerus and proximal ulna were assessed.

Results: The pseudotumour was identified in 7.8% of cases. No statistical differences were observed for age (p=0.1), laterality (p=0.08) or sex (p=0.79) for pseudotumour presence. Mean length of pseudotumour was 21 mm with mean distance from the articular surface of 16 mm.

Conclusions: The proximal radial pseudotumour is seen in 7.8% of elbow MRI studies and should be recognised as a normal variant of proximal radial marrow signal intensity.

Introduction

A pseudo-tumour could be defined as an abnormality that resembles a tumour but with an absence of neoplastic cells. Many pseudo-tumours have been described in the radiology literature [1], some of which relate to marrow signal abnormalities that present as potential interpretational pitfalls. Marrow signal abnormalities are becoming increasingly frequent dilemmas given the burgeoning use of fat suppressed imaging. The bone marrow is a complex organ whose proportions can vary greatly depending upon site and age [2,3], with typical conversion of yellow to red marrow in long bones occurring from the end of the bone to the central diaphyseal region [4]. Some studies have demonstrated that variations in this process exist [5]. However, islands of red marrow can persist from the original conversion stage into adulthood [3]. Multiple studies have been conducted looking at red marrow MRI signal around the knee joint in an attempt to assess its frequency and its clinical significance [6-8]. The presence of this red marrow has been assessed against patient factors such as weight, age, sex, haemoglobin levels and smoking. The elbow is a less frequently imaged joint than the knee but there have been observations with regards to alteration of marrow signal around the elbow, particularly in the distal humerus [9]. The purpose of the current study was to assess the incidence of this imaging feature at the elbow joint, particularly within the proximal radius following several cases referred to our institution with potential diagnoses of occult fracture, stress injury, reactive marrow oedema, osteitis and osteomyelitis.

Materials and methods

Following local Research and Development Board approval, a retrospective study of the most recent 100 consecutive MRI studies of the elbow joint was undertaken. MRI studies from both 1.5 and 3 Tesla (T) units were included in the study.

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Patient's age, sex, side and reason for MRI were documented. Clinical indications for elbow imaging were divided into 3 groups. Group 1 (n= 43): patients referred for a potential mass lesion or lesion follow-up of a mass; Group 2 (n= 13): patients referred for assessment of ulnar nerve and transpositions; Group 3 (n= 34): patients referred for investigation of a variety of elbow abnormalities including trauma, dislocation, congenital abnormality, soft tissue injuries, including ligamentous and joint degeneration.

The presence of a pseudo-tumour in the proximal radius was assessed by 2 consultant musculoskeletal radiologists with 4 and 7 years of experience, with the result agreed by consensus.

A radial pseudo-tumour was defined as a focal region of marrow abnormality in the proximal radius which had intermediate signal intensity (SI) between medullary fat and skeletal muscle on T1-weighted spin echo (W SE), T2-weighted turbo spin echo (W TSE) and proton density weighted turbo spin echo (PDW TSE) sequences, and was hyperintense to medullary fat but hypointense to joint fluid on short tau inversion recovery (STIR) and spectral attenuated inversion recovery (SPAIR) sequences. If the study was positive for a pseudo-tumour, then the dimensions of the lesion were measured as well as its distance from the proximal radial articular surface. If positive, then other local changes including cortical abnormality, active periostitis, surrounding soft tissue abnormality including oedema were recorded. Assessment for similar SI change in the distal humeral metaphysis and proximal ulna was also undertaken.

MRI parameters included 1.5T and 3T 'tumour' and 'non-tumour' protocols, as follows:

1. 1.5T (Philips Achieva) 'tumour' protocol; coronal T1W SE (TR 579.84, TE 20) and STIR (TR 4278.44, TE 30, TI 190), axial PDW FSE (TR 4502.4, TE 25) and SPAIR (TR 3211.4, TE 30), and sagittal T2W TSE (TR 3000, TE 90) sequences. Field of view (FOV): 120×120mm, slice thickness (ST): 3mm, 2 channel elbow coil.

2. 'Non-tumour' 1.5T protocol; coronal PDW FSE (TR 3500, TE 30) and SPAIR (TR 3653.5, TE 30), axial PDW FSE (TR 3000, TE 30) and SPAIR (TR 5561.3, TE 30), and sagittal T2W fast field echo (FFE) (TR 550, TE 11.5) sequences. FOV: 120×120mm, ST: 3mm, 2 channel elbow coil.

3. 3T (Philips Ingenia) 'tumour' protocol; coronal T1W SE (TR 526.96, TE 20) and STIR (TR 4465.31, TE 60, TI 210), axial PDW FSE (TR 3000, TE 30) and SPAIR (TR 3782.45, TE 30), and sagittal T2W TSE (TR 1934.68, TE 80) sequences. FOV: 120×120mm, ST: 3mm, 6 channel elbow coil.

4. 'Non-tumour' 3T protocol; coronal PDW FSE (TR 3126.19, TE 30) and SPAIR (TR 3059.09, TE 30), axial PDW FSE (TR 3000, TE 30) and SPAIR (TR 3057.71, TE 30), and sagittal T2W TSE (TR 1947.02, TE 80) sequences. FOV: 120x120mm, ST: 3mm (axial 2.5mm), 6 channel elbow coil.

Studies were excluded if the proximal radius was not included in the imaged field (n=3), if marrow signal was obscured by metal artifact (n=3) or if the proximal radius was involved by any pathological process involving the marrow (n=4). Four cases had pathology at the radial tuberosity affecting the adjacent marrow as follows; cystic change underlying the cortex of the radial tuberosity secondary to distal biceps tendinosis, cortical erosion and marrow-oedema-like SI in the radial tuberosity secondary to bicipitoradial bursitis, two cases of neoplastic marrow infiltration due to histologically proven leiomyosarcoma, and multiple lesions consistent with Brown tumours in patient with known hyperparathyroidism.

Univariate analysis to assess for association between age, sex, side and the presence of a pseudo-tumour was undertaken. A p-value of <0.05 was taken as statistically significant.

Results

Of the 100 successive elbow MRI cases identified, 10 were excluded. Therefore, the final study group comprised of 90 patients, 43 males and 47 females with a mean age of 41 years and age range of 7-80 years.

There were 11 (12.2%) patients imaged at 1.5T and 79 (87.8%) at 3T. Proximal radial pseudo-tumours were identified in 7 (7.8%) patients (Figures 1-5), 3 males and 4 females (p= 0.79). Pseudo-tumours involved the right elbow in 6 cases and left elbow in 1 (p=0.08). Age range for pseudo-tumour was 7-65 years with mean age 30 years, compared with 5-80 years with mean 42 years for no pseudo-tumour (p=0.1). The pseudo-tumours measures between 5 to 38mm in length with a mean of 21mm, and the distance from the radial articular surface varied from 4 to 32mm with a mean of 16mm. None of the pseudo-tumours was associated with cortical abnormality, active periostitis or soft tissue oedema-like SI. No abnormal marrow SI was identified in the distal humeral metaphysis or proximal ulna on any of the imaging series.

Discussion

Bone marrow is regarded as a dynamic organ and undergoes lifelong changes, with the capability to reverse these changes when placed under certain stresses [10]. It is this ability that renders bone marrow susceptible to changes as a result of not only metabolic stimulation, but also hyperactive osteoclastic activity. This can result in a pseudo-tumour appearance as

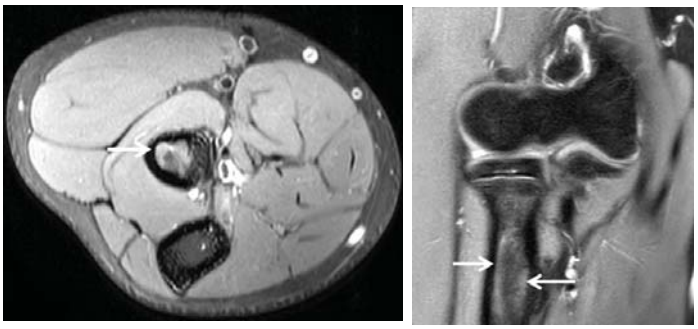

Figure 1: Axial PDW SPAIR (TR 3527.81; TE 30) and b coronal PDW SPAIR (TR 3238.66; TE 30) in 14 year old year old female referred for potential fracture demonstrates a pseudo tumour in radial tuberosity (white arrows). Compare with the marrow signal in adjacent proximal ulna (Figure 1a).

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something that mimics malignancy or an aggressive process. Reconversion of yellow to red marrow is considered to occur in an opposite longitudinal direction to its initial conversion, with reconversion widely accepted to begin in the ends of long bones then extending to the middle or central diaphyseal regions [4]. It is also accepted that there may be residual red marrow at the last conversion sites, which are in the proximal metaphyses of the femur and humerus. It is well-documented that these residual red marrow foci can show wide variation in location and morphology across the ages at these sites [3], but there is little literature on red marrow at sites other than these, such as around the elbow joint. This rarity of marrow signal abnormality in and

Figure 2: Coronal PDW SPAIR (TR 3885.5; TE 30) in 15 year old year old female referred for potential osteochondral defect demonstrates a pseudo tumour in radial tuberosity.

Figure 3: a. Axial PDW TSE (TR 4142.95; TE 30) and sagittal T2W TSE (TR 2421.35; 80) in 54 year old year old male referred for potential occult fracture demonstrates a pseudo tumour in radial tuberosity (white arrows). Compare with the marrow signal in adjacent proximal ulna (Figure 3a).

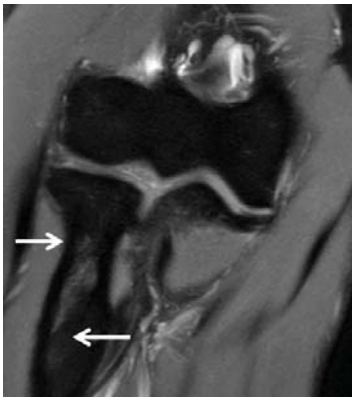

Figure 4: Coronal PDW SPAIR (TR 3885.59; TE 30) in 36 year old male referred for potential occult fracture demonstrates a pseudo tumour in radial tuberosity.c

Figure 5: a. Coronal T1W TSE (TR 500; TE 15) and b axial PDFS (TR 4451.33; TE 30) in 15 year old year old female referred for mass in proximal forearm demonstrates a pseudo tumour in radial tuberosity (white arrows). Compare with the marrow signal in adjacent proximal ulna (Figure 5b).

around the elbow joint is confirmed in a study that had only 1 elbow MRI study with a report of incidentally noted 'abnormal or heterogenous marrow signal' out of a total of 49,678 MRI studies [11]. A more recent study suggested wide variation in red marrow signal with diaphyseal marrow reconversion appearing to precede that of distal metaphyseal marrow in the femur [5]. Focal nodular hyperplasia of red marrow has been described as an abundance of focal red marrow due to aberrant red to yellow marrow conversion [12]. It is described as a rarely occurring localised form in the marrow of the spine and pelvis, compared to regional forms around the knees of endurance athletes, heavy smokers and in obesity [13]. Therefore, it is important to recognise aberrant marrow signal intensity as highlighted in our current study, and we postulate that this proximal radial

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pseudo-tumour represents a normal variant representing residual haemopoietic red marrow with morphology like that of focal nodular hyperplasia.

This is supported by various authors who have researched red marrow signal in and around the knee. Wilson, et al. [7], found clear gender, age, obesity and smoking-related differences in the prevalence of red marrow around the knee joint with a prevalence of 35%. They concluded that its presence should not be a cause for clinical concern. In another study, Haemoglobin (Hb) levels were not found to have an effect on marrow signal in the distal femoral metaphysis [6], although a later study suggested that complete marrow replacement in the distal femoral metaphysis in women was associated with significantly lower Hb levels, prompting advice of checking Hb levels if incidentally found on MRI [8]. Haemopoietic marrow has also been documented as having high prevalence in asymptomatic marathon runners [14].

The current study uses basic MRI sequencing to assess the marrow signal which is universally applied to most MRI protocols for assessment of marrow lesions and its characteristics. It utilises the inherent maintenance of intrinsic fat content within the red marrow resulting in intermediate SI between medullary fat and skeletal muscle on T1-W SE and T2-W TSE. Advances in MRI techniques have led to new sequences as problem-solving tools in the assessment of marrow lesions that have the potential benefit of quantification. This includes the DIXON technique which relies on the resonance frequencies of fat and water resulting in the ability to quantify the amount of fat within a bone lesion [15]. Established 'cut-off' threshold levels of <20% (1.5Tesla) or <25% (3Tesla) signal intensity decrease has high sensitivity and specificity for a non-neoplastic lesion such as hyperplastic red marrow. [15]. Historically, the quantifiable DIXON technique has utilised T1-W imaging, but T2-W DIXON has recently been shown to adequately differentiate between yellow, red marrow and osseous lesions [16]. Diffusion weighted (DW) imaging is a different type of quantifiable MRI sequence that utilises measuring Brownian motion of water molecules in a voxel [17]. More recently intravoxel-incoherent DW MRI demonstrated significantly lower pure diffusion coefficient values for hyperplastic marrow compared with vertebral malignant lesions, and outperformed Attenuated Diffusion Coefficient (ADC) for differentiating these lesions [18]. Novel superposition of T1 and T2W MRI with mathematical statistical dominance algorithms has produced reproducible results for growth zone delineation in adolescent wrists, prompting the authors to postulate that this could potentially add value in marrow lesion assessment [19].

An obvious limitation of our study was not obtaining information regarding other parameters, particularly weight, Hb levels, exercise levels and smoking history from the retrospective review, but the purpose of the study was to highlight the prevalence of this imaging feature in a routine and unselected group of patients undergoing elbow MRI.

Conclusion

The proximal radial pseudo-tumour is seen in approximately 8% of elbow MRI studies, and should be recognised as a variant of proximal radial marrow signal. The increasing use of MRI will undoubtedly result in more incidental findings and documentation of the incidence and basic MRI imaging features at this location should increase confidence in MRI assessment and reduce the requirement to undertake needle biopsy for tissue diagnosis in this non-neoplastic condition.

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