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Review

A pragmatic approach to the imaging and follow-up of solitary central cartilage tumours of the proximal humerus and knee

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Central cartilage tumours of bone range from the benign enchondroma to the malignant chondrosarcoma. They are an incidental finding in up to 2.8% of routine magnetic resonance imaging (MRI) examinations performed of the shoulder and knee. The purpose of this review is to provide a current appraisal of the imaging and histological challenges of distinguishing enchondroma from low-grade chondrosarcoma. The general radiologist, encountering these lesions in the proximal humerus and around the knee, is introduced to the Birmingham Atypical Cartilage Tumour Imaging Protocol (BACTIP). This provides a guide to the initial assessment and diagnosis, a stepwise imaging follow-up plan, and the indications for onward specialist orthopaedic oncology referral or discharge from follow-up.

Introduction

Central cartilage tumours of bone range in a spectrum from the benign enchondroma through to the high-grade chondrosarcoma. Enchondroma is the second commonest benign bone tumour, particularly common in the hands and feet, but also frequently seen around the knee and in the proximal humerus. The malignant counterpart is the central chondrosarcoma that can be histologically graded on the basis of cellularity, mitosis, and cellular atypia. The distinction of enchondroma from intermediate (grade 2) and high-grade (grade 3) chondrosarcoma is relatively straightforward, whereas the distinction between enchondroma and low-grade (grade 1) chondrosarcoma can be challenging not only on imaging, but also histologically. With access to magnetic resonance imaging (MRI), which is now freely available in most healthcare systems, the prevalence of central cartilage tumours is greater than it ever was historically. The aim of this review is to quantify the problem based on the authors' experience in a specialist orthopaedic oncology service and to suggest a minimalist imaging management protocol, so that when encountered these lesions arising in the proximal humerus or around the knee can be assessed, followed up, or where appropriate, referred on for a specialist opinion. Surface cartilage lesions and enchondromatosis syndromes (e.g., Ollier disease and Mafucci's syndrome) are not discussed as their biological behaviour differs from solitary enchondroma.

Incidence of enchondroma in the proximal humerus and around the knee

Enchondromas are a relatively common incidental finding in the proximal humerus (2.1%)[1] and around the

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knee (2.8%)[2,3] on routine MRI. In 2011, a census recorded the population in England to be 53 million that would equate to approximately 1.5 million individuals with one or more central cartilage tumours in the proximal humerus or around the knee. Clearly, the vast majority will be both asymptomatic and not requiring MRI of the proximal humerus or knee for other purposes. In the authors' orthopaedic unit using one static scanner (7 days a week) and a mobile scanner (onsite 10 days a month) approximately 380 shoulder and 2,130 knee MRI are performed for non-oncological indications per annum, which can be expected to reveal a total of approximately 60 newly identified central cartilage tumours each year, all requiring some degree of assessment and a management recommendation. Other MRI units can be expected to generate their own cases varying in number dependent on scanner throughput and case mix. Frequently, these cases will be identified on MRI without any radiographs having been performed.

Incidence of chondrosarcoma in the proximal humerus and around the knee

Although it is well recognised that central chondrosarcoma can develop from a pre-existing enchondroma, there are no reliable data quantifying the risk.[4] Estimates that 2.4–6% may undergo malignant transformation does seem a gross overestimate, as it does not take into account the many thousands of cases of asymptomatic lesions in the population.[5–9] Therefore, the risk can be assumed to be less than the <1%, usually associated with the more familiar malignant transformation of a solitary osteochondroma to a peripheral chondrosarcoma. The National Cancer Intelligence Network recorded 96 new cases of chondrosarcoma of bone at all sites in England in 2014. Based on the typical distribution of chondrosarcoma in the skeleton, that approximates to 23 new cases per year located in the proximal humerus and around the knee.[10] Central chondrosarcoma tends to present over the age of 30 years. The population in England >30 years is approximately 33 million. This would equate to approximately 924,000 individuals in England with one or more central cartilage tumours in the proximal humerus or around the knee in the typical age group for central chondrosarcoma. Thus the real individual risk of malignant transformation is 924,000/23, which equates to approximately 1 in 40,170 per annum. Indeed, the risk of malignant transformation in this category may be even less as the recorded national cancer data includes both solitary central and peripheral chondrosarcomas of bone as well as those associated with enchondromatosis syndromes (e.g., Ollier disease and Mafucci's syndromes).

Orthopaedic oncology unit experience

In order to put the theoretical figures given above into some context, we have reviewed the data for bone lesions referred to our tertiary orthopaedic oncology unit over a 12-month period. This was approved by the Institutional Audit Review Board. In 2017, we received 1,854 referrals for bone lesions of which 186 (10%) were ultimately diagnosed as primary malignant bone tumours. Of these, 42 (23%) were diagnosed as chondrosarcoma. In the same period, we received 82 referrals (4.4% of the total) for assessment of central cartilage tumours in the proximal humerus and around the knee equating to approximately seven new referrals per month. Twenty-nine (35%) cases underwent needle biopsy and eight were diagnosed as chondrosarcoma and 21 as benign following multidisciplinary discussion of both the histological and imaging findings. The remaining 53 were given the presumptive diagnosis of enchondroma on imaging findings alone and either discharged or follow-up imaging advised.

Histology and biopsy

As stated above the histological distinction of enchondroma from low-grade chondrosarcoma can be challenging. Sampling error, whereby the needle biopsy specimen is subsequently found not to be representative of the highest grade component of the tumour is well recognised in up to 30% cases.[11,12] Even in the presence of an adequate biopsy specimen, one 10-year-old study demonstrated that amongst experienced bone pathologists, the interobserver distinction from benign to malignant in these borderline cases was unacceptably low.[13] Similar findings, with high interobserver variability particularly in the pathological distinction of enchondroma from grade 1 chondrosarcoma, was confirmed in a later study.[14] This is a regular problem in clinical practise when trying to determine appropriate imaging and subsequent management. It also impacts on the interpretation of the literature as it does beg the question as to what is the diagnostic reference standard in these publications? The reader can justifiably be sceptical of reports regarding the value of different imaging techniques if the very basis of the final diagnosis can be queried. Crim and coworkers have identified the various systematic biases that can skew the evaluation of the diagnostic accuracy in many of the studies on this subject.[15] In reality a multidisciplinary approach is usually required in routine practise to establish an acceptable working diagnosis.[16] In recognition of this diagnostic dilemma, there has been a subtle, albeit significant, change to the World Health Organization (WHO) categorisation of chondrogenic tumours of bone between the classifications published in 2002[17] and 2013.[4] Currently, this contentious cross-over group have been combined into a single atypical cartilaginous tumour (ACT)/low-grade (grade 1) chondrosarcoma category differentiating them from enchondroma (i.e., benign with no worrying features) and higher grade (grades 2 and 3) chondrosarcoma. Although a useful technique, needle biopsy is too invasive and expensive to be used routinely in the numerous cases presenting with a central cartilaginous tumour in the proximal humerus and around the knee irrespective of the diagnostic shortcomings of histopathology. A recent study showed good concordance between the needle biopsy and subsequent postoperative surgical specimen in central chondrosarcoma of the long bones, somewhat at variance

with studies cited above, but the study does not appear to have looked at the diagnosis of enchondroma versus ACT.[18] One specialist orthopaedic oncology unit is sufficiently sceptical about the value of needle biopsy that it advocates only performing biopsy on those cases with higher-grade features identified on imaging.[19,20]

Symptomatic assessment

There is a longstanding belief that increasing pain can be a sign of malignant transformation of an enchondroma, but pain per se is subjective and almost always present to some degree in a patient undergoing MRI of their shoulder or knee. Previous studies identified an explanation for the pain, other than the enchondroma, in 65% cases in the knee[21] and 82% in the proximal humerus[22] and 75% in long bones in general.[23] Pain is, therefore, an unreliable discriminator between benign and malignant in this context. In addition, the radiologist typically has limited clinical information in this respect when he/she initially reports the scans and is making further recommendations, particularly if the enchondroma is an incidental finding. The reader will hardly be surprised that orthopaedic oncologists also show fairly poor agreement for grading of these lesions using initial clinical as well as imaging features.[24]

Imaging assessment

Imaging usually differentiates benign enchondroma from higher-grade chondrosarcoma. Frequently, because of the relative rarity of chondrosarcoma, publications have included all categories of tumour from enchondroma through to de-differentiated chondrosarcoma. The focus of this review is on the imaging assessment of suspected enchondroma versus ACT commencing with MRI as this is often the first imaging technique performed.

Static MRI

Central cartilage tumours, both benign and malignant, appear lobulate and hyperintense on fluid-sensitive sequences due to the high water content of the hyaline cartilage and, therefore, relatively low signal intensity on T1-weighted images. There have been numerous publications describing features that are commoner in higher grade (2 and 3) chondrosarcomas, but can still be seen in a minority of ACT/grade 1 cases and can therefore not be considered definitive. These include bone expansion, cortical thickening, and active periostitis.[25,26] Vanel and coworkers have suggested identifying islands of hyaline cartilage surrounded by marrow fat as oppose to diffuse marrow replacement to be a useful way to differentiate benign from malignant.[27] Conversely, true cortical destruction with a soft-tissue mass is virtually pathognomonic for a higher-grade chondrosarcoma and may be the first indication of dedifferentiation necessitating prompt referral to a specialist orthopaedic oncology unit (Fig 1).[26,28] In terms of measurement, chondrosarcomas tend to be larger (mean length 8 cm) than enchondroma (mean length 5 cm; Fig 2)[29,30] and endosteal scalloping with a depth of more than two-thirds found in 67% chondrosarcomas, but only 11% of enchondromas.[29] The caveat to the latter observation is that small endosteally based enchondromas are frequently associated with cortical scalloping by virtue of their eccentric origin within the long bone (Fig 3).[31]

Contrast-enhanced MRI

On static contrast-enhanced MRI the interlobular fibrovascular septae in central cartilage tumours are accentuated to give a ring-and-arc pattern, but this feature cannot differentiate benign from malignant tumours.[32] It is almost 30 years since the first paper was published on the use of dynamic contrast-enhanced (DCE)-MRI in musculoskeletal

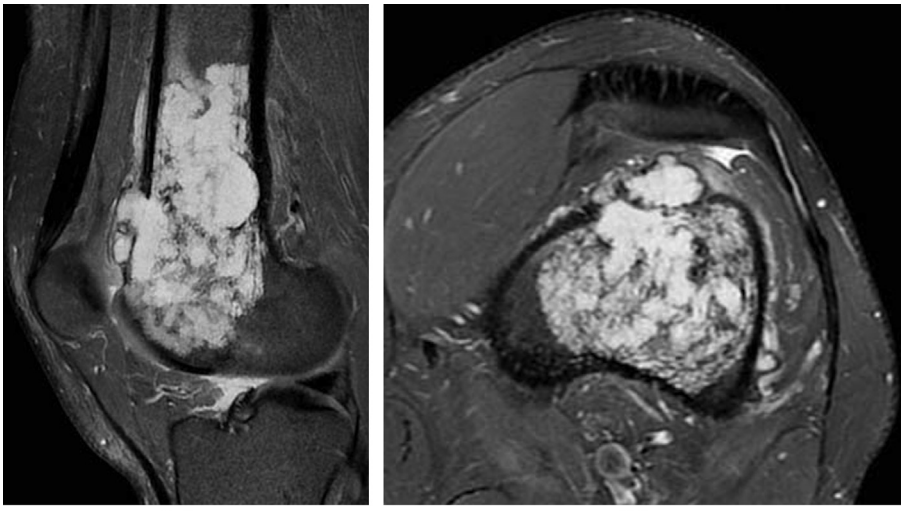

Figure 1 (a) Sagittal and (b) axial proton-density fat-saturated images showing aggressive features in a 9.7 cm central cartilage tumour (CCT) in the distal femur indicated by anterior cortical destruction and soft-tissue extension. Biopsy showed grade 1 chondrosarcoma. Resection histology revealed focal areas of grade 2 (category III).

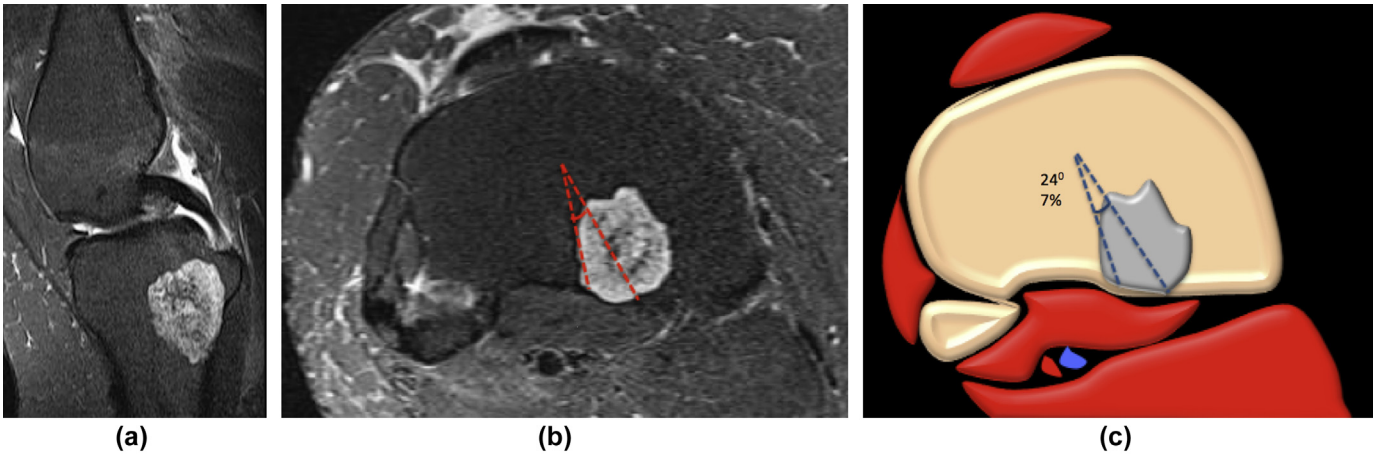

Figure 2 (a) Sagittal and (b) axial proton-density fat-saturated images, with (c) transverse schematic showing a 3.1 cm enchondroma in the proximal tibia with focal endosteal scalloping (category IB).

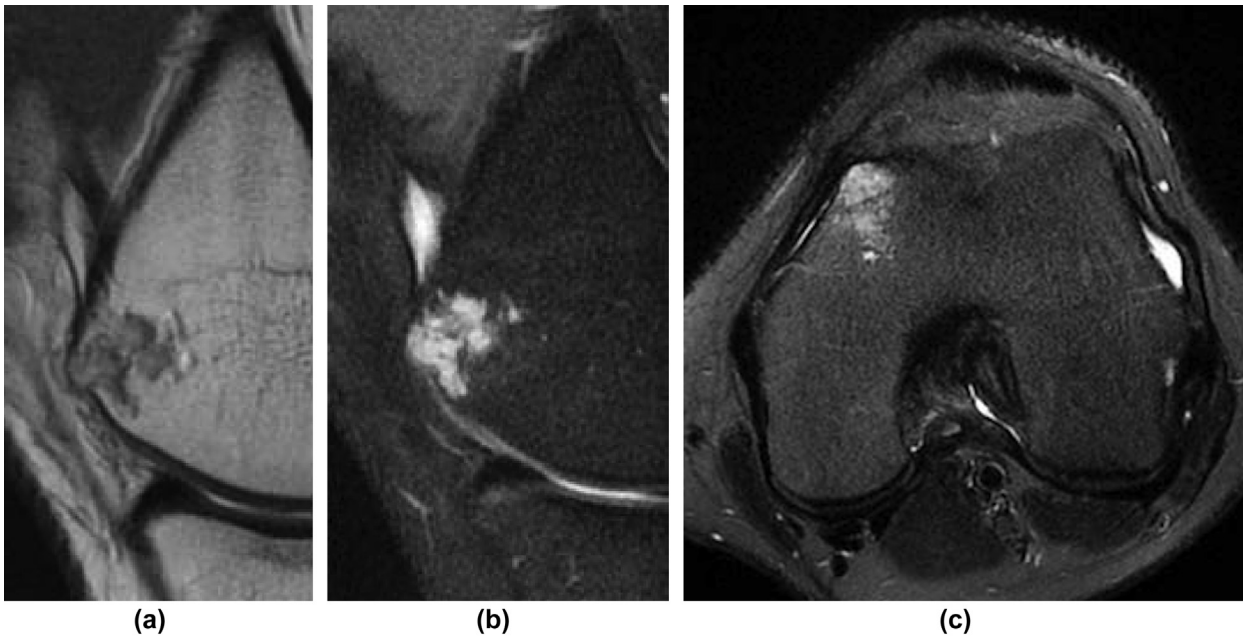

Figure 3 (a) Sagittal proton-density fat-saturated and (b) axial proton-density fat-saturated images showing a 1.6 cm eccentric enchondroma in the distal femur with focal endosteal scalloping (category IB).

tumours[33] allowing quantification of tissue perfusion and kinetics.[34] In 2000, the Leiden group suggested that this technique could assist in the distinction between benign and malignant cartilaginous tumours.[35] Subsequently, De Coninck and co-workers confirmed these findings reporting an impressive 100% sensitivity, but a rather disappointing 63% specificity when applying particular cut-off values for relative enhancement compared with muscle and the rate of enhancement.[36] The most compelling conclusion of this paper was that the accuracy of the standard MRI parameters was equal to the DCE-MRI parameters. A recent paper from our own unit concluded that DCE-MRI was not useful in differentiating enchondroma from grade 1 chondrosarcoma.[37] To date the inference from the literature has to be that routine use of contrast medium in central cartilage tumours is not necessary. The exception may be to use DCE-MRI to identify possible areas of dedifferentiation in higher-grade tumours to minimise sampling error. A complementary role for DCE-MRI in relatively large numbers of cases is, however, insufficient to justify the additional cost and recent concerns regarding the long-term safety of gadolinium chelates is another issue that cannot be ignored.[38]

Diffusion-weighted imaging

Diffusion-weighted imaging (DWI) is a functional MRI technique increasingly used in oncological imaging to characterise lesions and assessment of treatment response.

One scientific presentation with a very small sample size suggested a statistically significant, albeit slight, difference in the mean ADC values of enchondroma and chondrosarcoma.[39] A more recent retrospective study, comprising a larger sample size, concluded that DWI cannot differentiate between enchondromas and chondrosarcoma, and furthermore, it does not aid in the distinction of low-grade from high-grade chondrosarcoma.[40]

Radiographs

Changes to modern imaging practice mean that many patients undergo MRI of the knee and shoulder before radiographs are obtained. Indeed, in many cases MRI is diagnostic of many bone and soft-tissue diseases, and the added value of subsequent radiographs is considered low.[41] As assessment of radiographs does not form part of the protocol described, the well-recognised radiographic features of central cartilage tumours are not described in this review.

99m-Tc MDP scintigraphy

A study, predating the WHO reclassification, claimed that the degree of uptake of the radionuclide in comparison to anterior–superior iliac spine (ASIS) was higher in chondrosarcoma of all grades than enchondroma, but a direct comparison was not made between enchondroma and grade 1 chondrosarcoma.[42] Other studies have suggested that the degree of activity is not related to the biological activity, i.e., likelihood of malignancy.[23,43] A further study of 133 cases did not show any statistically significant difference in uptake between enchondroma and ACT relative to the ASIS, but did note that 83% cases with lower activity were finally diagnosed as enchondroma.[44] There is, therefore, little value in using bone scintigraphy in the differentiation of enchondroma and ACT. It is also worth noting that whole-body bone scintigraphy is not useful in the initial surgical staging of chondrosarcoma irrespective of the histological grade.[45]

2-[^{18}F]-Fluoro-2-deoxy-D-glucose positron-emission tomography

An early paper suggested that, using a maximum standardised uptake value (SUVmax) cut-off of 2, it was possible to differentiate benign from malignant cartilage tumours (sensitivity 90.9%, specificity 100%, and accuracy 96.6%).[46] The sample size in this study was small and included central, peripheral, and extra-skeletal chondrosarcomas. Another study using combined positron-emission tomography (PET) and computed tomography (CT), again used a SUVmax cut-off of 2, showed that 18 of 19 cases with a SUVmax >2, who underwent surgery, were chondrosarcomas with one enchondroma.[47] None of the presumed enchondroma group with an SUVmax <2 showed disease progression over a mean period of 38 months, but there was no histological correlation in this latter group. A recent systematic review of the literature on PET and chondroid neoplasms concludes a very low SUVmax supports a diagnosis of benign tumour, whereas an elevated SUVmax is suggestive of higher-grade chondrosarcoma.[48] The keywords in this conclusion are “supports” and “suggestive”, both used to indicate that PET could not be considered a definitive test in differentiating benign from malignant central cartilage tumours. At this point in time, the routine use of PET or PET-CT in this clinical context cannot be recommended if only because of the cost implications and radiation exposure.

Follow-up imaging protocol

It is mandatory that central cartilage tumours showing aggressive features on imaging, namely cortical destruction and soft-tissue extension, should be promptly referred to a specialist orthopaedic oncology unit for needle biopsy and surgical management as these are likely to be proven to be higher-grade chondrosarcomas (Fig 1). As discussed above, it is the enchondroma versus ACT/low-grade chondrosarcoma spectrum of central cartilage tumours that cause the greatest diagnostic problems and generate the largest number of problem cases particularly in the proximal humerus and around the knee. This poses two fundamental questions. First, accepting the limitations of the histological evaluation and that it is not necessary or practical to biopsy all cases, which cases should undergo biopsy? Second, how should cases that are not subjected to biopsy be managed? One study reasonably suggests distinguishing “active” lesions (endosteal scalloping >2/3 cortex and >2/3 length of tumour, cortical thickening, and bone expansion) from “quiescent” lesions lacking these features advocating biopsy for the former and radiological follow-up for the latter.[49] A similar study divided these tumours into an “active” group (total growth on follow-up MRI >6 mm in all three planes) from a “latent” group (<6 mm growth) again advocating biopsy for the former and a further surveillance MRI examination to be performed at 3 years for the latter.[23] This paper also recommended CT at presentation as “active” lesions showed <50% calcification whereas “latent” lesions tended to be heavily calcified. Another recent publication concluded that in most of these patients, there was little medical indication for surgery, but then went on to advise annual radiological follow-up for asymptomatic enchondroma or ACT in the long bone, irrespective of tumour size.[50] Crim and co-workers also recommend serial follow-up rather than curettage for non-painful cartilage lesions of any size.[15] Campanacci and co-workers suggested serial follow-up for asymptomatic cartilage lesions <5 cm.[51] One recent study claims that up to 50% of cases will show regression on follow-up MRI.[52] Although aware of this phenomenon, we would not consider it typical behaviour of central cartilage tumours.[53]

If these apparently latent/quiescent cases are to be followed up, what type of imaging should be performed, how often, and for how long? If the figures stated above are to be believed, the majority of cases will never undergo

malignant change and those that do may take decades. The existing literature, comprising patients presenting to secondary care, indicates a low percentage of cases with one quoting a mean time for malignant transformation of 41 months,[50] another a median time of 7.7 years with a further systematic review giving a range of 6 months–30 years.[9] A two-decade follow-up for modest to large solitary enchondroma has been suggested if detected after the age of 25.[54] Were radiologists to accept this advice, they would in effect be unwittingly introducing an image-based screening service with a progressive year-on-year increase in the number of patients imaged as routine MRI continues to identify newly diagnosed central cartilage tumours. It is unrealistic to subject these patients to follow-up for 20 years, but it is more appropriate to concentrate on identifying those that may be undergoing, albeit very slowly, early malignant transformation at the time of first presentation. In other words, focusing on what is happening in the short term rather than what may or may not occur at some time in the future. To this end, we have developed a protocol (Birmingham Atypical Cartilaginous Tumour Imaging Protocol/BACTIP; Fig 4) that applies only to central cartilage tumours of the proximal humerus and around the knee. Lesions in the proximal femur are excluded as these are more frequently malignant. Lesions in the distal tibia and fibula are similarly excluded as enchondroma at this site is 13 times less common than in the proximal humerus and around the knee and chondrosarcoma is 11 times less common.[11] In addition, the demand for MRI at both sites is significantly less than for the knee and shoulder. The protocol is a modification of that proposed by Sampath Kumar and colleagues.[23] We have dropped the requirement for CT of the lesion. This entails an additional hospital attendance for the patient, a modest financial cost to the healthcare system, a minor ionising radiation dose, and to our mind, only a minor impact on lesion assessment. The protocol is based purely on the unenhanced MRI findings, as this is frequently the only imaging available at the time of the first presentation and allows for recommendations to be made remotely without the need for additional imaging and further hospital attendances. Assuming that all those cases with aggressive appearances have been pre-selected for prompt referral to a specialist orthopaedic oncology, the two features assessed at MRI are the length of the tumour and the presence or absence of endosteal scalloping.

Length

The longest dimension of the cartilage tumour in the longitudinal plane is measured to the nearest millimetre on the PACS workstation. The measurement should be replicated in an identical manner if any follow-up MRI examinations are performed with the original images available for direct comparison. Sampath Kumar and co-workers advocated measurements in all three orthogonal planes and then summing the differences when comparing images.[23]

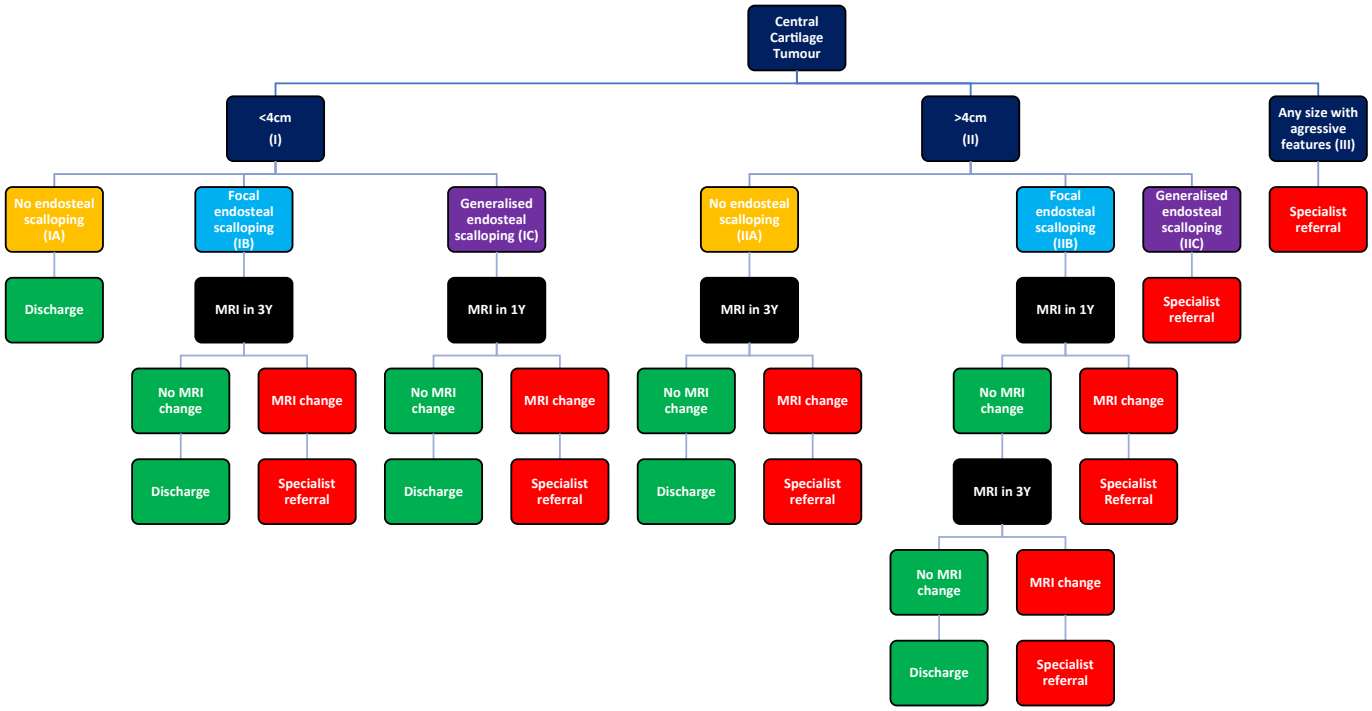

Figure 4 Birmingham Atypical Cartilaginous Tumour Imaging Protocol (BACTIP). Algorithm for the MRI management of central cartilage tumours of the proximal humerus and around the knee. Aggressive features = bone expansion and/or cortical thickening, periostitis, cortical destruction and soft-tissue mass. No aggressive features = absence of above criteria and absent or only localised endosteal scalloping. MRI change = increase in longitudinal length of lesion ≥1 cm and/or development of aggressive features including increasing endosteal scalloping. DISCLAIMER: This graphic schematic is for advice only and has not been clinically validated. The authors and publishers do not accept responsibility for any issues arising from its use.

We feel that this methodology is rather fiddly and that most tumours extend in the line of least resistance that is within the marrow along the bone. In addition, any significant increase in size in the transverse plane is likely to result in the development or increase in endosteal scalloping (see below). We have allocated the lesions to one of two categories based on the length measurement (<4 and ≥4 cm; Figs 5 and 6). Why the 4 cm category as 5 cm is a figure often quoted in the literature? This is purely pragmatic, erring on the safe side to ensure that the protocol is risk averse. In addition, from personal experience many of the lesions present just above or just below the 5 cm measurement. We have also taken a 1 cm increase in length as the indicator of activity. The 6 mm proposed by Sampath Kumar and coworkers is within the tolerance level expected of interobserver variation when measurements are performed in routine clinical practice as opposed to the rigour of a scientific study.

Endosteal scalloping

This is defined as erosion of the inner surface of the cortex and per se is not a reliable indicator of malignancy particularly if the cartilage tumour originates in an eccentric location (Fig 3)[31]; however, if identified on the imaging at presentation or is shown to increase on follow-up imaging, this is a cause for concern. If only to ensure that, in years to come, were a central cartilage tumour to subsequently undergo malignant transformation, a bone tumour expert, with the benefit of hindsight, could not claim negligence on the part of the original radiologist because he/she had "missed the earliest signs". A frequently quoted 20-year-old paper identifies scalloping of more than two-thirds of the cortex as significant.[30] In routine practice, taking into consideration the quality of many imported MRI scans we see as a specialist orthopaedic oncology unit, precise measurements are impractical. We, therefore, categorise endosteal scalloping as absent (Figs 5 and 7), or present and if the latter focal (<10% circumference of lesion based on the axial image with the greatest involvement; Figs 2 and 8) or extensive (≥10%; Fig 6). Put another way, on the assumption the long bone is relatively round on axial images, this equates to approximately <36° of the circumference for focal and >36° for extensive endosteal scalloping.

Fig. 1 shows the BACTIP for the assessment of a central cartilage tumour arising in the proximal humerus or around the knee. This is based on the evaluation of the initial MRI with first a quantitative measurement of the longitudinal extent of the tumour (<or ≥ 4 cm) with second a semi-quantitative estimation of the absence or presence of endosteal scalloping (<10% or ≥10% circumference). Small (<4 cm) tumours with no endosteal scalloping (category IA) are recommended for discharge (Fig 5). Small tumours with focal endosteal scalloping (category IB) are recommended for a follow-up MRI after 3 years (Figs 2 and 3). This in recognition of the fact that small central cartilage tumours are unlikely to show measurable change if the follow-up MRI is performed within a matter of months or only at 1 year. Small tumours with generalised endosteal scalloping (category IC), a rarity in our experience, merit a follow-up MRI at 1 year.

Longer lesions (≥4 cm) with no endosteal scalloping (category IIa; Fig 7) are recommended to undergo a follow-up MRI after 3 years. Whereas an earlier scan at 1 year is advised in longer lesions with focal endosteal scalloping (category IIB; Fig 8). If there is no change at 1 year in this latter category, then a repeat follow-up MRI is suggested after a further 3 years.

On the assumption that longer lesions with generalised endosteal scalloping could represent an ACT/low-grade (grade 1) chondrosarcoma (category IIC; Fig 6), it is

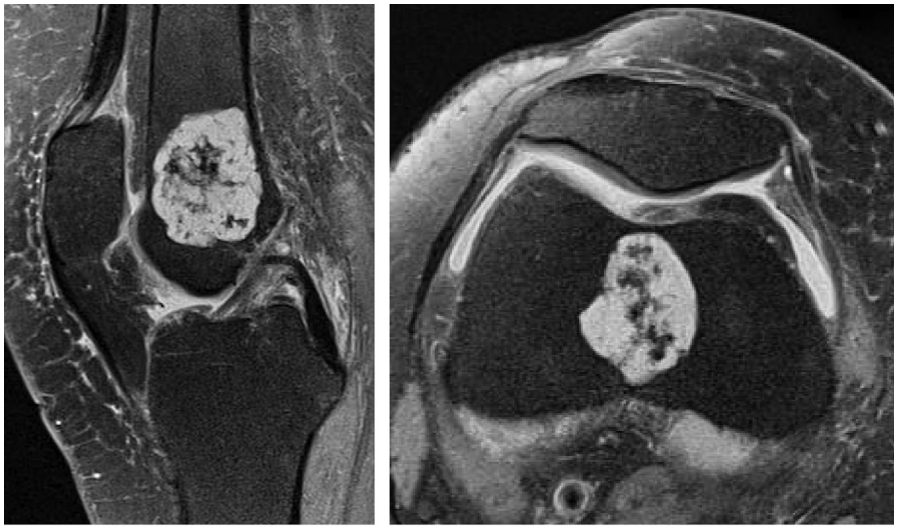

Figure 5 (a) Sagittal and (b) axial proton-density fat-saturated images showing a 3.6 cm enchondroma in the distal femur with no endosteal scalloping (category IA).

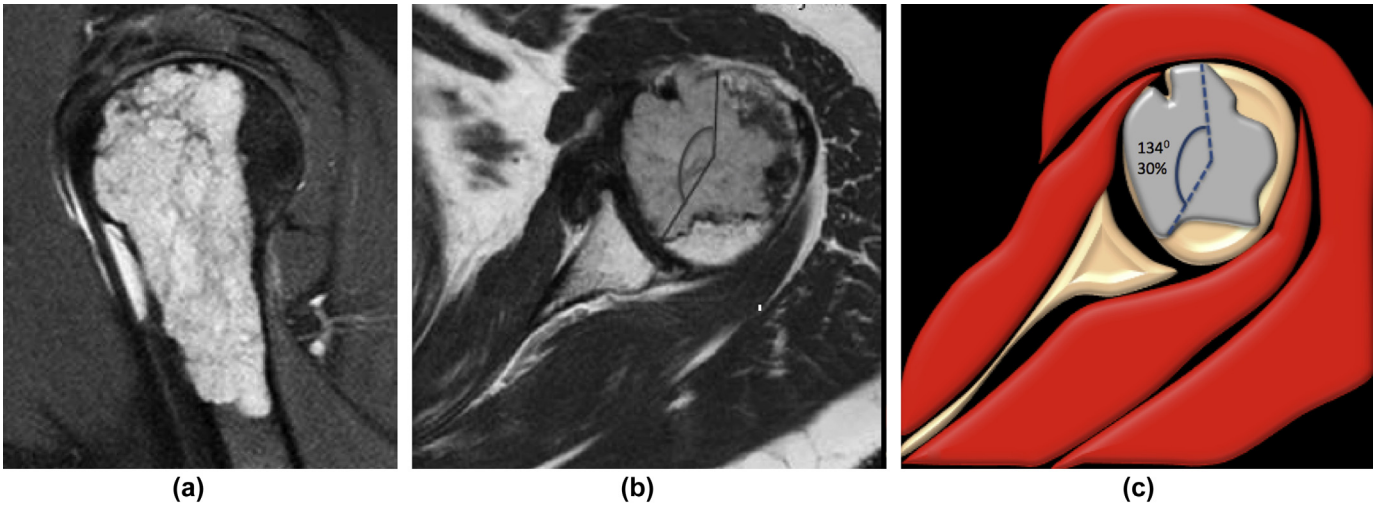

Figure 6 (a) Sagittal proton-density fat-saturated and (b) axial T2-weighted images, and (c) transverse schematic showing a 6.8 cm central cartilage tumour (CCT) in the distal femur with generalised endosteal scalloping. Biopsy and resection histology revealed grade 1 chondrosarcoma (category IIC).

recommended that these cases are referred at the time of presentation directly to a specialist orthopaedic oncology unit. Specialist referral is also advised for any cases that show change on subsequent MRI. Change is defined as an increase in longitudinal length of the tumour by $\geq$1 cm, increasing endosteal scalloping, irrespective as to whether it remains focal or not (i.e., <10% or 36° of the circumference) and the development of any frankly aggressive/malignant features such as cortical destruction and soft tissue extension (category III; Fig 1). It is not the intention of the authors that the BACTIP should be applied too rigidly. It can be difficult to accurately compare MRI images, particularly if the sequences employed, coils applied, limb positioning, or even scanner manufacturer differ between the two examinations. Therefore, the authors would not quibble, for example, if a measurement increase in length of 8–9mm triggered a specialist referral.

The purpose of the BACTIP is to provide the radiology community with a tool with which to assess central cartilage tumours and thereby highlight those cases appropriate for onward referral to a specialist orthopaedic oncology unit. It will be up to the individual specialist centres to determine how best to manage these cases be it further follow-up (i.e., a watch-and-wait policy) for the smaller, more indolent looking lesions, or needle biopsy when malignancy is suspected. Any patient with a central cartilage tumour that meets the criteria for "discharge" should be advised to seek medical attention should he/she develop

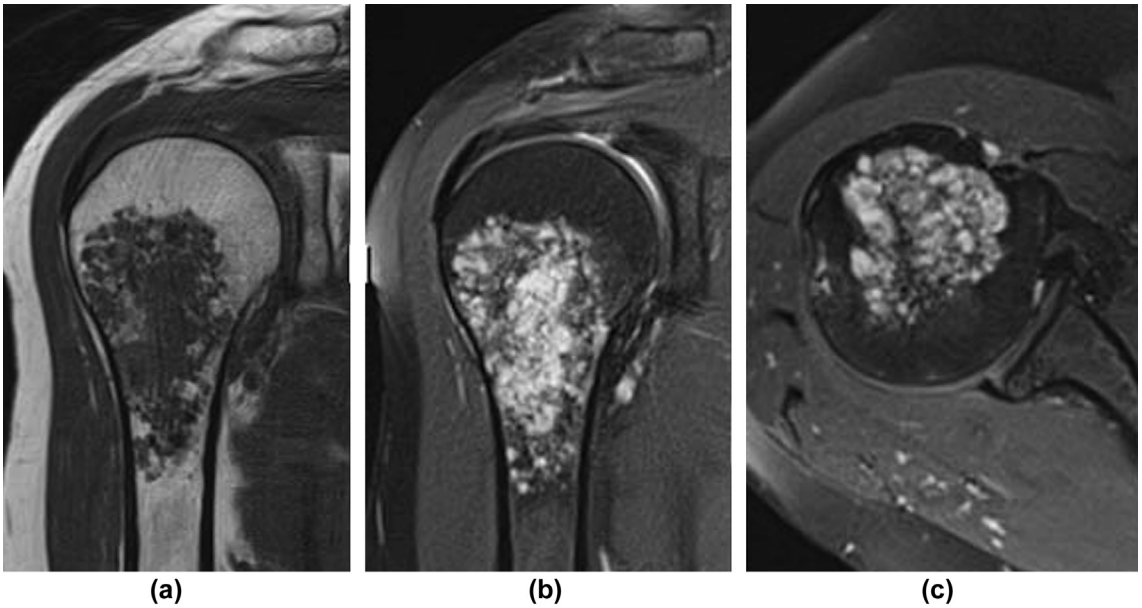

Figure 7 (a) Coronal T1-weighted, (b) coronal short tau inversion recovery, and (c) axial proton-density fat-saturated images showing a 6 cm enchondroma in the proximal humerus with no endosteal scalloping (category IIA).

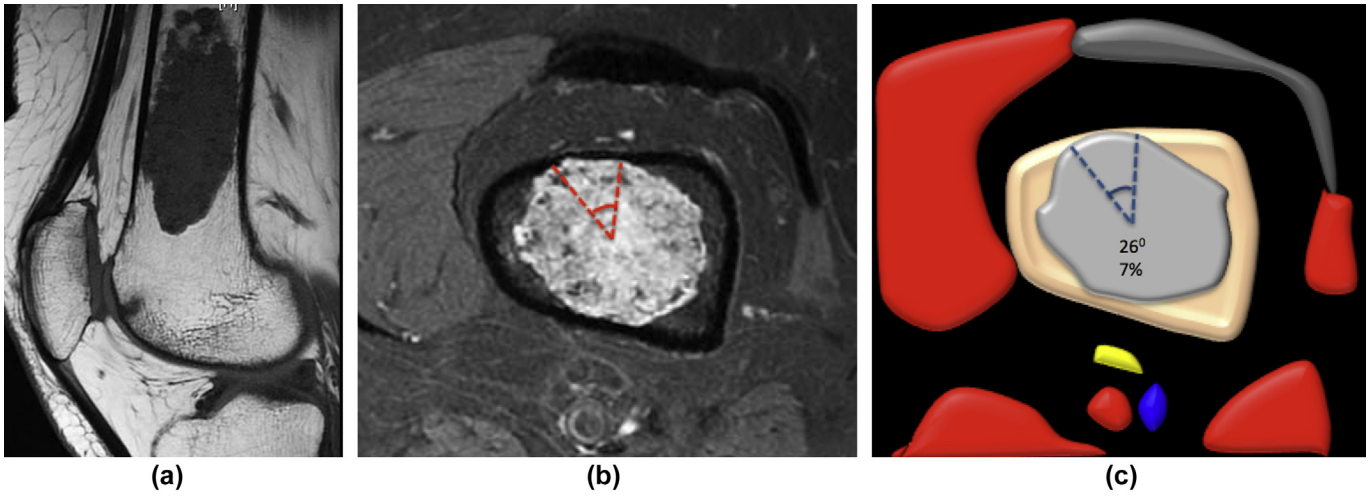

Figure 8 (a) Sagittal T1-weighted and (b) axial proton-density fat-saturated images, and (c) transverse schematic showing a 6.3 cm enchondroma in the distal femur with focal endosteal scalloping (category IIB).

deteriorating or new symptoms at the relevant site in the future. It would also be prudent that the risk of future malignant transformation, albeit small, is communicated with the patient's general practitioner (community physician) to ensure that this information is documented in the medical records.

Conclusion

Is the BACTIP based on science? It forms a pragmatic compromise on what is known and ensures that the advice and follow-up is practical, sustainable, and not a cause of prolonged undue anxiety for the patients. It is an attempt to minimise over-medicalisation[55] of what, for most patients, is an incidental finding, and ensure that they do not become unnecessary victims of modern imaging technology (VOMIT).[56] It must be emphasised that BACTIP only applies to central cartilage tumours arising in the proximal humerus and around the knee as cartilage tumours of the axial skeleton and proximal femur are much more frequently malignant.

Conflict of interest

The authors declare no conflict of interest.

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