MODERN RADIOLOGY eBook

Musculo-skeletal Imaging

骨骼肌肉影像学

EUROPEAN SOCIETY OF RADIOLOGY

Preface

Modern Radiology is a free educational resource for radiology published online by the European Society of Radiology (ESR). The title of this second, rebranded version reflects the novel didactic concept of the ***ESR eBook*** with its unique blend of text, images, and schematics in the form of succinct pages, supplemented by clinical imaging cases, Q&A sections and hyperlinks allowing to switch quickly between the different sections of organ-based and more technical chapters, summaries and references.

Its chapters are based on the contributions of over 100 recognised European experts, referring to both general technical and organ-based clinical imaging topics. The new graphical look showing Asklepios with fashionable glasses, symbolises the combination of classical medical teaching with contemporary style education.

Although the initial version of the ***ESR eBook*** was created to provide basic knowledge for medical students and teachers of undergraduate courses, it has gradually expanded its scope to include more advanced knowledge for readers who wish to 'dig deeper'. As a result, *Modern Radiology* covers also topics of the postgraduate levels of the *European Training Curriculum for Radiology*, thus addressing postgraduate educational needs of residents. In addition, it reflects feedback from medical professionals worldwide who wish to update their knowledge in specific areas of medical imaging and who have already appreciated the depth and clarity of the ***ESR eBook*** across the basic and more advanced educational levels.

I would like to express my heartfelt thanks to all authors who contributed their time and expertise to this voluntary, non-profit endeavour as well as Carlo Catalano, Andrea Laghi and András Palkó, who had the initial idea to create an ***ESR eBook***, and - finally - to the ESR Office for their technical and administrative support.

Modern Radiology embodies a collaborative spirit and unwavering commitment to this fascinating medical discipline which is indispensable for modern patient care. I hope that this ***educational*** tool may encourage curiosity and critical thinking, contributing to the appreciation of the art and science of radiology across Europe and beyond.

Minerva Becker, Editor
Professor of Radiology, University of Geneva, Switzerland

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

前言

*《现代放射学》*是由欧洲放射学协会 (European Society of Radiology, ESR) 在线发布的免费放射学教育资源。第二版（更名版）标题反映了 ***ESR 电子书***新颖的教学概念，它以简洁页面的形式巧妙地融合文本、图像和示意图，并辅以临床影像学案例、问答部分和内容超链接，使读者能够在各基于器官的部分、更具技术性的章节、摘要以及参考文献之间快速切换浏览。

其章节以 100 多名公认欧洲专家的优秀稿件为根基，涉及各类一般技术和基于器官的临床影像学主题。同时采用了全新的图形外观，展示了佩戴时尚眼镜的 Asklepios，象征着传统医学教学与现代风格教育的结合。

虽然初版 ***ESR 电子书***旨在为医学生和本科生教师提供医学基础知识，但现已逐渐扩充其知识领域，为希望“深入挖掘”的读者提供了更多高阶技术知识。因此，*《现代放射学》*还涵盖了*欧洲放射学培训课程*研究生水平的各类主题，旨在解决住院医师的研究生教育需求。此外，书中还囊括了全球医疗专业人士的反馈，他们希望更新自己在医学影像特定领域的知识，并对 ***ESR 电子书***在基础和高等教育水平上的深度和清晰度表示高度赞赏。

我要衷心感谢所有为这项非营利活动自愿贡献时间和专业知识的作者，以及最初提出创作 ***ESR 电子书***的 Carlo Catalano、Andrea Laghi 和 András Palkó，最后还要感谢 ESR 办公室所提供的技术和行政支持。

*《现代放射学》*充分体现了医者的协作精神和对这门热门医学学科坚定不移的承诺，这是现代患者护理必须具备的优秀精神品质。我希望这款***教育***工具能够激励各位始终保持好奇心和批判性思维，从而促进整个欧洲乃至欧洲以外地区对放射学艺术和科学的认识。

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NOTE FROM THE COORDINATORS:
Thank you to Chinese radiology experts for bridging languages and open the world-class English resource by ESR to every Mandarin-speaking student, fueling global radiology talent with a single click

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Musculo-skeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

翻译致谢

本章节为《现代放射学电子书》的部分译文。

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骨骼肌肉影像学

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译者寄语：
感谢中国放射学专家们的倾力奉献！你们跨越了语言的鸿沟，将欧洲放射学会 (ESR) 的世界级学术宝库呈献给广大中文学子。如今，前沿智慧一键即达，为全球放射学人才的蓬勃发展注入了强劲动力。

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Signage

<▪> CORE KNOWLEDGE

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>▪< FURTHER KNOWLEDGE

>|< COMPARE

<∞> REFERENCES

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导示

<▪> 核心知识

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<?> 问题

MODERN RADIOLOGY eBook

Based on the ESR Curriculum for Radiological Education

Musculo-skeletal Imaging

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/ **Musculo-skeletal** Imaging

CHAPTER OUTLINE:

/ **骨骼肌肉** 影像学

章节大纲：

基于 **ESR** 课程的放射学教育

骨骼肌肉影像学

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Imaging Anatomy

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影像解剖

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章节大纲：

Musculoskeletal (MSK) Imaging Anatomy

Radiology is a fascinating specialty in medicine, dealing—by way of its diagnostic and interventional procedures—with not only recognition, but also treatment or palliation of abnormalities and diseases. The first known radiological image of human body from 22 December 1895 (**Figure 1**) is reportedly the hand radiograph of Anna Bertha Ludwig, the wife of the discoverer of X rays, Dr. Wilhelm Conrad Röntgen, who is considered to be the founder of radiology. This makes musculoskeletal imaging literally the first subspecialty in radiology!

Currently, musculoskeletal (MSK) radiologists use a wide array of ingenious techniques to diagnose—and sometimes treat—abnormalities and diseases in humans. Knowledge of musculoskeletal anatomy is essential in this context.

The **musculoskeletal (MSK) system** comprises bones, muscles, joints, subcutaneous tissue and distinct anatomic compartments, which play an important functional role.

FIGURE 1

Image from Wikipedia, Public Domain.

Musculo-skeletal Imaging

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骨骼肌肉影像学

章节大纲：

骨骼肌肉 (MSK) 影像解剖

放射学是医学中的一门热门专业，通过其诊断和介入程序，不仅可识别异常，还能治疗或缓解异常和疾病。据报道，已知的第一张人体放射图像（**图 1**）是 X 射线发现者 Wilhelm Conrad Röntgen 医生（放射学创始人）于 1895 年 12 月 22 日获得的来自其妻子 (Anna Bertha Ludwig) 的手部放射图像。这使得骨骼肌肉影像学成为放射学的首个医学分科！

目前，骨骼肌肉 (MSK) 放射科医生能够使用各项精妙技术来诊断人类的异常和疾病，有时甚至进行治疗。在这个前提下，掌握骨骼肌肉解剖学知识显得尤为重要。

骨骼肌肉 (MSK) 系统由骨骼、肌肉、关节、皮下组织和不同的解剖隔室组成，各部分起着重要的功能作用。

图 1

图片来自维基百科 (Wikipedia) 公共领域。

/ Imaging Anatomy of Bones

All **long bones** comprise epiphysis, metaphysis, diaphysis—and sometimes apophysis (**Figures 2 and 3**). Apophyses do not contribute to longitudinal growth and do not form a joint part as do the epiphyses. The physes normally close during adolescence and no longer remain visible as radiolucent bands by the end of the second decade or the early years of the third decade of life.

The thickness of the bone cortex (or **cortical bone**) can vary among different bones and even within the same bone. It is usually thicker in the diaphysis.

The **bone medulla** (containing medullary bone or trabecular bone) comprises trabeculae, red and yellow marrow. The trabecular bone is also called “cancellous” bone.

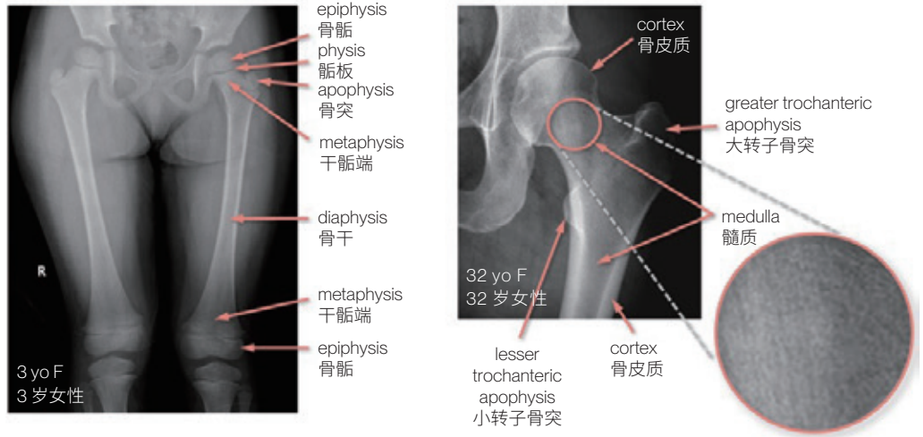

FIGURE 2

Conventional radiographs illustrating parts of a long bone (here the femur) in a child and an adult.

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章节大纲：

骨骼影像解剖

所有**长骨**均包括骨骺、干骺端和骨干，有时还包括骨突（**图 2 和图 3**）。骨突不会促进纵向生长，也无法像骨骺起到形成关节部分的作用。骺板通常在青春期闭合，到 20 岁末或 30 岁早期不再显示为透亮带。

骨皮质（或**皮质骨**）的厚度在不同骨骼之间甚至在同一骨骼内也可能不同，在骨干中通常较厚。

骨松质（含髓质骨或小梁骨）由小梁、红骨髓和黄骨髓组成。小梁骨也称为“松质”骨。

图 2

儿童和成人的部分长骨（此处为股骨）的常规 X 线片。

Carpal and tarsal bones, apophyses and sesamoids are considered as epiphysis analogues. Lesions with a predilection for epiphyses, therefore, also tend to involve these analogues, which are an established location for certain tumours that preferentially involve epiphyses.

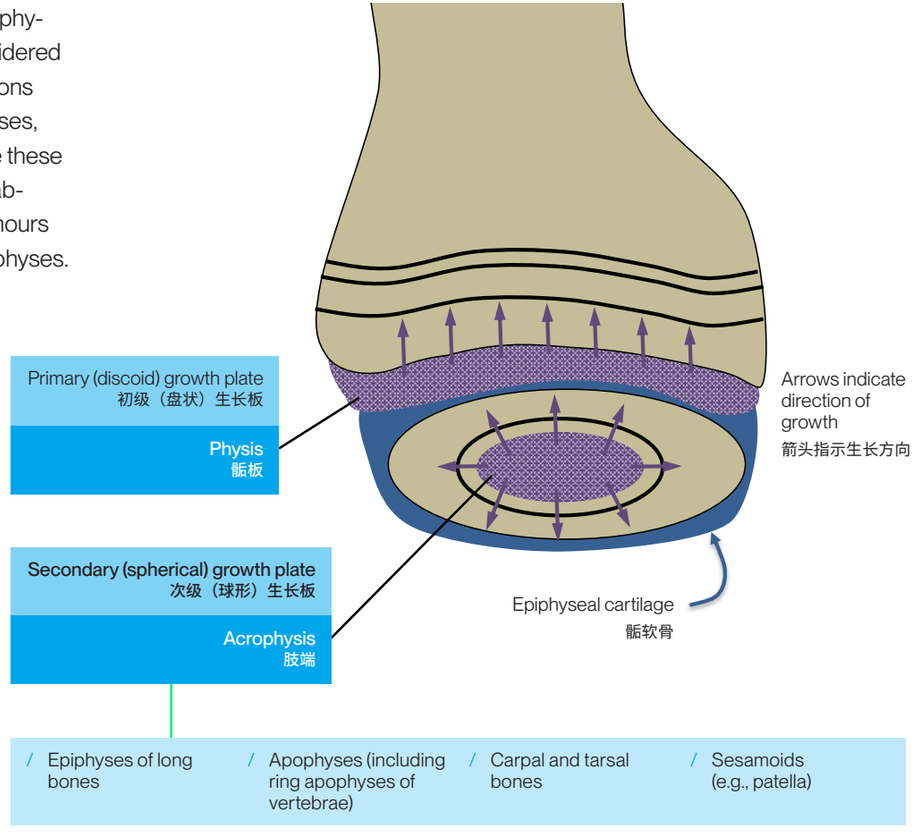

FIGURE 3

Drawing based on Oestreich AE. Skeletal Radiol 2003.

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腕骨和跗骨、骨突和籽骨被认为是骨骺类似物。因此，倾向于骨骺的病变也往往涉及这类类似物，它们是某些常发生累及骨骺的肿瘤的既定部位。

图 3

图示基于 Oestreich AE。Skeletal Radiol 2003。

/ 长骨骨骺 / 骨突（包括椎骨的环状骨突） / 腕骨和跗骨 / 籽骨（如髌骨）

Formerly referred to as growth "arrest" lines, **growth "recovery" lines** indicate periods of renewed or increased growth, presumably after a period of inhibited growth of the bone (**Figure 4**). They may, however, occur during normal growth and growth spurts.

FIGURE 4

Growth recovery lines (**arrows** on **A**) on MRI in a 4-year-old boy with resolved osteomyelitis elsewhere in this extremity. Growth recovery lines may occasionally present as curvilinear intra-epiphyseal silhouettes (**arrowheads** on **B** and **C**), giving the bone-within-bone appearance as in this 31-year-old woman, who sustained an ipsilateral femoral diaphyseal fracture at 10 years of age, whereupon she had had limited mobility for 6 months. Her other leg was unremarkable.

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生长“恢复”线，以前称为生长“停滞”线，表示生长恢复或加速的时期，可能发生在骨骼生长受抑制一段时间之后（图 4），也可能发生在正常生长和生长突增期间。

图 4

1 名 4 岁男孩在 MRI 上的生长恢复线（A 上箭头），该肢体其他部位的骨髓炎已消退。生长恢复线偶尔可能表现为骨骺内曲线轮廓（B 和 C 上箭头），呈现骨内骨外观，如这位 31 岁女性，她在 10 岁时发生同侧股骨干骨折，此后活动受限 6 个月。另一条腿无明显异常。

/ Imaging Anatomy of Muscles

Muscles have bellies, myotendinous junctions, tendons and tendo-osseous junctions (**Figure 5**).

The **myotendinous junction** is the site of most muscle strains (**Figure 6**), while the **tendo-osseous junction** is an expected site of overuse injury (**Figure 7**).

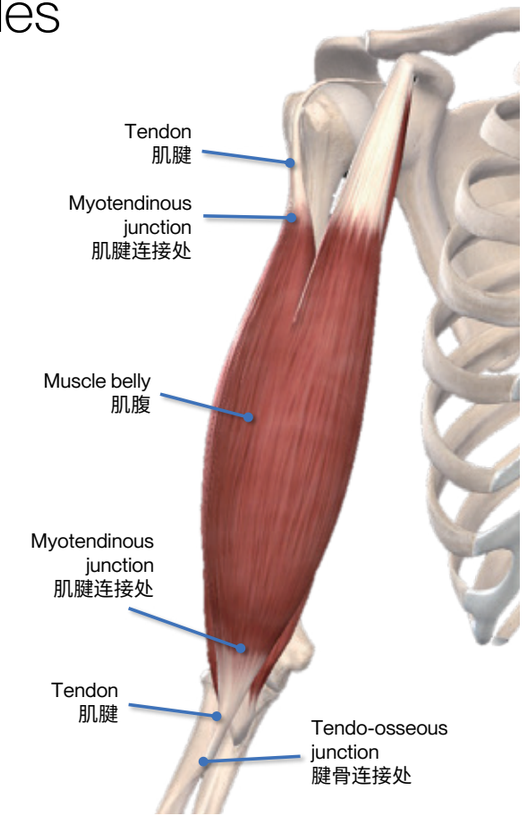

FIGURE 5

Various muscle components.

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章节大纲：

/ 肌肉影像解剖

肌肉包括肌腹、肌腱连接处、肌腱和肌腱-骨连接处（图 5）。

肌腱连接处是大多数发生肌肉拉伤的部位（图 6），而**肌腱-骨连接处**是过度使用损伤的预期部位（图 7）。

图 5

各肌肉组分。

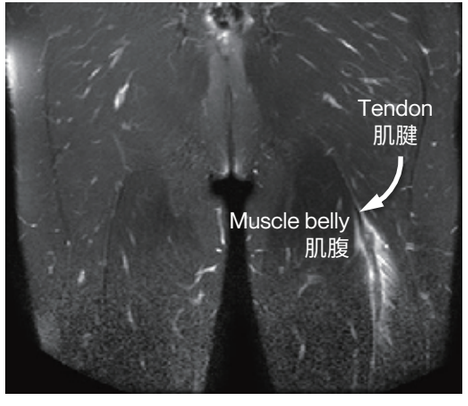

FIGURE 6

Left hamstring strain involving the myotendinous junction in an amateur football player. Fluid-sensitive MRI sequences such as the ones here show oedema as conspicuously white areas and are extensively used in MSK imaging.

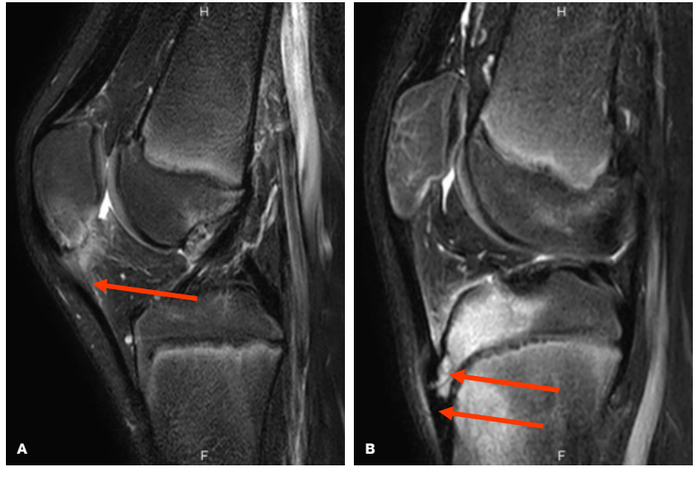

FIGURE 7

Chronic overuse injury at the tendo-osseous junctions of the proximal (**A**) and distal (**B**) aspects of the patellar tendon in two different 13-year-old boys (**arrows**).

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图 6

一名业余足球运动员的左腘绳肌腱拉伤，累及肌腱连接处。液体敏感性 MRI 序列（例如此处序列）显示水肿为明显的白色区域，广泛用于 MSK 影像。

图 7

两位不同的 13 岁男孩在髌腱近端 (**A**) 和远端 (**B**) 的肌腱-骨连接处出现慢性过度使用性损伤（箭头）。

/ Imaging Anatomy of Joints

Synovial joints (**Figure 8**) are surrounded by a capsule which is continuous with the periosteum of the articulating bones and sometimes formed by a continuum of collagen-rich structures such as ligaments, bands and tendons.

Some ligaments (e.g., anterior and posterior cruciate ligaments of the knee) and tendons (e.g., biceps long head tendon in the shoulder and popliteus tendon in the knee) are intraarticular.

Ligaments inside a joint are usually covered by synovium—joint-traversing tendons are usually not.

Some joints have specialised structures such as meniscus (knee), labrum (shoulder and hip) and triangular fibrocartilage complex (TFCC; wrist), which serve primarily as either buffer (menisci, TFCC) or deepen the socket-type joint (labra).

The most important component of a synovial joint is the **joint cartilage**, the loss of which is usually associated with a cascade of events leading to the dysfunction and destruction of a joint.

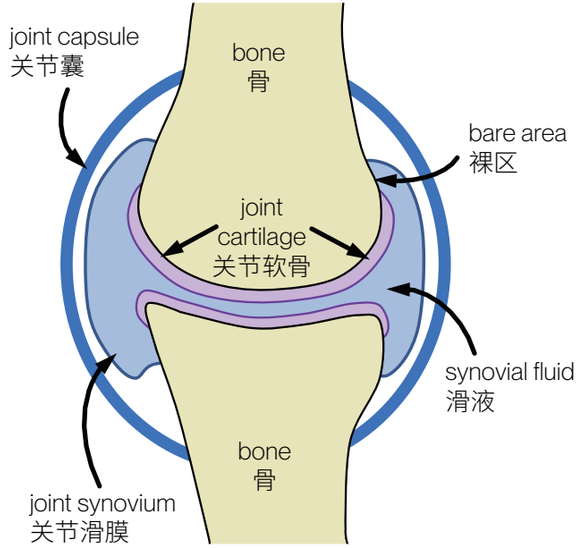

FIGURE 8

A synovial joint.

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滑膜关节（图 8）被关节囊包围，关节囊与关节骨的骨膜相连，有时由富含胶原的连续结构（如韧带、腱带和肌腱）形成。

部分韧带（如膝关节的前交叉韧带和后交叉韧带）和肌腱（如肩关节的肱二头肌长头肌腱和膝关节的胭肌腱）位于关节内。

关节内的韧带通常被滑膜覆盖，而横穿关节的肌腱通常未被其覆盖。

部分关节具有特殊结构，如半月板（膝）、盂唇（肩部和髋部）和三角纤维软骨复合体（TFCC；腕部），主要用作缓冲（半月板，TFCC）或加深凹窝型关节（盂唇）。

滑膜关节最重要的组成部分是**关节软骨**，软骨缺失通常与导致关节功能障碍和损伤的一连串活动有关。

图 8

滑膜关节。

Although they do not provide cross-sectional information, radiographs are the **first-line imaging modality to study joints**. Cross-sectional examination of joints is best accomplished by magnetic resonance imaging (MRI, see **Figure 9**), which gives the most comprehensive non-invasive information about not only the soft tissue components of a joint, but also the bones that form it.

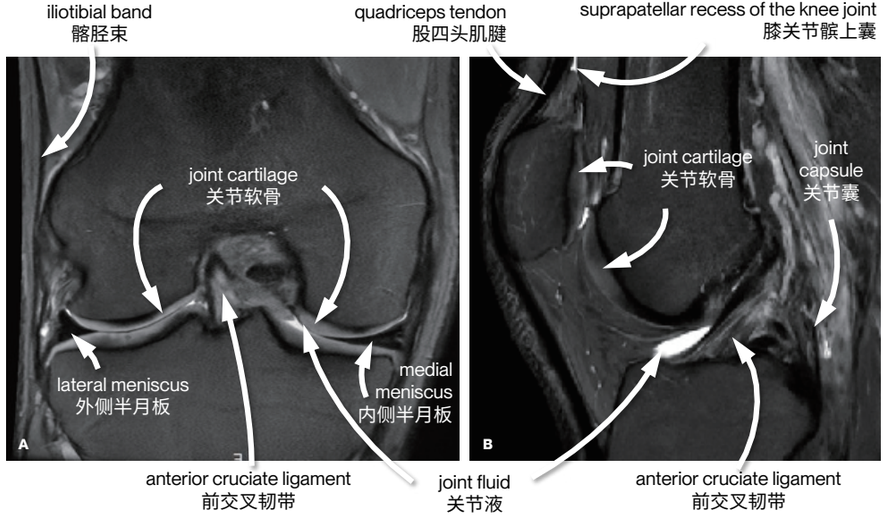


FIGURE 9

Normal anatomy of the knee joint as seen on MRI. Coronal plane (**A**) and sagittal plane (**B**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

X 线片虽然无法提供横断面信息，但仍是**研究关节的首选影像学检查方法**。关节横断面检查最好通过磁共振成像（MRI，见图 9）来完成，这是一种无创的医学影像检查技术，不仅可提供最全面的关节软组织信息，还包含构成关节的骨骼信息。

图 9

MRI 显示膝关节解剖结构正常。冠状位 (**A**) 和矢状位 (**B**)。

Radiographs give important clues about bones and soft tissue components of joints. Uses of such clues include—but are not limited to—**joint effusion estimation** and joint **cartilage loss assessment** (see Arthropathies>Osteoarthritis).

<!> ATTENTION

Joint fluid estimation on radiographs

The knee is the largest joint in the human body. The suprapatellar recess (**Figure 9**) can be used for joint effusion assessment on radiographs. **Figure 10A** shows a normal suprapatellar recess (arrows) with a thickness ≤ 5 mm in a properly obtained lateral radiograph. **Figure 10B** shows a knee joint effusion with a distended suprapatellar recess (**arrows**). Also note the increased joint fluid tracks along the femoral trochlea (**arrowheads**), a feature not visible on **A**, where there is no joint effusion.

Suprapatellar recess distention with effusion can also be used to search for intra-articular fractures by taking advantage of the gravity-dependent layering of bone marrow fat and blood that flow into the joint space with such fractures (see Fractures and Dislocations>Pearls and Pitfalls in Identifying Fractures). Such use entails cross-table horizontal projection of X-rays to the image detector.

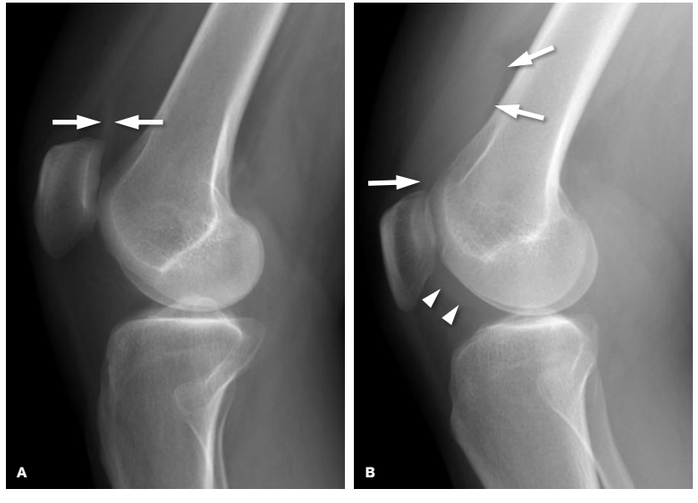


FIGURE 10

Lateral radiographs of a normal knee joint (**A**) and a joint with knee effusion (**B**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

X 线片可提供关节骨骼和软组织成分的重要线索。此类线索的用途包括但不限于**关节积液评估**和关节**软骨缺失评估**（请参阅“关节病>骨关节炎”）。

<!> 注意

X 线片关节液评价

膝关节是人体中最大的关节。髌上囊（图 9）可用于通过 X 线检查对关节积液评估。图 10A 显示了正常髌上囊（箭头），厚度 ≤ 5mm（在正确获得的侧位 X 线片上）。图 10B 显示了膝关节积液伴髌上囊扩张（箭头）。此外，还应注意沿股骨滑车增加的关节液（箭头尖端部分），该特征在 A 图上未见（因为 A 中没有关节积液）。

髌上囊扩张伴关节积液也可用于寻找关节内骨折，方法是利用发生此类骨折流入关节间隙的骨髓脂肪和血液的重力依赖性分层（请参阅识别骨折中的“骨折与脱位 > 要点和误区”）。过程中，需要 X 线水平投照于探测器上。

图 10

正常膝关节 (**A**) 和存在膝关节积液 (**B**) 的侧位 X 线片。

骨骼肌肉影像学

章节大纲：

/ Imaging Anatomy of Subcutaneous Tissue

Anatomists, surgeons and radiologists tend to use different terms to describe the components of the fascial system. The **radiological approach** is illustrated in **Figure 11**. Where muscles abut bones, the deep intermuscular fascia is in continuity with the periosteum. These structures are best depicted on MRI.

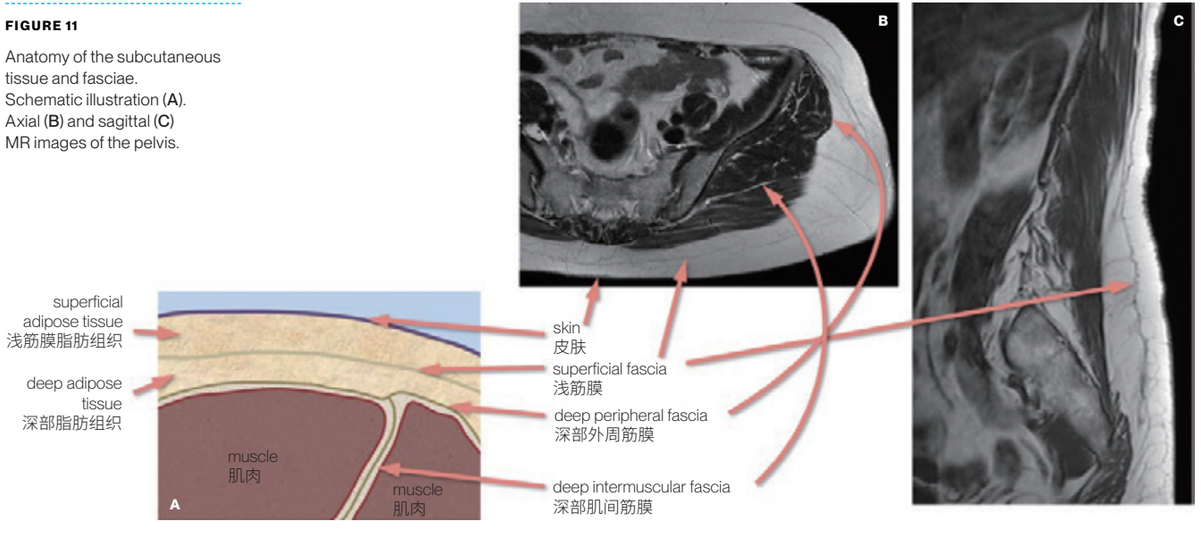


FIGURE 11

Anatomy of the subcutaneous tissue and fasciae. Schematic illustration (**A**). Axial (**B**) and sagittal (**C**) MR images of the pelvis.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

/ 皮下组织影像解剖

解剖学家、外科医生和放射科医生倾向于使用不同的术语来描述筋膜系统的组成部分。**放射学方法**如**图 11** 所示。在肌肉毗邻骨骼的位置，深部肌间筋膜与骨膜相连。这些结构在 MRI 上表现最佳。

章节大纲：

图 11

皮下组织和筋膜解剖结构示意图 (**A**)。盆腔轴位 (**B**) 和矢状位 (**C**)MR 图像。

Compartmental Anatomy and How It Relates to Imaging

Compartments are anatomic spaces with natural boundaries to tumour spread. Each bone and each joint is a distinct compartment. Muscles or muscle groups are compartments. Compartmental involvement of primary malignant musculoskeletal tumours is an important parameter in the **Enneking staging system** (**Figure 12**), which is used in patient management and outcome prediction.

As an example, the thigh muscles are divided into three compartments: anterior, medial and posterior (**Figure 13**). The femur itself is a distinct compartment.

>=< FURTHER KNOWLEDGE

STAGE	TUMOUR	METASTASES	GRADE
IA	T1	M0	G1
IB	T2	M0	G1
IIA	T1	M0	G2
IIB	T2	M0	G2
III	T1 or T2	M1	G1 or G2

- T1, tumour is intra-compartmental; T2, tumour is extra-compartmental.
- M0, no regional or distant metastasis; M1, regional or distant metastases.
- G1, low histological grade; G2, high histological grade.

FIGURE 12

The Enneking staging system.

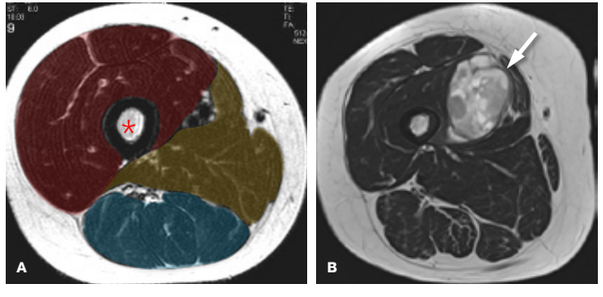


FIGURE 13

A. Thigh muscle compartments as seen on axial MRI: anterior (**red**), medial (**yellow**), posterior (**blue**). Femur (**asterisk**). B. Intra-compartmental synovial sarcoma (**arrow**) in a 44-year-old woman. The mass lesion is limited to the anterior compartment of the thigh.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

间室解剖结构及其与影像的关系

间室是解剖空间，具有肿瘤扩散的自然边界。每块骨骼和每个关节都是一个独立的间室。肌肉或肌群为复合间室。原发性恶性骨骼肌肉肿瘤的间室受累是 Enneking 分期系统（图 12）中的一个重要参数，用于患者管理和结果预测。

例如，大腿肌肉可分为三个间室：前侧、内侧和后侧（图 13）。股骨自身是一个独立的间室。

>=< 进阶知识

分期	肿瘤部位	转移	分级
IA	T1	M0	G1
IB	T2	M0	G1
IIA	T1	M0	G2
IIB	T2	M0	G2
III	T1 或 T2	M1	G1 或 G2

- T1：肿瘤位于间室内；T2：肿瘤位于间室外。
- M0：无局部或远处转移；M1：有局部或远处转移。
- G1：低组织学分级；G2：高组织学分级。

图 12

Enneking 分期系统。

图 13

A. 轴位 MRI 上所见大腿肌肉间室：前侧（红色）、内侧（黄色）、后侧（蓝色）。股骨（星号）。B. 1 名 44 岁女性的间室内滑膜肉瘤（箭头）。肿块病变局限于大腿前侧间室。

Interventional radiologists or oncologic orthopaedists perform tumour biopsies. It is best to make the biopsy at the medical centre where definitive surgery will be performed.

The **general principles for safe musculo-skeletal tumour biopsy** are (**Figure 14**):

- Use the shortest path between skin and lesion
- Avoid neurovascular and joint structures, lung, bowel, other organs
- Needle path needs to be in the approximately same location where the incision for the definitive surgery will be made, so that the biopsy tract can be resected
- Needle should not traverse an uninvolved or critical compartment, joint or neurovascular bundle

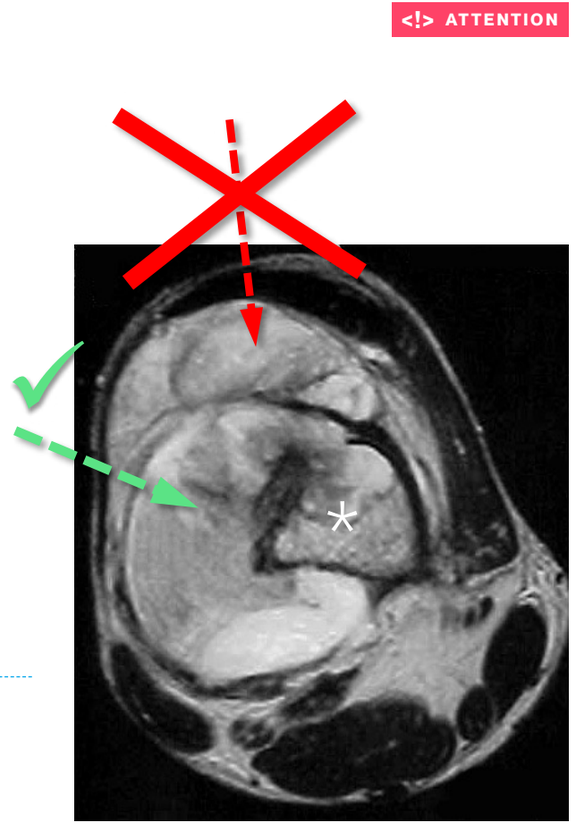


FIGURE 14

Axial MRI image. Femur (*). The **biopsy tract** for this expansile destructive distal femoral lesion not only should use the shortest path from the skin but also needs to avoid the undue contamination of the knee extensor mechanism (*the red route*), which, if the red route is used, would have to be considered contaminated (by tumour seeding) and resected during definitive surgery. The green route is to be preferred.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

介入放射科医生或肿瘤骨科医生进行肿瘤活检。最好在进行最终手术的医疗中心进行活检。

<!> 注意

骨骼肌肉肿瘤安全活检的一般性原则包括（图 14）：

- 采用皮肤与病变之间的最短路径
- 避免接触神经血管和关节结构、肺、肠和其他器官。
- 空针路径需要位于与最终手术切口大致相同的位置，以便切除活检通道
- 针头不得穿过未受累或关键间室、关节或神经血管束

图 14

轴位 MRI 图像。股骨 (*)。对于这种扩张性、破坏性股骨远端病变，**活检通道**不仅应采用距离皮肤最短的路径，还需避免膝关节伸肌结构的过度污染（*红色路径*）。若要使用红色路径，则必须考虑污染（通过肿瘤传播）并在最终手术中切除受污染部位。绿色路线为首选路线。

Strengths, Weaknesses and Roles of Imaging Modalities

Musculo-skeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

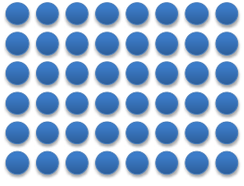
章节大纲：

影像学检查方法的优势、劣势和作用

The Concept of Resolution in Radiology

There are three distinct types of resolution in radiology (**Figure 15**).
Imaging modalities vary in their advantages on any given type of resolution.

Spatial resolution

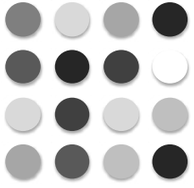


Ability to discern **closeness** in **space of two adjacent pixels**

Better:
As small a pixel size as possible

Conventional radiographs and CT have excellent spatial resolution, which, however, is not equally matched with contrast resolution.

Contrast resolution

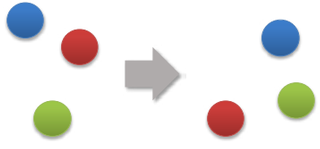


Ability to discern
structural variations of different pixels

Better:
As subtle a pixel variation as possible

MRI has excellent contrast resolution, which, however, is not usually equally matched with spatial resolution. US has very good contrast and spatial resolution.

Temporal resolution



Ability to discern
pixel differences over time

Better:
As short a time period as possible

Especially important in dynamic contrast-enhanced studies. Digital angiography and real-time fluoroscopy have excellent temporal resolution.

FIGURE 15

Differences between spatial, contrast and temporal resolution.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

放射学中的分辨率概念

放射学中有三种不同类型的分辨率（图 15）。
在任何给定的分辨率类型上，不同影像学技术的优势不尽相同

空间分辨率

辨别两个相邻像素在空间中接近程度的能力

理想情况：
像素大小尽可能小

常规 X 线片和 CT 的空间分辨率很高，但对比度分辨率较差。

对比度分辨率

辨别
不同像素结构变化的能力

理想情况：
像素变化尽可能细微

MRI 具有出色的对比度分辨率，但空间分辨率通常差强人意。超声具有良好的对比度和空间分辨率。

时间分辨率

辨别
随时间变化的像素差异的能力

理想情况：
时间越短约好

在动态对比增强研究中尤其重要。数字血管成像和实时荧光透视具有出色的时间分辨率。

图 15

空间、对比度和时间分辨率之间的差异。

/ Conventional Radiographs (CRX): Five Shades of Grey

Although not capable of giving cross-sectional information, radiographs are the **first-line imaging tool** in the MSK system. Radiographs feature five basic shades of grey, depending on the density (or X-ray attenuation) of the content imaged (**Figure 16**).

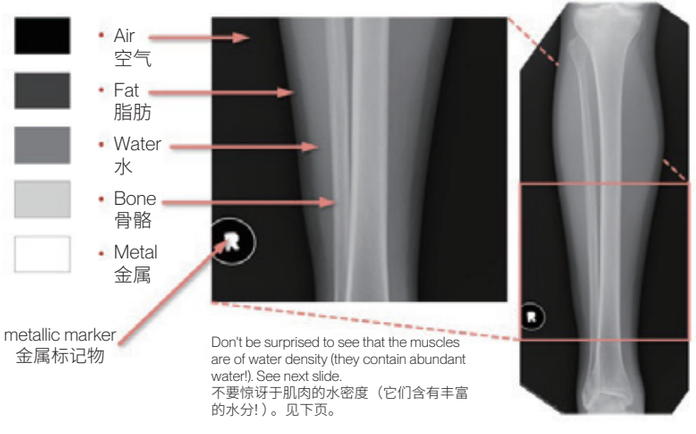


FIGURE 16

Basic grey shades on conventional radiographs (CRX).

>|< COMPARE

PROS

+ Easy
+ Inexpensive

CONS

− Not cross-sectional
− Ionising radiation

COSTS

Radiographs << US < CT < MRI

<!> ATTENTION

Don't be surprised to see that muscles are of water density (they contain abundant water)!

Note that subcutaneous fat is of intermediate density between ambient air and muscles (mostly water), which makes sense, because fat is less dense than water, but denser than air.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 常规 X 线片 (CRX)：五种灰度

X 线片虽然无法提供横断面信息，但仍是 MSK 系统的**首选影像学检查工具**。X 光片具有五种基础灰度，具体取决于成像内容的密度（或 X 射线衰减）（**图 16**）。

>|< 比较

优势

+ 容易
+ 便宜

劣势

− 非横断面
− 电离辐射

成本

X 线摄影 << US < CT < MRI

<!> 注意

不要惊讶于肌肉的水密度（它们含有丰富的水分）！

请注意，皮下脂肪的密度介于环境空气和肌肉（主要是水）之间，这合情合理，因为脂肪的密度低于水，但高于空气。

图 16

常规 X 线片 (CRX) 的基础灰度。

/ Conventional Radiography (CRX): A Chicken Soup of Five Shades of Grey

I poured into a paper cup first drinking water, then sunflower oil. I also put in a chicken bone. I covered the partly filled cup with a metal lid. I then X-rayed the cup (**Figure 17**, centre). The resulting radiograph (**Figure 17**, right) displays densities of air, fat, water, bone and metal.

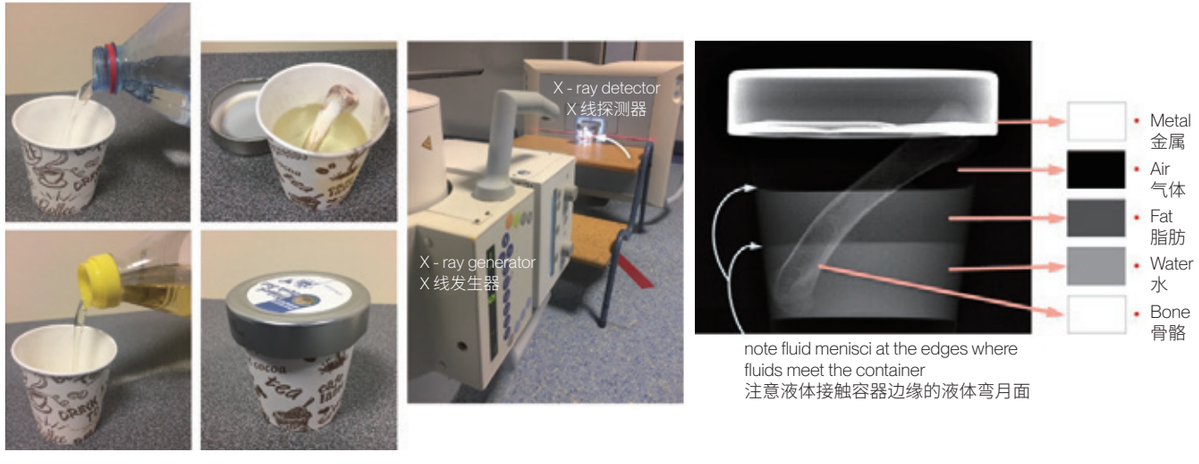


FIGURE 17

Basic grey shades on conventional radiography (CRX).

/ Musculo-skeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 常规 X 线片 (CRX)：鸡汤的五种灰度

我先往纸杯里倒饮用水，再倒入葵花籽油。我还放了一根鸡骨头。我用金属盖盖住了半满的杯子。然后对该杯子进行了 X 光检查（图 17，中间）。生成的 X 线片（图 17，右）显示了空气、脂肪、水、骨骼和金属的密度。

图 17

常规 X 线片 (CRX) 的基础灰度。

I then made a CT scan of the same cup (**Figure 18**). CT, like CRX, utilises X-rays (i.e., features ionising radiation). Note that on CT image bone marrow is largely composed of fat. This information will be useful when we overview "lipohaemarthrosis".

<!> ATTENTION

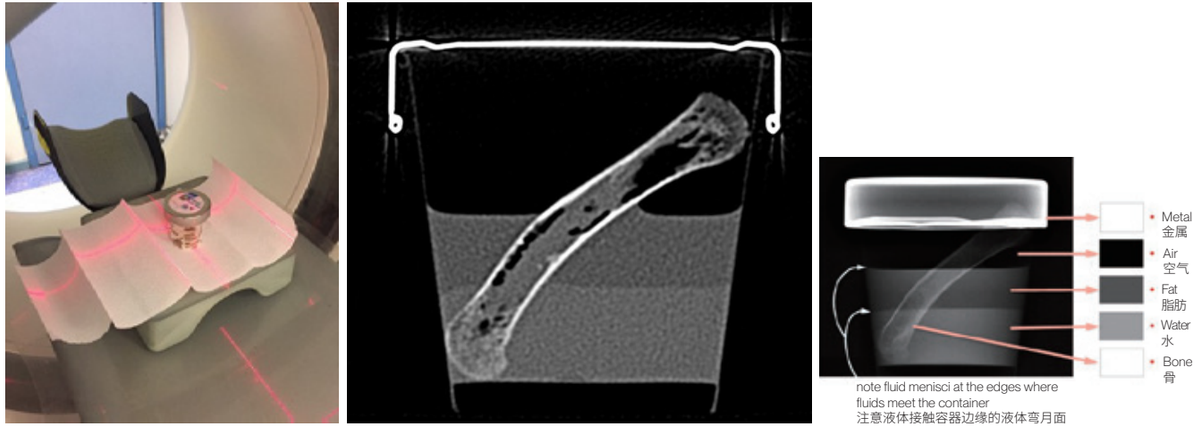


FIGURE 18

Basic grey shades on computed tomography (CT) and conventional radiography (CRX).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

然后，我对同一杯子进行了 CT 扫描（图 18）。CT 与 CRX 相同，均使用 X 射线（即具有电离辐射）。请注意，在 CT 图像上，骨髓主要由脂肪组成。当我们判读“关节脂血症”时，这些信息会很有用。

<!> 注意

图 18

计算机断层扫描 (CT) 和常规 X 线片 (CRX) 的基础灰度。

/ Computed Tomography (CT): Best to Characterise and Classify Fractures and Show Mineralisation

/ CT is widely used to identify, characterise and classify fractures (**Figure 19**).

/ Orthopaedic surgeons like to see three-dimensional CT representations of bone lesions that they might operate on (**Figure 20**).

/ CT is also used for guidance during bone biopsies and other interventional radiological procedures.

/ CT superbly demonstrates subtle calcifications in soft tissues or within the matrix of a bone lesion (**Figure 20**).

>|< COMPARE

PROS	CONS
+ Great spatial resolution	− Ionising radiation
+ Examination times are very short	− Contrast resolution is not as good as with MRI

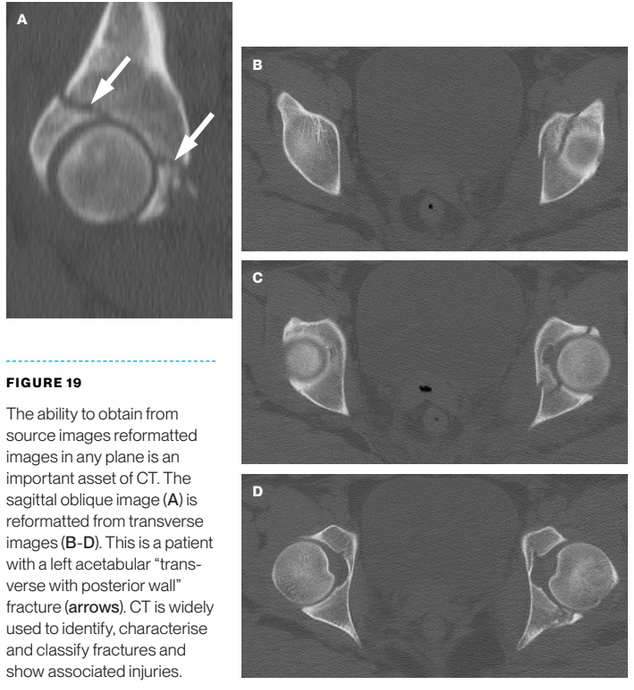


FIGURE 19

The ability to obtain from source images reformatted images in any plane is an important asset of CT. The sagittal oblique image (**A**) is reformatted from transverse images (**B-D**). This is a patient with a left acetabular "transverse with posterior wall" fracture (**arrows**). CT is widely used to identify, characterise and classify fractures and show associated injuries.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 计算机断层扫描 (CT)：骨折表征和分类及显示矿化的理想方法

/ CT 广泛用于骨折识别、表征和分类（图 19）。

/ 整形外科医生乐于看到可能进行手术的骨病变 3D CT 表现（图 20）。

/ CT 也用于指导骨活检和其他介入放射治疗。

/ CT 能出色地显示软组织中或骨病变基质内的细微钙化（图 20）。

>|< 比较

优势	劣势
+ 出色的空间分辨率	− 电离辐射
+ 检查时间很短	− 对比度分辨率不如 MRI

图 19

CT 的一项关键优势便在于能够从源图像中获得任意平面的重组图像。斜矢状面影像 (A) 是由横断面影像 (B-D) 重组而成。这是一名左髋臼“横行伴后壁”骨折的患者（箭头）。CT 广泛用于骨折识别、表征和分类，并显示相关损伤。

FIGURE 20

Three-dimensional rendering of bone lesions is another advantage of CT (**A**), enabling orthopaedic surgeons to better visualise what they will encounter during surgery as in this 23-year-old woman with osteo-chondromatosis (**arrows**). **B** is one of the source images.

/ Musculo-skeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

图 20

骨病变的 3D 渲染是 CT 的另一优势（**A**），使骨科医生能够更好地可视化在手术过程中遇到的具体情况，比如这位患有骨软骨瘤病的 23 岁女性患者（箭头）。B 是源图像之一。

/ Ultrasonography (US): Great Soft Tissue Detail, No Ionising Radiation

US is capable of giving real-time cross-sectional information without any ionising radiation and can be used for interventional procedures (**Figures 21** and **22**).

>|< COMPARE

PROS

+ Easy for the patient
+ Relatively inexpensive
+ No ionising radiation
+ Dynamic exam feasible
+ Doppler mode shows vascularity
+ Can be used for guidance in some procedures (e.g., soft tissue lesion biopsy, barbotage for calcific tendonitis)

CONS

– Does not show bones
– Deep soft tissues are usually beyond the scope of ultrasound probe for subtle lesions
– Operator-dependent
^ *This means that significant expertise is needed to be able to identify and characterise MSK soft tissues*

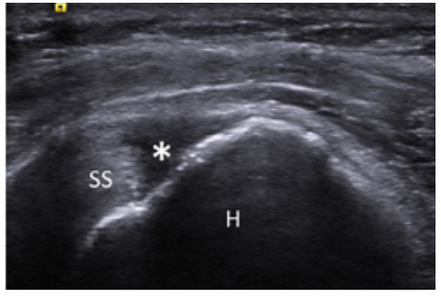


FIGURE 21

Shoulder US shows a focal full-thickness tear (**asterisk**) of the supraspinatus (**SS**) tendon at its insertion near the humeral head (**H**).

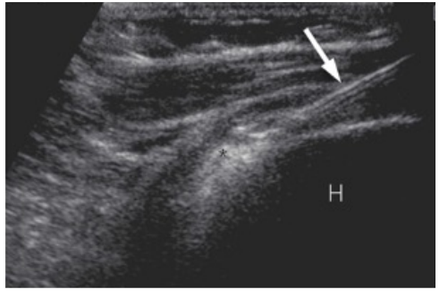


FIGURE 22

US-guided barbotage for calcific tendonitis (**asterisk**) entails introduction and aspiration of physiologic saline through a needle (**arrow**) to disperse the calcific deposit. (**H**, humeral head).

/ **Musculoskeletal** Imaging

CHAPTER OUTLINE:

/ **骨骼肌肉** 影像学

章节大纲：

/ 超声 (US)：出色的软组织细节信息，无电离辐射

US 能够在无任何电离辐射的情况下提供实时断层信息，可用于介入手术（图 21 和图 22）。

>|< 比较

优势

+ 方便患者
+ 相对便宜
+ 无电离辐射
+ 动态检查可行
+ 多普勒模式显示血管结构
+ 可用于指导部分手术（如软组织病变活检、钙化性肌腱炎穿刺）

劣势

– 不显示骨骼
– 深层软组织通常超出超声探头对细微病变的探测范围
– 依赖操作者
^ *这意味着需要大量专业知识才能识别和表征 MSK 软组织*

图 21

超声引导下钙化性肌腱炎穿刺（星号）需要通过针头（箭头）注入生理盐水并进行抽吸，以分散钙化沉积物。（H，肱骨头）。

图 22

肩部 US 显示冈上 (SS) 肌腱在肱骨头 (H) 附近的止点处出现局灶性全层撕裂（星号）。

Orthopaedic implant impingement on superficial soft tissues is exquisitely displayed on US (**Figure 23**).

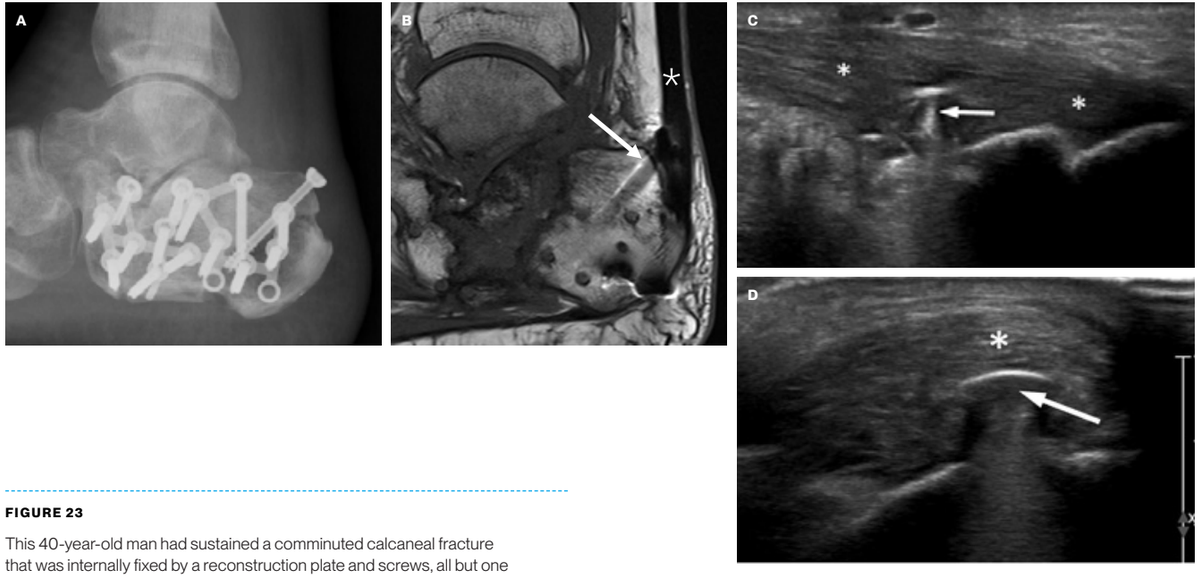


FIGURE 23

This 40-year-old man had sustained a comminuted calcaneal fracture that was internally fixed by a reconstruction plate and screws, all but one of which was later removed. Lateral CRX (**A**) before screw removal, sagittal MRI (**B**) and US images (**C** and **D**) after removal of all but one screw. The impingement of the remaining screw (**arrows**) upon the Achilles tendon (**asterisks**) was best demonstrated not on MRI (**B**) but on US images, which enabled precise measurement of the depth of intrusion.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

超声可清晰显示骨科植入物对浅表软组织的撞击（图 23）。

章节大纲：

图 23

这名 40 岁男性患有粉碎性跟骨骨折，用重建骨板和螺钉进行了内部固定，后续仅保留了一枚螺钉，其余螺钉均被移除。螺钉移除前的侧位 CRX (**A**)，仅保留一颗螺钉拆除所有螺钉后的矢状位 MRI (**B**) 和 US 图像（**C** 和 **D**）。US 图像（而非 MRI (**B**)）更加清晰地展示了剩余螺钉（箭头）对跟腱（星号）的撞击，能够精确测量侵入深度。

/ Magnetic Resonance Imaging (MRI): An Excellent Tool for One-Stop Imaging of a Great Variety of Structures

MRI is widely used in most MSK problems. Its excellent contrast resolution covers soft tissues and bone marrow, making it an excellent tool for one-stop imaging of all MSK structures (**Figure 24**).

>|< COMPARE

PROS

+ Superb contrast resolution
+ No ionising radiation

CONS

– Expensive
– Longer examinations than CT
– Not readily tolerated by some patients
– Not possible in some patients
– Subtle calcifications or small bone fragments might be missed

FIGURE 24

This man had an anterior shoulder dislocation, during which the posterolateral aspect of the humeral head smashes the anteroinferior part of the glenoid (**CRX, A**). MRI shows the resulting humeral head impaction fracture (**B, arrow**) with underlying bone marrow contusion (**B, asterisk**), shoulder haemarthrosis with layering of blood haematocrit (**C, arrowheads**) and the torn anterior glenoid labrum (**D, circle**).

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 磁共振成像 (MRI)：多结构一站式成像的优选工具

MRI 广泛用于大多数 MSK 问题，其出色的对比度分辨率可覆盖各软组织和骨髓，使其成为对所有 MSK 结构进行一站式成像的优质工具（图 24）。

>|< 比较

优势

+ 出色的对比度分辨率
+ 无电离辐射

劣势

– 昂贵
– 检查时间比 CT 长
– 部分患者不易耐受
– 某些患者不适用
– 可能会遗漏细微的钙化或小骨碎片

图 24

该男子肩前脱位，期间肱骨头的后外侧撞击了关节盂的前下部（CRX,A）。MRI 显示导致的肱骨头撞击骨折（B、箭头）伴关节面下的骨挫伤（B、星号），肩关节血肿伴分层（C、箭头尖端）以及前盂唇撕裂（D、圆形）。

MRI is the most extensively used imaging modality to show such sports- and other activity-related injuries (**Figure 25**, **arrows**) as tears of the menisci (1, 2), anterior cruciate ligament (3), rotator cuff tendons (4), anterior talofibular ligament (5) and cartilage lesions ranging from superficial delamination (6) to full-thickness loss (7, 8). Although US can also show some of these lesions at superficial locations (e.g., shoulder, ankle; see **Figure 21**), it can neither display as nicely many deeper-seated structures nor any co-existing bone marrow lesions—as does MRI.

FIGURE 25

The many uses of MRI in sports- and other activity-related conditions.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

MRI 是显示运动和其他活动相关损伤（图 **25**、箭头）最广泛使用的影像学检查方法，例如半月板（1、2）、前交叉韧带 (3)、肩袖肌腱 (4)、距腓前韧带的撕裂 (5) 以及软骨从浅表 (6) 到全层的缺失（7、8）。虽然超声也能显示浅表部位（如肩、踝；见图 **21**）的部分病变，但它不具备 MRI 的强大功能，既不能显示许多深层结构，也不能显示任何共存的骨髓病变。

图 25

MRI 在运动和其他活动相关病症中的多种用途。

/ MR-/CT-Arthrography: A Special Method in MSK Imaging

Cross-sectional imaging mostly with MRI (sometimes with CT) following intraarticular injection of contrast material is occasionally used to better delineate small structures within joints (**Figures 26** and **27**).

The injected contrast not only distends the joint space but also dilutes the joint fluid, making it possible for the otherwise somewhat viscous joint fluid to enter the nooks and crannies and disclose tears.

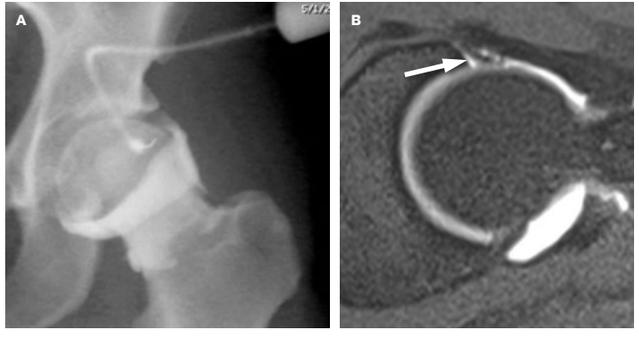


FIGURE 26

MR-arthrography (**B**) after intraarticular injection of contrast material into the left hip joint under fluoroscopy guidance (**A**) showed a tear at the base of the anterior acetabular labrum (**arrow**).

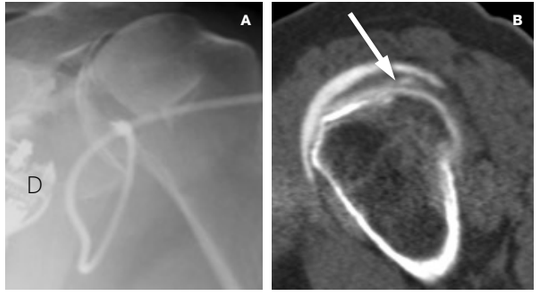


FIGURE 27

This patient had a cardiac defibrillator (**D**) and could not undergo MRI. Injection of contrast material under fluoroscopic guidance (A) and CT-arthrography (**B**) showed a tear (**arrow**) of the infraspinatus tendon filling with the intraarticularly injected contrast material.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ MR-/CT-关节造影：一种特殊的 MSK 影像方法

关节腔内注入对比剂后常采用 MRI（有时采用 CT）进行横断面成像，偶尔用于更加清晰地显示关节内的小结构（**图 26** 和 **27**）。注入的对比剂不仅能够扩大关节间隙，还可稀释关节液，使原本略粘稠的关节液有可能进入凹处和缝隙，显示出撕裂部位。

图 26

在荧光透视引导下 (**A**) 向左髋关节内注入对比剂后 MR 关节造影 (**B**) 显示，髋臼前盂唇基底部撕裂（箭头）。

图 27

该患者体内有心脏除颤器 (**D**)，无法进行 MRI。在透视引导下注入对比剂 (A) 后 CT 关节造影 (**B**) 显示，冈下肌腱撕裂（**箭头**），撕裂口由注入关节内的对比剂填充。

Arthropathies

关节病

Musculo-skeletal Imaging

骨骼肌肉影像学

CHAPTER OUTLINE:

章节大纲：

General Principles

One of the main tasks while dealing with arthropathy in a patient is to decide whether it is degenerative (e.g., osteoarthritis) or inflammatory (e.g., rheumatoid arthritis). Pathophysiologic mechanisms and therefore imaging findings in these two main conditions are quite different (**Figure 28**).

Normal joint

Bare areas of the bone (*) are within the joint space but not covered with joint cartilage.

Osteoarthritis

Bones rub against each other with non-uniform loss of joint cartilage. Osteophytes attempt to stabilise the joint. Subchondral sclerosis is a stress response to cartilage loss and mechanical imbalance. Cysts may occur.

Rheumatoid arthritis

Synovial inflammation first erodes bare areas and later expands inside and outside the joint. As the disease progresses, the loss of joint cartilage is usually uniform, resulting in an evenly narrowed joint space on radiographs.

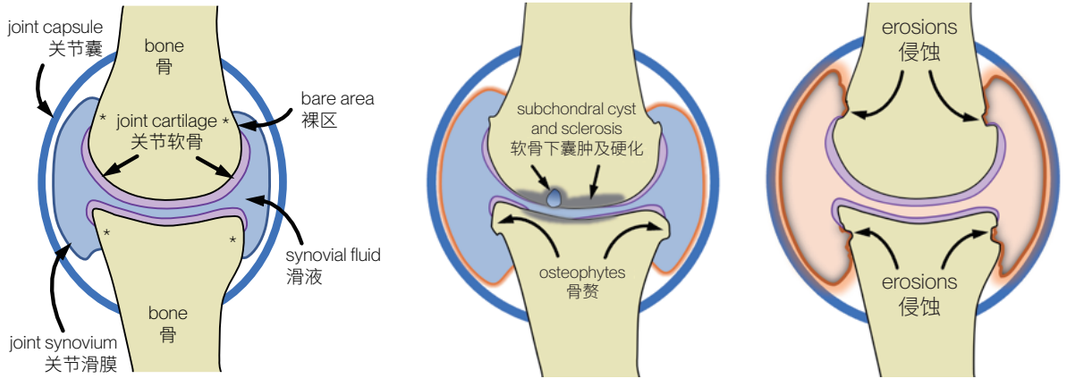


FIGURE 28

Schematic illustration of the differences between osteoarthritis and rheumatoid arthritis.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

一般原则

面对关节病患者时，主要任务之一是鉴别其是退行性（如骨关节炎）还是炎症性（如类风湿关节炎）。这两种性质的关节病所对应的病理生理机制和影像学表现截然不同（图 28）。

正常关节

骨骼的裸露区域 (*) 在关节间隙内，但未被关节软骨覆盖。

骨关节炎

骨骼相互摩擦，导致关节软骨不均匀缺失。骨赘会尝试稳定关节。软骨下硬化是对软骨缺失和机械失衡的应力性反应。可能会出现囊肿。

类风湿关节炎

滑膜炎症首先侵蚀裸区，随后蔓延至关节内外。随着疾病的进展，关节软骨均匀破坏，X 线片显示关节间隙均匀变窄。

图 28

骨关节炎和类风湿关节炎之间的差异示意图。

Osteoarthritis: The Hallmark of Degenerative Joint Disease

Osteoarthritis is the most common joint disease. Characteristic radiographic features (**Figure 29**) are asymmetric (non-uniform) joint space narrowing (due to joint cartilage loss) with osteophytes, bone sclerosis and subchondral cysts in the absence of such inflammatory features as erosions. Synovitis and osteitis, however, can be seen in osteoarthritis..

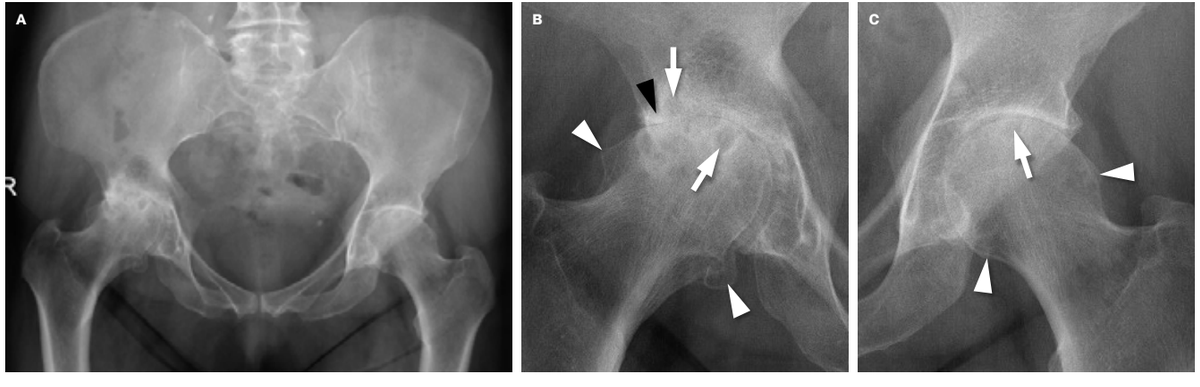


FIGURE 29

Anteroposterior radiograph showing right>left hip osteoarthritis in a 64-year-old woman (hips enlarged in **B** and **C**). Characteristic features include non-uniform narrowing of the joint space, subchondral sclerosis (**black arrowhead**) and cysts (**arrows**) and marginal osteophytes (**white arrowheads**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

骨关节炎：退行性关节疾病的标志

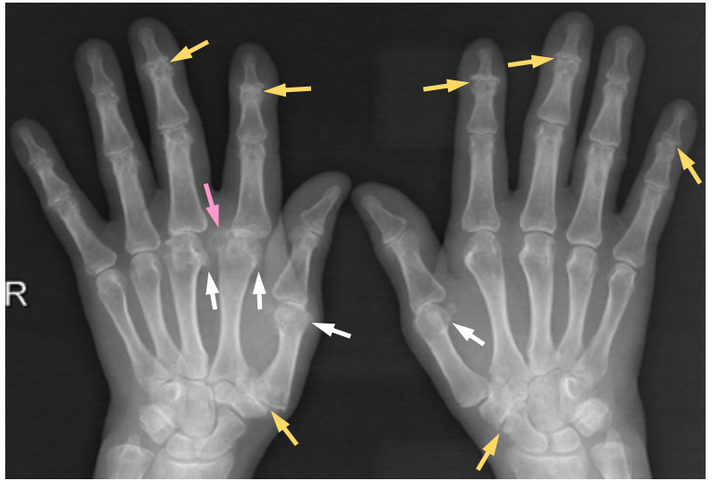
骨关节炎是最常见的关节疾病。X 线特征表现（图 29）为不对称（不均匀）关节间隙狭窄（由于关节软骨缺失）伴骨赘、骨硬化和软骨下囊肿，无侵蚀等炎症特征。滑膜炎和骨炎，可以在骨关节炎中看到。

图 29

前后位 X 线片显示一名 64 岁女性患者，右 > 左侧严重的髋关节骨关节炎（**B** 和 **C** 髋关节肿大）。其特征包括关节间隙不均匀狭窄、软骨下硬化（**黑色箭头**）、囊肿（箭头）和边缘骨赘（**白色箭头尖端**）。

/ Osteoarthritis: Primary and Secondary

Primary (idiopathic) osteoarthritis is the more common form of the disease and occurs without a prior insult (**Figure 30**), which is the characteristic of secondary osteoarthritis. Crystal deposition, inflammatory arthritis and other synovial disease, trauma, infection, developmental dysplasia and impingement syndromes can all lead to **secondary osteoarthritis** (**Figures 31** and **32**), whereby imaging can help establish the background.



<!> ATTENTION

Bones in the hands, wrists, feet and ankles make up slightly more than half of all bones in the human body and the respective joints account for one third of all our articulations. It should therefore come as no surprise that distal aspects of our extremities are extensively examined in the work-up of arthritis.

FIGURE 30

Primary osteoarthritis manifestations in a 59-year old woman include non-uniform narrowing, subchondral cysts and marginal osteophytes at the distal interphalangeal, first carpometacarpal and scaphoid-trapezium joints (**yellow arrows**). Secondary osteoarthritis in the form of calcium pyrophosphate dihydrate deposition (CPPD) arthropathy is also evident at the right second and third and left first metacarpohalangeal (MCP) joints with hook osteophytes in the distal metacarpals (**white arrows**) and right second MCP joint cartilage calcification (**pink arrow**).

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 骨关节炎：原发性和继发性

原发性（特发性）骨关节炎更常见，往往不伴有先前损伤（**图 30**）。而继发性骨关节炎常继发于先前损伤后晶体沉积、炎症性关节炎和其他滑膜疾病、创伤、感染、发育不良和撞击综合征均可能导致**继发性骨关节炎**（**图 31** 和 **32**），因此影像学表现有助于提示病因。

<!> 注意

手、腕、足和踝的骨骼总量占人体所有骨骼的一半以上，其中各部分占全部关节的三分之一。因此，在关节炎的检查中，四肢远端检查显得十分重要。

图 30

一名 59 岁女性的原发性骨关节炎表现包括不均匀狭窄、软骨下囊肿以及远端指间关节、第一腕掌关节和舟大多角骨关节边缘骨赘（**黄色箭头**）。继发于焦磷酸钙二水合物沉积 (CPPD)的 骨关节炎累及右侧第二、第三和左侧第一掌指 (MCP) 关节，在远端掌骨处可见钩状骨赘（**白色箭头**）和右侧第二 MCP 关节软骨钙化（**粉色箭头**）。

Osteoarthritis: Secondary

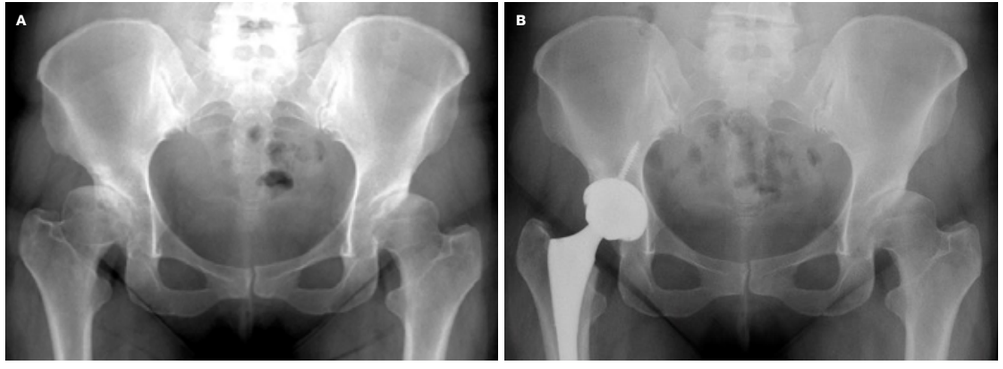


FIGURE 31

Right hip osteoarthritis (**A**) in this 41-year-old woman resulted from untreated developmental dysplasia of the hip (DDH). She ended up undergoing a total right hip replacement surgery (**B**). She has DDH also on the left side, which, too, is on track for secondary osteoarthritis.

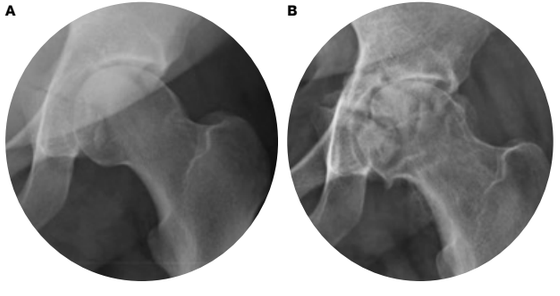


FIGURE 32

An acetabular fracture (**A**) after a motor vehicle accident in this 25-year-old woman resulted in left hip osteoarthritis (**B**) within 7 months. She was pregnant at the time of her injury and declined surgery.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

骨关节炎：继发性

图 31

这名 41 岁女性的右髋骨关节炎 (**A**) 继发于未经治疗的髋关节发育不良 (DDH)。她最终接受了右侧全髋关节置换术 (**B**)。左侧也有 DDH，正进展为继发性骨关节炎。

图 32

一名 25 岁女性机动车事故导致髋臼骨折 (**A**)，7 个月后继发左髋关节骨关节炎 (**B**)。患者受伤时正值怀孕，拒绝手术。

/ Degenerative Disease of the Spine: Bones and Discs

Degenerative diseases of the intervertebral discs are usually in the form of **intervertebral osteochondrosis** (**Figures 33** and **34**), which originates from the nucleus pulposus and **spondylosis deformans** (**Figure 34**), which starts in the outer fibres of annulus fibrosus. **Facet joints** can also have osteoarthritis.

MRI is extensively used in the diagnosis of disc herniation, which is usually associated with **low back or neck pain** (both of which are among the most common complaints in adults).

The terms disc bulge, protrusion (**Figure 33**), extrusion, migration and sequestration on MRI reports all have specific meanings.

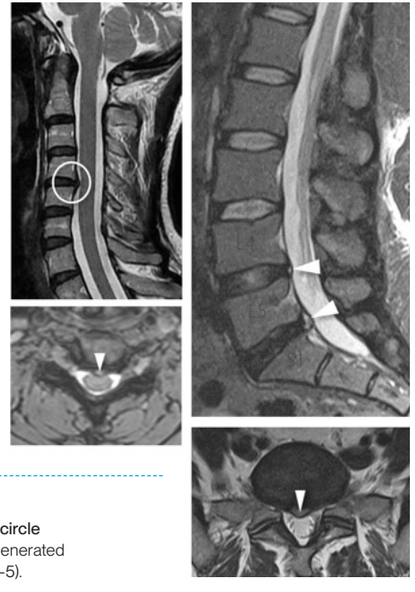


FIGURE 34

MRI shows protrusions (**circle** and **arrowheads**) of degenerated discs (C4–5, L5–S1>L4–5).

"Traction" osteophytes in spondylosis deformans (**Figure 34**) are characteristically transverse or oblique in orientation. They occur secondary to chronic traction of Sharpey fibres (at the periphery of the annulus fibrosus), which are stretched by the bulging disc.

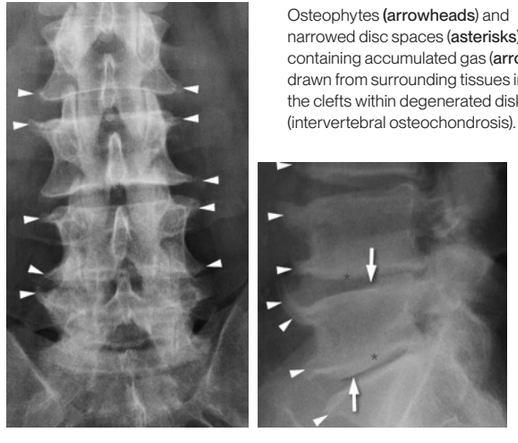


FIGURE 33

Osteophytes (**arrowheads**) and narrowed disc spaces (**asterisks**) containing accumulated gas (**arrows**) drawn from surrounding tissues into the clefts within degenerated disks (intervertebral osteochondrosis).

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 脊柱退行性疾病：骨骼和椎间盘

/ 骨骼肌肉影像学

章节大纲：

椎间盘退行性疾病常表现为**椎间骨软骨病**（起始位置：髓核）（图 33 和 34）和**变形性脊椎病**（起始于纤维环的外层纤维）（图 34）。**关节突关节**也可能发生骨关节炎。

MRI 广泛用于诊断椎间盘突出，通常伴有**腰痛或颈部疼痛**（两者均是成人中最常见的主诉）。

MRI 报告上的术语椎间盘膨出、突出（图 33）、脱出、移位和游离均有特定的含义。

变形性脊椎病中的“牵引状”骨赘（图 34）的特征是横向或斜向走行，继发于纤维环外周 Sharpey 纤维的慢性牵拉，该纤维被膨出的椎间盘拉伸。

图 34

MRI 显示退变的椎间盘（C4–5、L5–S1>L4–5）有突出（圆圈和箭头尖端）。

图 33

骨赘（箭头）和狭窄的椎间盘间隙（星号）积气（箭头），气体从周围组织吸入退化椎间盘（椎间骨软骨病）的裂隙内。

/ Rheumatoid Arthritis (RA): The Hallmark of Inflammatory Arthritis

Characteristic radiographic findings of rheumatoid arthritis (RA) include uniform narrowing of the joint space, erosions starting from the bare areas and periarticular osteopenia. Common places to look for erosions are hands, wrists and feet – especially the radial aspects of the second and third metacarpophalangeal (MCP) joints and the ulnar aspect of the fifth MCP joint (**Figures 35** and **36**).

FIGURE 35

Hand-wrist and foot radiographs showing characteristic erosions (**arrows** and **ellipses**) and mild uniform narrowing of joints in two patients with rheumatoid arthritis.

>▪< FURTHER KNOWLEDGE

FIGURE 36

Radiographic findings of rheumatoid arthritis can be subtle as in this 22-year-old woman with narrowing of the second MCP joint and radiocarpal joint on one side (**ellipses**, left) and the third MCP joint on the other side (**ellipse**, right). No erosions are visible.

CHAPTER OUTLINE:

/ 类风湿关节炎 (RA)：炎症性关节炎的标志

章节大纲：

类风湿关节炎 (RA) **X 线片特征表现**包括关节间隙均匀狭窄、始于裸露区的侵蚀和关节周围骨质疏松。常见侵蚀部位是手、腕和足部，尤其是第二和第三掌指 (MCP) 关节的桡侧以及第五 MCP 关节的尺侧（图 35 和图 36）。

图 35

2 例类风湿关节炎患者的手-腕和足部 X 线片显示特征性侵蚀（箭头和椭圆形）和关节轻度均匀狭窄。

>▪< 进阶知识

图 36

类风湿关节炎 X 线片表现通常十分细微，如这名 22 岁女性，其一侧第 2 MCP 关节和桡腕关节（**椭圆形**，左）变窄，另一侧第 3 MCP 关节（椭圆形，右）变窄。未见侵蚀。

<!> ATTENTION

Contrast-enhanced MRI is capable of detecting joint involvement in RA in the absence of radiographic signs on CRX (Figure 37).

FIGURE 37

Wrist pansynovitis, extensive MCP joint synovitis and flexor tenosynovitis manifesting as extensive enhancement on contrast enhanced MRI (centre and right) in a 48-year-old woman with RA. Note also erosions (**arrows**). Her CRX (left) is unremarkable.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

<!> 注意

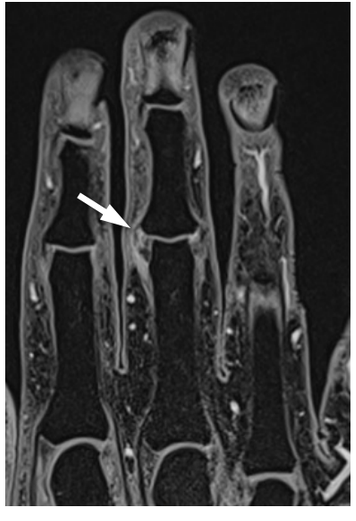
对比增强 MRI 能够检出 CRX 上影像学表现阴性的关节受累情况（图 37）。

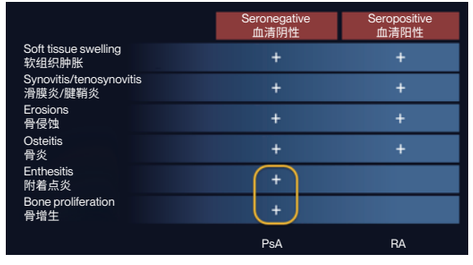
图 37

一名 48 岁 RA 女性患者的全腕关节滑膜炎、广泛性 MCP 关节滑膜炎和屈肌腱鞘炎，在对比增强 MRI（中心和右侧）上表现为弥漫性强化。还应该注意侵蚀（箭头）。她的 CRX（左侧）表现正常。

Common and Distinctive Imaging Features of Seropositive and Seronegative Arthritis

Some features are common to both seropositive (e.g., RA) and seronegative (e.g., psoriatic arthritis [PsA]) arthritis: soft tissue swelling, synovitis or tenosynovitis, erosions and osteitis. **Enthesitis and bone proliferation**, however, are almost exclusively seen in seronegative spondyloarthritis. A small portion of cases with RA are seronegative. **Figures 38** and **39** illustrate MRI features of seronegative arthritis.





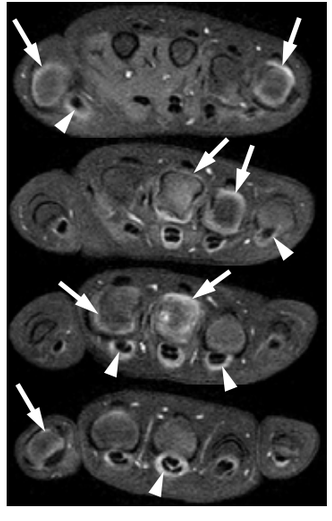


FIGURE 38

Enthesitis at the capsular attachments of the third proximal interphalangeal joint (**arrow**) is exquisitely depicted as the earliest imaging finding of seronegative arthritis on this MR image of a 29-year-old woman with psoriasis

FIGURE 39

First through fifth metacarpophalangeal and right first interphalangeal joint synovitis (**arrows**) and first through fifth flexor tenosynovitis (**arrowheads**) are seen on MRI of this 8-year-old girl with seronegative juvenile idiopathic arthritis.

Musculoskeletal Imaging

CHAPTER OUTLINE:

Musculoskeletal Imaging

章节大纲：

血清阳性与血清阴性关节炎的共同和特征性影像学特征

血清阳性（如 RA）和血清阴性（如银屑病关节炎 [PsA]）关节炎的共同特征：软组织肿胀、滑膜炎或腱鞘炎、侵蚀和骨炎。但**附着点炎和骨增生**几乎只见于血清阴性脊柱关节炎。一少部分 RA 病例表现为血清相关因子呈阴性。**图 38** 和**图 39** 显示血清阴性关节炎的 MRI 特征。

图 38

一名 29 岁银屑病女性患者的 MR 图像上，第三近端指间关节（箭头）关节囊附着处的附着点炎是血清阴性关节炎的最早影像表现

图 39

患有幼年特发性血清阴性关节炎的 8 岁女孩，MRI 上可见第一到第五掌指关节和右手第一指间关节滑膜炎（箭头尖端）和第一到第五屈肌腱鞘滑膜炎（箭头）。

Periarticular Osteitis on Sacroiliac Joint MRI: A Major Finding for Diagnosing Axial Spondyloarthritis

Periarticular bone marrow edema/osteitis on MRI (**Figures 40** and **41**) is one of the cardinal features for diagnosing axial spondyloarthritis in patients with inflammatory type back pain ≥ 3 months and age at onset < 45 years. Axial spondyloarthritis is a complex immune-mediated health condition with characteristic clinical features such as enthesitis, sacroiliitis and spondylitis, and extraarticular manifestations such as anterior uveitis, psoriasis and inflammatory bowel disease.

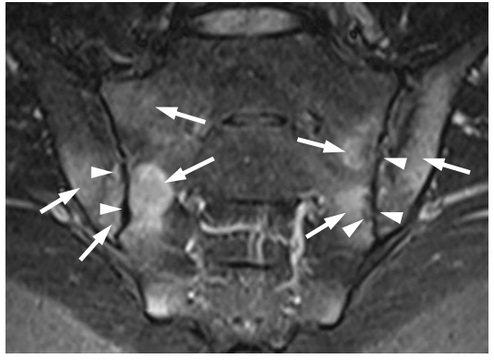


FIGURE 40

Bilateral periarticular bone marrow oedema (**arrows**) and iliac>sacral-sided periarticular erosions (**arrowheads**) are characteristic of acute on chronic sacroiliitis in this 28-year-old man with ankylosing spondylitis.

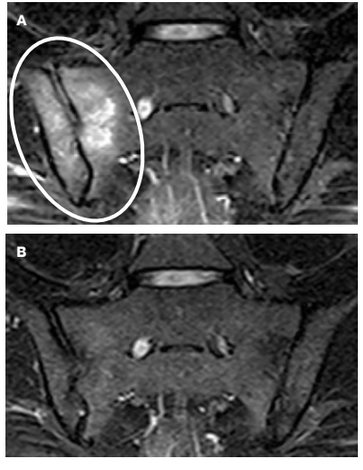


FIGURE 41

Periarticular bone marrow oedema denoting active sacroiliitis on the right (**ellipse**, **A**) has resolved following treatment (**B**) in this 33-year-old man with ankylosing spondylitis.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骶髂关节 MRI 上的关节周围骨炎：诊断中轴型脊柱关节炎的主要特征

MRI 显示的关节周围骨髓水肿/骨炎（**图 40** 和**图 41**）是诊断背疼 ≥ 3 个月且发病年龄 < 45 岁的炎症型背痛患者的中轴型脊柱关节炎的基本特征之一。中轴型脊柱关节炎是一种复杂的免疫介导疾病，具

图 40

双侧关节周围骨髓水肿（箭头）和髂 > 骶侧关节周围侵蚀（箭头尖端）是这名 28 岁强直性脊柱炎男性慢性骶髂关节炎患者急性发作的特征。

图 41

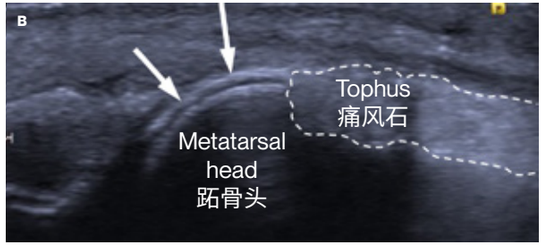
这名 33 岁男性强直性脊柱炎患者的关节周围骨髓水肿提示右侧活动性骶髂关节炎（椭圆形，A），进行治疗后 (B) 已缓解。

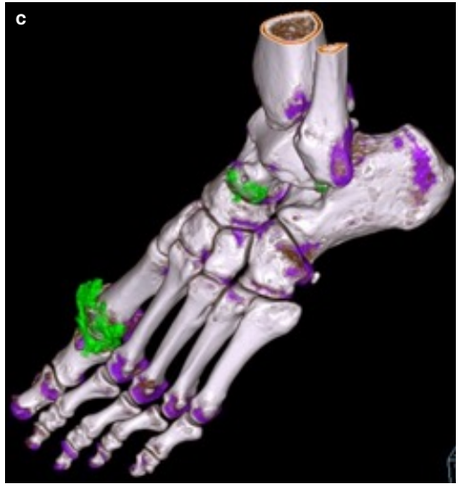
Musculoskeletal Imaging

章节大纲：

/ Gout: The Hallmark of Metabolic Arthritis

Monosodium urate crystal deposition within joints and surrounding soft tissues (including tendons and bursae) in gout results in some characteristic imaging findings as shown in **Figures 42** and **43**.





<!> ATTENTION

FIGURE 42

Punched out erosions with overhanging edges (**arrows**, **A**) surrounding the first metatarsophalangeal joint along with preservation of joint space width are characteristic of gout in this 58-year-old man. "Double contour" sign in a sagittal US image (**B**) denotes crystal deposition across the joint cartilage surface (**arrows**). Dual-energy CT (**C**) accurately depicts monosodium urate crystals (**green**) and is useful for disease quantification in the follow-up.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 痛风：代谢性关节炎的标志

痛风患者关节和周围软组织（包括肌腱和滑囊）内尿酸单钠晶体沉积的特征性影像学表现，如图 **42** 和图 **43** 所示。

<!> 注意

图 42

第一跖趾关节周围有突出边缘（箭头，A）的悬垂样侵蚀，关节间隙保持正常，是这名 58 岁男性痛风的特征。矢状 US 图像中的"双轮廓"标志 (B) 表示晶体沉积贯穿于关节软骨表面（箭头）。双能 CT (C) 准确地显示了尿酸单钠晶体（绿色），有助于后续的疾病量化。

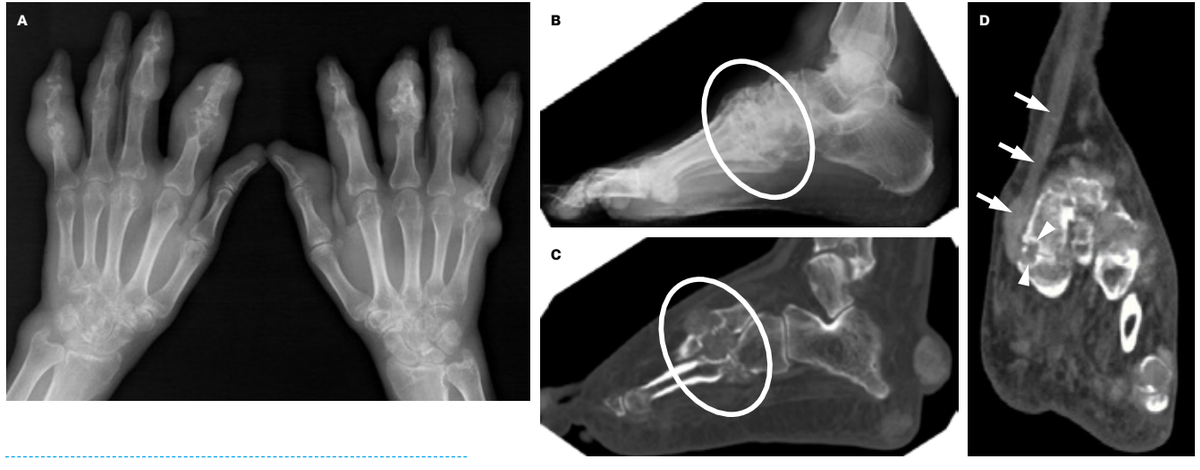


FIGURE 43

Lumpy-bumpy appearance due to tophi around joints and periarticular erosions with overhanging edges (**A**), tarsometatarsal joint erosions (**ellipses** and **arrowheads**) on foot radiograph (**B**) and CT (**C** and **D**) are typical imaging findings of gout. Note the distal tophus along the anterior tibial tendon (**arrows**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

图 43

在足部 X 线片 (**B**) 和 CT（**C** 和 **D**）上，由于关节周围痛风石和关节周围的侵蚀而形成的凹凸不平的外观 (**A**) 以及跗跖关节侵蚀（**椭圆形和箭头尖端**）是痛风的典型影像学表现。注意沿胫骨前肌腱的远端痛风石（**箭头**）。

Calcium Pyrophosphate Dihydrate (CPPD) Arthropathy

Although gout is considered as the hallmark of metabolic arthritis, CPPD is more common than gout, given the fact that it is usually seen in an older age group and that humans have increased longevity. In fact, CPPD arthropathy is more common than rheumatoid arthritis – and second, in frequency, only to osteoarthritis. Characteristic findings are shown in **Figure 44**.

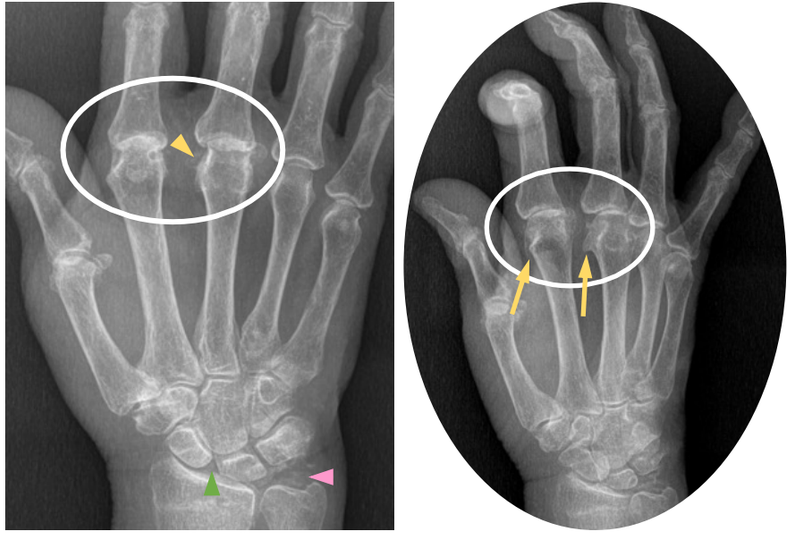


FIGURE 44

CPPD arthropathy in a 94-year old woman. Second and third metacarpophalangeal (MCP) joint arthritis (**ellipses**), hook osteophytes along radial aspects of second and third distal metacarpals (**arrows**), calcification at the triangular fibrocartilage (**pink arrowhead**), scapholunate ligament (**green arrowhead**) and third MCP joint cartilage (**yellow arrowhead**).

>=< FURTHER KNOWLEDGE

Interestingly, CPPD arthropathy can present without visible calcifications within joints. Involvement of the characteristic locations (MCP joints and radiocarpal compartment, both of which are unusual locations for primary osteoarthritis) along with second and third distal metacarpal hook osteophytes in a patient >50 years would be clues to CPPD arthropathy, even in the absence of intraarticular calcifications on imaging.

CHAPTER OUTLINE:

焦磷酸钙二水合物 (CPPD) 关节病

虽然痛风被认为是代谢性关节炎的标志，但 CPPD 比痛风更常见，它通常出现在年龄较大的人群中，年龄越大，出现 CPPD 的概率越高。事实上，CPPD 关节病比类风湿关节炎更常见，仅次于骨关节炎。特征表现如图 **44** 所示。

图 44

一名 94 岁女性 CPPD 关节病患者。第二和第三掌指 (MCP) 关节炎（椭圆形），沿着第二和第三远端掌骨桡侧的钩状骨赘（箭头），三角纤维软骨（粉红色箭头）、舟月韧带（绿色箭头）和第三 MCP 关节软骨（黄色箭头）可见钙化。

>=< 进阶知识

值得注意的是，CPPD 关节病可以出现关节内无明显钙化。对于超过 50 岁的患者，涉及特征性部位（MCP 关节和桡腕关节间隙，两者均为原发性骨关节炎的罕见部位）以及第二和第三远端掌骨钩状骨赘，即使影像学检查未见关节内钙化，仍为提示 CPPD 关节病的重要线索。

章节大纲：

An Algorithm for Imaging Diagnosis of Arthropathies

The algorithm shown in **Figure 45** can be used for imaging diagnosis of arthritis. It is not without shortcomings, however, and some of the exceptions are given in **Figure 46**.

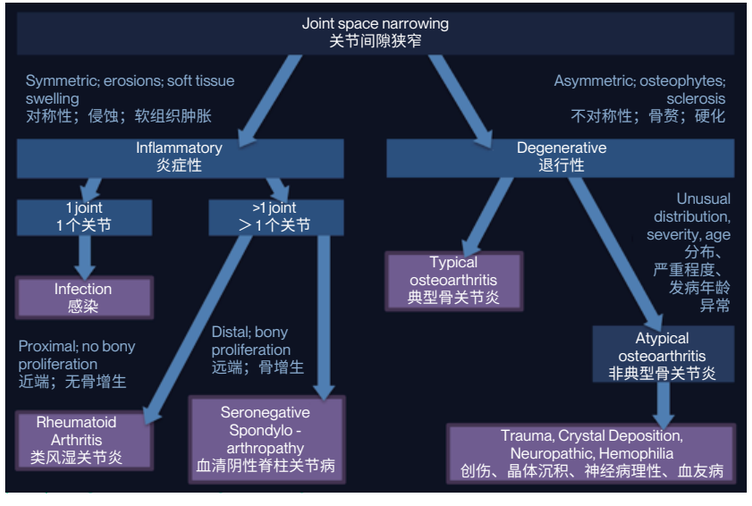


FIGURE 45

Adapted from Jacobson JA et al. Radiology 2008.

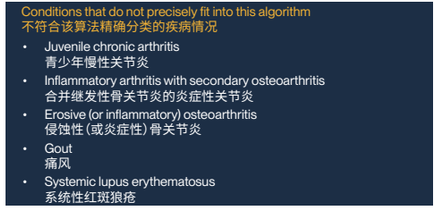


FIGURE 46

Exceptions to the algorithm shown in **Figure 41**.

Musculoskeletal Imaging

CHAPTER OUTLINE:

关节病影像学诊断思路图

图 45 所示诊断思路图可用于关节炎的影像学诊断。然而，它并非没有缺点，图 46 中列出了一些例外情况。

骨骼肌肉影像学

章节大纲：

图 45

改编自 Jacobson JA et al. Radiology 2008。

图 46

图 41 中列出了诊断思路的例外情况。

Fractures and Dislocations

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

骨折与脱位

Basic Principles in Imaging Fractures and Dislocations

- **More than one radiographic projection** is needed for any part of the body.
- Although radiographs are the first-line imaging tool to look for fractures and/or dislocations, CT is more appropriate in body parts with complex anatomy (e.g., face, thoracic cage, pelvis).
- **Two radiographic projections** perpendicular to each other need to be used for extremity segments (i.e., arm, forearm, thigh and calf; **Figure 47**).
- **Three radiographic projections** (anteroposterior/posteroanterior, lateral, oblique) are recommended for most joints (e.g., wrist, hand, ankle, foot).
- Stress radiographs (e.g., scaphoid view for suspected fracture of this wrist bone) or additional projections (e.g., axillary view and/or Y-view in the shoulder) can be used in some joints and certain conditions.
- Radiographs need to cover the joints adjacent to a long bone (**Figure 47**); if a single X-ray detector plate does not suffice to include joints at both ends, two acquisitions are needed for each projection.
- Due to the ongoing ossification in children, comparative radiographs

FIGURE 47

Normal anteroposterior and lateral CRX of the calf.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

骨折与脱位影像学的基本原则

- 身体的所有部位都需要**一种以上的放射线投影**。
- 尽管 X 线片是诊断骨折和/或脱位的首选影像学工具，但 CT 更适合检查解剖结构复杂的身体部位（例如，面部、胸廓、盆腔）。
- 四肢节段（例如，手臂、前臂、大腿和小腿；**图 47**）需要使用两种相互垂直的**放射线投影**。
- 对于大多数关节（例如，腕、手、踝、足），建议采用**三种放射线投影**（前后向/后前位、侧位、斜位）。
- 应力位 X 线片（如舟状骨位用于疑似腕骨骨折）或附加投影（如腋窝和/或肩部 Y 投影）可用于某些关节和特定情况。
- X 线片需要覆盖与长骨相邻的关节（**图 47**）；若单个 X 射线探测器板不足以包含两端的关节，则需要对每次投影进行两次采集。
- 由于儿童的骨化仍在进行，可能需要进行未受影响的一侧 X 线片检查用于对比。

图 47

正常的小腿前后位和侧位 CRX。

/ Describing Fractures and Dislocations on Imaging

/ Fractures are commonly described according to the **location/alignment** of the DISTAL aspect of the major DISTAL fracture fragment (displaced or non-displaced, angulated, rotated; **Figure 48**).

/ **Dislocation** is an injury resulting in loss of anatomical congruence of bones at a joint (**Figure 49**).

/ **Subluxation** refers to an incomplete dislocation where joint surfaces remain partially facing each other (**Figure 50**).

/ Joint dislocations (and subluxations) are usually described in terms of the **position** of the distal bone in relation to the proximal bone.

FIGURE 48

Spiral fracture of the distal tibial diaphysis with mild lateral and minimal posterior displacement.

FIGURE 49

Medial and dorsal dislocation of the fourth PIP joint (**arrow**).

FIGURE 50

Medial and dorsal subluxation of the fourth proximal interphalangeal (PIP) joint with a comminuted intraarticular fracture of the middle phalangeal base.

/ **Musculoskeletal** Imaging

CHAPTER OUTLINE:

/ **骨骼肌肉**影像学

章节大纲：

/ 影像学上描述骨折和脱位

/ 骨折通常根据主要远端骨折碎片的远端**位置/排列**来描述（移位或非移位、成角、旋转；图 48）。

/ **脱位**是指导致关节处失去骨骼解剖结构的完整性（图 49）。

/ **半脱位**是指关节面部分吻合的不完全脱位（图 50）。

/ 关节脱位（和半脱位）通常根据远端骨相对于近端骨的**位置**来描述。

图 48

胫骨远端骨干螺旋形骨折，伴轻度外侧移位和轻微后侧移位。

图 49

第四 PIP 关节内侧和背侧脱位（箭头）。

图 50

第四近端指间 (PIP) 关节内侧和背侧半脱位，伴中指骨基底粉碎性关节内骨折。

/ Fractures: Terminology

There are many ways to describe a fracture depending on its properties (**Figures 51** and **52**). Based on the **orientation or shape** of the fracture line, a fracture can be described as transverse, oblique or spiral. **Avulsion** fractures happen at the insertion sites of tendons or ligaments, due to their sudden pull. Sometimes fracture fragments override each other or one fracture fragment impacts onto another. **Impaction** fractures in the spine are called vertebral collapse; there might be retropulsion of the fracture fragments narrowing the spinal canal and compromising its contents.

>▪< FURTHER KNOWLEDGE

Transverse fracture | Oblique fracture | Spiral fracture | Overriding fracture | Avulsion fracture (of the left anterior superior iliac spine) | Impacted fracture | Traumatic vertebral collapse with retropulsion

FIGURE 51

Different types of fractures (**arrows**, **ellipse** and **asterisk**). Explanations are given in the text above.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 骨折：术语

根据骨折性质，描述骨折有多种方法（图 51 和图 52）。根据骨折线的**方向或形态**，骨折描述为横形、斜形或螺旋形。**撕脱性**骨折发生于肌腱或韧带的附着部位，由于肌腱或韧带突然产生的牵拉力所致。有时，骨折碎片会相互重叠，或者一个骨折碎片撞击另一个骨折碎片。脊柱内**嵌入性**骨折被称为椎体塌陷；可能出现骨折碎片后移位，使椎管变窄并损害椎管内所含物。

>▪< 进阶知识

横形骨折 | 斜形骨折 | 螺旋形骨折 | 重叠骨折 | 撕脱性骨骨折（左髂前上棘） | 嵌入性骨折 | 创伤性椎体塌陷伴后移位

图 51

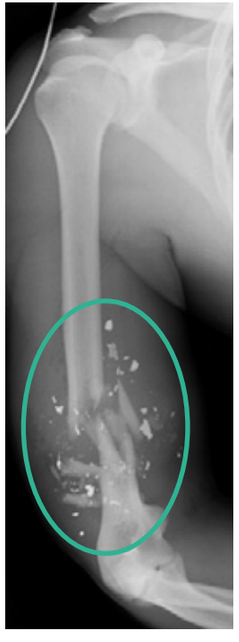
不同类型的骨折（箭头、椭圆形和星号）。在上方文本中进行了说明。

When a fracture is comminuted, open or intraarticular (**Figure 52**), management is more difficult. Imaging makes it possible to identify such fractures.

Comminuted fracture

Radiographs show three or more fragments in a fracture. Small fracture pieces are called "butterfly fragments" due to their similarity to butterfly wings.

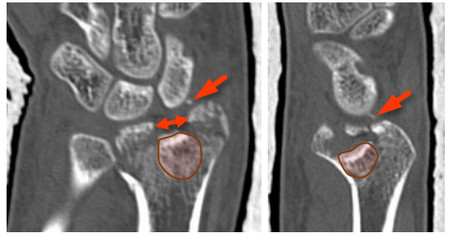
Metallic opacities at the fracture site in this patient are bullet fragments.



Open fracture

The skin is disrupted and at least one of the fracture fragments is exposed to the outside. By default, they are considered contaminated. A splint is in place on this patient.

Intraarticular fracture



The fracture extends into a joint. Intra-articular fractures usually require surgery. Gap (**red double arrow**) or step-off between fracture fragments at the articular surface or fragments within joint space are searched with radiographs – or better with CT. Fragments (**red arrow**) within the joint space need to be removed, otherwise they would damage the intact joint cartilage. When an impacted fracture fragment (**area outlined in red**) is present, bone grafting may be necessary.

FIGURE 52

Different types of complex fractures.

CHAPTER OUTLINE:

当骨折为粉碎性、开放性或关节内骨折时（图 52），治疗会更加困难。影像学检查可以识别上述类型骨折。

章节大纲：

粉碎性骨折

X 线片显示至少有 3 个骨折碎片。较小的骨折碎片称为"蝴蝶碎片"，因其与蝴蝶翅膀相似。

这名患者骨折部位的金属不透亮影为子弹碎片。

开放性骨折

皮肤被破坏，至少一个骨折碎片暴露在外面。默认被视为受到污染。这名患者体内已放置夹板。

关节内骨折

骨折累及到关节。关节内骨折通常需要手术治疗。关节面骨折碎片之间的间隙或分隔、关节间隙内的骨折碎片（**红色双箭头**）可通过 X 线片或 CT（效果更佳）来更好的显示。需要清除关节间隙内的骨折碎片（**红色箭头**），否则会损坏完整的关节软骨。当存在嵌入性骨折碎片（**红色区域**）时，可能需要进行骨移植。

图 52

不同类型的复杂性骨折。

/ Fractures: Stress (Load) Versus Strain (Deformation)

The stress-strain curve for any material (**Figure 53**) displays the relationship between the amount of load it can absorb and the deformation it can tolerate before reaching its yield point and ultimately its failure point. **Figure 54** illustrates the effects of non-reversible deformation on the fibula and tibia, passing the yield and failure points, respectively.

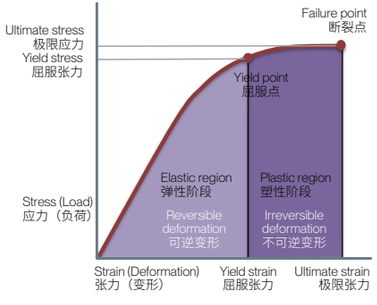


FIGURE 53

Drawing adapted from Pathria M et al. Radiology 2016.

>▪< FURTHER KNOWLEDGE

FIGURE 54

Comminuted fracture of the tibial diaphysis in this 17-year-old boy, who was shot at, shows butterfly fragments. The paperclip is used to mark the bullet entry site. No exit site is marked because the bullet hit the tibia, fractured it and was then dispersed into the calf muscles (*presumed path of the bullet is shown with dashed arrows on the lateral radiograph below*). The fibula is bowed ("plastic bowing deformity"). Since the ossification is not yet complete in this boy, the fibula could be bent back into its normal shape during reduction of the tibial fracture, which was then fixed with an intramedullary nail and locking screws (right). The fibula was in the "plastic region" on the graph at far left, while the tibia had already passed beyond this region. Note that a drain (**D**) and a splint (**S**) are in place post-operatively (right). Also note that the bullet fragments have not been removed during surgery, which would have violated the first principle of medicine.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨折：应力（载荷）与张力（变形）

任何材料的应力-张力曲线（图 53）显示了在达到其承受点和最终失效点之前，可以吸收的载荷量与所能承受的变形之间的关系图 54 说明了不可逆变形对腓骨和胫骨的影响，分别通过了承受点和失效点。

/ 骨骼肌肉影像学

章节大纲：

>▪< 进阶知识

图 54

这名 17 岁男孩的胫骨干粉碎性骨折，他遭遇了枪击，显示为蝴蝶样骨碎片。回形针用于标记子弹射入口位置。之所以未标记射出口位置，是因为子弹击中胫骨，使其骨折，然后子弹碎片分散到小腿肌肉中（下方侧位 X 线片上用虚线箭头展示了*推测的子弹路径*）。腓骨弯曲（"塑性弯曲畸形"）。由于这名男孩尚未完全骨化，因此在胫骨骨折复位期间，腓骨可以弯曲回其正常形状，然后用髓内钉和锁定螺钉（右）固定。腓骨位于图中最左边的"塑性区域"：而胫骨已经超出了该区域。请注意，术后（右）放置了引流管 (**D**) 和夹板 (**S**)。此外，未在手术过程中取出子弹碎片，这违反了医学的第一原则。

图 53

图表摘自 Pathria M et al. Radiology 2016。

/ Fractures in Children: Special Features

The growing skeleton in children presents challenges and opportunities to detect fractures. Some fracture types, such as **greenstick** and **torus (buckle) fractures**, are almost exclusively seen in children (**Figure 55**). Tendons and ligaments are quite strong in children, whereas the tensile strength of their attachment sites in bones are not equally up to task; therefore avulsion fractures, too, are more common in children (**Figure 56**). The orderly appearance of ossification centres around the elbow can be used to detect fractures in children before their teens (**Figure 57**).

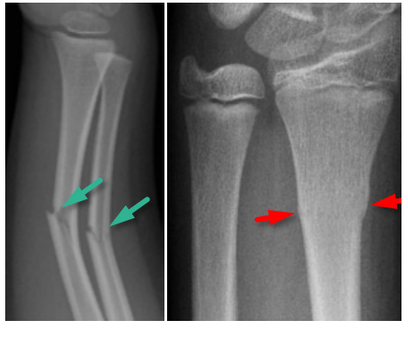


FIGURE 55

Difference between greenstick fracture and torus fracture. In greenstick fracture, the side opposite the bending force fractures completely, whereas the side under the force can remain intact (**green arrows**). The torus fracture is an impaction fracture in which the cortex around all or part of the bone circumference is buckled (**red arrows**).

FIGURE 56

Avulsion fracture of the tibial eminence at the attachment site (**pink arrow**) of the anterior cruciate ligament (**asterisk**) in a 12-year-old girl.

>=< FURTHER KNOWLEDGE

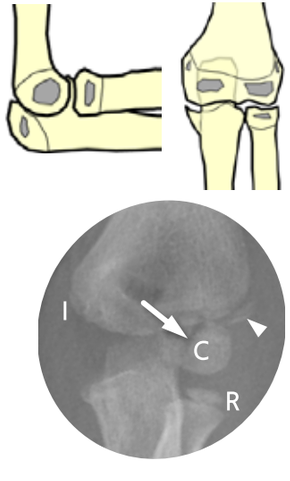


FIGURE 57

Using the orderly appearance of ossification centres to detect elbow fractures in children. Ossification centres around the elbow (drawings) follows this order: capitellum, radial head, internal (medial) epicondyle, trochlea, olecranon, lateral epicondyle (mnemonic: CRITOL). Therefore, what appears to be the lateral epicondyle (arrowhead on the CRX) in this 6-year-old boy with a capitellar fracture (arrow) has to be an additional avulsion fracture. Because, although the radial head (R) and internal epicondyle (I), as well as the capitellum (C) have already appeared, the trochlea is not yet visible.

/ **Musculoskeletal** Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 儿童骨折：特殊特征

儿童骨骼一直处于不断生长的状态，这为骨折的检出带来了挑战和机遇。某些骨折类型，如**青枝骨折**和**隆起（弯曲）骨折**，几乎只在儿童中出现（图 55）。儿童自身的肌腱和韧带非常结实，但其在骨骼中附着部位的抗拉强度相对不足；因此，撕脱性骨折更常见于儿童中（图 56）。肘部周围骨化中心的有序出现可用于检测十几岁之前儿童的骨折（图 57）。

图 55

青枝骨折与隆起骨折的区别。在青枝骨折中，与受弯曲力相对的一侧完全断裂，而受弯曲力的一侧保持完整（**绿色箭头**）。隆起骨折则是一种嵌入性骨折，表现为骨周围全部或部分发生皮质弯曲（**红色箭头**）。

图 56

一名 12 岁女孩发生前交叉韧带（星号）附着部位胫骨隆起的**撕脱性骨折**（**粉红色箭头**）。

>=< 进阶知识

图 57

利用骨化中心有序出现的特点检测儿童肘部骨折。肘关节周围骨化中心（图示）遵循以下顺序：肱骨小头、桡骨头、内上髁、滑车、鹰嘴、外上髁（助记头字语：CRITOL）。因此，这名 6 岁男孩小头骨折（箭头）的外上髁（CRX 上的箭头）为另一处撕脱性骨折。原因如下：虽然桡骨头 (R) 和内上髁 (I) 以及小头 (C) 已经出现，但未见滑车。

<!> ATTENTION

Special emphasis is given to the physis and its vicinity in children, as fractures or disturbances in this area may negatively affect skeletal growth

- The **Salter-Harris classification** divides physeal and periphyseal fractures into nine types. The more common Types 1–4 are shown in **Figure 58**. Type 1 involves exclusively the physis. Type 2 is the most common (75%).
- When an insult results in premature closure of the primary growth plate, a **physeal bridge (or bar)** may occur (**Figure 59**).
- A **physeal tongue** occurs when metaphyseal vascular compromise disrupts endochondral ossification and allows chondrocytes (that later ossify) to extend into the metaphysis (**Figure 60**).

>‖< FURTHER KNOWLEDGE

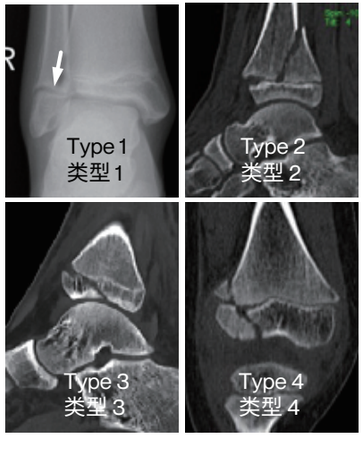


FIGURE 58

Salter-Harris classification.

FIGURE 59

Physeal bar in the right distal femoral physis (**circle**) in this 4-year-old boy resulted in limb length discrepancy (**right**). Note that the right leg is shorter than the left. He had been hospitalised for infection as a newborn.

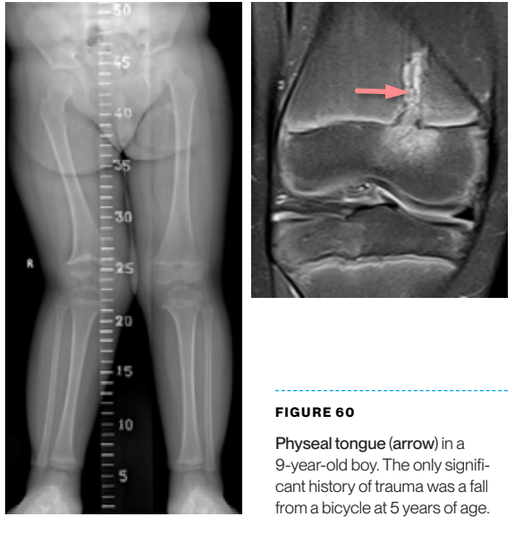


FIGURE 60

Physeal tongue (**arrow**) in a 9-year-old boy. The only significant history of trauma was a fall from a bicycle at 5 years of age.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

<!> 注意

应特别关注儿童的骨骺及其附近区域，因为该区域的骨折或紊乱可能会影响骨骼生长

>‖< 进阶知识

- Salter-Harris 分型将骺板和骺板周围骨折分为九种类型。较常见的 1-4 型如图 58 所示。1 型仅累及骺板。2 型最常见 (75%)。
- 当损伤导致初级生长板过早闭合时，可能会出现**骺板骨桥**（图 59）。
- 当干骺端血管受损破坏软骨内骨化并允许软骨细胞（随后骨化）延伸到干骺端时，就会发生**骨骺舌**（图 60）。

图 58

Salter-Harris 分型。

图 59

这名 4 岁男孩右侧股骨远端骺板（圆形）中的**骺板骨桥**导致双下肢不等长（**右侧**）。请注意，右腿比左腿短。患者刚出生时曾因感染而接受住院治疗。

图 60

一名 9 岁男孩的**骨骺舌**（箭头）。唯一明显的创伤史是 5 岁时从自行车上跌落。

/ Stress Fractures

"Stress fractures" occur without major (i.e., high-energy) trauma during daily activities due to a mismatch between repetitive mechanical stress and bone strength. Stress fractures are usually seen in the lower extremities or the spine. There are two types of stress fractures:

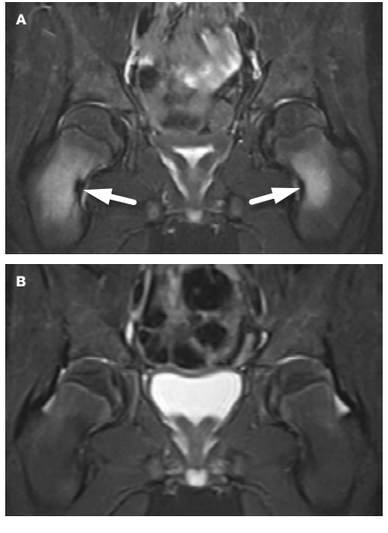


FIGURE 61

A. MRI shows right>left femoral neck incomplete fatigue fractures (**arrows**) surrounded by bone marrow oedema in an otherwise healthy 9-year-old basketball player. **B.** Follow-up MRI seven months later shows disappearance of fractures and complete resolution of marrow oedema.

- Fatigue fracture (overuse fracture) is caused by abnormal stress or abnormally strenuous activity on a normal bone. The continuous application of an increased stress (e.g., running) in a normal body can cause microfractures. When they accumulate faster than the body can heal, these microfractures eventually give way to macroscopic failure (an overt stress fracture) visible on imaging (**Figure 61**).
- Insufficiency fracture is caused by normal stress on abnormal bone, e.g., associated with vitamin D deficiency or osteoporosis (**Figure 62**).

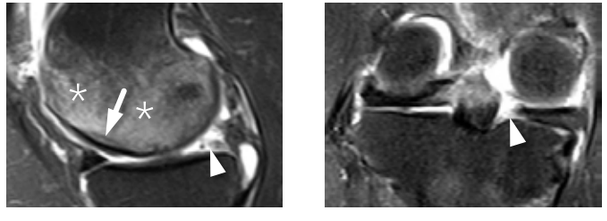


FIGURE 62

MRI shows a subcortical incomplete insufficiency fracture (**arrow**) surrounded with bone marrow oedema (*****) at the weight-bearing portion of the medial femoral condyle in this 65-year-old woman with osteoporosis. The posterior root avulsion of the degenerated medial meniscus (**arrowheads**) resulted in medial meniscus extrusion, likely paving the way for this fracture. A small amount of stress during normal daily activities is sufficient to cause such a fracture in the background of osteoporosis.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 应力性骨折

由于重复性机械应力和骨强度之间的不匹配导致“应力性骨折”，在日常活动过程中通常没有重大（即高能）创伤。应力性骨折常见于下肢或脊柱。应力性骨折分为两种类型：

- 疲劳性骨折（过度使用性骨折）是由正常骨骼受到异常压力或异常剧烈活动引起。对正常人体持续施加增加的应力（例如，跑步）可引起微骨折。当微骨折积累的速度超过身体的愈合速度时，最终会导致影像检查上可见的宏观破坏（明显的应力性骨折）（图 61）。
- 不全性骨折是由正常应力作用于异常骨骼上所致，例如，与维生素 D 缺乏症或骨质疏松症有关（图 62）。

图 61

A. MRI 显示一名 9 岁健康篮球运动员右侧 > 左侧股骨颈不完全疲劳性骨折（箭头），周围有骨髓水肿。**B.** 7 个月后随访 MRI 显示骨折消失，骨髓水肿完全消退。

图 62

MRI 显示这名 65 岁骨质疏松女性患者，股骨内侧髁负重部分皮质下不完全不全性骨折（箭头），周围有骨髓水肿（*）。退化的内侧半月板（箭头尖端）后根撕脱导致内侧半月板被挤压，很可能是发生该骨折的基础。再加之骨质疏松症，正常日常活动期间少量的应力就足以引起这类骨折。

/ Stress Fractures in the Spine

Spinal column is a common location for stress fractures, especially the insufficiency type (**Figure 63**). Fatigue fractures of the pars interarticularis (**Figure 64**), seen in adolescents and young adults and also known as “spondylolysis”, can result in spondylolisthesis.

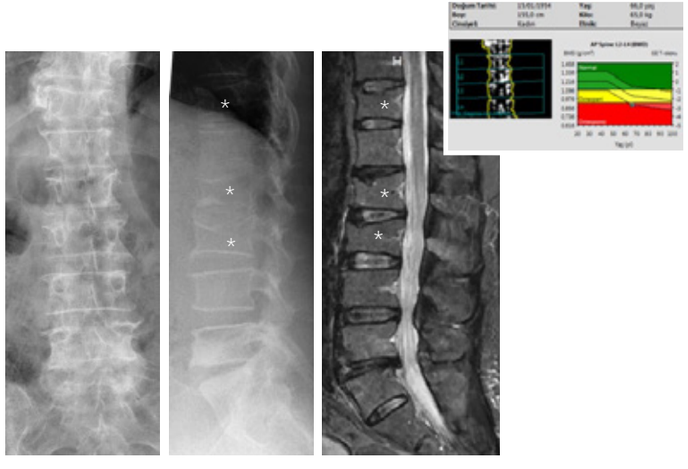


FIGURE 63

Radiographs and MRI show insufficiency type vertebral compression fractures (**asterisks**) in a 66-year-old woman with osteoporosis, confirmed with dual energy X-ray absorptiometry (**top right**).

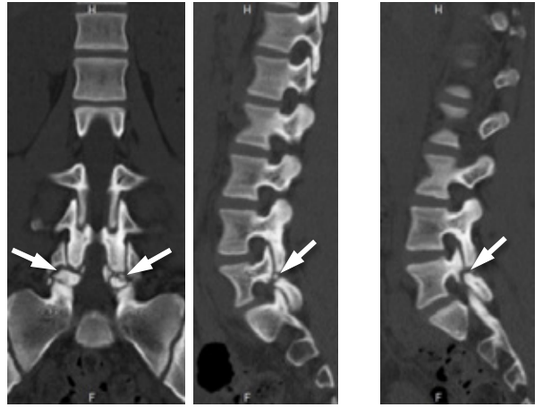


FIGURE 64

CT shows bilateral L5 pars interarticularis fatigue fractures (**arrows**) with comminution in a 13-year-old girl.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 脊柱应力性骨折

脊柱是应力性骨折的常见部位，尤其是不全型（图 63）。关节间部疲劳性骨折（也称为“峡部裂）（图 64），见于青少年和年轻人”，可导致脊椎滑脱。

/ 骨骼肌肉影像学

章节大纲：

图 63

X 线片和 MRI 显示，1 名 66 岁骨质疏松症女性患者发生不全型椎体压缩性骨折（**星号**），骨质疏松经双能 X 射线吸收测量法证实（**右上**）。

图 64

CT 显示 1 名 13 岁女孩双侧 L5 关节间部疲劳性骨折（箭头）伴粉碎性骨折。

/ Pathological Fractures

<!> ATTENTION

There is no “physiological” fracture. Yet, some fractures are called “pathological”. Some consider insufficiency type stress fractures also as pathological fractures, because of the underlying condition of generalised bone fragility. Generally, however, pathological fractures are considered to occur at the location of a focal benign or malignant lesion (**Figure 65**).

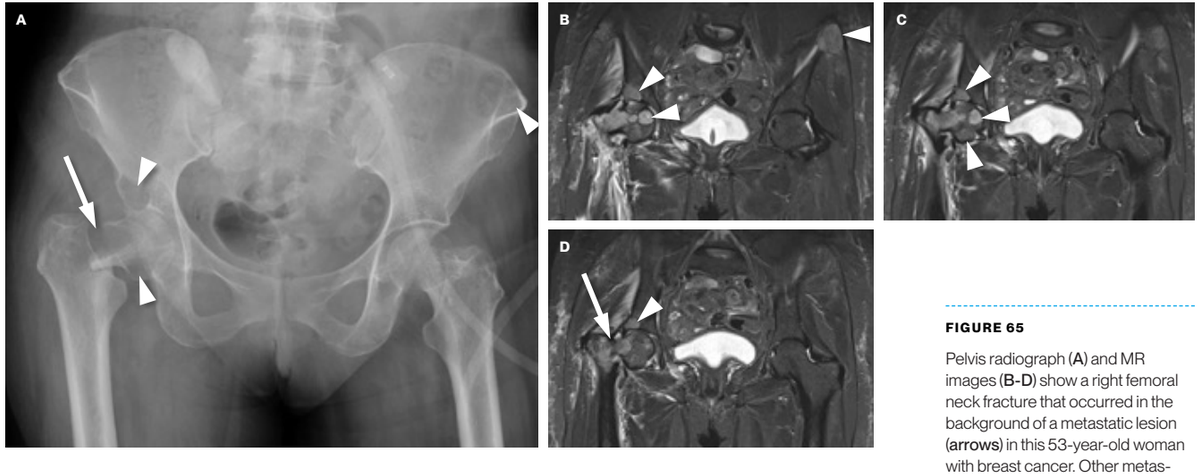


FIGURE 65

Pelvis radiograph (**A**) and MR images (**B-D**) show a right femoral neck fracture that occurred in the background of a metastatic lesion (**arrows**) in this 53-year-old woman with breast cancer. Other metastases are marked by arrowheads.

CHAPTER OUTLINE:

/ 病理性骨折

<!> 注意

并不存在“生理性”骨折。然而，有些骨折被称为“病理性”骨折。有些人认为不全型应力性骨折也是病理性骨折，因为存在全身性骨脆性的潜在情况。然而，通常认为病理性骨折发生在局灶性良性或恶性病变部位（图 65）。

章节大纲：

图 65

盆腔 X 线片 (**A**) 和 MR 图像 (**B-D**) 显示，这名 53 岁乳腺癌女性患者发现转移（箭头）导致右股骨颈骨折。其他转移病变用箭头尖端标记。

/ Pearls and Pitfalls in Identifying Fractures

We use a systematic approach to look for fractures on radiographs, making use of some pearls. All along, we need to take into account also some pitfalls so as not to misidentify a fracture.

Cortices of all bones on radiographs need to be followed. When there is a break in the cortical continuity, there might be a fracture (**Figure 66**).

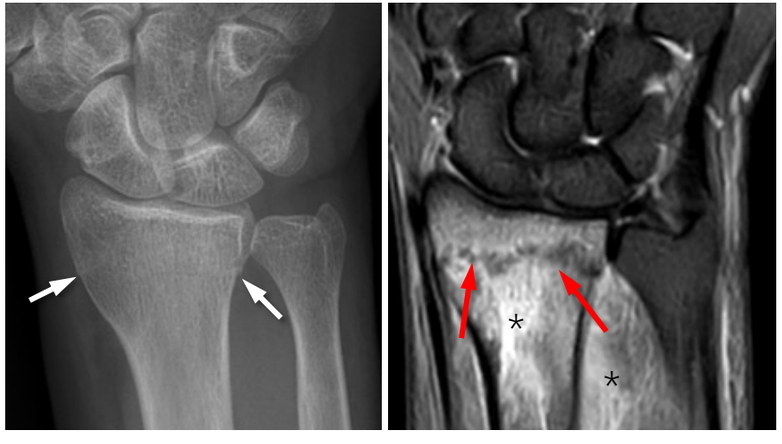


FIGURE 66

This 65-year-old woman slipped on ice and fell onto her outstretched hand. The breaks in cortical continuity of the distal radius (**white arrows**) represent a fracture, later confirmed by MRI (**red arrows**), which also showed both the bone marrow and soft tissue oedema (*).

<!> ATTENTION

Following cortical continuity on radiographs is essential.

MRI is the best modality to show an **acute fracture** (chronic fractures and tiny intraarticular fracture fragments, however, might be easily missed on MRI). There is a simple reason for this: Two things always happen in an acute fracture (even if it is an incomplete fracture): Bone marrow oedema surrounding the fracture line and soft tissue oedema at the immediate vicinity of the fracture. MRI is the only imaging modality to show both of these exquisitely. When a fracture is not visible on radiographs but identified on MRI (or sometimes on CT), it is called an **occult fracture**.

CHAPTER OUTLINE:

章节大纲：

/ 骨折鉴别要点和误区

我们采用系统性方法并依据鉴别要点，通过 X 线片检查是否出现骨折。同时，也应注意避免某些误区，以免误诊骨折。

X 线片上所有骨骼的皮质均需要注意。若皮质连续性中断，则表示可能发生骨折（图 66）。

<!> 注意

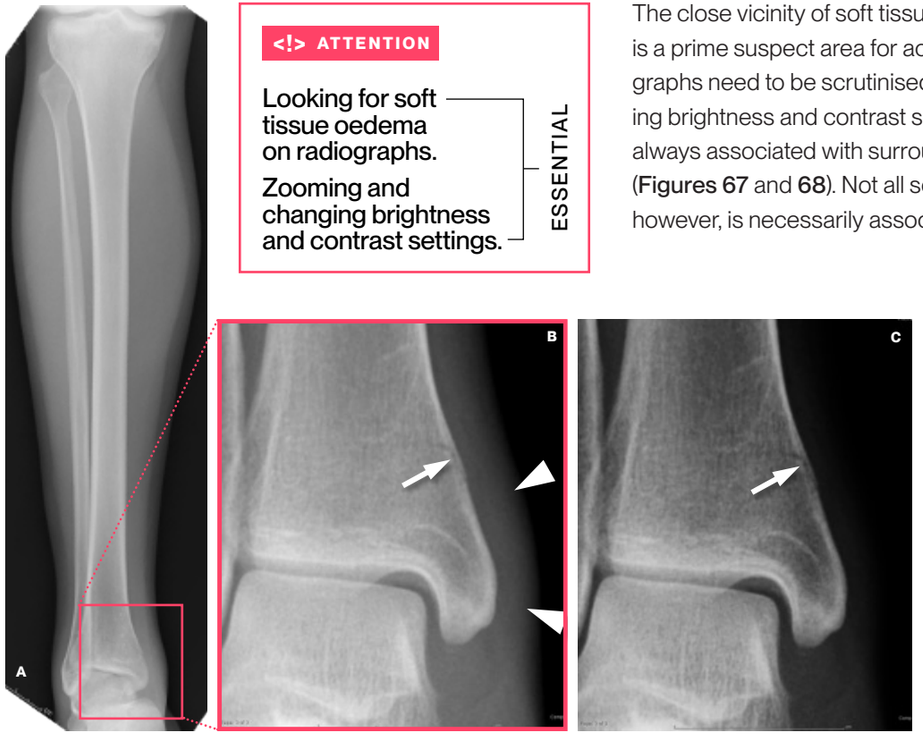
通过 X 线片随诊皮质连续性至关重要。

MRI 是显示**急性骨折**的理想检查方式（然而，MRI 很容易漏诊慢性骨折和微小的关节内骨折碎片）。原因很简单 — 急性骨折（即使是不完全骨折）总伴随着两种表现：骨折线周围的骨髓水肿和骨折部位附近的软组织水肿。MRI 是唯一一种能精确显示这两种表现的影像学检查。若骨折在 X 线片上不可见但通过 MRI（或有时在 CT 上）发现，医学上将这类骨折称为**隐匿性骨折**。

图 66

这名 65 岁女性在冰上滑倒，压到了伸出的手。桡骨远端皮质连续性中断（**白色箭头**）提示有骨折，随后经 MRI（**红色箭头**）证实。此外，MRI 还显示存在骨髓和软组织水肿 (*)。

/ Pearls in Identifying Fractures



<!> ATTENTION

Looking for soft tissue oedema on radiographs.

Zooming and changing brightness and contrast settings.

ESSENTIAL

The close vicinity of soft tissue oedema on radiographs is a prime suspect area for acute fractures. All radiographs need to be scrutinised by zooming and changing brightness and contrast settings. Acute fractures are always associated with surrounding soft tissue oedema (**Figures 67** and **68**). Not all soft tissue oedema, however, is necessarily associated with fractures.

FIGURE 67

The only clinical information given to the radiologist about this patient was "pain". CRX of the calf (**A**) and zoomed detail (**B** and **C**). Careful examination of the subcutaneous fat density reveals oedema (water density) overlying the medial ankle (**arrowheads**). Note that there is an incomplete fracture (**arrow**) underlying the soft tissue oedema. The fracture is better appreciated on a different brightness and contrast setting (**arrow, C**). It was later confirmed with the patient that her pain was indeed in this location.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 骨折鉴别要点

X 线片上紧邻软组织水肿的区域是急性骨折的主要可疑区域。所有 X 线片均需通过缩放、改变亮度以及对比度设置进行仔细检查。急性骨折总是伴有周围软组织水肿（**图 67** 和**图 68**）。然而，并非所有软组织水肿都伴有骨折。

<!> 注意

通过 X 线片检查是否有软组织水肿。

缩放和更改亮度和对比度设置。

必要步骤

图 67

关于这名患者，提供给放射科医生的唯一临床信息为“疼痛”。小腿 CRX(**A**) 和缩放细节图（**B** 和 **C**）。仔细检查皮下脂肪密度可发现内侧踝关节（箭头尖端）有水肿（水密度）。请注意，软组织水肿下存在不完全骨折（箭头）。使用不同的亮度和对比度设置（箭头、**C**）可以更好地识别出骨折。后来与患者确认，她的疼痛确实发生在这个部位。

<!> ATTENTION

Looking for soft tissue edema on radiographs is essential.

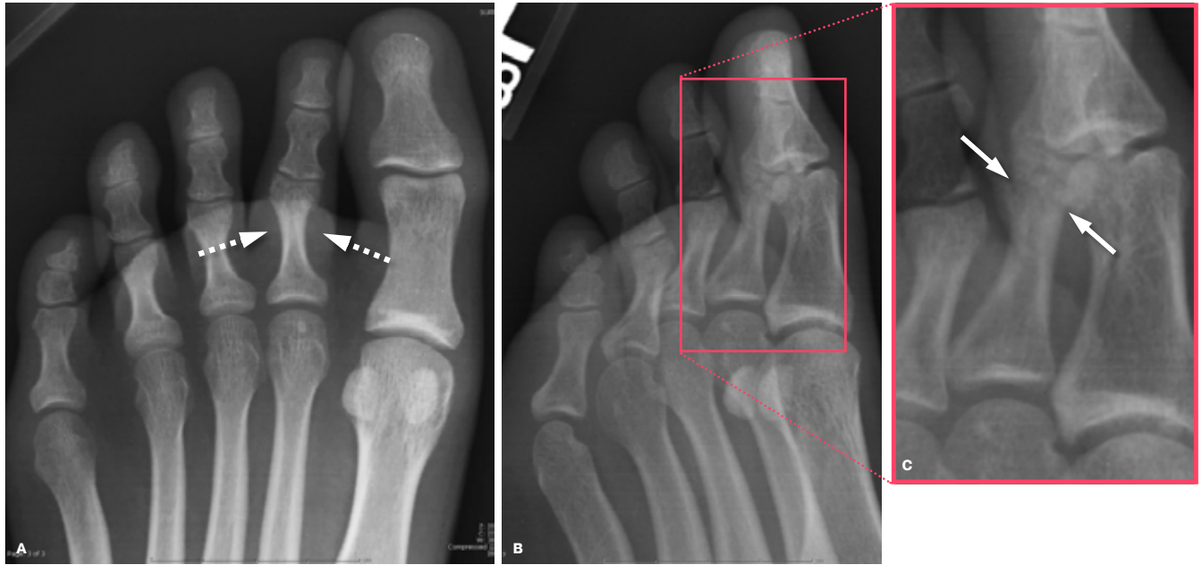


FIGURE 68

Note mild thickening of the base of the second toe (**A**), consistent with oedema in this patient (**dashed arrows**). Oblique radiograph (**B**) and zoomed detail (**C**) show a fracture at the neck of the proximal phalanx (**white arrows**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

<!> 注意

通过 X 线片检查是否有软组织水肿至关重要。

图 68

注意第二趾底 (**A**) 轻度增厚，与该患者的水肿特征一致（**虚线箭头**）。斜位 X 线片 (**B**) 和放大细节图 (**C**) 显示近节趾骨颈部骨折（**白色箭头**）。

<!> ATTENTION

Lipohaemarthrosis
> Telltale sign of an intraarticular fracture

When a fracture extends into a joint, fat and blood from the bone marrow flow into the joint space (and its recesses), hence the name "lipohaemarthrosis". Gravity-dependent layering of fat, serum and haematocrit can be seen by sending a horizontal beam through the joint and picking up these “cross-table” X-rays on a detector plate (Figure 69).

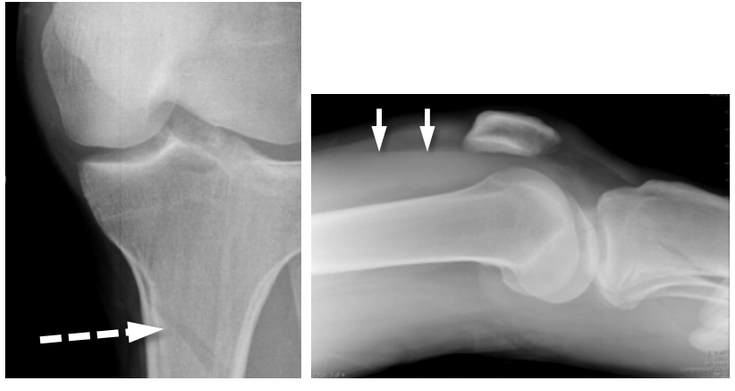
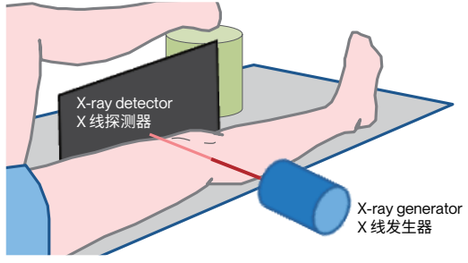
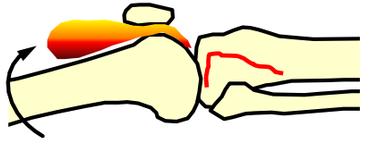


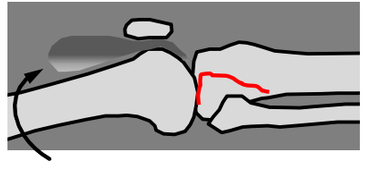
FIGURE 69

Intraarticular extension of the proximal tibial fracture (**dashed arrow**) in this patient was ascertained by the use of cross-table radiographic technique showing layering (**solid arrows**) of bone marrow fat and blood within the suprapatellar recess of the knee.





Blood and fat from the bone marrow of the fractured proximal tibia filling the suprapatellar recess.



Radiographic appearance of the layered bone marrow fat-serum-haematocrit filling the suprapatellar recess.

<!> 注意

关节脂血症
> 存在关节内骨折的警示征象

当骨折延伸到关节内时，骨髓中的脂肪和血液会流入关节间隙（及其隐窝），因此称为“关节脂血症”。通过发送水平光束穿过关节，并在检测器板上接收这些“水平”X 射线，即可看到脂肪、血清和血细胞比容的重力依赖性分层现象（图 69）。

图 69

使用水平线束放射成像技术，显示膝关节髌上囊内骨髓脂肪和血液分层现象（实线箭头），确定这名患者胫骨近端骨折的关节内延伸（虚线箭头）。

胫骨近端骨折骨髓中的血液和脂肪，填充了髌上囊。

填充髌上囊的分层骨髓脂肪-血清-红细胞压积的影像学表现。

Lipohaemarthrosis

Gravity-dependent layering of fat, serum and haematocrit can be seen not only on a “cross-table” radiograph (**arrows**, right), but also on cross-sectional imaging such as CT and MRI (**Figure 70**).

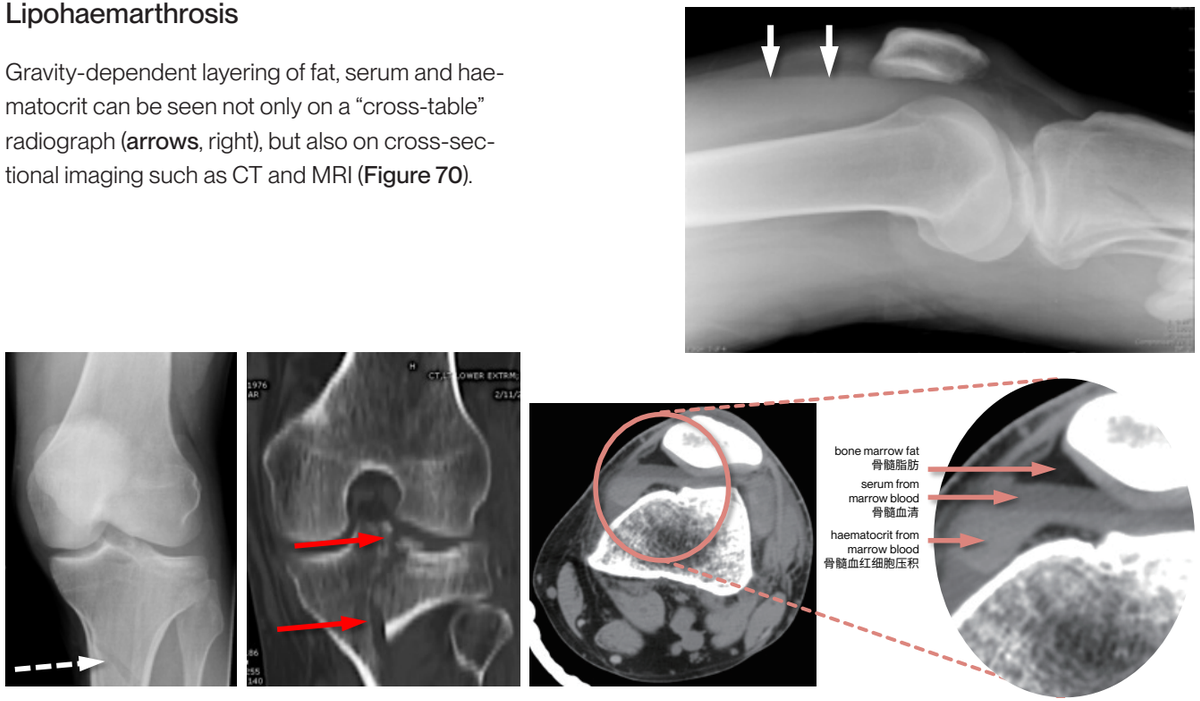


FIGURE 70

Same patient as in **Fig. 69**. Intraarticular extension of the proximal tibial fracture (**dashed arrow**) was also shown on the coronal CT reformation (**red arrows**). Transverse CT image and corresponding zoomed detail (in ellipse) display the layering of the bone marrow fat, serum and haematocrit within the suprapatellar recess of the knee.

关节脂血症

脂肪、血清和血细胞比容的重力依赖性分层不仅可在“水平线束”X线照片（箭头，右）上看到，而且能在 CT 和 MRI 等横断面成像上看到（图 **70**）。

图 70

与图 **69** 对应同一患者。冠状位 CT 重建图（**红色箭头**）上也显示了胫骨近端骨折的关节内延伸（**虚线箭头**）。横轴位 CT 图像和相应的放大细节图（椭圆形）显示膝关节髌上囊内的骨髓脂肪、血清和红细胞压积分层现象。

Acute Fracture versus Old Fracture

One of the hallmarks of an acute fracture is the lack of cortical bone at the fracture edges opposing each other. Over time cortication of ununited fracture fragments occurs. This is an important distinction for estimating fracture age (acute versus old) as shown in **Figures 71** and **72**.

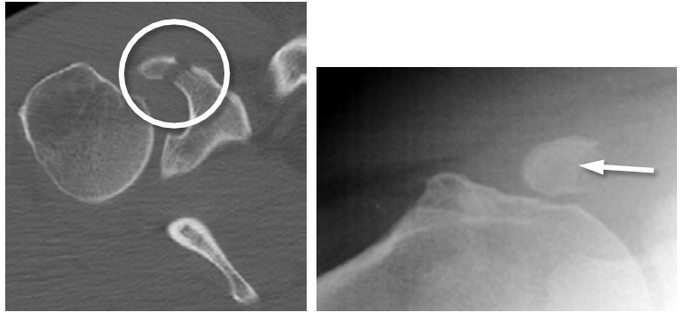


FIGURE 71

Note the non-white (i.e., uncorticated) and craggy edges at the opposing surfaces of fracture fragments in this coracoid fracture (**circle**, left; **arrow**, right).

>|< COMPARE

FIGURE 72

Compare the uncorticated edges at the opposing surfaces of fracture fragments in this comminuted intra-articular fracture of the fifth metacarpal base (**circles**) with the corticated old fracture of the hook of the hamate (**arrows**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

急性骨折与陈旧性骨折

>|< 比较

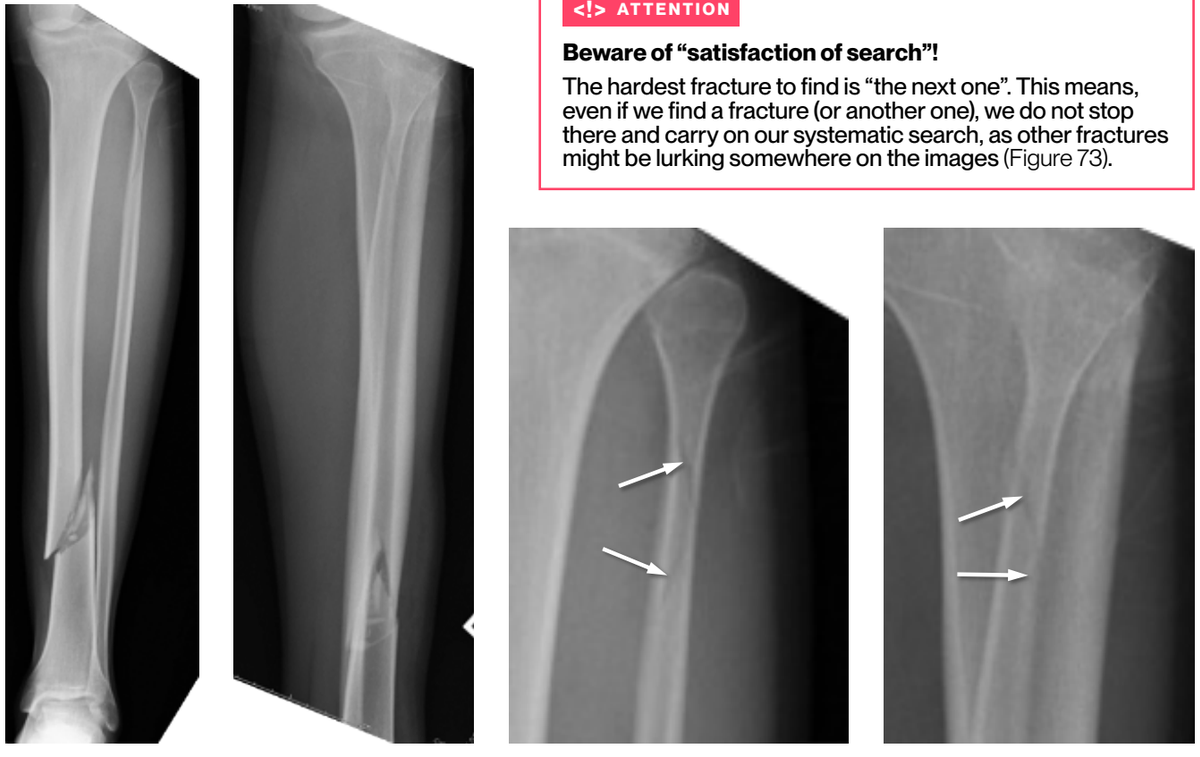
急性骨折的标志之一是彼此相对的骨折边缘缺乏皮质骨。随着时间的推移，不愈合的骨折碎片会逐渐形成皮质化。这是骨折时间（急性与陈旧性）的重要区别，如图 **71** 和图 **72** 所示。

图 71

请注意在这种喙突骨折中，骨折碎片相对面的非白色（即无皮质）和不规则边缘（圆圈，左；箭头，右）。

图 72

比较这种第五掌骨基部关节内粉碎性骨折（圆形）中骨折碎片相对面的无皮质边缘与钩骨钩状皮质陈旧性骨折（箭头）。



<!> ATTENTION

Beware of "satisfaction of search"!

The hardest fracture to find is "the next one". This means, even if we find a fracture (or another one), we do not stop there and carry on our systematic search, as other fractures might be lurking somewhere on the images (Figure 73).

FIGURE 73

Comminuted fracture of the tibia diaphysis is easily identified in this patient. The fracture of the proximal fibula, (**arrows**, enlarged views on the right), however, was missed.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

<!> 注意

警惕"识别出一处骨折的满足感"！

最难发现的往往是"下一处骨折"。这意味着，即使发现了一处骨折（或另一处骨折），切勿就此止步，应继续进行系统性寻找，因为可能还有其他骨折仍隐藏在图像上的某个位置（图 73）。

图 73

对于这名患者，很容易识别出胫骨干粉碎性骨折。然而，腓骨近端骨折（**箭头**，右侧放大图）漏诊。

Pitfalls of Fractures: Skin Folds, Intra-articular Gas, Physeal Lines, Nutrient Vessels

- A skin fold or intraarticular gas might sometimes be mistaken for a fracture (**Figure 74**).
- A physeal line around the time of its closure can also mimic a fracture (**Figure 74**).
- Another common mimicker of fractures is a nutrient vessel (**Figure 75**).

FIGURE 74

Skin fold (**white arrows**), intra-articular gas (**red arrow**) and physeal lines (**arrowhead**) mimicking fractures.

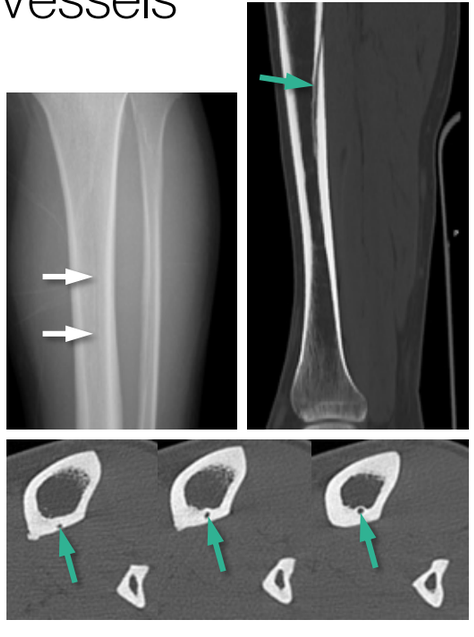


FIGURE 75

Nutrient vessel (**white arrows**, top left) mimicking a fracture on CRX. CT clearly shows that this appearance is caused by a nutrient vessel (green arrows).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨折鉴别误区：皮肤褶皱、关节内气体、骨骺线和营养血管

- 皮肤褶皱或关节内气体有时会被误认为是骨折（图 74）。
- 闭合时的骨骺线也可能被当作骨折（图 74）。
- 另一种常见的易与骨折混淆的是营养血管（图 75）。

骨骼肌肉影像学

章节大纲：

图 74

皮肤褶皱（**白色箭头**）、关节内气体（**红色箭头**）和骨骺线（箭头）易与骨折混淆。

图 75

CRX 上的营养血管（左上**白色箭头**）可能会被当成骨折，而 CT 上清楚地显示此处表现由营养血管引起（绿色箭头）。

/ Imaging Fracture Healing

Fracture healing is a complex process that involves inflammatory (days to weeks), reparative (weeks to months) and remodelling (months to years) phases, which can be monitored by radiographs. Calcified callus is usually first depicted on radiographs a few weeks after the injury (**Figure 76**).

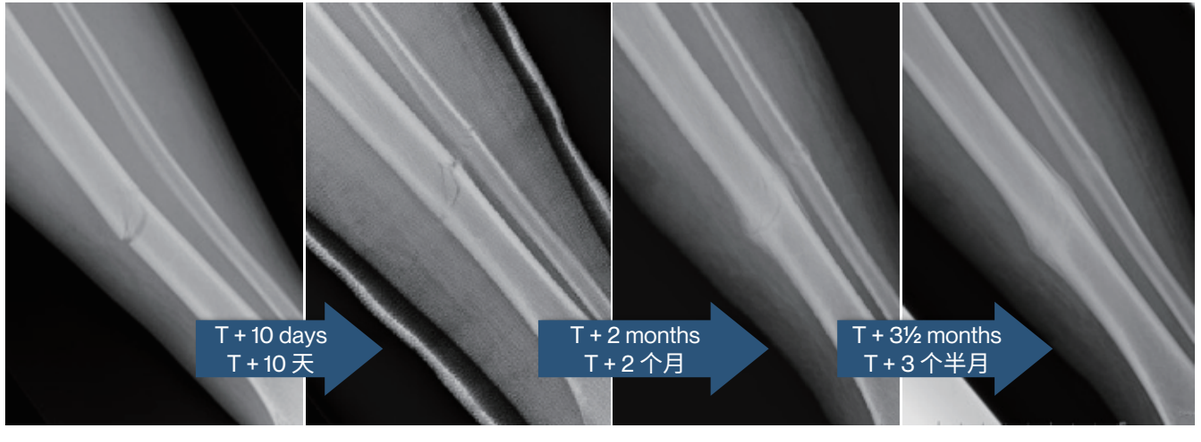


FIGURE 76

Fracture healing after trauma (T) as seen on CRX.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 骨折愈合影像学检查

骨折愈合过程复杂，包括炎症期（数日至数周）、修复期（数周至数月）和重塑期（数月至数年），可通过 X 线片监测。钙化骨痂通常在损伤后数周首次出现在 X 线片上（图 **76**）。

图 76

CRX 所示创伤后骨折愈合 (T)。

Imaging Fracture Healing – or the Lack of It

- "**Non-union**" means failure of normal fracture healing, whereby solid bone healing will not occur without further therapeutic intervention. Currently there is no consensus definition of non-union. According to one of the proposed definitions, however, non-union is considered when a fracture does not show evidence of increased healing in three consecutive radiographs each taken one month apart (**Figure 77**).
- In "**malunion**", fracture fragments heal in poor position or alignment so that functional or cosmetic problems arise (**Figure 78**).

FIGURE 77

Absence of calcified callus formation in the distal radius fracture 4 weeks (**centre**) and 12 weeks (**right**) after the initial injury (**left**) is consistent with non-union.

FIGURE 78

Malunion of an intra-articular lateral condylar fracture (**centre** and **right**) in a 20-year-old man two and a half years after the initial injury (**left**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

骨折愈合/未愈合影像学检查

- "**不愈合**"是指正常骨折愈合失败，即如果不进行进一步的治疗干预，不会发生骨牢固愈合。目前尚无关于不愈合的共识定义。根据提出的其中一项定义，当骨折发生后连续三次 X 线片检查（每次间隔一个月）中，若未显示出愈合增加的证据，则视为不愈合（**图 77**）。
- "**畸形愈合**"是指骨折碎片愈合中位置或对位不佳，导致出现功能或外观问题（**图 78**）。

图 77

桡骨远端骨折在初次损伤（**左侧**）和 4 周后（**中间**）和 12 周后（**右侧**）无钙化骨痂形成，符合不愈合的特征。

图 78

一名 20 岁男性在初次受伤（**左侧**）两年半后关节内外侧髁骨折的畸形愈合（**中间和右侧**）。

Infection

感染

Musculoskeletal Imaging

骨骼肌肉影像学

CHAPTER OUTLINE:

章节大纲：

/ Osteomyelitis

/ **Hematogenous spread of infection**—usually to the metaphysis—triggers a cascade of events resulting in subperiosteal abscess, draining sinus, sequestrum and involucrum formation—although, depending on the microorganism's virulence and the efficiency of treatment, not every feature in this cascade necessarily appears on imaging (**Figure 79**).

/ Findings on the combination of radiographs and MRI (**Figures 80-83**), which are extensively used for diagnosing osteomyelitis, closely reflect pathophysiology.

<!> ATTENTION **In infancy and after adolescence, infection may spread into the adjacent epiphysis through the physis (growth plate).**

FIGURE 80

CRX (**A**) and contrast-enhanced MRI (**B**) in a child with calcaneal osteomyelitis. A sinus tract (**arrowhead**, **B**) drains pus.

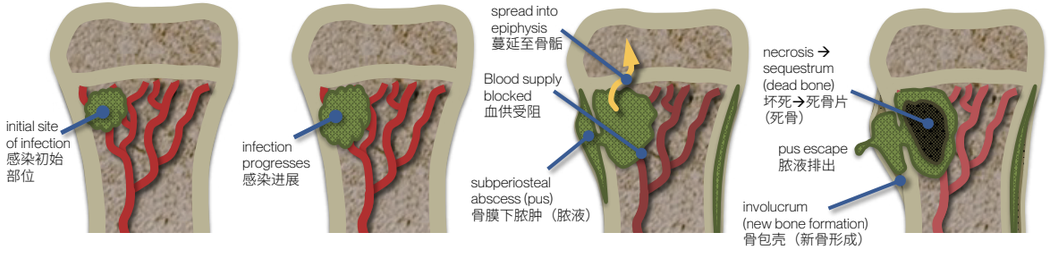


FIGURE 79

The cascade of events in osteomyelitis.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨髓炎

/ **感染的血源性播散**（通常累及干骺端）可能引发一系列连锁反应，导致骨膜下脓肿、引流窦、死骨和包壳形成。然而，并非连锁反应中的每项特征都一定出现在影像学检查上，具体取决于微生物毒性和治疗效果（图 79）。

/ X 线片与 MRI 联合检查结果（图 80-83）广泛用于骨髓炎的诊断，能够反映病理生理学情况。

<!> 注意 **婴儿期和青春期之后，感染可能通过骺板（生长板）播散到邻近骨骺。**

图 79

骨髓炎的连锁反应。

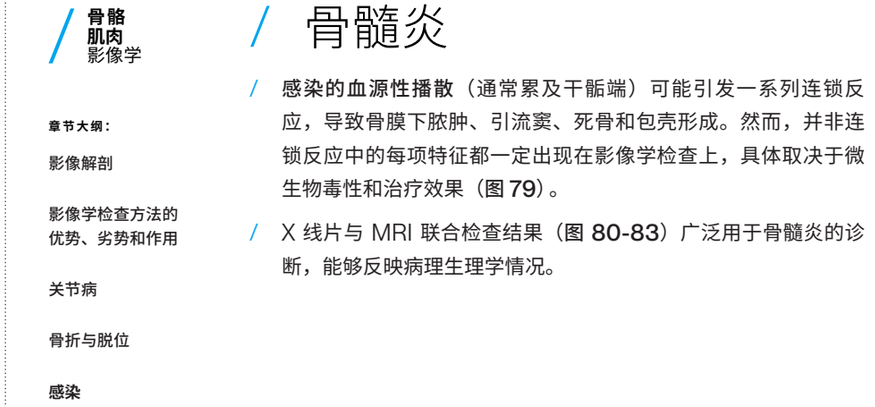
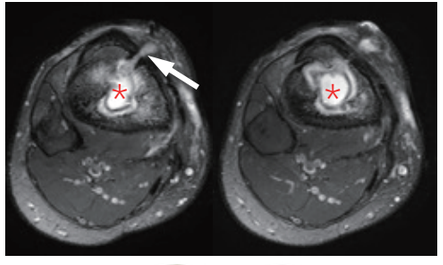


图 80

跟骨髓炎患儿的 CRX (**A**) 和对比增强 MRI(**B**) 结果。窦道（箭头尖端，**B**）排出脓液。

/ 骨骼肌肉影像学

章节大纲：



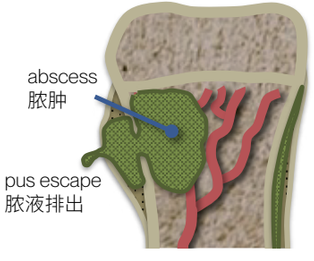
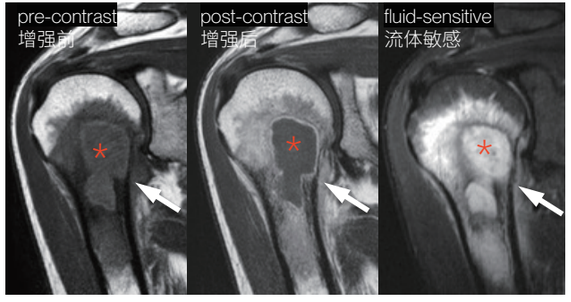


FIGURE 81

MRI shows how accumulated pus (**asterisk**) within the proximal tibial metaphysis (axial fluid-sensitive MR images) finds its way into the skin through a sinus tract (**arrow**) in a 29-year-old man with S. aureus osteomyelitis.



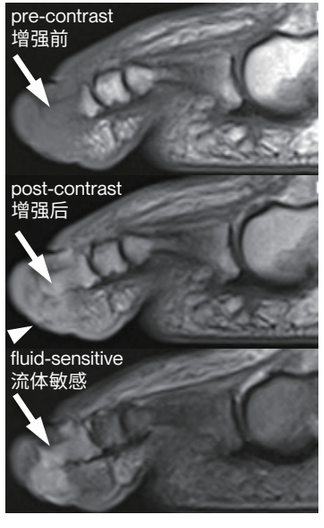


FIGURE 82

MR images display subacute osteomyelitis (Brodie abscess, **asterisk**) in a 20-year-old man (S. aureus infection). Note periosteal inflammation with contrast enhancement and high signal on the fluid-sensitive image (**arrows**), more on the medial than lateral aspect. The abscess shows only peripheral rim enhancement and has otherwise a high signal on the fluid sensitive image (**asterisks**).

<!> ATTENTION

MRI is widely used to confirm or rule out osteomyelitis in diabetic foot. Abnormal bone signal adjacent to a skin ulcer, sinus tract or abscess is highly suggestive of osteomyelitis, which is ruled out when bone signal is normal.

FIGURE 83

MR images show distal phalangeal great toe osteomyelitis (**arrows**) subjacent to a sinus tract (**arrowhead**) in a 53-year-old man with diabetes.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

图 81

MRI 显示了一名 29 岁金黄色葡萄球菌骨髓炎男性患者的胫骨近端干骺端内积聚的脓液（星号）（轴位液体敏感 MR 图像）如何通过窦道（箭头）进入皮肤。

图 82

MR 图像显示一名 20 岁男性（金黄色葡萄球菌感染）的亚急性骨髓炎（Brodie 氏骨脓肿，星号）。注意骨膜炎症，在液体敏感图像上有对比增强和高信号（箭头），更多地在内侧而不是外侧。脓肿仅表现为周围边缘强化，在液体敏感图像上呈高信号（星号）。

<!> 注意

MRI 广泛用于确诊或排除糖尿病足的骨髓炎。邻近皮肤溃疡、窦道或脓肿的骨信号异常高度提示骨髓炎。若骨信号正常，则可排除骨髓炎。

图 83

MR 图像显示一名 53 岁糖尿病男性患者的远端趾骨大脚趾骨髓炎（箭头），位于窦道（箭头）下方。

/ Periprosthetic Infection

- **Hip replacement** is the most common joint replacement surgery with an OECD average of 174 per 100,000 population in 2019.
- **Special MRI sequences** have been developed for use in suspected infections adjacent to prosthetic implants, which, due to their metallic components, create image artifacts and present a challenge for MRI (**Figures 84** and **85**).
- **Ultrasonography** can be used for guidance in fluid sampling for micro-biological analysis.

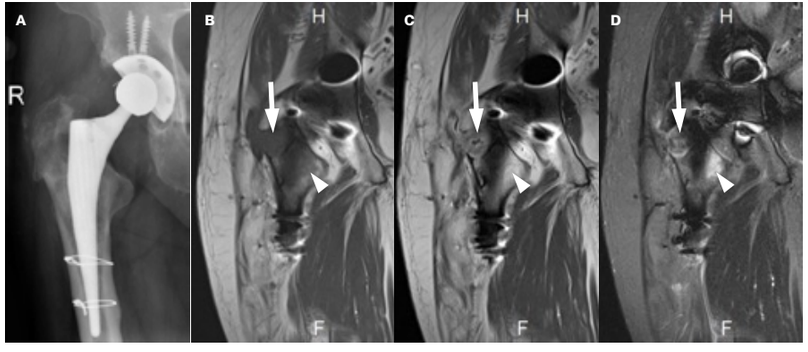


FIGURE 84

CRX (**A**) shows a total hip prosthesis. Periprosthetic infection was suspected. MRI before (**B**) and after i.v. contrast (**C** and **D**) show areas consistent with infection. Contrast-enhancement shows active bone (**arrowheads**) or soft tissue inflammation. Arrows point to an abscess.

>=< FURTHER KNOWLEDGE

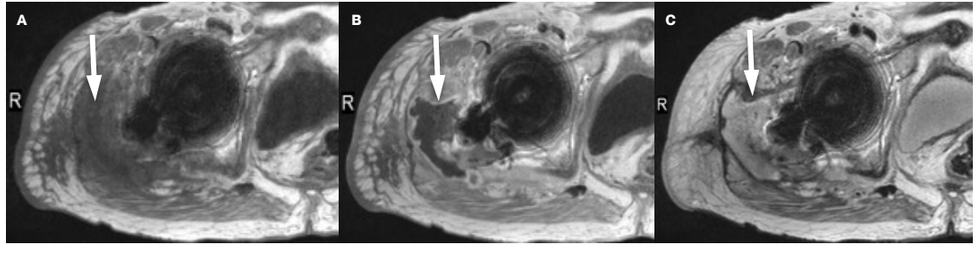


FIGURE 85

Axial MR images before (**A**) and after i.v. contrast (**B**) and fluid-sensitive image (**C**) in an 82-year-old woman with total hip replacement and suspected infection. Arrows point to a large periprosthetic abscess.

/ Musculo-skeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 假体周围感染

- **髋关节置换术**是最常见的关节置换术，2019 年 OECD 平均每 10 万人中有 174 例。
- 由于假体植入物的金属组件会产生图像伪影，这给 MRI 带来了一定的挑战，目前已成功研发出**特殊的 MRI 序列**用于诊断假体植入物附近的疑似感染（**图 84** 和**图 85**）。
- 超声可用于指导液体采样进行微生物分析。

图 84

CRX (**A**) 显示了全髋关节假体。疑似假体周围感染。静脉注射对比剂前 (**B**) 和注射后 MRI 图像（**C** 和 **D**）显示该区域符合感染特征。对比增强图像提示活动性骨（箭头尖端）或软组织炎症。箭头所指为脓肿。

>=< 进阶知识

图 85

一名 82 岁女性接受全髋关节置换术后疑似感染的静脉注射对比剂前 (**A**)和注射后轴位 MR 图像 (**B**) 以及液体敏感图像 (**C**)。箭头所指为较大的假体周围脓肿。

Septic Arthritis

<!> ATTENTION

- There is no pathognomonic imaging finding for septic arthritis. Therefore imaging should not delay joint aspiration and microbiological examination when there is clinical suspicion for septic arthritis.

- Radiographs may show joint effusion in the early stage. MRI is especially suggestive in the presence of periarticular abscess(es), but otherwise non-specific for aetiology of monoarthritis (**Figure 86**). Ultrasonography can be used for ascertaining joint effusion and guides joint fluid aspiration.

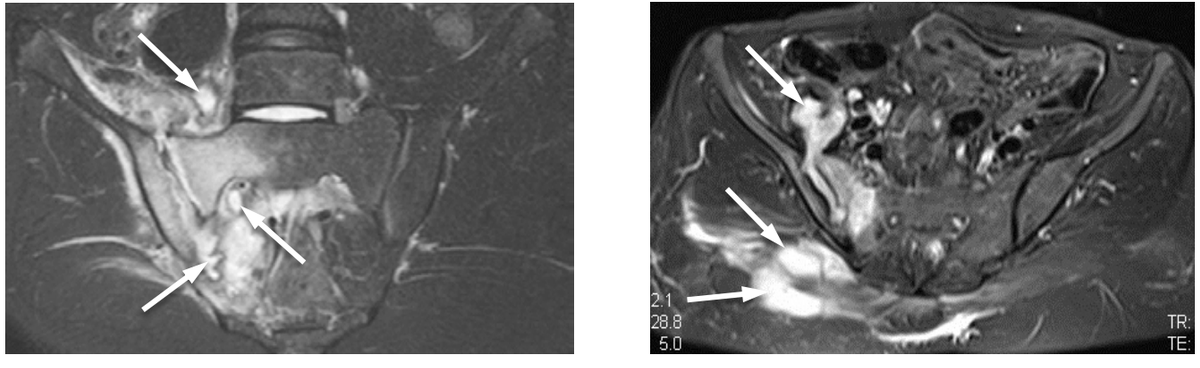


FIGURE 86

Fluid-sensitive MR images obtained in two different patients. Septic right sacroiliitis is evidenced by synovitis, osteitis and periarticular abscesses (**arrows**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

化脓性关节炎

<!> 注意

- 没有确诊化脓性关节炎的影像学表现。因此，当临床怀疑为化脓性关节炎时，不能因影像学检查而推迟关节穿刺和微生物学检查。

- X 线片可能会显示早期的关节积液。存在关节周围脓肿时，MRI 具有特殊提示意义，除此之外，对于单关节炎的病因，无特殊提示意义（图 86）。超声可用于确定关节积液并指导关节液抽吸。

图 86

2 名不同患者的液体敏感 MR 图像。右侧化脓性骶髂关节炎表现为滑膜炎、骨炎和关节周围脓肿（箭头）。

Pyomyositis, Septic Fasciitis, Necrotising Fasciitis and Septic Tenosynovitis

- Infection in a muscle usually presents in the form of scattered small abscesses, termed **pyomyositis** when caused by bacteria (**Figure 87**).
- **Septic fasciitis** is another form of soft tissue infection involving muscles and fascia; when necrotising, it can be life threatening (**Figure 88**).
- In **septic tenosynovitis**, infection and/or pus are found within the tendon sheath (**Figure 89**).

FIGURE 87

Contrast-enhanced MRI displays scattered abscesses (**arrows**) representing pyomyositis in an immune-compromised 58-year-old man with S. aureus septicaemia.

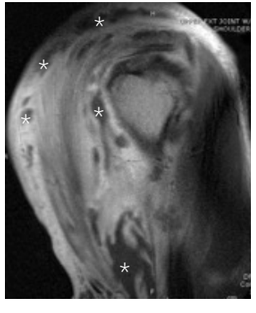


FIGURE 88

MRI (contrast-enhanced image) shows non-enhancing (dark) geographic areas (**asterisks**) consistent with necrotising fasciitis involving the superficial, peripheral and deep fascia in this adult male i.v.. drug abuser, who had to undergo left arm amputation later.

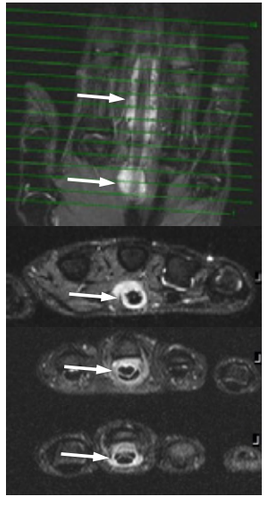


FIGURE 89

MRI (fluid-sensitive coronal and axial images, left) of tuberculous tenosynovitis in a 28-year-old radiology resident following a needle puncture during an interventional procedure. Note fluid accumulation in the tendon sheath and surrounding inflammation (arrows). Intraoperative image courtesy of Dr. Gürsel Leblebicioğlu, Ankara, Turkey.

Musculo-skeletal Imaging

CHAPTER OUTLINE:

Musculo-skeletal Imaging

章节大纲：

化脓性肌炎、脓毒性筋膜炎、坏死性筋膜炎和脓毒性腱鞘炎

- 肌肉感染通常以分散的小脓肿的形式出现，由细菌引起的感染称为**化脓性肌炎**（图 87）。
- **脓毒性筋膜炎**是另一种累及肌肉和筋膜的软组织感染；坏死性筋膜炎可危及生命（图 88）。
- **脓毒性腱鞘炎**，腱鞘内可见感染和/或脓液（图 89）。

图 87

对比增强 MRI 显示分散脓肿（箭头），代表这名 58 岁免疫功能低下的金黄色葡萄球菌败血症男性患者，存在化脓性肌炎。

图 88

MRI（对比增强图像）显示非增强（深色）区域（星号），符合坏死性筋膜炎特征，涉及浅表、外周和深筋膜。这名成年男性是名吸毒者，后来不得不接受左臂截肢手术。

图 89

1 名 28 岁放射科住院医师在介入手术期间穿刺后，结核性腱鞘炎 MRI 图像（液体敏感冠状位和轴位图像，左）。注意腱鞘内积液和周围炎症（箭头）。术中图片由土耳其安卡拉的 Gürsel Leblebicioğlu 医生提供。

/ Lymphoedema versus Cellulitis

/ **Cellulitis** is an infection of the skin and subcutaneous fatty tissue, usually caused by bacteria, whereas **lymphoedema** is accumulation of lymph in the soft tissues due to impaired lymphatic flow.

/ Although usually straightforward, differentiating cellulitis from lymphedema clinically can sometimes be challenging. Cellulitis shows contrast enhancement on MRI, lymphedema does not (**Figure 90**).

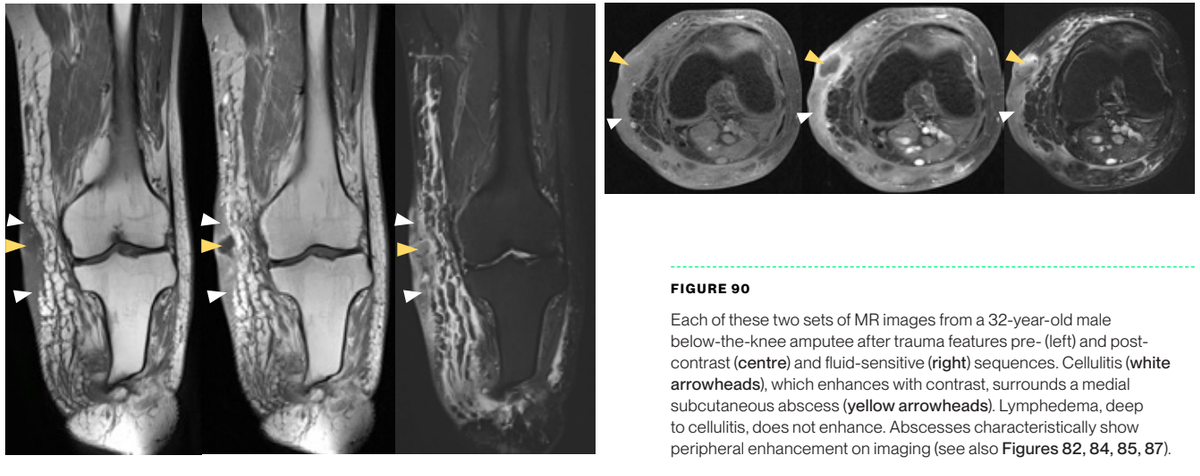


FIGURE 90

Each of these two sets of MR images from a 32-year-old male below-the-knee amputee after trauma features pre- (left) and post-contrast (**centre**) and fluid-sensitive (**right**) sequences. Cellulitis (**white arrowheads**), which enhances with contrast, surrounds a medial subcutaneous abscess (**yellow arrowheads**). Lymphedema, deep to cellulitis, does not enhance. Abscesses characteristically show peripheral enhancement on imaging (see also **Figures 82, 84, 85, 87**).

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 淋巴水肿和蜂窝织炎

/ **蜂窝织炎**是一种皮肤和皮下脂肪组织的感染，通常由细菌引起，而**淋巴水肿**是由于淋巴回流障碍导致淋巴液在软组织中积聚。

/ 虽然在临床上通常易于区分蜂窝织炎与淋巴水肿，但有时也具有一定的难度。蜂窝织炎在 MRI 上表现为对比增强，而淋巴水肿没有这一特征（图 **90**）。

图 90

这两组 MR 图像均来自一名外伤后经膝下截肢的 32 岁男性，采用注射对比剂前（**左**）和注射对比剂后（**中心**）以及液体敏感（**右**）序列。蜂窝织炎（**白色箭头尖端**）在对比剂下增强，包围着内侧皮下脓肿（**黄色箭头尖端**）。淋巴水肿，深至蜂窝织炎，未见对比剂强化。脓肿的特征性影像学表现为外周强化（另见图 **82、84、85、87**）。

Tumours and Tumour-like Conditions

Musculo-skeletal Imaging

CHAPTER OUTLINE:

肿瘤和肿瘤样疾病

骨骼肌肉影像学

章节大纲：

/ "Don't Touch" Lesions

<!> ATTENTION

These are benign lesions where a radiological diagnosis is made without a differential diagnosis list and biopsy is NOT to be performed (it is unnecessary, may be misleading and may even lead to unnecessary surgery).

>=< FURTHER KNOWLEDGE

"Don't touch" lesions include:

- / Fibrous cortical defect (**Figure 91**)
- / Non-ossifying fibroma (**Figure 91**)
- / Bone island (**Figure 91**)
- / Bone infarct (**Figure 91**)
- / Solitary bone cyst (**Figure 91**)
- / Distal femoral cortical irregularity (**Figures 92** and **93**)
- / Myositis ossificans (**Figure 94**)

FIGURE 91

The self-explanatory fibrous cortical defect (**A**) is called non-ossifying fibroma (NOF) when it is > 2cm (**B**) and features lobulated contours (**arrows**). These are usually incidental. NOF may be slightly expansile. Bone island (**C**) presents as a hyperdense (sclerotic) lesion with spiculated contours (arrow). Bone infarcts (**D**) are heterogeneously sclerotic lesions with geographic contours. Solitary bone cyst (**E**) presents as a well defined radiolucency. The "fallen fragment" sign denotes pathological cortical fracture fragment(s) that are displaced into the cyst (**arrows**).

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ "勿需处理"的病变

/ 骨骼肌肉影像学

章节大纲：

<!> 注意

这些病变为良性病变，可在没有鉴别诊断列表的情况下进行放射学诊断，并且不进行活检（活检并不是必要程序，可能会具有误导性，甚至导致不必要的手术）。

>=< 进阶知识

"勿需处理"的病变包括：

- / 纤维性皮质缺损（图 91）
- / 非骨化性纤维瘤（图 91）
- / 骨岛（图 91）
- / 骨梗死（图 91）
- / 孤立性骨囊肿（图 91）
- / 股骨远端皮质不规则（图 92 和 93）
- / 骨化性肌炎（图 94）

图 91

当明确的纤维性皮质缺损 (A) > 2 cm (B) 并呈分叶状轮廓（箭头）时，将其称为非骨化性纤维瘤 (NOF)，通常在检查时偶然发现。NOF 可轻微扩张。骨岛 (C) 表现为高密度（硬化）病变，轮廓呈毛刺状（箭头）。骨梗塞 (D) 是具有地图状轮廓的不均匀硬化病变。孤立性骨囊肿 (E) 表现为边界清晰的透亮区。"碎片陷落"征象表示病理性皮质骨折碎片进入囊肿内（箭头）。

/ Distal Femoral Cortical Irregularity (aka “Cortical Desmoid”)

A cortical irregularity at the posterior aspect of the distal femoral metaphysis corresponding to tendon attachment sites (most commonly that of medial head of gastrocnemius) is a frequent incidental finding in children at MRI with a presumably mechanical stress-related origin (**Figures 92** and **93**).

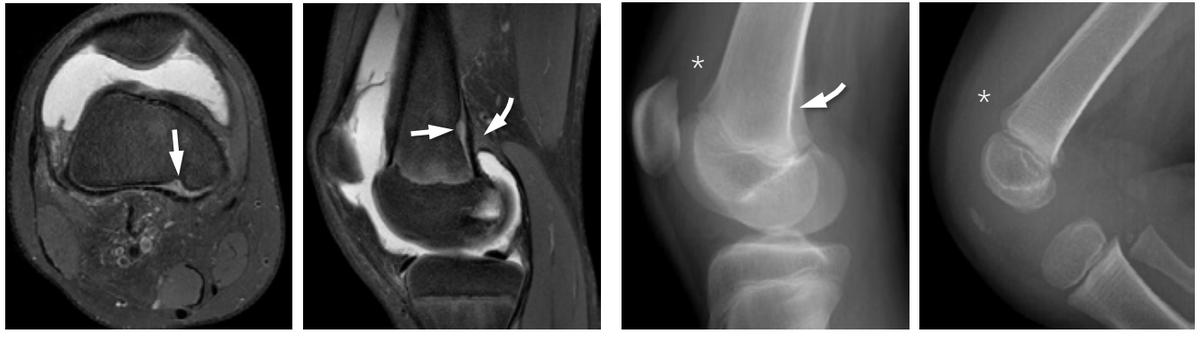


FIGURE 92

MRI shows an incidental focal cortical lesion (**arrows**) at the posteromedial aspect of the distal femoral metaphysis in a child with a large knee joint effusion due to juvenile idiopathic arthritis. The lesion is at the level of the insertion of medial head of gastrocnemius (**curved arrow**).

FIGURE 93

A lateral radiograph shows mild radiolucency at the lesion location (**arrow**). Note that no such lesion is present at this location on the radiograph when the child was 2 years old (right). Joint effusion (*), however, is visible on both radiographs of this child with longstanding juvenile idiopathic arthritis.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 股骨远端皮质不规则（又名“皮质硬纤维瘤”）

股骨远端干骺端后侧与肌腱附着部位（最常见的是腓肠肌内侧头）相对应的皮质不规则经常在进行儿童 MRI 检查时偶然发现，可能与机械应力有关（图 92 和 93）。

图 92

MRI 显示，一名儿童股骨远端干骺端后内侧出现偶发局灶性皮质病变（箭头），该儿童因幼年特发性关节炎导致出现大量膝关节积液。病变位于腓肠肌内侧头附着点（弯曲箭头）。

图 93

侧位 X 线片显示病变部位表现为轻度透亮区（箭头）。请注意，孩子 2 岁时，X 线片上此处位置无该病变（右）。然而，由于长期患有特发性关节炎，在两张 X 线片上均可见关节积液 (*)。

/ Myositis Ossificans

Myositis ossificans (**Figure 94**) is the most common form of heterotopic ossification occurring usually after trauma. Biopsy on such a lesion may be misleading as aggressive histologic appearance can mimic sarcoma (and, unfortunately on occasions in the past, resulted in radical surgery).

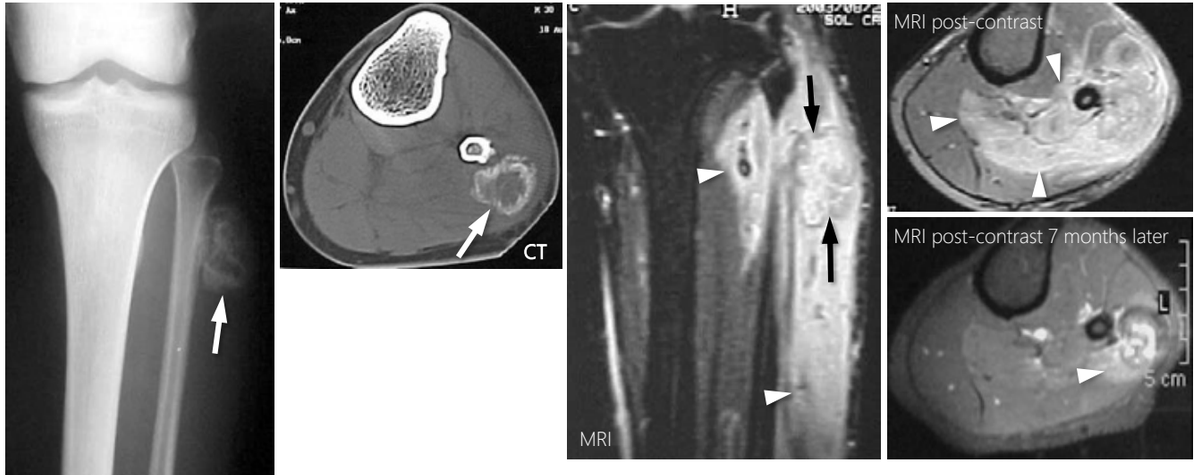


FIGURE 94

Typical radiographic appearance of myositis ossificans is circumferential calcification with a lucent centre (**arrows**). MRI shows extensive soft tissue inflammation (arrowheads) surrounding the lesion which, over time, subsides and resolves.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 骨化性肌炎

骨化性肌炎（图 94）是最常见的异位骨化形式，通常发生在创伤后。对此类病变进行活检可能会产生误导，因为其侵袭性组织学表现可能类似于肉瘤（不幸的是，过去曾因此导致患者接受根治性手术）。

图 94

骨化性肌炎的典型影像学表现为周边环形钙化伴中央透亮区。（箭头）。MRI 显示病变周围存在广泛的软组织炎症（箭头尖端），随着时间的推移，炎症消退。

/ Radiology of Bone Tumours and the Roles of the Radiologist

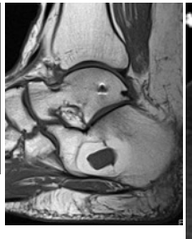
<!> ATTENTION

The role of the radiologist in bone tumours is manifold: to identify and characterise tumours, to plan (and perform) biopsy, to help stage and (sometimes) treat tumours, to assess treatment response and to follow up (Figure 95).

Identification

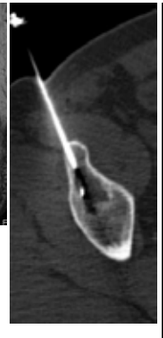
Plain films are the first-line imaging tool in the identification of bone lesions (a chondromyxoid fibroma in this patient).

Characterisation



Cross-sectional imaging provides additional diagnostic clues in characterising bone lesions (e.g., cystic, myxoid, solid, lesion matrix and its mineralisation).

Biopsy

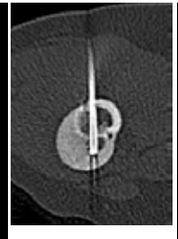


Biopsy of some bone tumours is performed by radiologists.

Staging

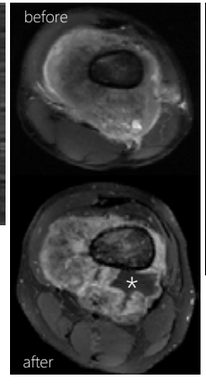
Skip metastasis (**arrowhead, left**) in a patient with Ewing sarcoma (**arrow**) increases the tumour stage.

Treatment



Radiofrequency ablation of an osteoid osteoma is performed by an interventional radiology team.

Treatment Response



Necrosis (**asterisk**) development within an osteosarcoma after chemotherapy.

Follow-up

Tumour recurrence in a patient operated on for osteosarcoma.

FIGURE 95

Roles of the radiologist in bone tumours

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 骨肿瘤放射学和放射科医生职责

<!> 注意

放射科医生在骨肿瘤中承担着多方面的职责：识别和表征肿瘤、计划（和执行）活检、帮助肿瘤分期和（有时）治疗、评估治疗疗效和随访（图 95）。

鉴别	表征	活检	分期	治疗	治疗疗效评估	随访
平片是鉴别骨病变（本例中为软骨粘液样纤维瘤）的首选影像学工具。	横断面成像检查可为骨病变（如囊性、黏液样、实性、病变基质及其矿化）的表征提供额外的诊断线索。	部分骨肿瘤的活检由放射科医生执行。	尤因肉瘤患者（箭头）的跳跃性转移（箭头尖端，左）会增加肿瘤所处阶段。	骨样骨瘤的射频消融术由介入放射团队执行。	骨肉瘤（星号）化疗后出现坏死。	骨肉瘤手术患者的肿瘤复发。

图 95

放射科医生在骨肿瘤中承担的职责

/ Patient Age and Location of Tumours

<!> ATTENTION

Patient age is the key demographic factor in bone tumours. Along with lesion location across the body and within a bone, it greatly helps to narrow down the differential diagnostic possibilities (Figure 96). When attempting to diagnose bone tumours, it is helpful to remember the adage from real estate business, “Location is everything”, which, although not absolute, frequently holds true.

>=< FURTHER KNOWLEDGE

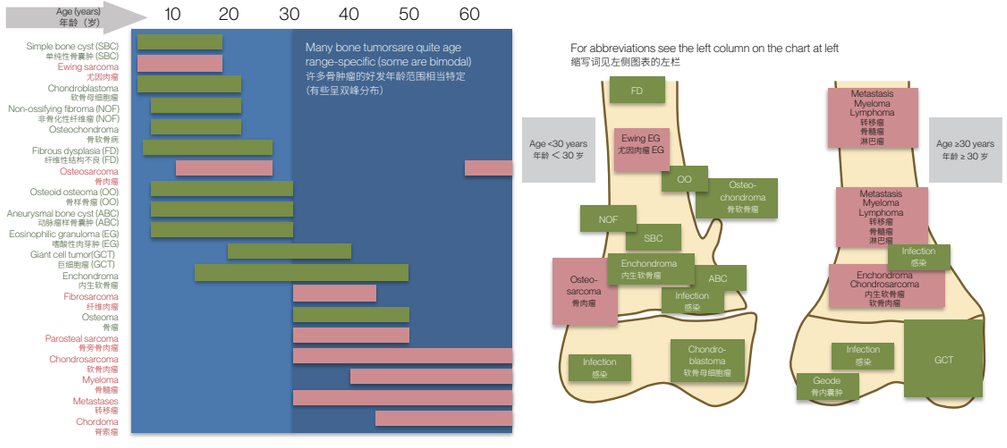


FIGURE 96

Chart and drawings adapted from radiology-assistant.nl

/ Musculo-skeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 患者年龄和肿瘤部位

<!> 注意

患者年龄是判断骨肿瘤的一项重要统计学因素，再结合病变在全身和骨骼内的位置，可极大地缩小鉴别诊断范围（图 96）。尝试诊断骨肿瘤时，不妨参考房地产业的一句名言“位置决定一切”，虽然并非绝对，但通常适用。

>=< 进阶知识

图 96

图表和图像改编自 radiologyassistant.nl

/ Lesion Borders

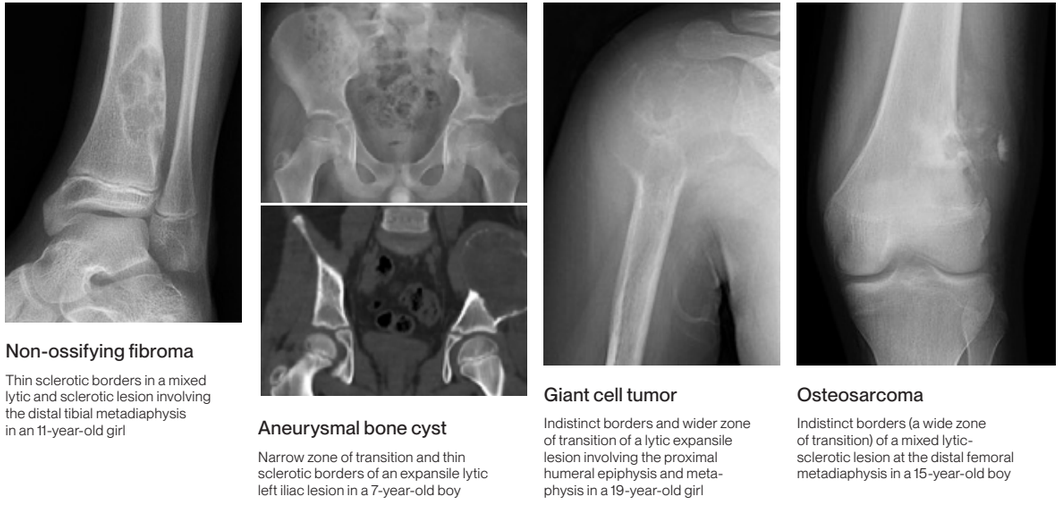
<!> ATTENTION

Sclerotic borders generally imply the successful attempt of the body to contain a lesion. Conversely, ill-defined contours and a wide zone of transition on radiographs hint at an aggressive lesion (malignant or due to a highly virulent microorganism). Permeative or moth-eaten pattern of bone involvement also suggests aggressiveness. See **Figure 97**.

>▪< FURTHER KNOWLEDGE

FIGURE 97

Examples of various types of lesion borders



Non-ossifying fibroma

Thin sclerotic borders in a mixed lytic and sclerotic lesion involving the distal tibial metadiaphysis in an 11-year-old girl

Aneurysmal bone cyst

Narrow zone of transition and thin sclerotic borders of an expansile lytic left iliac lesion in a 7-year-old boy

Giant cell tumor

Indistinct borders and wider zone of transition of a lytic expansile lesion involving the proximal humeral epiphysis and metaphysis in a 19-year-old girl

Osteosarcoma

Indistinct borders (a wide zone of transition) of a mixed lytic-sclerotic lesion at the distal femoral metadiaphysis in a 15-year-old boy

/ 病变边界

<!> 注意

硬化边界通常意味着机体成功限制病变范围。相反，X 线片上边界不清和宽过渡区提示侵袭性病变（恶性或由高毒性微生物引起）。渗透性或虫蚀样骨受累也表明具有侵袭性。参见**图 97**。

>▪< 进阶知识

图 97

各类病变边界的示例

非骨化性纤维瘤

一名 11 岁女孩累及胫骨远端干骺端的混合溶骨性硬化病变 — 薄硬化边界

动脉瘤样骨囊肿

一名 7 岁男孩左侧髂骨膨胀性溶骨性病变，表现为窄的过渡带及薄的硬化边界

巨细胞瘤

一名 19 岁女孩累及肱骨近端骨骺和干骺端的膨胀性溶骨性病变 — 边界不清且过渡区较宽

骨肉瘤

一名 15 岁男孩股骨远端干骺端混合溶骨性硬化病变 — 边界不清（较宽的过渡区）

/ Lesion Matrix and its Mineralisation

<!> ATTENTION

Many bone lesions have an underlying matrix, which can become mineralised. Different types of matrix (and their mineralisation), which are usually discernible on radiological imaging, point to different groups of lesions (Figure 98).

>=< FURTHER KNOWLEDGE

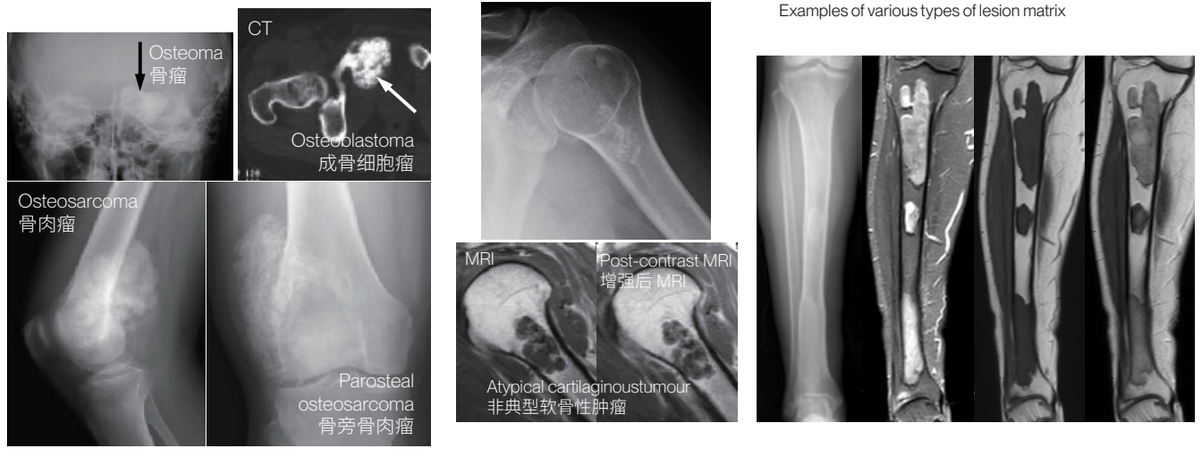


FIGURE 98

Examples of various types of lesion matrix

Osteoid matrix

Marble-/cloud-like or ill-defined amorphous densities are characteristic in osteoid producing lesions

Cartilaginous matrix

Focal stippled or flocculent densities or "rings and arcs" of calcifications or enhancement are seen in cartilage producing lesions

Fibrous matrix

A ground-glass matrix is characteristic for fibrous dysplasia. Second through fourth images: MRI, the image on the far right is a post-contrast image.

CHAPTER OUTLINE:

章节大纲：

/ 病变基质及其矿化

<!> 注意

许多骨病变有潜在的可能会矿化的基质。不同类型的基质（及其矿化方式）通常可在影像学上辨别，有助于指向不同类别的病变（图 98）。

>=< 进阶知识

图 98

各类病变基质的示例

类骨质基质

类骨质病变的特征性表现为大理石样/云雾样或边界不清的不规则致密影

软骨基质

在软骨性病变中可见局灶性点状或絮状致密影，或呈“环与弧”样钙化或强化。

纤维基质

毛玻璃样基质是纤维异常增殖症的特征性表现。第二到第四张图像：MRI，最右侧图像为增强后图像。

/ Periosteal Reaction

Periosteal reaction associated with a lesion gives important clues regarding its behaviour. Benign (or less aggressive) lesions tend to show a **solid periosteal reaction** (**Figure 99**), whereas more aggressive lesions display **lamellated** (**Figure 100**) or spiculated periosteal reaction (**Figure 101**) or the so-called "**Codman triangle**" (**Figure 102**), which denotes disruption of an already lamellated periosteal reaction by aggressively invading tumour.

<!> ATTENTION

More than one type of aggressive periosteal reaction can be seen simultaneously

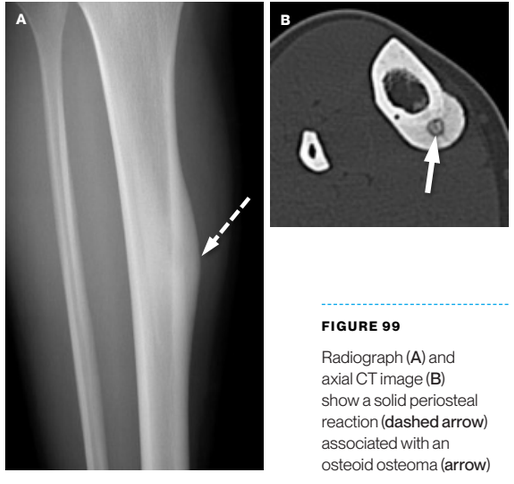


FIGURE 99

Radiograph (**A**) and axial CT image (**B**) show a solid periosteal reaction (**dashed arrow**) associated with an osteoid osteoma (**arrow**)

FIGURE 100

Radiograph (**A**), coronal CT reformation (**B**) and coronal (**C**) and axial (**D**) MR images show a lamellated (onion skin) periosteal reaction associated with a Ewing sarcoma

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨肌影像学

章节大纲：

/ 骨膜反应

与病变相关的骨膜反应对判断其生物学行为有重要提示作用。良性（或侵袭性较弱）病变往往表现为**实性骨膜反应**（**图 99**），而侵袭性较强的病变表现为**层状**（**图 100**）或毛刺状骨膜反应（**图 101**）或所谓的"**Codman 三角**"（**图 102**），这表明由于侵袭性肿瘤的侵入破坏，出现层状的骨膜反应。

<!> 注意

可同时观察到一种以上的侵袭性骨膜反应

图 99

X 线片 (**A**) 和轴位 CT 图像 (**B**) 显示与骨样骨瘤（箭头）相关的实性骨膜反应（**虚线箭头**）

图 100

X 线片 (**A**)、冠状位 CT 重建 (**B**)、冠状位 (**C**) 和轴位 (**D**) MR 图像显示与尤文肉瘤相关的层状（洋葱皮样）骨膜反应

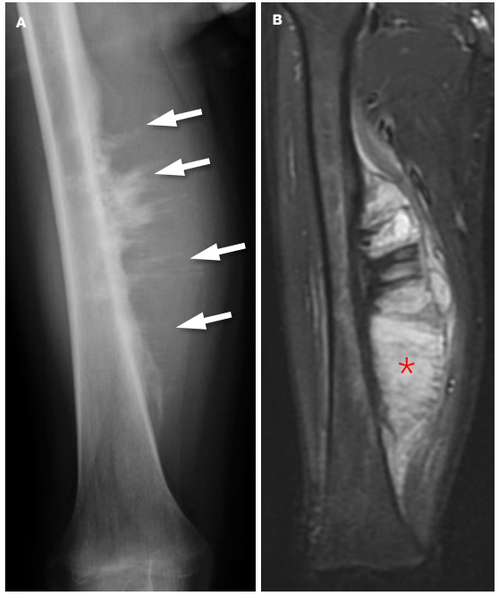


FIGURE 101

Radiograph (**A**) and MRI (**B**) show spiculated periosteal reaction (**arrows**) associated with an osteosarcoma (**asterisk**)

FIGURE 102

Coronal CT reformation (**A**) and MRI (**B**) show a Codman triangle (**arrows**) associated with an osteosarcoma (**asterisks**)

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

图 101

X 线片 (**A**) 和 MRI(**B**) 显示与骨肉瘤（星号）相关的毛刺状骨膜反应（箭头）

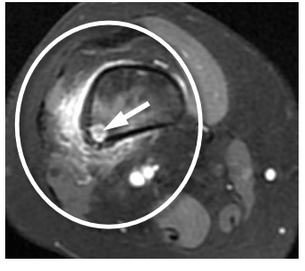
图 102

冠状位 CT 重建 (**A**) 和 MRI(**B**) 显示与骨肉瘤（星号）相关的 Codman 三角（箭头）

/ Characteristic Imaging Features

Some bone tumours have characteristic, if not pathognomonic, radiological findings that greatly help in their diagnosis (**Figure 103**).

Reactive bone and soft tissue inflammation surrounding an active osteoid osteoma



Osteoid osteomas (OO) release prostaglandins and elicit significant reactive inflammation (hence their marked response to salicylates/antiprostaglandins), which is readily shown on fluid-sensitive MR images (note the OO nidus [arrow] within the circle that highlights such reaction)

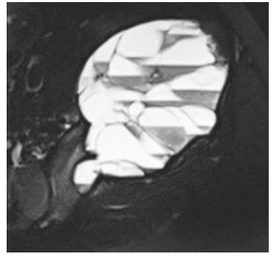
"Fallen fragment" sign in solitary bone cyst

This is actually a pathological fracture in the background of a benign lesion

Codman triangle

It shows the aggressiveness of the lesion, usually an osteosarcoma or, less commonly, osteomyelitis

Fluid-fluid levels



Fluid-fluid (or blood) levels are seen in some lesions such as aneurysmal bone cyst (above, transverse MR image of a left iliac lesion) and telangiectatic osteosarcoma

"Punched-out" lesions in multiple myeloma

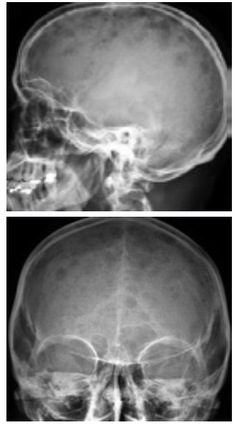


FIGURE 103

Examples of characteristic imaging findings in some bone tumours

/ Musculo-skeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 特征性影像学表现

部分骨肿瘤具有特征性（即使不是典型表现）影像学表现，这对识别诊断有很大帮助（图 103）。

活动性骨样骨瘤周围的反应性骨和软组织炎症

骨样骨瘤 (OO) 可释放前列腺素类并引起明显的反应性炎症（因此对水杨酸盐/抗前列腺素有显著反应），这在液体敏感序列 MRI 上清晰显示（注意圆圈内 OO 病灶 [箭头]，突出显示了这种反应）

孤立性骨囊肿的“碎片陷落”征象

实际上是良性病变背景下的病理性骨折

Codman 三角

提示病变的侵袭性，常见于骨肉瘤，少见于骨髓炎

液-液平面

可见于部分病变，如动脉瘤样骨囊肿（上图，左髂骨病灶的横断面 MRI）和毛细血管扩张性骨肉瘤

多发性骨髓瘤的“穿凿样”病变

图 103

部分骨肿瘤的特征性影像学表现示例

/ Radiology of Soft Tissue Tumours

On imaging, a soft tissue mass with well-defined margins is **not necessarily** benign. Smaller (≤ 5 cm) and superficial (versus deep-seated) lesions are more likely benign. Ganglion cysts and lipomas are the most common soft tissue masses. Ultrasonography is useful in discriminating solid versus cystic lesions and further characterising some solid lesions. The best combination of "MRI plus radiographs" provides specific diagnosis in only about 30%–50% of cases.

MRI is the modality of choice to show compartmental involvement, which is important in staging and to plan the route for biopsy, which is usually performed under US or CT guidance. Examples of soft tissue tumours as seen on MRI are shown in **Figure 104**.

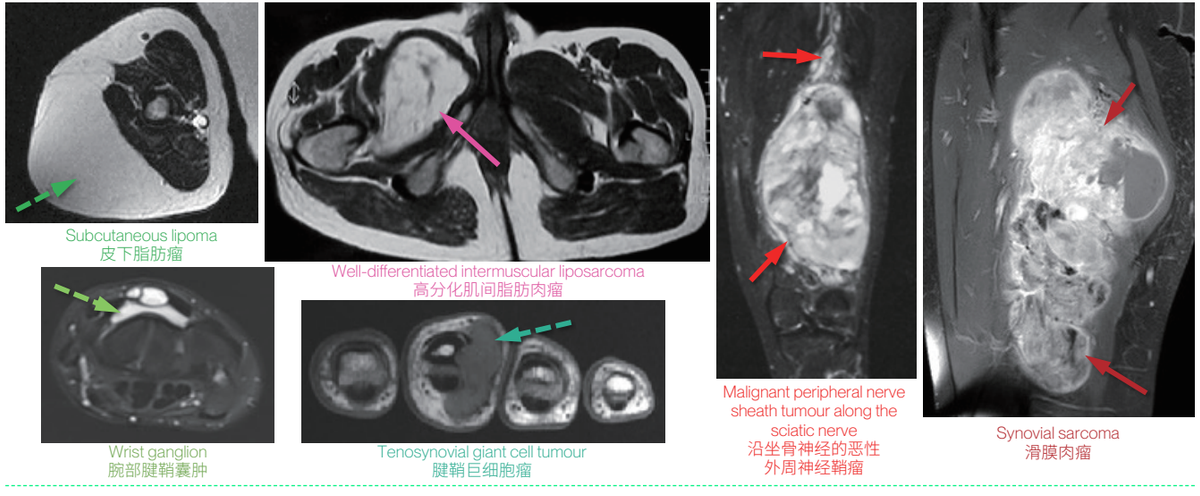


FIGURE 104

Examples of benign (**dashed arrows**) and malignant (**arrows**) soft tissue tumours as depicted by MRI.

/ Musculo-skeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 软组织肿瘤的放射学

在影像学检查显示为边界清晰的软组织肿块**不一定**是良性病变。较小 (≤ 5 cm) 和浅表层（相对于深层）病变为良性病变的可能性更大。最常见的软组织肿块是腱鞘囊肿和脂肪瘤。超声有助于区分实性和囊性病变，并可进一步表征部分实性病灶。MRI 联合 X 线片的检查仅能在约 30%–50% 的病例中提供特异性诊断。

MRI 是显示间室受累的首选方式，这对于分期和规划活检路径（通常在超声或 CT 引导下进行）非常重要。MRI 上观察到软组织肿瘤的示例见**图 104**。

图 104

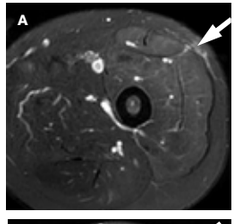
MRI 上显示的良性（**虚线箭头**）和恶性（**箭头**）软组织肿瘤示例。

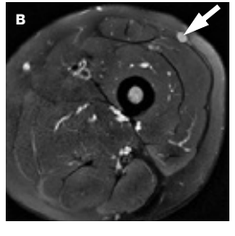
Radiology of Soft Tissue Tumours

For subcutaneous lesions, **relation with the peripheral muscular fascia** (see **Figure 11**) is important. While a preserved fascial plane between a subcutaneous mass lesion and the peripheral fascia is no guarantee of a benign histology, fascial violation by the mass lesion is a clear sign of aggressive behaviour (**Figure 105**). MRI is the best imaging modality in the follow-up of malignant soft tissue masses (**Figure 106**). Some properties of mass lesions such as internal haemorrhage or melanin content can also be identified on MRI (**Figure 107**).

FIGURE 105

Violation of the peripheral fascia (**arrows**) is a clear sign of malignancy in this myxofibrosarcoma.





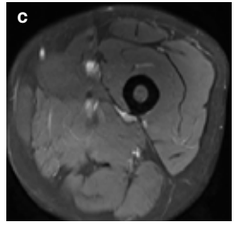


FIGURE 106

This patient was operated on for a subcutaneous mass that turned out to be an undifferentiated pleomorphic sarcoma (not shown). Postsurgicalchanges are evident in the first MRI shortly after surgery (**arrow, A**). Ten weeks later, a new soft tissue mass was identified (**arrow, B**), which was excised and confirmed to be local recurrence. Follow-up MRI four months later (**C**) was free of neoplastic masses.

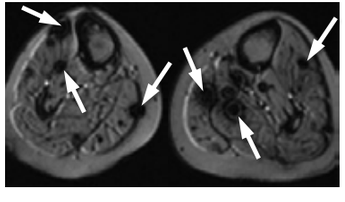


FIGURE 107

Arrows point to some of the extensive haemorrhagic calf muscle metastases from an alveolar soft part sarcoma in this special MRI sequence called "susceptibility-weighted imaging". Within the MRI machine, which features a strong magnetic field, the paramagnetic property of iron content from hemosiderin (due to haemorrhage) makes these so-called "blooming" artifacts (**arrows**) and thereby highlights bleeding.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

软组织肿瘤的放射学

对于皮下病变，理清**与周围肌肉筋膜的关系**（见图 11）非常关键。虽然皮下肿块病变和周围筋膜之间的筋膜平面保存完好并不代表组织学类型为良性，但肿块病变侵犯筋膜是侵袭性行为的明确体征（**图 105**）。MRI 是恶性软组织肿块随访中的理想影像学检查方法（**图 106**）。肿块病变的部分性质（如内出血或黑色素含量）也可在 MRI 上识别（**图 107**）。

图 105

该黏液纤维肉瘤侵犯周围筋膜（箭头），是一种恶性明确征象。

图 106

这名患者因皮下肿块接受了手术，最终由病理证实为未分化多形性肉瘤（未显示）。术后不久的第一次 MRI 检查显示术后变化明显（箭头，**A**）。10 周后，发现一个新的软组织肿块（箭头，**B**），切除后证实为局部复发。4 个月后，(**C**) 随访 MRI 显示无肿瘤肿块。

图 107

箭头指向特殊的 MRI 序列中（被称为“磁敏加权成像”），显示来自腺泡状软组织肉瘤的小腿肌肉转移灶中的广泛出血。由于磁共振成像仪具有强磁场，含铁血黄素（由于出血）的铁含量的顺磁性产生了这些所谓的“开花”伪影（箭头），从而突出显示了出血症状。

Metabolic Diseases

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

代谢疾病

/ Metabolic Diseases

The musculoskeletal system is the most bulky organ array in the human body. Because bone is a metabolically active tissue with a continuous cycle of synthesis and resorption, numerous metabolic conditions can affect not only the developing skeleton but also its final form in adults. Radiology of only a few select conditions are overviewed in this chapter:

- **Osteoporosis** (= decreased total bone mass due to decreased size of bone trabeculae and cortical bone thinning; the bone is otherwise structurally normal)
- **Osteomalacia** (osteoid = fails to undergo normal mineralisation because of vitamin D deficiency or other causes of calcium depletion)
- **Rickets** (= "childhood-equivalent" of osteomalacia)
- **Hyperparathyroidism** (= increased osteoclastic bone erosion because of excessive parathormone secretion due to a parathyroid adenoma or parathyroid hyperplasia)
- **Renal osteodystrophy** (= different patterns of bone abnormalities associated with chronic kidney disease)

CHAPTER OUTLINE:

/ 代谢疾病

章节大纲：

骨骼肌肉系统是人体中最庞大的器官系统。由于骨骼是一种代谢活跃的组织，具有连续合成和再吸收循环的特性，因此许多代谢疾病不仅会影响发育中的骨骼，还会影响成人骨骼的最终形态。本章仅对少数特定疾病的放射学做了概述：

- **骨质疏松症**（= 由于骨小梁变细和皮质骨变薄导致的骨总量减少，但骨的结构正常）
- **骨质软化**（类骨质 = 由于维生素 D 缺乏或其他缺钙原因而未能进行正常矿化）
- **佝偻病**（= 儿童期等同于骨质软化）
- **甲状旁腺功能亢进症**（= 由于甲状旁腺腺瘤或甲状旁腺增生导致甲状旁腺素分泌过多，造成破骨细胞性骨吸收增加）
- **肾性骨营养不良**（= 与慢性肾病相关的不同骨异常类型）

/ Osteoporosis: The Most Common Metabolic Bone Disease

Osteoporosis is characterised by diminished but otherwise normal bone. It may be a local phenomenon (e.g., disuse osteoporosis, **Figure 108**) as well as a generalised condition (**Figure 109**). The World Health Organization defines osteoporosis as a dual-energy X-ray absorptiometry-based (DEXA) T-score less than -2.5 standard deviations (SD) of young healthy adults (**Figure 110**). **Osteopenia** is a mild form of osteoporosis.

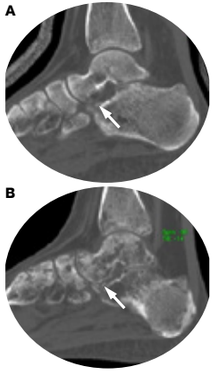


FIGURE 108

Disuse osteopenia on CT 5 weeks (**A**) and 15 weeks (**B**) after the initial injury in a 25-year-old woman with a sustentaculum tali fracture (**arrows**).

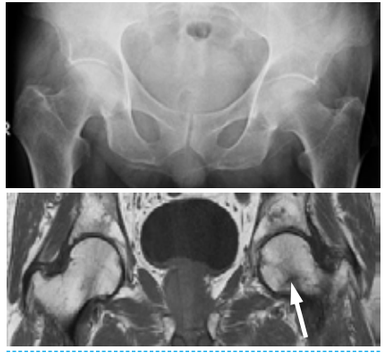


FIGURE 109

Hip fracture is the most dreaded complication of senile osteoporosis. Incomplete insufficiency fracture of the left femoral neck (**arrow**) in this 71-year-old man with osteoporosis was best shown on same-day MRI. A "hip" fracture denotes fracture of the proximal quarter of the femur.

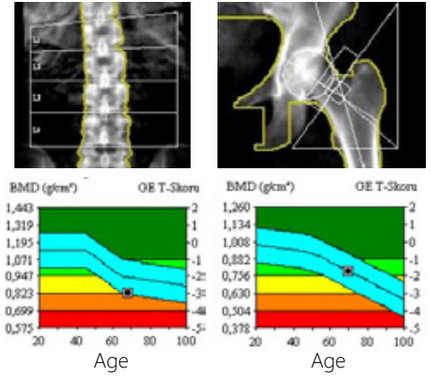


FIGURE 110

DEXA in a 70-year-old woman shows osteoporosis in the spine and osteopenia in the femoral neck.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 骨质疏松症：最常见的代谢性骨病

骨质疏松症的特征是骨量减少，但结构仍然正常。这种骨病可能发生在局部（例如，废用性骨质疏松症，图 108），也可能表现为全身性（图 109）。世界卫生组织将骨质疏松定义为：双能 X 线吸收法（DEXA）测得的 T 值低于健康年轻成人平均值 2.5 个标准差以上（图 110）。骨量减少是骨质疏松的轻度形式。

图 108

一名患有跟骨载距突骨折的 25 岁女性，在初次受伤 5 周后 (A) 和 15 周后 (B) CT 显示废用性骨量减少（箭头）。

图 109

髋关节骨折是老年性骨质疏松症最严重的并发症。这名 71 岁骨质疏松症男性的左股骨颈不全性骨折（箭头）在当天 MRI 检查中显示最为清晰。"髋关节" 骨折是指股骨近端四分之一骨折。

图 110

一名 70 岁女性 DEXA 检查示脊柱骨质疏松，股骨颈骨量减少。

/ Osteomalacia

Occurring **after the cessation of growth**, osteomalacia, in contradistinction to rickets, does **not** predominantly involve growth plates. Inadequate or abnormal mineralisation of trabecular and cortical bone is observed. Patients typically present with insufficiency fractures, formerly known as Looser zones (**Figure 111**). Large quantities of unmineralised osteoid are observed as indistinct/ill-defined trabeculae giving the impression of a "poor-quality" radiograph (**Figure 111**).

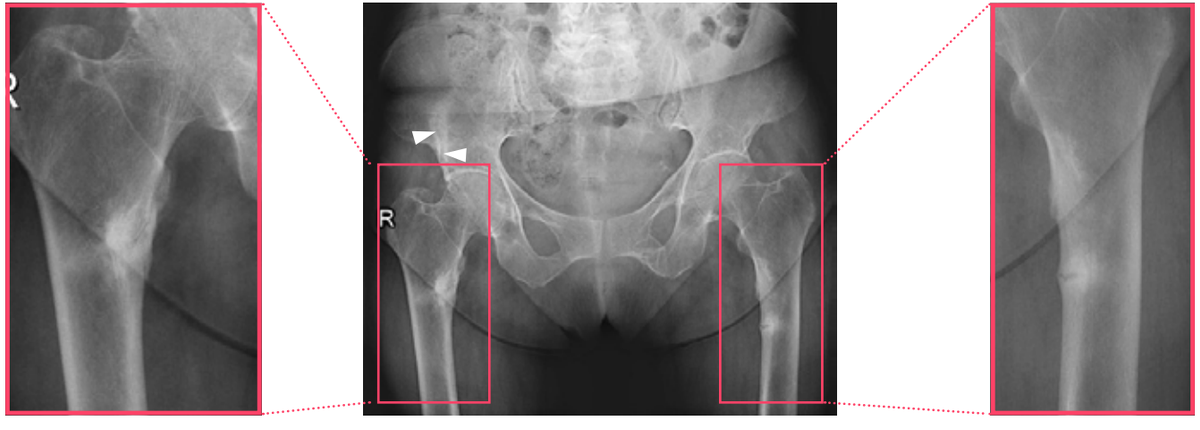


FIGURE 111

Looser zones along the bilateral medial femoral cortices, as well as in the right iliac bone (**arrowheads**), are present in this 74-year-old woman with osteomalacia. Large quantities of unmineralised osteoid are observed as indistinct/ill-defined trabeculae (especially in the diaphyses here).

/ 骨质软化

骨质软化**发生在生长停止后**，与佝偻病的区别在于主要不累及骨骺板。观察到小梁骨和皮质骨矿化不足或异常。患者通常表现为不全性骨折，以前称为 Looser 区（图 **111**）。观察到大量未矿化的类骨质，表现为小梁模糊不清/边界不清，给人一种 X 线片"质量差"的感觉（图 **111**）。

图 111

这名 74 岁骨质软化女性患者，双侧股骨内侧皮质及右髂骨可见 Looser 区（箭头）。观察到大量未矿化的类骨质，表现为小梁模糊不清/边界不清（尤其是此处的骨干）。

<!> ATTENTION

Osteomalacia can also have an oncogenic aetiology (Figure 112). This occurs when tumours secrete substances that inhibit the ability of kidney to absorb phosphate.

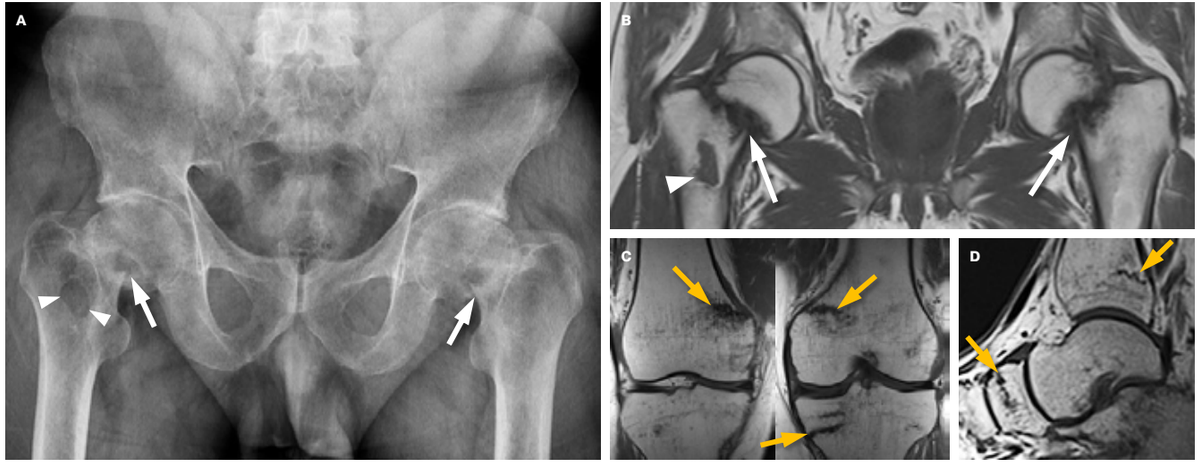


FIGURE 112

Radiograph (**A**) and cross-sectional images from different MRI examinations of the hips (**B**), knees (**C**) and ankle (**D**). This 53-year-old man had hypophosphatemia secondary to a biopsy-proven phosphaturic mesenchymal tumour in the right proximal femur (**arrowheads** in **A** and **B**), resulting in osteomalacia. Note bilateral femoral neck insufficiency fractures (**white arrows**) and indistinct/ill-defined trabeculae (representing extensive unmineralised osteoid), giving the impression of a "poor-quality" radiograph. The patient had insufficiency fractures (**yellow arrows**) also around his both knees and one ankle.

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

<!> 注意

骨质软化也可具有致癌病因（图 112）。当肿瘤分泌抑制肾脏吸收磷酸盐能力的物质时，就会成为致癌病因。

图 112

髋关节 (B)、膝盖 (C) 和踝关节 (D) 不同 MRI 检查的 X 线片 (A) 和横断面图像。这名 53 岁男性出现低磷血症，继发于活检证实的右股骨近端磷间质肿瘤（A 和 B 中的箭头尖端），导致骨质软化。注意双侧股骨颈不全性骨折（**白色箭号**）和骨小梁不清晰/界限不清（代表广泛的未矿化类骨质），给人一种 X 线片“质量差”的感觉。患者双膝和一侧踝关节周围也有不全性骨折（**黄色箭头**）。

/ Rickets

In rickets, the orderly development and mineralisation of growth plates is interrupted (**Figures 113** and **114**). Imaging findings are seen on the metaphyseal side of the growth plate because of the concentration of unmineralized osteoid there (**Figure 113**).

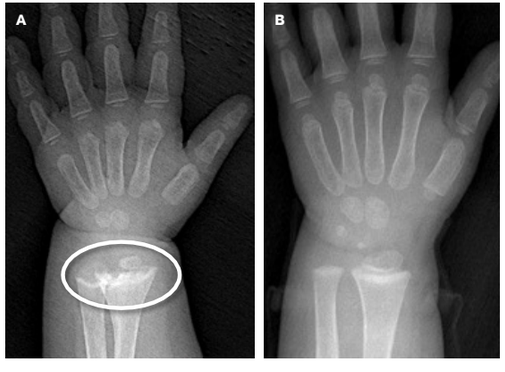


FIGURE 113

Metaphyseal widening, cupping and fraying in the distal radius and ulna (**ellipse**) of a 15-month-old girl with rickets (**A**) resolved after treatment (**B**).

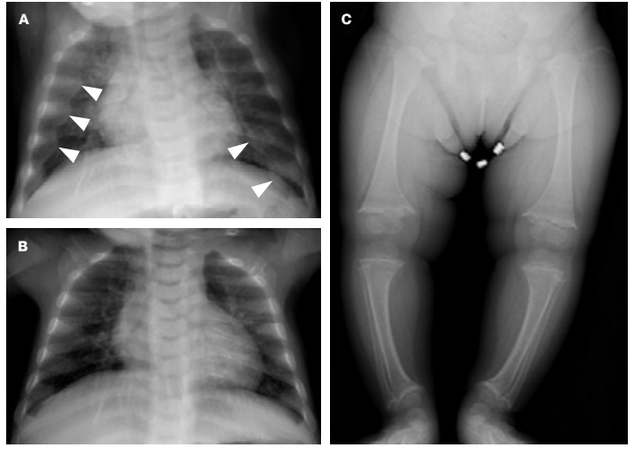


FIGURE 114

Rachitic rosary (**arrowheads** in **A**) denoting rib widening at the costochondral junctions in a 16-month-old girl with rickets resolved after treatment (**B**). Note bowing deformity of the lower extremities with metaphyseal flaring and fraying before treatment (**C**).

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 佝偻病

在佝偻病中，骺板的有序发育和矿化过程受阻（**图 113** 和 **114**）。影像学表现主要出现在骨骺板的干骺端侧，因未矿化类骨质集中于此（**图 113**）。

图 113

一名 15 个月大的佝偻病女孩 (**A**) 的桡骨远端和尺骨的干骺端增宽、呈杯状和毛糙（**椭圆形**），在治疗后消退 (**B**)。

图 114

一名 16 个月大的佝偻病女孩，串珠肋（**A** 中的箭头尖端）表示肋软骨连接处的肋骨变宽，治疗后痊愈 (**B**)。注意治疗前下肢弯曲畸形，伴干骺端扩张和毛糙 (**C**)。

Renal Osteodystrophy

Renal osteodystrophy encompasses findings seen in the setting of **chronic renal insufficiency**. Among these are findings of osteomalacia (and rickets in children) and secondary hyperparathyroidism (**Figures 115** and **116**).

Skeletal imaging findings in osteomalacia/rickets and hyperparathyroidism are **independent from the aetiology** of these three conditions.

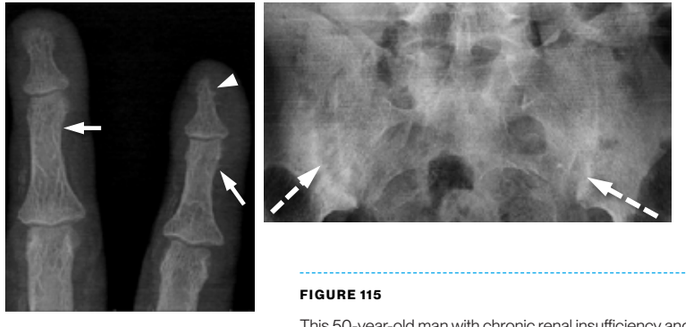


FIGURE 115

This 50-year-old man with chronic renal insufficiency and secondary hyperparathyroidism has subperiosteal bone resorption (**arrows**) at the radial aspects of the second and third middle phalanges and subchondral resorption (**dashed arrows**) in bilateral sacroiliac joints resulting in pseudo-widening. Note also acro-osteolysis in the second distal phalangeal tuft (**arrowhead**) and extensive vascular calcifications along fingers.

<!> ATTENTION

Radiologic findings of bone resorption are seen in hyperparathyroidism regardless of primary, secondary or tertiary type

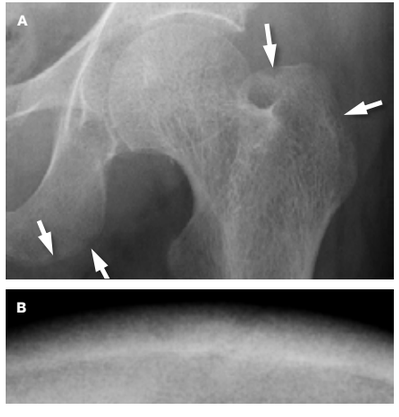


FIGURE 116

Subtendinous bone resorption (**arrows**) at the insertion sites of gluteus medius, minimus and hamstring tendons and trabecular paucity (**A** and **B**) because of cancellous bone resorption (**B** is an edge-on radiograph of the skull).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

肾性骨营养不良

肾性骨营养不良时慢性肾功能不全背景下的一系列表现。其中包括骨质软化（和儿童佝偻病）以及继发性甲状旁腺功能亢进症的发现（图 **115** 和 **116**）。

骨质软化/佝偻病和甲状旁腺功能亢进症的骨骼影像学表现与这三种疾病的病因**无关**。

<!> 注意

无论为原发性、继发性还是第三型，甲状旁腺功能亢进症均可见骨吸收的影像学表现

图 115

这名 50 岁男性患有慢性肾功能不全和继发性甲状旁腺功能亢进症，其第二和第三中指骨的桡侧出现骨膜下骨吸收（箭头），在双侧骶髂关节出现软骨下骨吸收（虚线箭头），导致假性关节间隙增宽。另可见末节指骨远端溶骨（箭头）及手指广泛血管钙化。

图 116

臀中肌、臀小肌和腘绳肌腱的插入部位出现腱下骨吸收（箭头），和松质骨吸收引起的小梁缺少（**A** 和 **B**）（**B** 为 X 线片）。

Renal Osteodystrophy: An Overlap of Osteomalacia/Rickets and Hyperparathyroidism

- Although findings in osteomalacia/rickets and hyperparathyroidism **tend to overlap**, radiographic findings of hyperparathyroidism predominate in adults, whereas those of rickets are in the foreground in children.
- The **"rugger jersey spine"** appearance (named after the pattern of horizontal stripes on jerseys worn by rugby players), denoting alternating bands of sclerosis along the vertebral body endplates and areas of lucency centrally is a characteristic feature of secondary hyperparathyroidism seen in renal osteodystrophy (**Figure 117**).
- **Soft tissue mineralisation** (in the form of vascular calcifications, chondrocalcinosis and tumoral calcinosis) is a characteristic feature of renal osteodystrophy (**Figure 118**).
- **Parathyroid adenomas** are seen in the primary and tertiary forms of hyperparathyroidism. Ultrasonography is used to detect parathyroid adenomas (**Figure 119**).

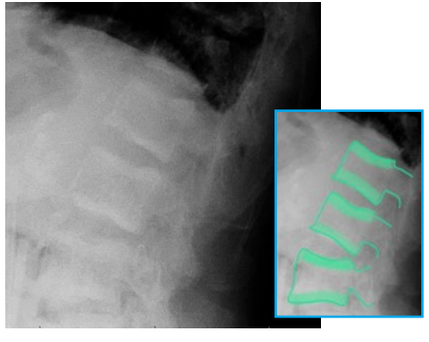


FIGURE 117

"Rugger jersey spine" appearance in a 55-year-old woman with end stage renal disease.

FIGURE 118

Soft tissue calcifications (**arrows**) in a 50-year-old man with chronic renal failure.

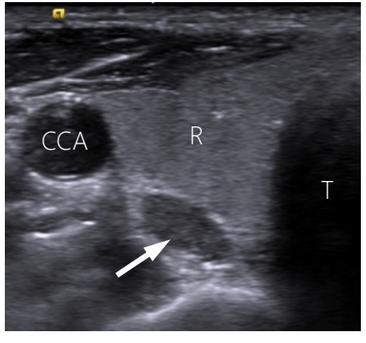


FIGURE 119

Ultrasonography (transverse image) shows a parathyroid adenoma (**arrow**) in a 36-year-old woman. Right lobe of the thyroid gland (**R**), right common carotid artery (**CCA**), trachea (**T**).

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

肾性骨营养不良：骨质软化/佝偻病和甲状旁腺功能亢进症的重叠

- 虽然骨质软化/佝偻病和甲状旁腺功能亢进症的表现**通常有所重叠**，但甲状旁腺功能亢进症的影像学表现主要见于成人，而佝偻病的影像学表现多见于儿童中。
- **"橄榄球衣征"**（以橄榄球运动员穿的球衣上的水平条纹图案命名）表明，椎体终板硬化带与中央透亮区交替分布，继发性甲旁亢特征性表现（**图 117**）。
- **软组织矿化**（表现为血管钙化、软骨钙质沉着和瘤样钙化）是肾性骨营养不良的特征性表现（**图 118**）。
- **甲状旁腺腺瘤**可见于原发性第三型甲状旁腺功能亢进症。超声为主要诊断手段（**图 119**）。

图 117

一名 55 岁终末期肾病女性患者的"橄榄球衣征外观。

图 118

一名 50 岁慢性肾功能衰竭男性的软组织钙化（箭头）。

图 119

超声（横断面图像）显示一名 36 岁女性有甲状旁腺腺瘤（箭头）。甲状腺右叶（R）、右颈总动脉（CCA）和气管（T）。

Developmental Abnormalities

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

发育异常

/ Developmental Abnormalities

Several examples of the numerous developmental abnormalities that can involve the musculoskeletal system are:

- Scoliosis (one of the etiologic factors in scoliosis is developmental dysplasia)
- Developmental dysplasia of the hip
- Femoral trochlear hypoplasia/dysplasia
- Glenohumeral dysplasia

Radiology not only brings diagnostic clues to developmental abnormalities but also provides information regarding the severity, outcome assessment and management follow-up of these conditions. Angular, point-to-point or projectional distance measurements on radiologic images are used for acquiring such information.

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 发育异常

可累及骨骼肌肉系统的多种发育异常示例如下：

- 脊柱侧凸（脊柱侧凸的病因之一是发育不良）
- 髋关节发育不良
- 股骨滑车发育不全/发育不良
- 盂肱发育不良

放射学不仅能为发育异常提供诊断线索，而且还提供了有关上述病症的严重程度、结果评估和管理随访的信息。放射学图像上的角度、点对点或投影距离测量用于获取此类信息。

/ Imaging in Scoliosis

Developmental dysplasia is only one of the causes of scoliosis, the most common type of which (i.e., adolescent idiopathic scoliosis, not shown here) remains of unknown aetiology. Radiographs, CT and MRI are widely used for the diagnosis and treatment planning, as well as follow-up of scoliosis (**Figure 120**).

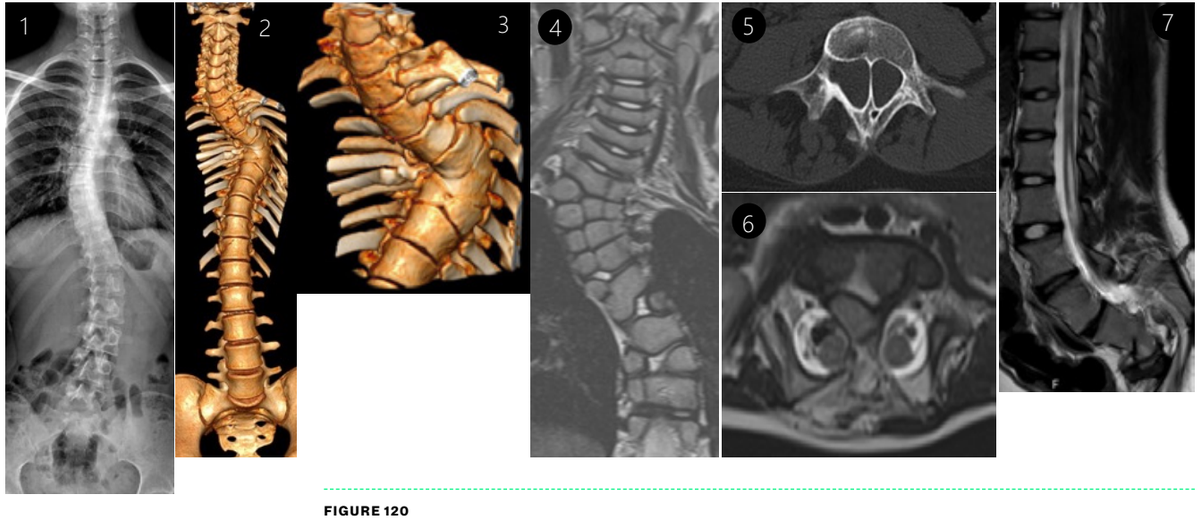


FIGURE 120

Radiographs (**1**), CT (**2, 3, 5**) and MRI (**4, 6, 7**) show scoliosis (**1**) and associated abnormalities, such as hemivertebra, block vertebra, butterfly vertebra (**2–4**), diastematomyelia (**5, 6**), tethered cord and syringomyelia (**7**) and caudal regression syndrome (**7**).

>▪< FURTHER KNOWLEDGE

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 脊柱侧凸的影像学检查

发育异常只是脊柱侧凸病因之一，其最常见类型（即青少年特发性脊柱侧凸，此处未显示）的病因尚不明确。X 线片、CT 和 MRI 广泛用于脊柱侧凸的诊断、治疗方案的制定以及随访（**图 120**）。

图 120

X 线片 (**1**)、CT（**2、3、5**）和 MRI（**4、6、7**）显示脊柱侧凸 (**1**) 和相关异常，如半脊椎畸形、阻滞椎、蝴蝶椎（**2–4**）、脊髓纵裂（**5、6**）、脊髓栓系、脊髓空洞症 (**7**) 以及尾部退化综合症 (**7**)。

>▪< 进阶知识

/ Imaging in Developmental Dysplasia of the Hip (DDH)

Ultrasonography is an excellent tool in screening for developmental dysplasia of the hip (DDH), which is recommended to take place as early as possible – but no later than the first six weeks after delivery (**Figure 121**). If untreated, DDH can progress to early-onset hip osteoarthritis (**Figure 122**).

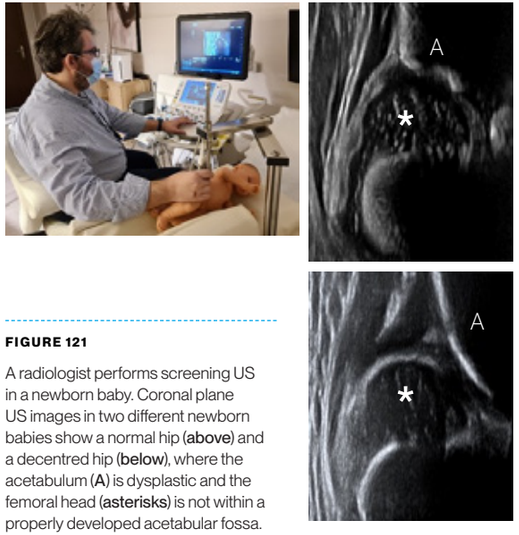


FIGURE 121

A radiologist performs screening US in a newborn baby. Coronal plane US images in two different newborn babies show a normal hip (**above**) and a decentred hip (**below**), where the acetabulum (**A**) is dysplastic and the femoral head (**asterisks**) is not within a properly developed acetabular fossa.

Ultrasonography images courtesy of Dr Konstantinos Chlapoutakis, Heraklion, Crete, Greece

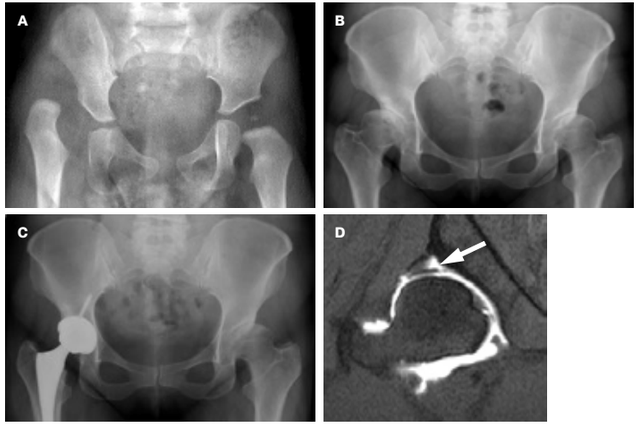


FIGURE 122

Radiographs show an infant with DDH on the right side (A) and a 37-year-old woman with DDH on both sides (**B**). The woman developed early-onset osteoarthritis and had a total hip replacement four years later (**C**). MR-arthrography image of the same woman (**D**) shows a thickened acetabular labrum with a tear (**arrow**).

/ Musculoskeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 髋关节发育不良 (DDH) 的影像学检查

超声是筛查髋关节发育不良 (DDH) 的良好工具，建议出生后尽早实施，且不迟于 6 周内（图 **121**）。如果不进行治疗，DDH 会发展为早发性髋关节骨关节炎（图 **122**）。

图 121

放射科医生对新生儿进行 US 筛查。两个不同新生儿的冠状位 US 图像显示，正常的髋关节（**上方**）和偏心的髋关节（**下方**），可见髋臼 (**A**) 发育不良及股骨头（**星号**）位置异常。

超声图像由希腊伊拉克利翁克里特岛的 Konstantinos Chlapoutakis 医生提供

图 122

X 线片显示，一名婴儿右侧患有 DDH(A)，一名 37 岁女性两侧患有 DDH(**B**)。该女性出现了早发性骨关节炎，四年后接受了全髋关节置换术 (**C**)。同一位女性的 MR 关节造影图像 (**D**) 显示髋臼唇增厚并伴有撕裂（箭头）。

/ Take-Home Messages

- Sufficient and relevant clinical information needs to be given to the radiologist by the referring clinician in order to provide the best service to the patient, which encompasses the validation or determination of the best imaging modality and technique and evaluation of the imaging study.
- First-line diagnostic modality in musculoskeletal (MSK) imaging is radiography.
- Computed tomography (CT) is usually reserved for the identification and better characterisation of some fractures, assessment of bone lesions in complex anatomic areas and estimation of the mineral load in gout.
- In the MSK system, ultrasonography (US) is mainly used in the evaluation of superficial structures.
- Magnetic resonance imaging (MRI) is an excellent tool for imaging soft tissues, joints and bone marrow—including occult fractures.
- An algorithmic approach starting with the identification of joint space narrowing on radiographs is useful in many arthropathies.
- After trauma, lipohaemarthrosis on imaging suggests that an intra-articular fracture is present.
- Imaging closely reflects pathophysiology in osteomyelitis—but should not delay joint fluid aspiration and microbiologic assessment in suspected septic arthritis.
- Location across the body and site within a bone are, along with the patient's age, the key determinants of a bone tumour.

/ Musculo-skeletal Imaging

CHAPTER OUTLINE:

/ 骨骼肌肉影像学

章节大纲：

/ 核心要点

- 转诊临床医生需向放射科医生提供充足且相关的临床信息，以便为患者提供理想服务，其中包括验证或确定理想影像学确认或选择最合适的影像学检查方法与技术，以及对影像学检查结果的评估。
- 骨骼肌肉 (MSK) 成像的首选诊断方式是 X 线摄影。
- 计算机断层扫描 (CT) 通常用于识别和更好地表征一部分骨折、评估复杂解剖区域的骨病变，以及估算痛风中的矿物沉积量。
- 在 MSK 系统中，超声主要用于评估浅表结构。
- 磁共振成像 (MRI) 是软组织、关节和骨髓（包括隐匿性骨折）成像的良好工具。
- 首先通过 X 线片识别关节间隙狭窄，这种算法适用于许多关节病。
- 在创伤后，影像学上出现关节脂血症提示存在关节内骨折。
- 在骨髓炎中，影像学能够较好地反映病理生理过程—但在怀疑化脓性关节炎时，影像学检查不应延误关节液穿刺及微生物学评估。
- 病变在全身的分布部位以及在单块骨中的具体位置，结合患者年龄，是诊断骨肿瘤的关键决定因素。

- Many aggressive bone lesions have indistinct margins on radiographs.
- A soft tissue mass with well-defined (distinct) margins on imaging is not necessarily benign.
- Biopsy of MSK lesions needs to be performed within the framework of compartmental anatomy.
- As the largest array of organs in the human body, the MSK system gives clues on imaging to many metabolic diseases.
- Imaging is essential in many generalised or focal developmental abnormalities.

Musculo-skeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

- 许多侵袭性骨病变在 X 线片上表现为边界不清。
- 在影像学检查上显示为边界清晰（明显）的软组织肿块不一定是良性病变。
- MSK 病变的活检需要依据间室解剖结构进行。
- 作为人体中最大的器官系统，MSK 系统通过影像学检查可为众多代谢性疾病提供指向性线索。
- 影像学在多种全身性或局灶性发育异常的诊断中至关重要。

Suggested Reading and Sources

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- Pathria MN et al. Acute and stress-related injuries of bone and cartilage: pertinent anatomy, basic biomechanics and imaging perspective. Radiology 2016; 280:21–38
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Musculo-skeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

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- Wu JS, Hochman MG. Soft-tissue tumors and tumorlike lesions: a systematic imaging approach. Radiology 2009; 253:297–316
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Test Your Knowledge

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

知识测试

Test Your Knowledge

<?> QUESTION

1 Which is the characteristic site of muscle strains?

- ☐ Muscle belly
- ☐ Myotendinous junction
- ☐ Tendon
- ☐ Tendo-osseous junction

CHAPTER OUTLINE:

章节大纲：

知识测试

<?> 问题

1 哪个部位是肌肉拉伤的特征性部位？

- ☐ 肌腹
- ☐ 肌腱连接处
- ☐ 肌腱
- ☐ 腱骨连接处

/ Test Your Knowledge

<?> ANSWER

1 Which is the characteristic site of muscle strains?

- ☐ Muscle belly
- ■ Myotendinous junction
- ☐ Tendon
- ☐ Tendo-osseous junction

CHAPTER OUTLINE:

章节大纲：

/ 知识测试

<?> 回答

1 哪个部位是肌肉拉伤的特征性部位？

- ☐ 肌腹
- ■ 肌腱连接处
- ☐ 肌腱
- ☐ 腱骨连接处

Test Your Knowledge

<?> QUESTION

2 Which is the first-line imaging modality to examine joints?

- ☐ Ultrasonography
- ☐ Computed tomography
- ☐ Magnetic resonance imaging
- ☐ Radiography

CHAPTER OUTLINE:

知识测试

<?> 问题

2 下方哪种影像学检查是关节检查的首选方法?

- ☐ 超声
- ☐ 计算机断层扫描
- ☐ 磁共振成像
- ☐ X 线摄影

章节大纲:

Test Your Knowledge

<?> ANSWER

2 Which is the first-line imaging modality to examine joints?

- ☐ Ultrasonography
- ☐ Computed tomography
- ☐ Magnetic resonance imaging
- ■ Radiography

CHAPTER OUTLINE:

知识测试

<?> 回答

2 下方哪种影像学检查是关节检查的首选方法?

- ☐ 超声
- ☐ 计算机断层扫描
- ☐ 磁共振成像
- ■ X 线摄影

章节大纲:

Test Your Knowledge

<?> QUESTION

3 Punched out erosions with overhanging edges surrounding the 1st metatarsophalangeal joint, along with preservation of joint space width, are characteristic of:

- ☐ Gout
- ☐ Rheumatoid arthritis
- ☐ Psoriatic arthritis
- ☐ Osteoarthritis

CHAPTER OUTLINE:

知识测试

章节大纲：

<?> 问题

3 第一跖趾关节周围伴有突出边缘的穿凿样侵蚀、关节间隙宽度保留，该描述是以下哪项疾病的特征：

- ☐ 痛风
- ☐ 类风湿关节炎
- ☐ 银屑病关节炎
- ☐ 骨关节炎

/ Test Your Knowledge

<?> ANSWER

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/ 知识测试

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Test Your Knowledge

<?> QUESTION

4 Which of the following is most likely an insufficiency fracture?

- ☐ Distal femur fracture in a 16-year-old girl following motor vehicle accident
- ☐ Hip fracture in a 72-year-old woman who fell in a bathroom
- ☐ Metatarsal fracture in a newly-recruited 21-year-old soldier
- ☐ Distal radius fracture in an otherwise healthy 34-year-old woman who slipped on ice and fell on her outstretched hand

Musculoskeletal Imaging

CHAPTER OUTLINE:

知识测试

骨骼肌肉影像学

章节大纲：

<?> 问题

4 下述哪种情况最可能是不全性骨折？

- ☐ 一名 16 岁女孩机在车祸后，出现股骨远端骨折
- ☐ 一名 72 岁女性在浴室跌倒后，出现髋关节骨折
- ☐ 一名 21 岁新招募的士兵出现跖骨骨折
- ☐ 一名 34 岁健康女性在冰上滑倒，摔倒时伸手撑地，出现桡骨远端骨折

/ Test Your Knowledge

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CHAPTER OUTLINE:

章节大纲：

/ 知识测试

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Test Your Knowledge

<?> QUESTION

5 Lipohaemarthrosis on a horizontal X-ray beam radiograph denotes that a fracture is:

- ☐ Comminuted
- ☐ Open
- ☐ Intra-articular
- ☐ Displaced

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

知识测试

<?> 问题

5 水平 X 射线束 X 线片上显示关节脂血症，表明骨折：

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- ☐ 开放性
- ☐ 关节内
- ☐ 移位性

Test Your Knowledge

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Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

知识测试

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/ Test Your Knowledge

<?> QUESTION

6 An otherwise healthy 20-year-old male presents with knee pain following trauma during a football game. Radiographs reveal soft tissue swelling about the knee and a well-defined 4-cm lytic cortical-subcortical lesion at the lateral aspect of the distal femur with a thin sclerotic rim and mildly lobulated outline. Later, MRI reveals an anterior cruciate ligament tear and no fluid-fluid levels within the described femur lesion. The previously asymptomatic distal femur lesion is most likely:

- ☐ an osteosarcoma
- ☐ an osteoid osteoma
- ☐ a non-ossifying fibroma
- ☐ an aneurysmal bone cyst

CHAPTER OUTLINE:

章节大纲：

/ 知识测试

<?> 问题

6 一名 20 岁健康男性在橄榄球比赛中因外伤导致膝盖疼痛。X 线片显示膝关节周围软组织肿胀，股骨远端外侧有边界清晰的 4 cm 溶骨性皮质-皮质下病变，薄硬化边界和轻度分叶状轮廓。随后，MRI 显示前交叉韧带撕裂，且上述股骨病变内无液-液平面。既往无症状的股骨远端病变最有可能是：

- ☐ 骨肉瘤
- ☐ 骨样骨瘤
- ☐ 非骨化性纤维瘤
- ☐ 动脉瘤样骨囊肿

/ Test Your Knowledge

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CHAPTER OUTLINE:

章节大纲：

/ 知识测试

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- ☐ 动脉瘤样骨囊肿

/ Test Your Knowledge

<?> QUESTION

7 What would be your recommendation for the bone lesion in the previous question?

- ☐ Leave it alone
- ☐ Close follow-up with MRI every 3 months for a year
- ☐ Surgical resection
- ☐ Make a biopsy according to compartmental anatomy considerations

CHAPTER OUTLINE:

章节大纲：

/ 知识测试

<?> 问题

7 针对上述问题中的骨病变，您会给出何种建议？

- ☐ 不予处理
- ☐ 每 3 个月进行一次 MRI 密切随访，持续 1 年
- ☐ 手术切除
- ☐ 根据间室解剖结构注意事项进行活检

/ Test Your Knowledge

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/ **Musculo-skeletal** Imaging

CHAPTER OUTLINE:

/ **骨骼肌肉** 影像学

章节大纲：

/ 知识测试

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Test Your Knowledge

<?> QUESTION

8 **Which of the following suggests more aggressiveness for bone lesions on radiographs?**

- ☐ Solid type periosteal reaction
- ☐ Metaphyseal location
- ☐ Involvement of a long bone
- ☐ Permeative pattern
- ☐ Narrow zone of transition

Musculoskeletal Imaging

CHAPTER OUTLINE:

知识测试

骨骼肌肉影像学

章节大纲：

<?> 问题

8 **下列哪项表明放射学检查发现的骨病变更具侵袭性？**

- ☐ 实性骨膜反应
- ☐ 位于干骺端
- ☐ 长骨受累
- ☐ 渗透性
- ☐ 过渡区狭窄

Test Your Knowledge

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CHAPTER OUTLINE:

章节大纲：

知识测试

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- ☐ 长骨受累
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- ☐ 过渡区狭窄

Test Your Knowledge

<?> QUESTION

9 A soft tissue mass with well-defined (distinct) margins on imaging is benign.

- ☐ True
- ☐ False

知识测试

<?> 问题

9 影像学检查显示边界清晰（明显）的软组织肿块一定是良性病变。

- ☐ 对
- ☐ 错

Test Your Knowledge

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- ■ False

CHAPTER OUTLINE:

知识测试

章节大纲：

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Test Your Knowledge

<?> QUESTION

10 Osteoporosis is best assessed with:

- ☐ Radiographs
- ☐ Ultrasonography
- ☐ Magnetic resonance imaging
- ☐ Dual-energy X-ray absorptiometry

Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

知识测试

<?> 问题

10 骨质疏松症的理想评估方法：

- ☐ X 线
- ☐ 超声
- ☐ 磁共振成像
- ☐ 双能 X 线吸收测量法

Test Your Knowledge

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Musculoskeletal Imaging

CHAPTER OUTLINE:

骨骼肌肉影像学

章节大纲：

知识测试

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