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Musculoskeletal and Emergency Imaging

Imaging of facet joint diseases

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ABSTRACT

Facet joints are the important articular pillars of the spine. Several pathologies can occur in and around the facet joint, including extra ossicles, traumatic dislocation, osteoarthritis, synovial cyst, axial spondyloarthritis, rheumatoid arthritis, calcium pyrophosphate deposition disease, septic arthritis, and malignant and benign neoplasms. Imaging is the mainstay to detect and characterize these diseases. In this review, we discuss the anatomy and function of facet joints, imaging techniques, and the imaging findings of several facet joint diseases. This information may be helpful to radiologists to make the correct diagnosis and optimize the management of patients with facet joint diseases.

1. Introduction

Facet joints, also known as zygapophyseal joints, are the important articular pillars of the spine. They provide overall mobility while preserving mechanical stability of the spine. Several pathologies can occur in and around the facet joint. Imaging is the mainstay to detect and characterize these diseases. It is the task of the radiologist to make an accurate diagnosis. In this review, we discuss the anatomy and function of facet joints, imaging techniques, and the imaging findings of several facet joint diseases. This review may be helpful to practicing radiologists who are dealing with facet joint diseases.

2. Anatomy and function of facet joints

Facet joints are formed by the superior and inferior articular processes of two adjacent vertebrae (Fig. 1) which are covered with hyaline cartilage.^{1–3} At each spinal level, the bilateral facet joints are symmetrically positioned in the postero-lateral region.^{1–3} Facet joints are synovial joints: a fibrous joint capsule with a synovial lining which is continuous with the periosteum connects the articulating cartilaginous surfaces and forms a synovial cavity.^{2,3} The facet joints allow for spinal flexion and extension while limiting rotation and preventing the vertebrae from subluxing over each other.^{1,2} The articular processes and cartilage support axial loading while the fibrous joint capsule in conjunction with the ligamentum flavum resists tensile forces during rotations and translations.¹ The facet joint capsule, synovium, and

subchondral bone are highly innervated, providing proprioception and pain sensation.^{1–3} Because of regionally different biomechanics, the facet joint orientation and shape of the articulating surface vary between the cervical, thoracic, and lumbar spine.³ Facet articular surfaces are more horizontally-oriented in the cervical and upper thoracic spine, which enables a great degree of axial rotation and lateral bending.¹ In the lower thoracic and lumbar spine, the facet articular surfaces gradually become more vertically-oriented, which decreases both rotation and lateral bending.¹

3. Imaging techniques

Radiography is the first-line modality to assess spinal alignment and to detect gross pathology of the facet joints. However, radiography is rather insensitive and does not provide detailed information on the facet joints. CT and MRI are the leading imaging modalities for diagnosis of facet joint diseases. CT provides excellent bony detail and is highly sensitive in detecting calcifications, whereas MRI is superior in evaluating soft tissues and edema-like signal intensity in bone and soft tissue. CT and MRI are sometimes complementary in establishing the correct diagnosis. Nuclear imaging techniques, including bone scintigraphy and ¹⁸F-FDG PET, may be useful for the assessment of disease activity but they lack specificity.

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Fig. 1. Facet joint anatomy, cervical level, with axial (A) and sagittal (B) views. The superior and inferior articular processes form the articulating surfaces of the facet joints (magenta color in A and B). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.) Note that this figure was adopted from reference [45], which is in the public domain.

Fig. 2. 22-year-old man with Oppenheimer ossicles. Sagittal CT image shows well-defined ossicles with smooth corticated margins adjacent to the inferior articular processes of L2 and L3.

4. Facet joint diseases

4.1. Extra ossicles

In 1942, Albert Oppenheimer⁴ reported the presence of a normal variant ossicle near the facet joint, which was named after him. The Oppenheimer ossicle has been regarded to represent a non-fusion

remnant of secondary ossification centres of the articular processes.^{4–7} They are usually covered by cartilage and contained within the joint capsule.⁶ Although their size varies, they always have smooth corticated margins.⁵ Their prevalence in the general population is unknown and they are usually encountered as an incidental finding in a patient with no history of trauma, with the inferior articular processes of L2 and L3 being the most common location⁵ (Fig. 2). Oppenheimer ossicles have been reported to be bilateral or multiple in about 20% of cases.^{5,6} Noteworthy, a later study disputed the existence of normal variants such as the Oppenheimer ossicle.⁸ In their study, the majority (73%) of young symptomatic athletes with extra ossicles had posterior element stress changes (i.e. sclerosis and hypertrophy of laminae and pedicles) or pars interarticularis defects.⁸ Therefore, the authors postulated that these extra ossicles are indicative of stress-induced changes in the posterior neural arch rather than normal variants.⁸ Whether normal variants or not, radiologists should carefully look for posterior element stress changes or pars interarticularis defects whenever ossicles near facet joints are identified, especially in symptomatic individuals (Fig. 3). CT is the most accurate imaging modality to detect extra ossicles and pars interarticularis defects.^{8,9}

4.2. Traumatic dislocation

Although the more horizontal orientation of the facet joints in the cervical spine increases flexibility,¹ it also makes the cervical spine more vulnerable to dislocation after traumatic injury. Locked facet joint is a type of facet joint dislocation in which the inferior articular process has moved over the superior articular process and has become locked in that position (Fig. 4). On axial CT images, it appears as the “naked facet sign”.¹⁰ It is caused by flexion-distraction injury and indicative of severe ligamentous disruption and spinal instability.¹⁰ There may be an associated facet fracture (Fig. 4). The lower cervical spine levels are most frequently involved.^{11–14} Neurological morbidity is high, especially among patients with bilateral facet fracture-dislocation injuries.¹¹

4.3. Osteoarthritis (OA)

OA is a degenerative process involving the cartilage, subchondral bone, synovium, joint capsule, and periarticular soft tissues.¹⁵ Facet joint OA is strongly associated with degenerative disc disease and a

Fig. 3. 32-year-old man with a facet joint ossicle and pars interarticularis defect. Coronal (A) and axial (B) CT images show a well-defined ossicle with smooth corticated margins near the left L2-L3 facet joint. Sagittal CT image (C) shows a defect in the left pars interarticularis (arrowheads).

Fig. 4. 22-year-old man with facet fracture-dislocation after falling from a trampoline. Sagittal CT image (A) shows anterior dislocation of the inferior articular process of C5 over the superior articular process of C6 (arrow). There is an associated fracture of the superior articular process of C6 (arrowhead).

common cause of neck and back pain^{15,16} Facet joint OA is not evenly distributed throughout the spine. In the lumbar spine, prevalence is highest at L4-L5, followed by L5-S1. In the cervical spine, facet joint OA is more common in the mid-cervical region, at C3-C4 and C3-C5.¹⁵ Commonly reported risk factors for OA (including increasing age, female sex, overweight, trauma, occupational factors, and smoking) also apply to the facet joint¹⁵ (Fig. 5). In the spine, idiopathic scoliosis can cause facet joint OA due to the degenerative effects of chronic abnormal loading.¹⁷ On imaging, facet joint OA is characterized by cartilage loss,

joint effusion, subarticular bone erosions, subchondral cysts, subchondral sclerosis, subchondral bone marrow oedema-like lesions (BMLs), osteophyte formation, and hypertrophy of the articular processes.^{15,18,19} Neural complications may occur due to narrowing of the dural sac, lateral recess, and neural foramen. Numerous grading systems for facet joint OA exist²⁰ and, to our knowledge, there is no international consensus on the preferred system to use. Imaging markers which may be associated with symptomatic facet joint OA include subchondral BMLs on MRI¹⁵ and radionuclide uptake on SPECT/CT or PET/CT^{21–23} (Fig. 6).

4.4. Synovial cyst

Synovial cysts are cystic-appearing lesions with a synovial lining and they are continuous to the facet joint. They may occur in the setting of OA, spinal instability (such as in spondylolisthesis) and trauma.²⁴ Facet joint synovial cysts typically occur in the lumbar spine, with the L4–L5 level being the predilection site.²⁴ They may cause symptoms if they cause canal stenosis or nerve compression at the level of the lateral recess. On MRI, synovial cysts appear as well-delineated extradural lesions, adjacent to the facet joint.²⁴ The connection with the facet joint is usually not perceivable on imaging. Typical synovial cysts show internal fluid-like signal intensity and thin, peripheral contrast enhancement. However, synovial cysts may have a proteinaceous content with higher signal intensity than CSF.²⁴ They may also contain gas or calcification, and may even cause bony erosion, all of which are better depicted on CT²⁴ (Fig. 7). Although considered rare, synovial cysts may bleed (Fig. 7), which can lead to a sudden increase in volume and severe neurological deficits and/or painful symptoms.²⁵

4.5. Axial spondyloarthritis

Axial spondyloarthritis is an inflammatory rheumatic disease with a variable clinical presentation.²⁶ Ankylosing spondylitis is the most common subtype.¹⁵ The disease usually manifests in young adults and the sacroiliac joints are typically affected. However, the spine, including the facet joints, can also be involved.¹⁵ To date, there is no recommendation to routinely perform spine MRI for the initial diagnosis.²⁶ As such, the exact frequency of facet joint involvement in patients is patients with seronegative spondyloarthropathy is not clear. Facet arthritis

Fig. 5. 38-year-old woman with facet OA due to idiopathic scoliosis. Posteroanterior radiograph (A) shows mild left convex scoliosis with the apex at the L3-L4 level (note that there are 6 lumbar vertebrae). Posteroanterior radiograph (A), sagittal (B) and axial (C) CT images show osteophyte formation and hypertrophy of the articular processes at the L3-L4 level (arrows).

Fig. 6. 80-year-old woman with facet OA. Axial CT image (A) shows osteophyte formation and hypertrophy of the facet joints at the L5-S1 level (arrows). Axial fused PET/CT image (B) shows markedly increased ^{18}F -FDG uptake in the left facet joint (arrow), consistent with synovitis.

Fig. 7. 73-year-old man with a complex facet joint synovial cyst. Axial (A) and sagittal (B) T2-weighted images show a synovial cyst with hypointense content medial to the L4-L5 facet joint (arrows). The contents of the synovial cyst are hyperintense on the axial T1-weighted image (C). The hypointense T2 signal intensity and hyperintense T1 signal intensity are consistent with hemorrhage in the synovial cyst. Axial CT image (D) shows pressure erosion of the left posterior part of the L4 vertebral body (arrowhead).

Fig. 8. 60-year-old man with long-standing ankylosing spondylitis (Bechterew disease). Sagittal CT image shows ankylosis of the facet joint at the L2-L3 level (arrow). There are also bridging syndesmophytes (arrowheads).

on MRI manifests as joint effusion, synovial enhancement, erosions, and subchondral BMLs.^{27,28} Other spinal changes associated with axial spondyloarthritis are florid anterior or posterior spondylitis (i.e. Romanus lesion), florid diskitis (i.e. Andersson lesion), enthesitis of the interspinous ligaments, and costovertebral joints arthritis.²⁷ In later stage of the disease, syndesmophyte formation and ankylosis occur²⁷ (Fig. 8).

4.6. Rheumatoid arthritis (RA)

RA commonly affects the spine, and has a predilection for the cervical level.^{15,29} The most common radiological presentation of cervical involvement in RA is the presence of periodontoid pannus with possible atlantoaxial subluxation, cranial settling, and subaxial subluxation.²⁹ Cervical facet arthritis is observed in 25% to 80% of patients with RA.¹⁵ Involvement of the lumbar and thoracic spine is considered relatively uncommon, reportedly, affecting only 3% to 5% of patients with RA.¹⁵ Compared with OA, erosive features are more pronounced in RA, proliferative features are less frequent, and there may be facet subluxations.¹⁵

4.7. Gout

There is an abundance of case reports on spinal gout in the literature.³⁰ The true frequency of spinal gout is probably underestimated.³⁰ Middle-aged men are typically affected.³⁰ The spine may be the first location where gout causes clinical symptoms, including back pain and

nerve compression.³⁰ Most patients have a history of hyperuricemia or gout.³⁰ Spinal gout can occur throughout the entire spine, with the lumbar spine being the most commonly involved region according to the literature.^{30–33} Spinal gout may affect the facet joint, as well as the laminae, ligamentum flavum, and epidural space.³¹ MRI findings are rather nonspecific.³⁴ Tophi may demonstrate either homogenous or heterogeneous peripheral enhancement³⁴ (Fig. 9). If spinal gout is considered, CT can be very helpful to establish the diagnosis with more certainty. The most common CT findings include bony erosions with well-defined sclerotic margins, facet or intervertebral bone neoformation, and hyperdense juxta- or intra-articular masses³² (Fig. 9). Dual-energy CT, which differentiates materials based on their relative absorption of X-rays at different photon energy levels, can be used to detect monosodium urate crystal deposition (Fig. 9) with high sensitivity and specificity.³⁵

4.8. Calcium pyrophosphate deposition disease (CPPD)

CPPD represents the deposition of calcium pyrophosphate dihydrate crystals within articular cartilage and para-articular tissues.^{36–38} Aging is the main risk factor.³⁷ CPPD can cause acute arthritis and can essentially occur anywhere throughout the musculoskeletal system, with the knee, wrist, shoulder, pubic symphysis, hip, and periodontoideal area being the most commonly reported locations.^{36–39} In the spine, CPPD can occur around the odontoid, in the intervertebral disc, ligamentum flavum, the interspinous ligament, and facet joint.^{37–39} Isolated involvement of facet joints by CPPD (Fig. 10) has been reported to be uncommon.³⁸ CT is the most sensitive imaging modality to detect the punctate, linear, or mass-like calcifications in the setting of CPPD.³⁷

4.9. Septic arthritis

Isolated septic facet arthritis is an underdiagnosed clinical entity.⁴⁰ Most cases are caused by hematogenous seeding during episodes of transient or persistent bacteremia, whereas some cases are iatrogenic, secondary to facet injections or instrumentation.^{40,41} Patients with diabetes, chronic kidney disease, liver disease, immunosuppression, and intravenous substance abuse are at increased risk.⁴¹ Isolated septic facet arthritis has a more acute presentation compared to spondylodiscitis, and back pain is frequently unilateral.⁴⁰ In addition, the majority of patients have fever, bacteraemia, and elevated CRP.⁴⁰ Because the facet joint can only contain a small volume of purulent exudate, septic facet arthritis frequently shows paraspinal or epidural extension.^{40,41} The lumbar spine is most commonly affected, followed by the thoracic and cervical spine.⁴⁰ MRI is the imaging modality of choice, being very sensitive and specific for septic facet arthritis.⁴¹ MRI findings of septic facet arthritis include joint effusion, peri-articular bone marrow edema, and inflammatory changes in adjacent soft tissues, including phlegmon or abscesses in paraspinal muscles and the epidural space^{40,41} (Fig. 11).

4.10. Neoplasms

Some malignant and benign neoplasms can occur in the posterior elements, near the facet joint. In contrast to true articular facet disease, bone marrow abnormalities are usually not confined to the articulating superior and inferior articular processes, lesions may be expansile, and joint effusion is absent. These features mostly allow for a straightforward discrimination between neoplasms and other facet joint diseases. Metastases (Fig. 12) and hematologic malignancies (including multiple

Fig. 9. 55-year-old man with facet gout. Axial postgadolinium T1-weighted image with fat suppression (A) shows a mass with heterogeneous peripheral enhancement at the right L2-L3 facet joint (arrowheads). Coronal heavily T2-weighted MR myelography (B) demonstrates that the mass causes an indentation in the dural sac (arrow). Sagittal CT image (C) shows the mass to be hyperdense (arrowheads). Sagittal dual-energy CT image (D), in which green areas are indicative of uric acid, reveals the presence of monosodium urate crystal deposition (arrowheads), consistent with gout. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 10. 58-year-old woman with CPPD. Sagittal (A) and axial (B) CT images show mass-like calcifications around the left facet joint at the L4-L5 level (arrowheads).

Fig. 11. 80-year-old man with septic facet arthritis. Sagittal T2-weighted image with fat suppression (A) shows effusion in the right L4-L5 facet joint (arrowhead) and edema in the surrounding soft tissues (arrow). Axial postgadolinium T1-weighted image with fat suppression (B) shows enhancement of the right L4-L5 facet joint (large arrow), epidural enhancement (small arrow), and an abscess with rim enhancement in the right psoas muscle (arrowhead). Axial (C) and coronal (D) contrast-enhanced CT images also depict the abscess in the right psoas muscle (arrowheads).

Fig. 12. 75-year-old woman with breast carcinoma metastasis. Sagittal T1-weighted image (A) and sagittal postgadolinium T1-weighted image with fat suppression (B) show a metastatic lesion in the right superior articular process of T9 (arrows).

Fig. 13. 50-year-old man with chondrosarcoma. Sagittal proton-density weighted image with fat suppression (A), axial T2-weighted image (B), and axial diffusion-weighted image show an expansile mass in the left superior articular process of C6 (arrow). There is also involvement of the transverse process, pedicle, lamina, and base of the spinous process.

myeloma, and plasmacytoma) are by far the most common malignant lesions in the spine and posterior elements. Primary bone tumors near the facet joints are relatively rare. Primary malignant bone tumors include chondrosarcoma (Fig. 13), osteosarcoma, and Ewing sarcoma, all of which often show extension into the vertebral body.^{42–44} Primary benign tumors include osteoid osteoma (Fig. 14), osteoblastoma, aneurysmal bone cyst (Fig. 15), and osteochondroma (Fig. 16).^{42–44}

5. Conclusion

Several pathologies can occur in and around the facet joint, including extra ossicles, traumatic dislocation, OA, synovial cyst, axial spondyloarthritis, RA, CPPD, septic arthritis, and malignant and benign neoplasms. Knowledge of the distinctive imaging characteristics of each of these pathologies (Table 1) may help the radiologist to make the correct diagnosis and optimize patient management.

Fig. 14. 35-year-old man with osteoid osteoma. Axial T2-weighted image with fat suppression (A) shows bone marrow edema in the vertebral body, left pedicle, left transverse process, laminae, and spinous process (arrowheads). In addition, there is edema in the surrounding soft tissues (arrow). Axial (B) and sagittal (C and D) CT images show a lucent nidus (arrows in B and C) within surrounding sclerotic reactive bone (arrows in D).

Fig. 15. 16-year-old girl with aneurysmal bone cyst. Sagittal T2-weighted (A), axial T2-weighted (B), pre-gadolinium T1-weighted (C), and post-gadolinium T1-weighted images show a lesion in the posterior elements of T11 (arrows), with involvement of the bilateral facet joints at the T10-T11 and T11-T12 levels. The lesion has characteristic fluid-fluid levels, which is best depicted on the axial T2-weighted image (B). The lesion shows peripheral and septal enhancement (D).

Fig. 16. 40-year-old woman with osteochondroma. Axial CT image demonstrates a well-defined bone-forming tumor with lobulated contours arising from the posterior aspect of the left inferior articular process of C5 (arrow).

Table 1
Distinctive imaging characteristics of diseases in and around the facet joint.

Pathology	Distinctive imaging characteristics
Extra ossicles	Extra ossicles of variable size with smooth corticated margins There may be associated posterior element stress changes or pars interarticularis defects
Traumatic dislocation	“Naked facet sign” on axial CT images There may be an associated facet fracture
OA	Subchondral cysts, subchondral sclerosis, osteophyte formation, hypertrophy of articular processes
Synovial cyst	Well-delineated cystic-appearing extradural lesions adjacent to the facet joint
Axial spondyloarthritis	Coexistence of other spondyloarthritis features, including florid anterior spondylitis, florid diskitis, enthesitis of the interspinous ligaments, and costovertebral joints arthritis Syndesmophyte formation and ankylosis in later stage
RA	Pronounced erosions, subluxations Coexistence of periodontoid pannus
Gout	Hyperdense juxta- or intra-articular masses, monosodium urate crystal deposition at dual-energy CT
CPPD	Coexistence of CPPD calcification in typical locations such as the knee, wrist, shoulder, pubic symphysis, hip and around the odontoid
Septic arthritis	Presence of phlegmon or abscesses in paraspinal muscles and the epidural space
Neoplasms	Bone marrow abnormalities usually not confined to the articular processes, lesions may be expansile, and joint effusion is absent

Declaration of competing interest

The authors declare that they have no conflict of interest.

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