C15-How Imaging Modalities Assist in Providing Treatment Options for Heterotopic Ossification

Objectives

01

Define Heterotopic Ossification

02

Recognize the Clinical Significance of Accurate Diagnosis and Treatment Planning

03

Evaluate the Strengths and Limitations of Common Imaging Modalities

04

Identify why CT is the gold standard for diagnosing and staging HO

05

Understand the use of Modalities in Identifying Heterotopic Ossification

Introduction

What is Heterotopic Ossification?

Treatment Process

Imaging Types

- Radiographs
- CT
- MRI
- Ultrasound
- Nuclear Medicine

Preferred Imaging

Conclusion

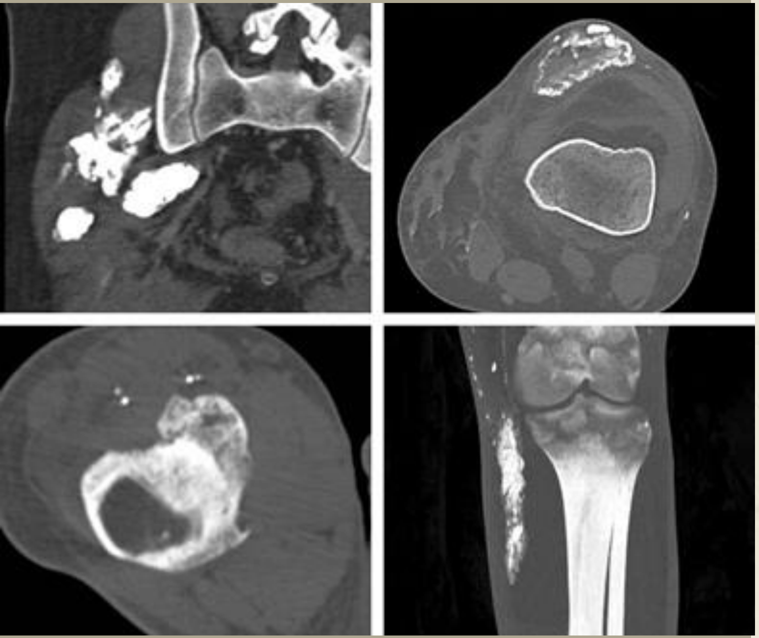


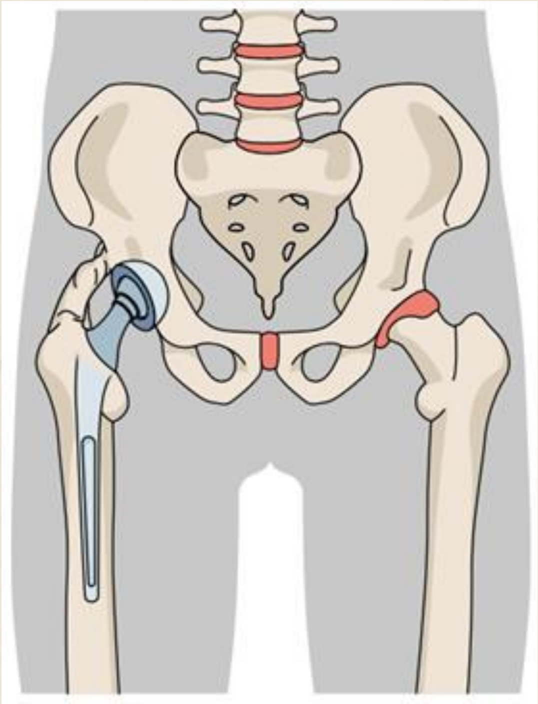
Figure A. Images of HO as seen through Computed Tomography
(Source: CTisus, 2025)

What is Heterotopic Ossification

- Heterotopic Ossification (HO), defined as “the abnormal growth of mature, extraskeletal lamellar bone within soft tissues such as joints, muscle tendons, or ligaments.” Commonly affected areas include the elbow, hip/femur, pelvis, and shoulder.

- HO most often develops following trauma, neurological injury, or genetic disorders. Symptoms typically appear between three and twelve weeks after the initial event (Shehab et al., 2004) and typically worsen as heterotopic bone expands.

- As HO progresses, patients may experience decreased range of motion, limited mobility, and difficulty performing daily tasks. Severe cases can result in compression of nerves and blood vessels, potentially causing chronic pain, neuropathy, deep vein thrombosis, or lymphedema.



A graphic illustrating HO of the right hip with a hip prosthetic provided by mindthegraph.com

Treatment Process

The treatment process for **heterotopic ossification (HO)** is usually **stepwise and individualized**, depending on the cause, severity, and symptoms. Treatment cannot begin without precise imaging.

Identification and Monitoring

- Imaging is used to confirm the diagnosis or track the progression of HO.
- Early detection helps guide prevention and limits functional impairment.

Preventative Management

- “Gentle ROM exercises, indomethacin, etidronate, and external beam radiation, which is primarily used after joint arthroplasty”(Sun & Hanyu-Deutmeyer, 2023).
- Use of NSAIDs as prophylaxis.

Surgical Intervention

- The affected area is resected or removed.
- Surgical intervention is deferred until full bony maturation to minimize the risk of recurrence.
- Considered when HO causes significant pain, nerve compression, or loss of joint function.

Imaging Types

Radiographs

CT

MRI

Ultrasound

Nuclear Medicine

Each of these modalities contributes unique information; the following will review their roles, limitations, and comparative value in imaging heterotopic ossification.

Radiographs

Figure 1. X-ray of HO in lateral knee. (Source: Woon, 2024)

- Radiography is a utilized imaging modality that uses high-energy, short-wavelength electromagnetic radiation to penetrate tissues and generate high-contrast images of dense anatomical structures, particularly bone.

- Can identify mature heterotopic bone; however, they provide limited soft tissue detail and may miss early HO, which can appear as vague, amorphous densities (Meyers et al., 2019).

- As a one-dimensional imaging modality, X-ray lacks the detail necessary to determine lesion maturity or evaluate involvement of surrounding structures.

Computed Tomography(CT)

Figure 5. CT scan of HO in right hip replacement.
(Source: Rasuli, 2025).

- Uses rotating X-ray beams and computer reconstruction to generate highly detailed cross-sectional images of the body's internal structures.

- Exceptional visualization of both mineralized bone and surrounding soft tissues, making it the gold standard for diagnosing and assessing HO (Mujtabaet al., 2019).

- Accurately depicts the extent, location, and maturity of heterotopic bone; key factors for effective decision-making regarding surgical removal and conservative management.

- Offers faster acquisition times, broad accessibility, and is more cost effective compared to MRI.

Magnetic Resonance Imaging (MRI)

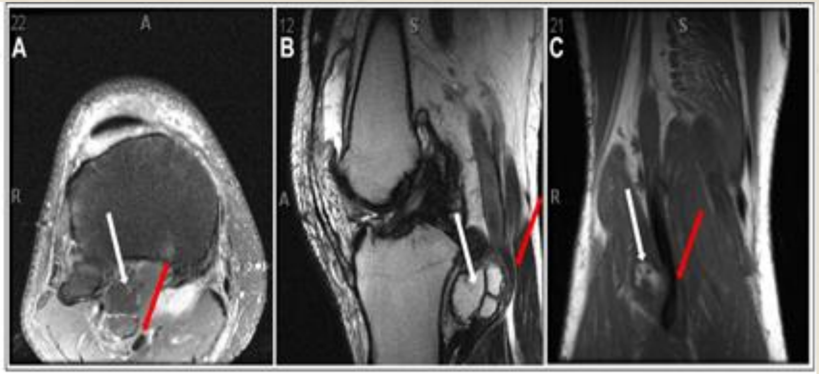


Figure 4. MRI scan of HO in right popliteal fossa.
(Source: Wu, et al., 2023).

- Uses radiofrequency pulses and magnetic fields to produce three-dimensional images of the body, particularly of soft tissue structures such as tendons, ligaments, and organs.

- Highly effective in detecting early inflammatory changes, edema, and soft tissue involvement before bone mineralization occurs.

- Limited by long scan times, susceptibility to metal-related certifications, and patient intolerance related to pain, implanted hardware, or claustrophobia.

- May misinterpret mature HO as neoplastic processes, such as osteosarcoma (Meyers et al., 2014), thereby reducing diagnostic accuracy in later stages.

Ultrasound

Figure 2. Ultrasound of HO in hip. (Source: Lin, S.-H. et al, 2014).

- It is a non-invasive imaging modality that uses high-frequency sound waves to generate real-time images of soft tissues, blood flow, and internal organs. It is cost-effective, widely accessible, radiation-free, and portable.

- Helpful in differentiating HO from conditions such as deep vein thrombosis (DVT), a condition that may share overlapping symptoms due to vascular compression (Lin, S.-H.et al., 2014).

- Limited by the poor penetration of deep structures and the inability to visualize calcified tissue. Dense bone casts acoustic shadows that obscure underlying anatomy, preventing comprehensive assessment of lesion extent.

- It cannot fully characterize HO or provide guidance for surgical planning.

Nuclear Medicine

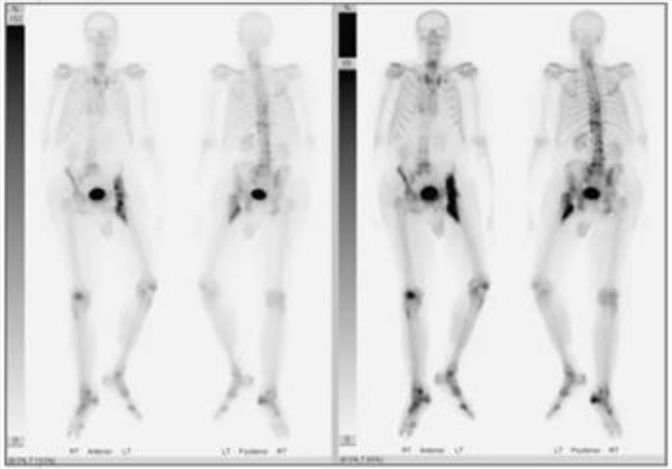


Figure 3. Triple phase bone scan of HO in left hip. (Source: *Heterotopic ossification,* 2019).

- It is a specialized medical imaging modality that uses small traces of a radioactive substance. Most commonly used for health research, diagnosis, and treatment of various conditions.
- One of the scans used is a **triple-phase bone scan** used to evaluate bone disorders, including fractures, infection, and tumors.

How it Works

1) Intravenous injection of a radioisotope
2) The radioisotope accumulates in areas of increased bone metabolism
3) Images are obtained in three phases: flow phase, blood pool phase, and delayed (bone) phase.
4) The gamma camera after several hours then captures images as seen in figure 3.

- Is regarded as the “most sensitive method for detecting HO, with the earliest detection being 2.5 weeks post trauma” (Mujtabaet al., 2019).
- Costly and slow acquisition times.

What Imaging is Preferred?

CT v. X-ray

- X-rays may miss early or subtle HO and provide only two-dimensional information.
- Overlapping structures can obscure lesion margins.
- CT detects HO earlier and accurately provides volumetric/spatial assessments (3D reconstruction).

CT v. US

- Ultrasound is limited by acoustic shadowing from dense structures such as bone.
- Cannot reliably assess deep or complex cases of HO; hard to fully characterize mineralization.
- CT offers a more consistent and reproducible image independent of depth or patient habitus.

CT v. Nuc Med

- Nuclear medicine detects early metabolic activity without the precise anatomical detail.
- CT provides localization, morphology, and the extent of the ossification.

CT v. MRI

- MRI excels in soft tissue analysis, but it is less sensitive to mineralized bone.
- CT clearly delineates calcification patterns and bone maturation with faster acquisition.

Conclusions

- Heterotopic Ossification is defined as abnormal bone growth typically found in the joint of soft tissue spaces, with treatment options ranging based on the severity of the condition.

- Medical imaging is a vital tool used in the monitoring and evaluation of treatment plans for Heterotopic Ossification.

- Each imaging modality has positive and negative effects when being used in the evaluation and treatment of Heterotopic Ossification.

- Computed Tomography (CT) is considered the gold standard due to its accurate depictions and impressive visualizations of both mineralized bone and soft tissue structures.

- Having an accurate understanding of the specifications of Heterotopic Ossification through the use of imaging, primarily CT, can assist in the individualized treatment planning and precise diagnosis of the condition.

References

Craig Hospital. (2024, January 26). *Heterotopic ossification*. https://craighospital-org.translate.goog/resources/heterotopic-ossification?_x_tr_sl=en&_x_tr_tl=tr&_x_tr_hl=tr&_x_tr_pto=tc

John Hopkins University. (n.d.). *Educational tools*. CTisus. https://ctisus.com/learning/features/ct-appearance/musculoskeletal-ct-appearances-heterotopic-ossification

Knipe, H. (2025, August 21). *Bone Scintigraphy*. Radiopaedia. https://radiopaedia.org/articles/bone-scintigraphy-1

Lin, S.-H., Chou, C.-L., & Chiou, H.-J. (2014). Ultrasonography in early diagnosis of heterotopic ossification. *Journal of Medical Ultrasound, 22*(4), 222–227. https://doi.org/10.1016/j.jmu.2014.10.004

Mayo Foundation for Medical Education and Research. (2024, April 2). *Bone scan*. Mayo Clinic. https://www.mayoclinic.org/tests-procedures/bone-scan/about/pac-20393136

Musculoskeletal Key. (2019, July 6). *Heterotopic ossification*. https://musculoskeletalkey.com/heterotopic-ossification-6/

References cont.

Meyers, C., Lisiecki, J., Miller, S., Levin, A., Fayad, L., Ding, C., Sono, T., McCarthy, E., Levi, B., & James, A. W. (2019). Heterotopic Ossification: A comprehensive review. *JBMR plus*, *3*(4), e10172. https://doi.org/10.1002/jbm4.10172

Mujtaba, B., Taher, A., Fiala, M. J., Nassar, S., Madewell, J. E., Hanafy, A. K., & Aslam, R. (2019). Heterotopic ossification: radiological and pathological review. *Radiology and oncology*, *53*(3), 275–284. https://doi.org/10.2478/raon-2019-0039

Northwestern Memorial Hospital Department of Radiology & Department of Nuclear Medicine. (2023, November). *Triple-phase bone scan* [Patient education handout]. Northwestern Memorial HealthCare.

Professional, C. C. medical. *(2025, September 23). What are X-rays?* Cleveland Clinic. *https://my.clevelandclinic.org/health/diagnostics/21818-x-ray*

Rasuli, B. (2025, September 6). *Heterotopic ossification: Radiology reference article*. Radiopaedia. https://radiopaedia.org/articles/heterotopic-ossification?lang=us

Shehab, D., Elgazzar, A. H., & Collier, B. D. (2002, March 1). Heterotopic ossification. *Journal of Nuclear Medicine*. https://jnm.snmjournals.org/content/43/3/346

References cont.

Sun, E., & Hanyu-Deutmeyer, A. A. (2023, July 31). *Heterotopic Ossification*. Nih.gov; StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK519029

Tan, B. (Ed.). (2021). *Heterotopic ossification*. Physiopedia. https://www.physio-pedia.com/Heterotopic_Ossification

Wheeless, C. R. (2020, July 22). *Triphasic bone scan*. Wheeless' Textbook of Orthopaedics. https://www.wheelessonline.com/bones/triphasic-bone-scan/

Woon, C. (n.d.). *Heterotopic ossification*. Orthobullets. https://www.orthobullets.com/pathology/8044/heterotopic-ossification

Wu, Y., et al. (2023). Heterotopic ossification in right popliteal fossa causing arterial insufficiency. *Journal of Vascular Surgery Cases, Innovations and Techniques, 9*(4), 101360. https://doi.org/10.1016/j.jvscit.2023.101360