

Clinical benefits of Spectral CT for investigation of two musculoskeletal conditions.



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Introduction

Computed tomography has an important role in musculoskeletal radiology. Fractures, tumors, and other conditions can be easily evaluated by CT. Conventional Single Energy CT (SECT) provides information about the size, shape and structural integrity of bone anatomy and surrounding soft tissues. Dual Energy CT (DECT) achieves the same as SECT but also provides additional information

such as, iodine maps, Effective Z, Electron Density, material density information, and multi-energy Monochromatic images. In this paper we will report two clinical applications of Spectral DECT which cannot be achieved with SECT.

Canon Medical recently introduced the Aquilion ONE / PRISM Edition CT System. The company's new Spectral CT technology, based on rapid kV switching coupled with Deep Learning Reconstruction, is installed in the Aquilion ONE / PRISM Edition CT system (Figure 1).

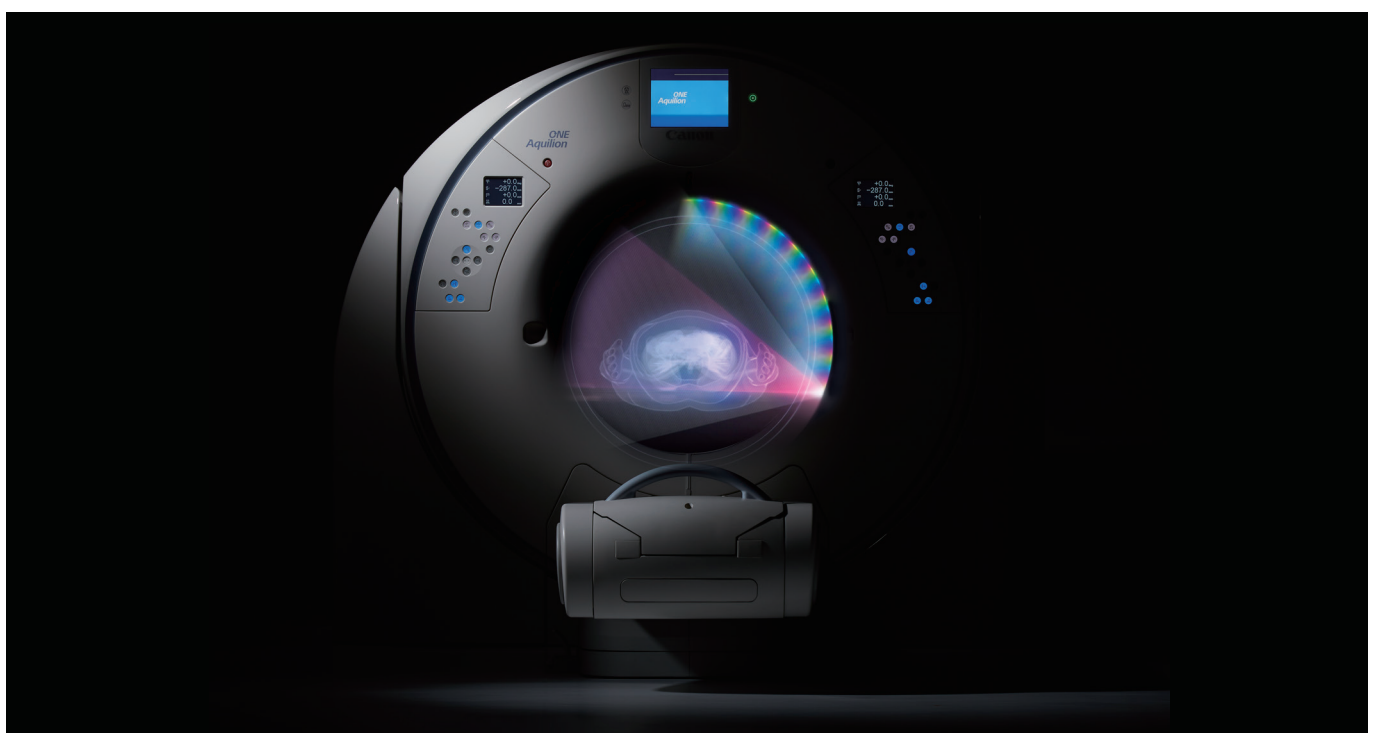


Figure 1: Aquilion ONE / PRISM Edition and Spectral acquisition.

Deep Learning Spectral CT

The Spectral CT technology in the Aquilion ONE / PRISM Edition is based on rapid kV switching with patient specific mA modulation combined with Deep Learning Reconstruction and is available in both helical and volume scan mode with a full 50 cm FOV coverage. The Spectral Volume scan mode provides 16 cm of longitudinal coverage and supports one-rotation acquisition, convenient for anatomy such as the head, hands, and feet.

The advantage of Spectral Deep Learning Reconstruction is its ability to transform multi-energy raw data sets into complete and separate high and low energy sinograms. Spectral Reconstruction works by transforming energy – agnostic information from one energy to the other to create Deep Learning Views (DLVs). DLVs are generated by

the trained neural network using measured data from both the opposite energy views as well as adjacent same energy views. The result is two complete high and low energy sinograms that are precisely aligned providing excellent energy separation.

The reconstruction process is completed by taking advantage of the established noise reduction capabilities of Deep Learning to create low noise Spectral CT image data (Figure 2). This provides high resolution and low noise properties you would expect from a routine diagnostic CT exam. The result of this Spectral DLR is two basis material pairs: water (iodine) and iodine (water). These two basis material pairs are the foundation for all further spectral image creation and the input volumes required for all Spectral post-processing tools available on the Vitrea workstation. (Figure 3).

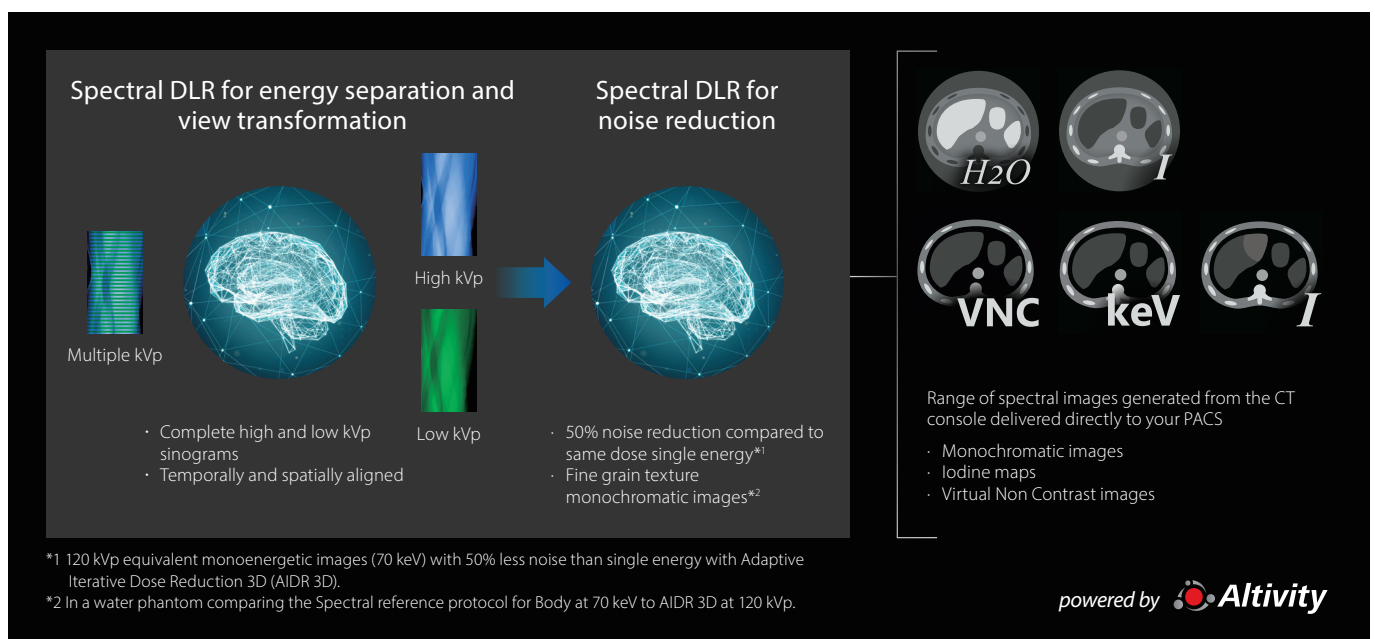


Figure 2: Spectral CT Deep Learning Reconstruction process.

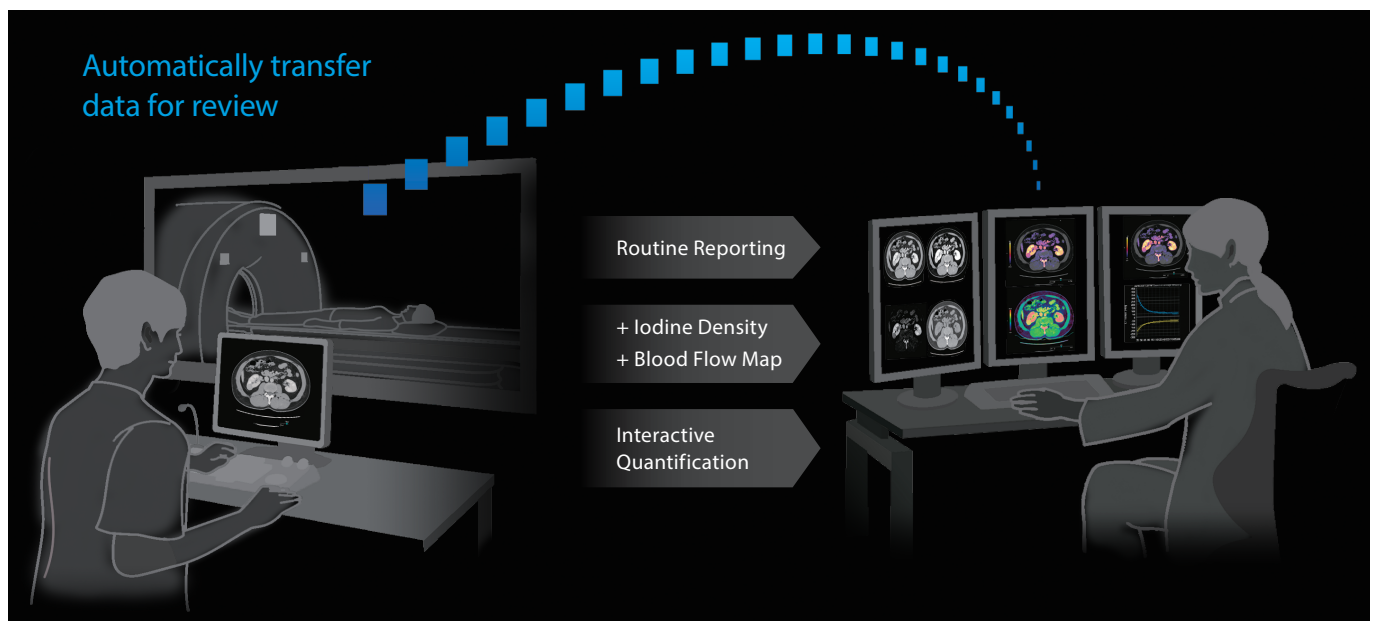


Figure 3: Spectral CT provides a seamless workflow and an extensive suite of application tools on the Vitrea Workstation.

Bone Marrow Edema

Bone Marrow Edema (BME) is associated with biomechanical alterations or post-traumatic situations; it can also be generated by acute or chronic inflammation¹. BME is easily identified on Magnetic Resonance (MRI) examination as an area of hyperintensity in specific sequences of fat suppression²⁻³.

The detection of bone marrow edema is important because of its diagnostic and prognostic value. The edema may indicate underlying structural damage and may modify the clinical management of patients depending on the pathology found⁴⁻⁶.

Spectral Dual Energy and Bone Marrow Edema

The Dual Energy technique has also been shown to be useful in the clinical evaluation of BME, tendons and ligaments⁷. The Spectral Analysis application on the Vitrea Workstation can generate a Virtual Non-Calcium (VNCa) map. In the VNCa map the cortical bone can be suppressed allowing visualization of the bone marrow. Bone marrow has a high fat content and has a Hounsfield Unit range similar to adipose tissue. Blood and other fluids cause the bone marrow to increase in density which may be visible in the VNCa maps (Figures 4 & 5).

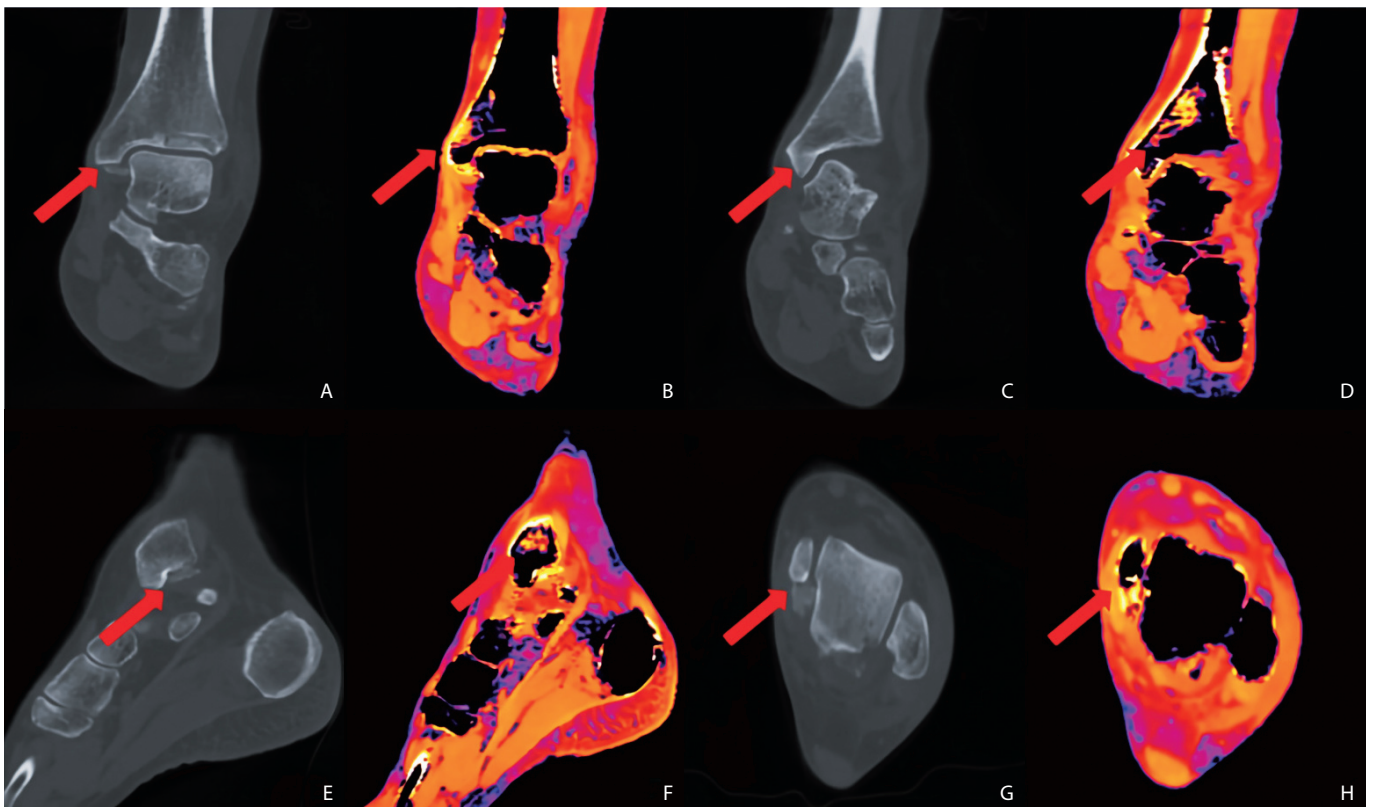


Figure 4: Ankle Fracture. Spectral monochromatic images at 70 keV. Images A, C, E and G show impacted microfractures in the medial aspect of the distal metaphyseal region of the tibia. Images with color maps (B, D, F and H) in the coronal, sagittal and axial planes reveal a pattern of bone edema caused by the fracture. This pattern becomes visible exclusively through the utilization of the spectral technique, which effectively suppresses calcium and generates the VNCa map.

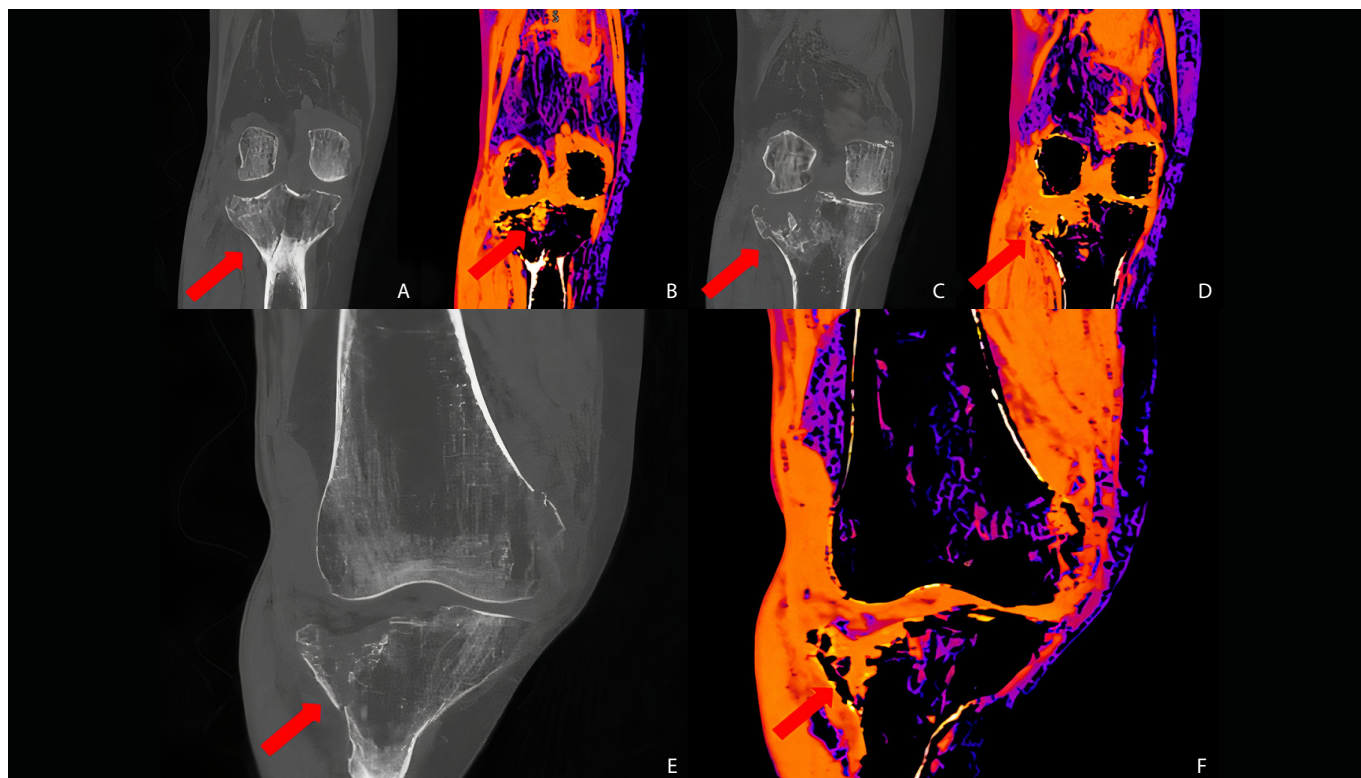


Figure 5: Knee fracture. Spectral monochromatic images at 70 keV. Comminuted fracture of the tibial plateau and external region of the femoral condyle. There is a misalignment between the bone fragments and a sinking of the articular surface (images A, B and E). Images B, D and F reveal massive bone edema in the joint region and in the circumferential region of the knee.

Spectral Dual Energy and Gout

Gout is a manifestation and periarticular inflammatory response to deposition of monosodium urate (MSU) crystals in soft tissues and joints. The formation of these crystals can lead to acute or chronic arthropathy and the formation of gouty tophi and nodular aggregates similar to masses of urate crystals¹⁰.

Gout is one of the most common types of arthropathies with crystal deposition, and its incidence and prevalence continue to increase, which may be related to the increased consumption of alcohol, especially red wine and beer, a diet rich in certain types of foods (purine), physical trauma, surgeries, chemotherapy and diuretic use¹¹.

The diagnosis of gout has traditionally been based on clinical findings, laboratory results and joint aspirates, with imaging tests used as adjuncts. Typically, patients may present with clinical features of pain affecting peripheral joints, along with hyperuricemia on hematological investigations¹².

Spectral CT and the Spectral Composition Analysis application on the Vitrea workstation can confirm the presence of MSU in patients with a tophus. Spectral Composition Analysis outputs the MSU volume estimate and applies a color overlay on 3D / 2D images for visualization of the MSU. Figure 6 shows clinical examples of gout in Spectral CT.

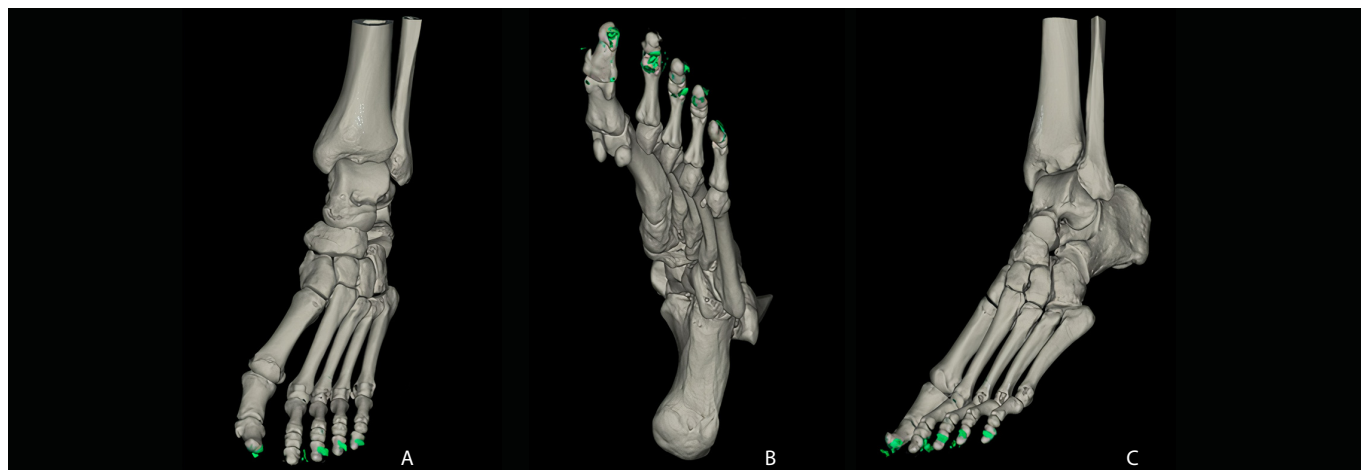


Figure 6: Tophaceous (green) deposits in the distal phalanges on the 3D images.

Conclusion

Canon's Spectral technology offers excellent anatomical image quality and low noise. By utilizing Spectral Analysis on the Vitrea workstation, clinicians can generate novel maps for BME evaluation and employ Spectral Composition Analysis to identify tophi aggregates in peri-articular anatomy, which is crucial for diagnosing Gout. These innovative features add significant value to musculoskeletal radiology, contributing to more informed clinical decisions and improving radiological therapeutic approaches. Undoubtedly, Canon's Spectral technology enhances value in MSK imaging and contributes to improved patient care.

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