Why Cone Beam CT Can Make 3D the Standard of Care in Extremity Imaging

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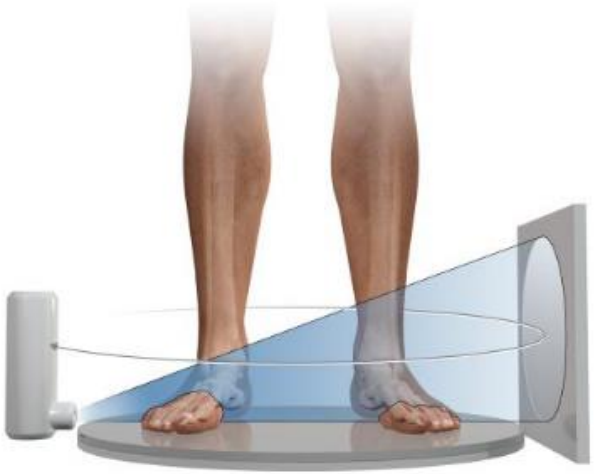
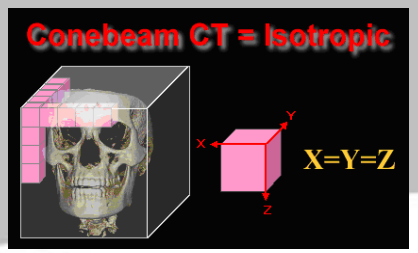
Council on Ionizing Radiation Measurements and Standards
2017 Silver Anniversary Meeting

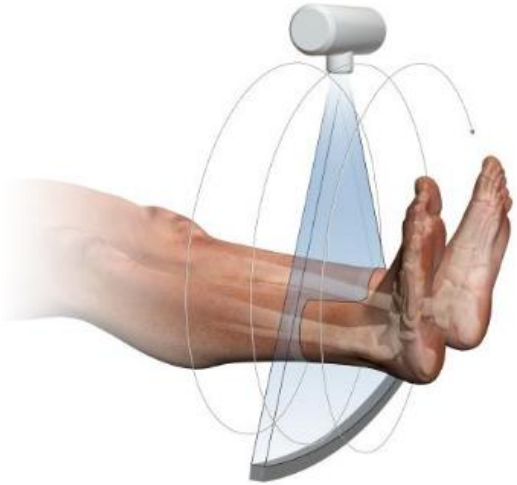
What is Cone Beam CT?

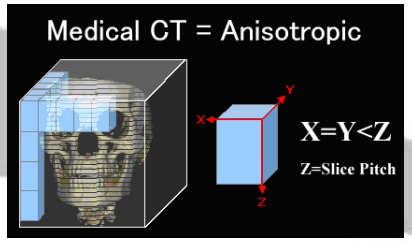
Cone Beam CT – rectangular, cone shaped beam scans with designated area of interest





Multi-Detector Medical CT – narrow, fan shaped beam with spiral scanning area of interest





Cone Beam CT vs Traditional CT

Pro's

Cone Beam CT	Medical CT
Lower Dose	Higher Dose
Smaller Footprint, point of care	Larger Footprint, external imaging center
More Affordable	More Expensive
True Weight-bearing capabilities for lower extremities	Only simulated weight-bearing capabilities
True sitting up position for skull	Only supine position for skull

Cons

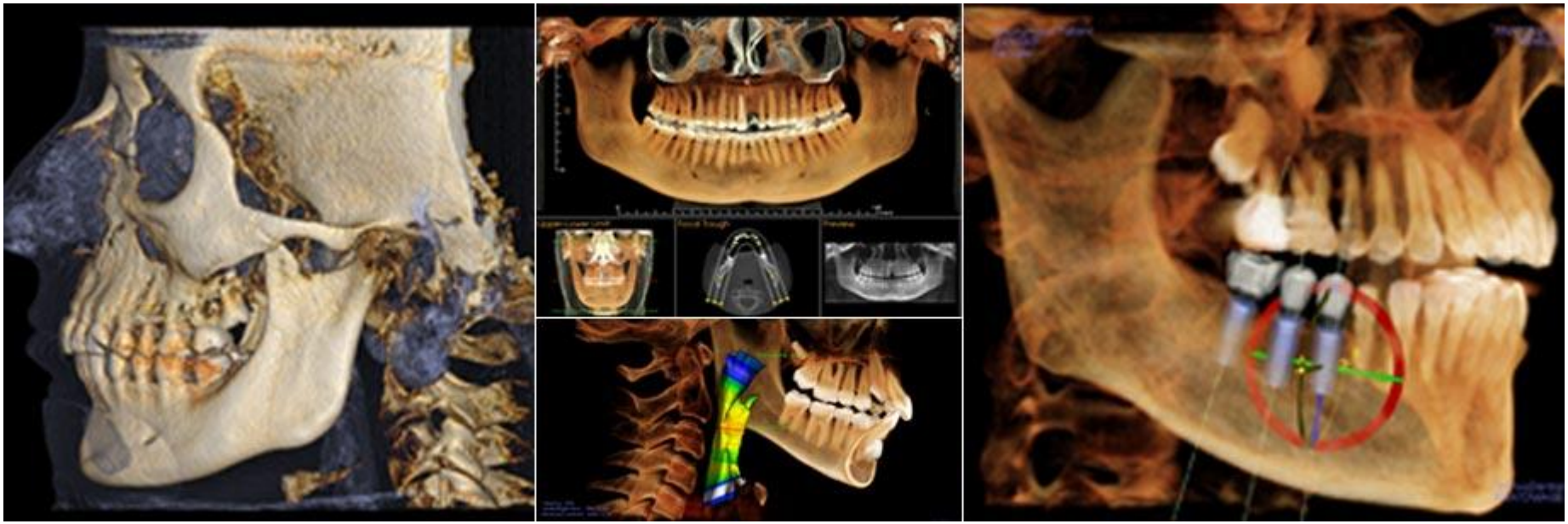
Cone Beam CT	Medical CT
Higher Noise	Lower Noise
Higher Scatter Radiation	Lower Scatter Radiation
Specific Extremities only	Whole body

History – Dental and Maxillofacial Radiology

NewTom 9000

i-CAT

History – Dental and Maxillofacial Radiology



Cone Beam CT transformed the Dental and Maxillofacial Industry by allowing specialists to plan bite corrections and jaw alignment surgeries in 3D. Invisalign®, custom implants, and braces customized to the patient are possible because of CBCT.

CurveBeam pedCAT

- Single or bilateral scan of foot and ankles
- Scan time under one minute
- Plugs into standard 115 VAC outlet
- 0.3 mm isotropic slices
- Up to 30cm Diameter x 20 cm height

CareStream OnSite

Planmed Verity

CurveBeam InReach (510(k) Pending) and LineUp (Investigational)

Dose Information

Technique	Effective Dose in microseverts (µSv)
Daily Background	8 per day (or 3000 µSv per year) **
Difference of daily background for high altitude locations (i.e: Denver) vs. sea level	50% more per day (or 1500 µSv more per year) **
Coast to coast round trip airline flight	30 **
PedCAT Cone Beam CT	
Medium FOV (1 foot)	**2** ****
Large FOV (2 feet)	**5** ****
Medical MDCT of the lower extremity (foot & ankle)	25-70-1000 *** **** *****
Chest Film X-ray	100 **
Extremity Film X-ray	1 **
Medical CT of Chest	7000 **
Dental Medium FOV Medical CT scan (Sonatom 64 slice)	860 *
Dental Panoramic (OrthoPhos Plus DS)	32.2 *
Dental Full Mouth Series (Average of various techniques)	50 *
Dental Cone Beam CT exam (i-CAT, medium FOV)	87 *

References:

*__Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology__
John B. Ludlow, DDS, MS, FDS RCSEd,a and Marija Ivanovic, PhD,b Chapel Hill, North Carolina
UNIVERSITY OF NORTH CAROLINA

**__RadiologyInfo.org__ developed jointly by American College of Radiology and Radiological Society of North America. www.radiologyinfo.org

***Nagel HD. __Dose values from CT examinations.__ In: Nagel HD, ed. Radiation exposure in computed tomography. Hamburg, Germany: CTB Publications, 2002:15 -24

****Biswas D, Bible JE, Bohan M, et al: Radiation Exposure From Muscoloskeletal Computerized Tomographic scans, Yale University and Yale-New Haven Hospital, 2009

*****Report on CurveBeam CBCT Foot Dosimetry, John Ludlow, DDS, MS, FDS RCSEd

Dose Measurement PedCat - CTDIvol (mGy)

Procedure	TIME OF SCAN (s)	kVp	mA	HEIGHT (cm)	CTDI – free air (mGy)	CTDI100 Center (mGY)	CTDI100 Peripheral (mGy)	CTDIvol (mGy)*
Center Small Pt	16	100	5	20	0.70	0.421	0.497	0.47 +/- 0.01
Center	16	120	5	20	1.04	0.80	0.931	0.89 +/- 0.02
Offset Small Pt	32	100	5	20	1.04	0.627	0.626	0.63 +/- 0.02
Offset	32	120	5	20	1.63	1.25	1.081	1.10 +/-0.03

Center Small Pt = Small Patient: Medium Field (100kVp) procedure option.
Center = Medium Field (120kVp) procedure option.
Offset Small Pt = Small Patient: Large Field (100kVp) procedure option.
Offset = Large Field (120kVp) procedure option

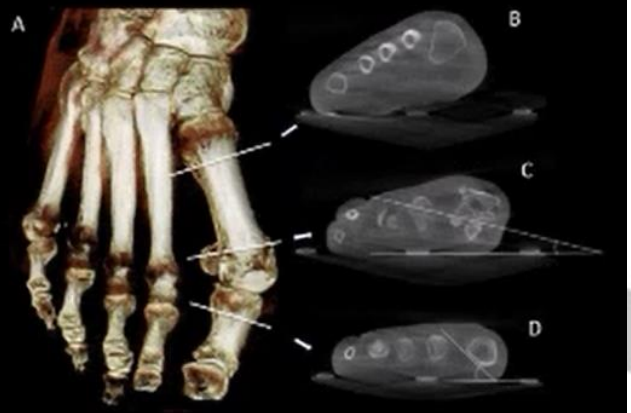
Dose Area Product (DAP) Measurements

Protocol	dGy*cm*cm	µGy·m²
MEDIUM FOV 120	8.03	80.26
MEDIUM FOV 100	4.92	49.15
LARGE FOV 120	14.84	148.44
LARGE FOV 100	8.97	89.68

Why Weight-Bearing?

Many foot and knee conditions such as misalignment, osteoarthritis, and surgical bone fusions can only be properly diagnosed and/ or analyzed in a weight bearing position

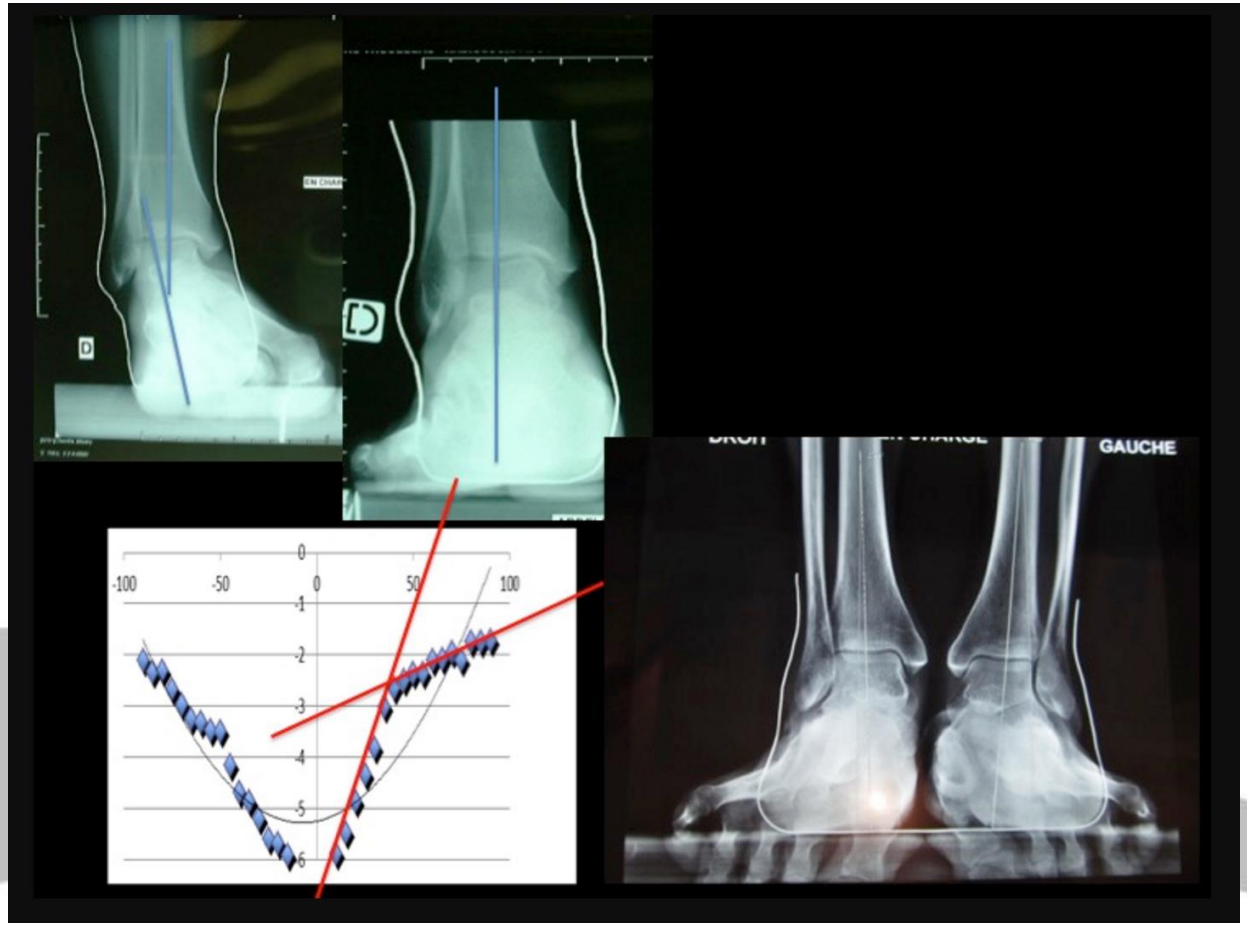
- Collan et al, 2013:[1]
  - 10 patients with hallux valgus deformity
  - 5 controls
  - alignment of the 1st ray
  - controls:
    - no differences WB vs. non-WB
  - patients with hallux valgus deformity:
    - significant differences WB vs. non-WB



[1] Collan et al, Foot Ankle Surg, 2013.

Why 3D?

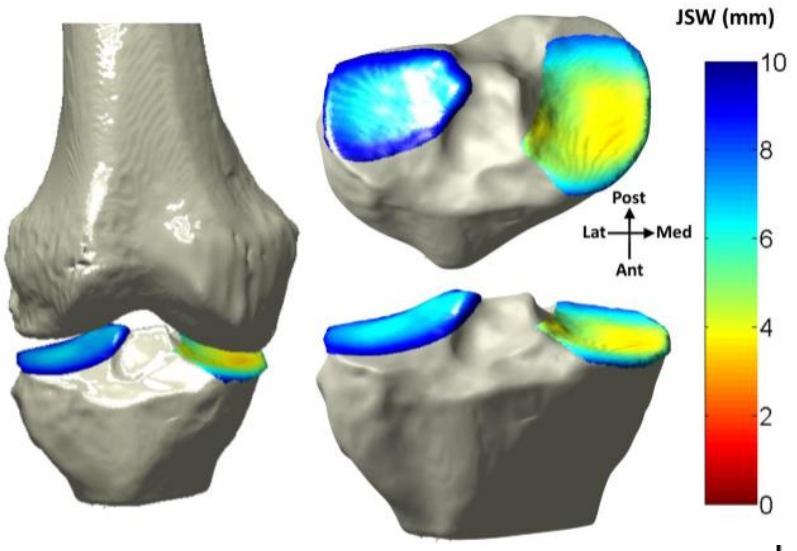
2D X-Ray images vary based on patient positioning and X-ray beam angle. The top left images show X-Rays of the same patient taken on the same day, but because of the differences in position and angle, one shows the foot with good alignment while the other shows a misalignment – X-Rays can be misleading



TALAS™ (Torque Ankle Lever Arm System) – a new paradigm to measure alignment in weight-bearing 3D

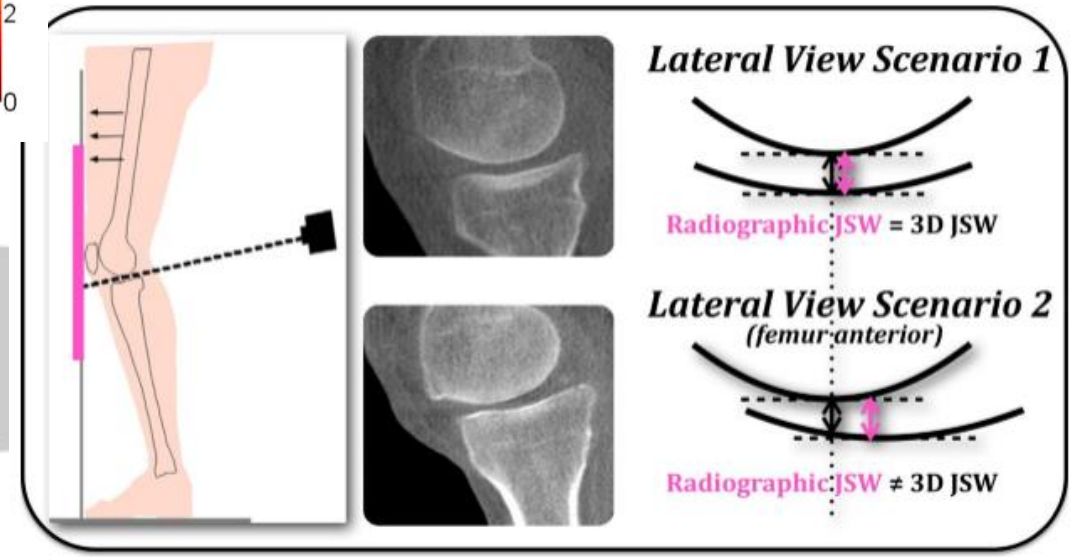
Joint Space in Knee (Osteoarthritis Detection)

Figure 4: Tibiofemoral Joint Space Width



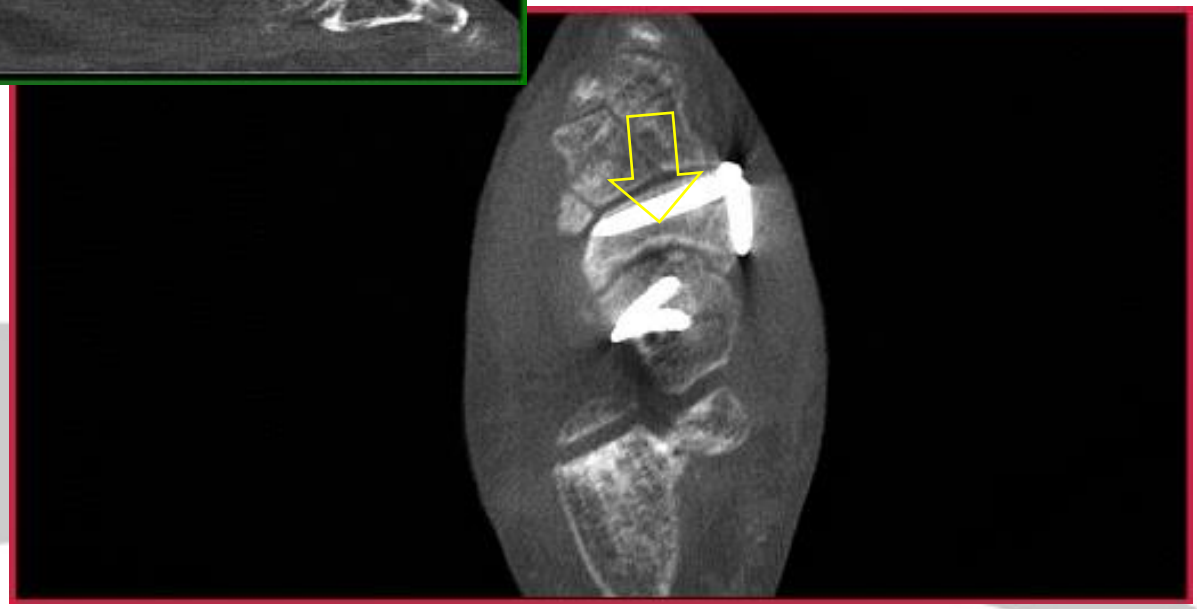
Accurate measurement of the joint space width in the knees allows for early detection of osteoarthritis

Minimum JSW Measurements by Radiographs and 3D SCT

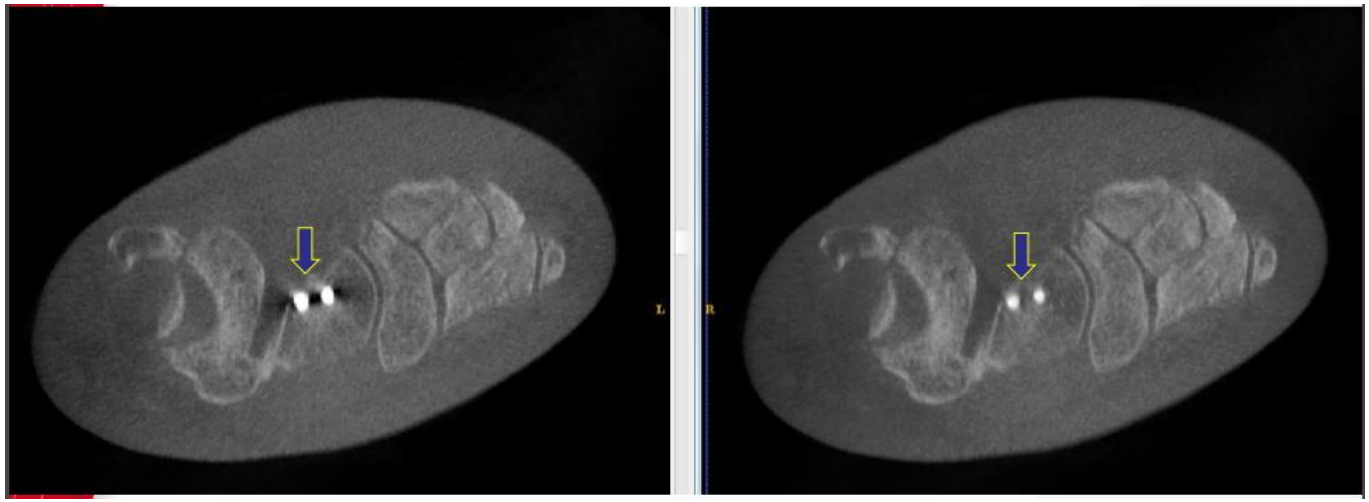


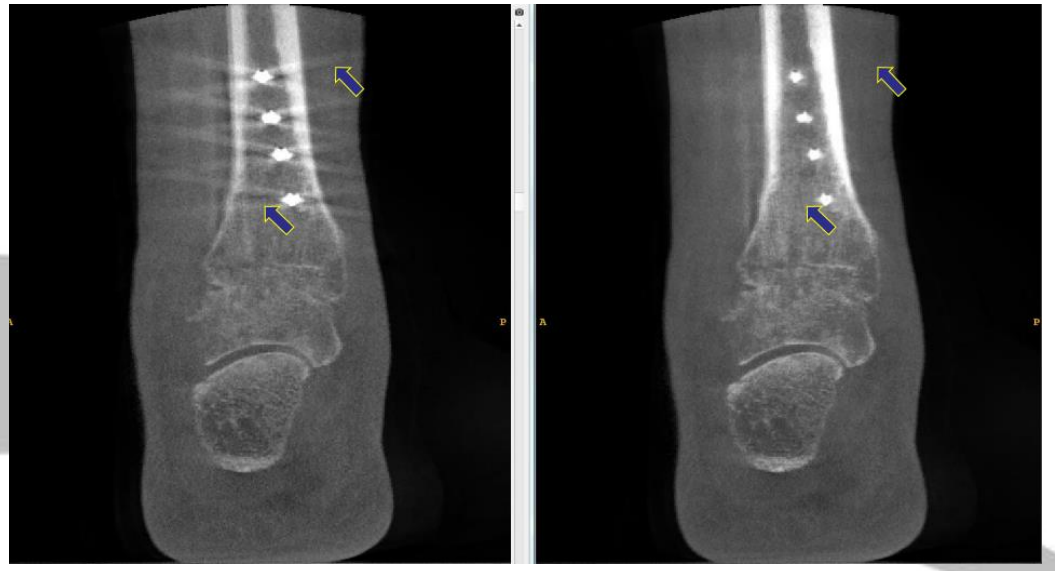
Segal et el, Journal of Orthopaedic Research, August 2016

Talar Navicular Non Union



3D Reconstruction Advancements - Metal Artifact Reduction






H
unknown
PEDCATACQ
A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unknown
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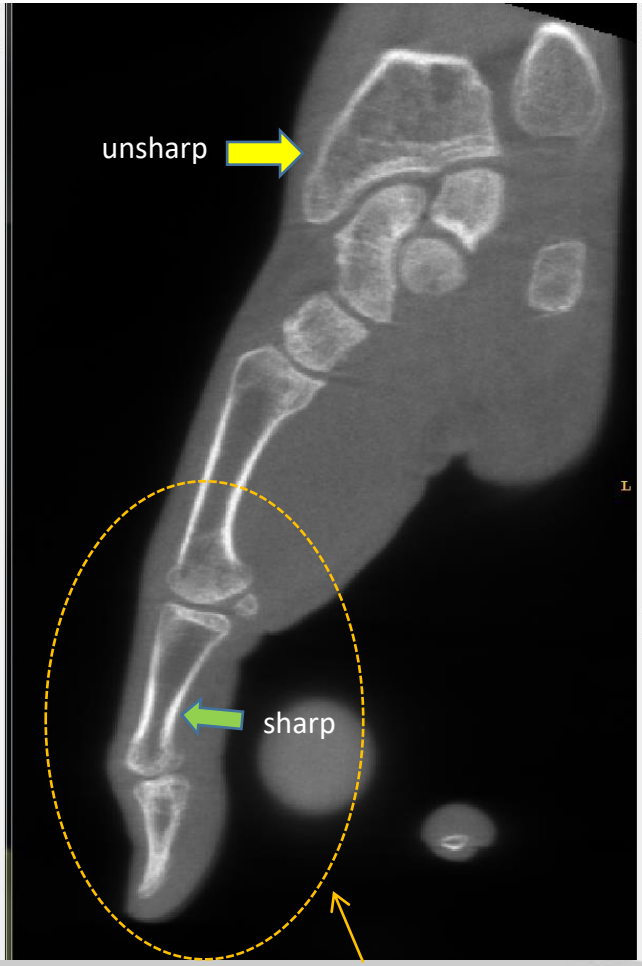
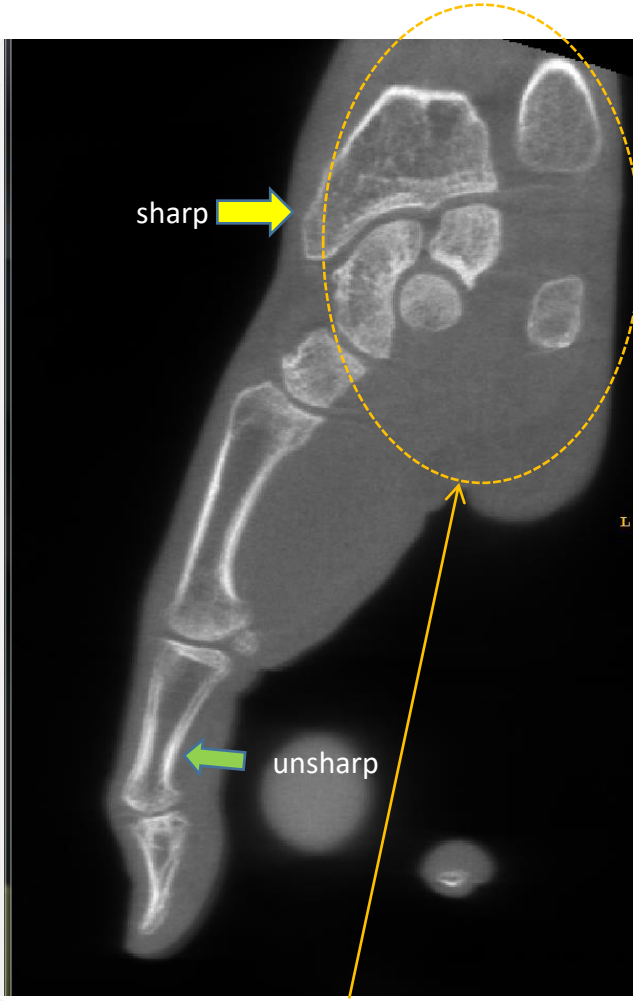
3D Reconstruction Advancements – Motion Correction

Focus off

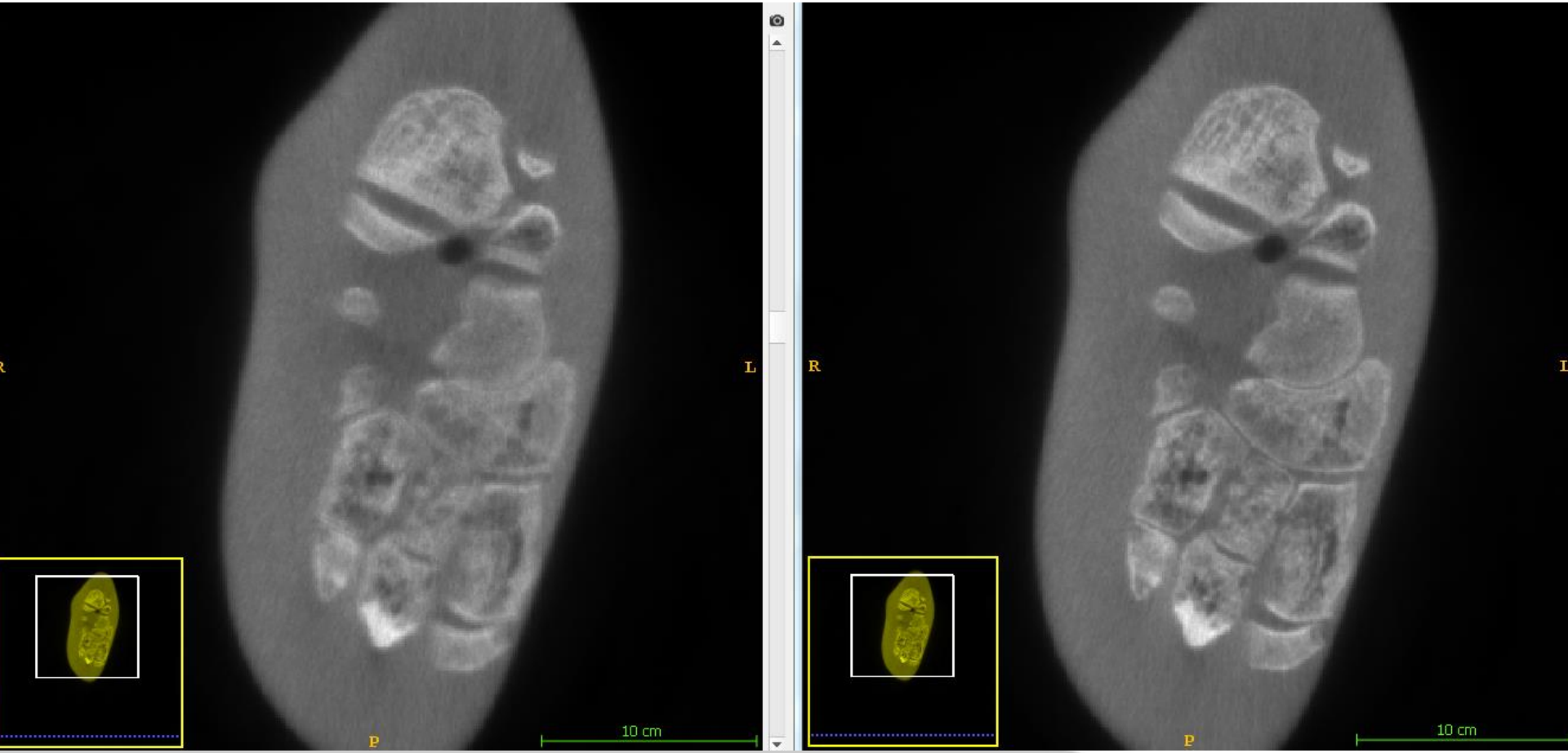


Focus
(on thumb)



Focus
(on palm)

3D Reconstruction Advancements - Auto-Calibration

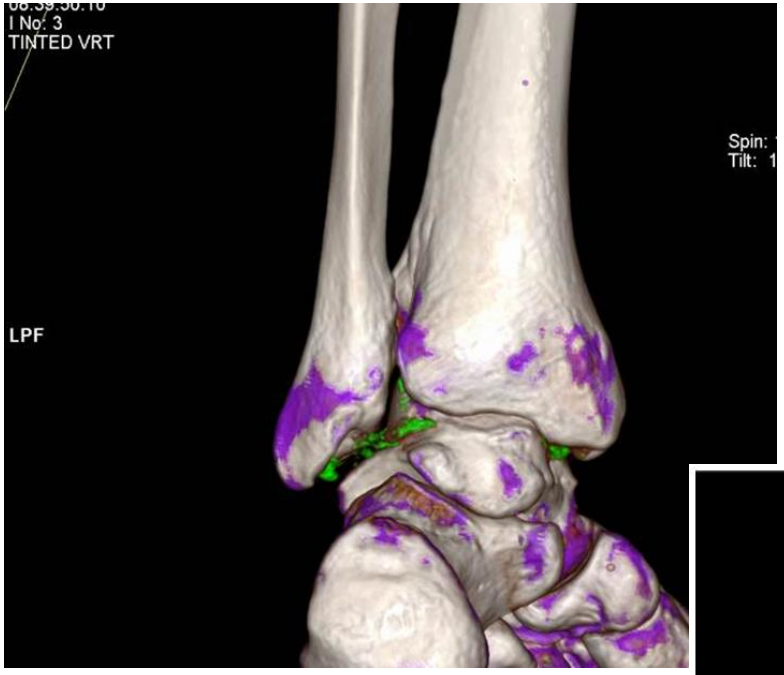


original

calibrated

Soft Tissue Visualization – Gout

Images are from medical CT- Development is underway to bring the same technology to CBCT



Images from :

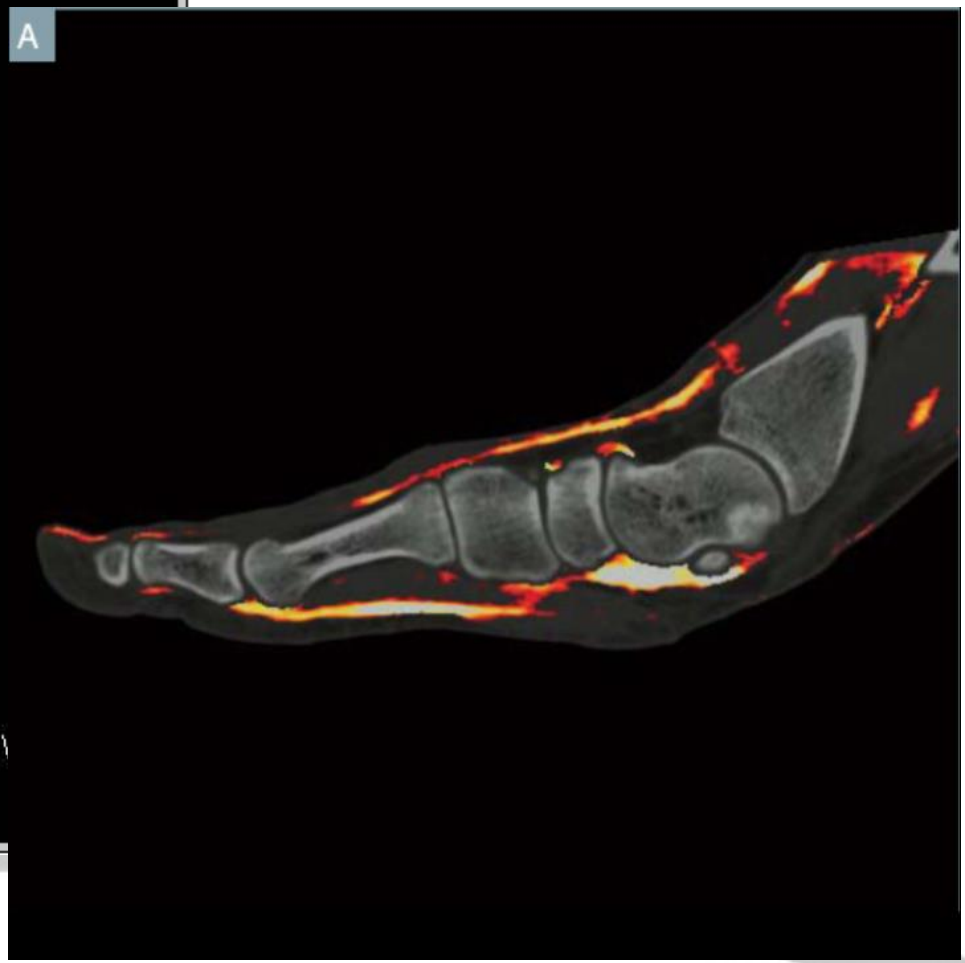
Naveen Subhas, MD, Cleveland Clinic
http://www.clevelandclinicmeded.com/medicalpubs/diseasemanagement/rheumatology/gout-and-pseudogout/

J Rheum Dis. 2011 Jun;18(2):137-141
https://doi.org/10.4078/jrd.2011.18.2.137

Soft Tissue Visualization – Tendons and Ligaments

Images are from medical CT- Development is underway to bring the same technology to CBCT

https://www.healthcare.siemens.com/computed-tomography/options-upgrades/clinical-applications/syngo-dual-energy-musculoskeletal

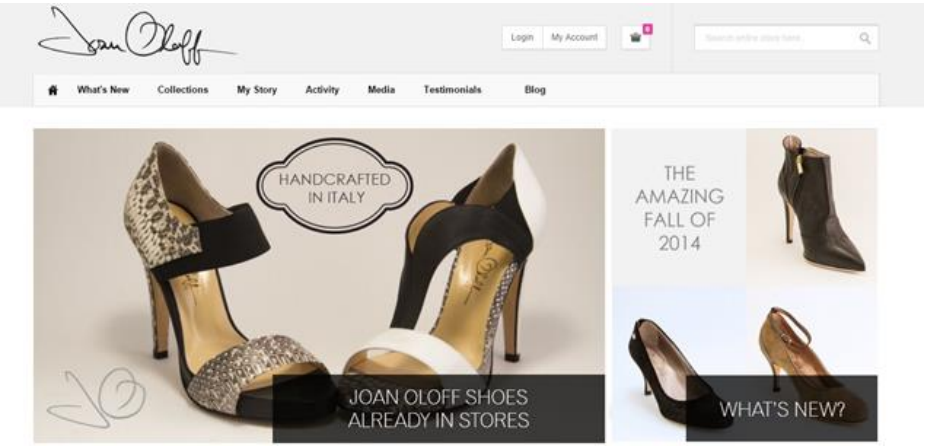


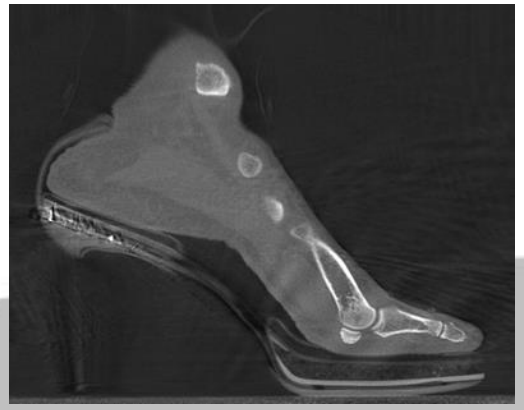
http://www.dsct.com/index.php/article-series-dual-energy-ct-scientific-evidence-and-clinical-application-57-extremities/

True Custom Orthotics

First Orthotic insert to account for patient's specific bone anatomy

Shoe Design





Allows show manufacturers to see how bones are affected in high heels and athletic footwear

Thank You