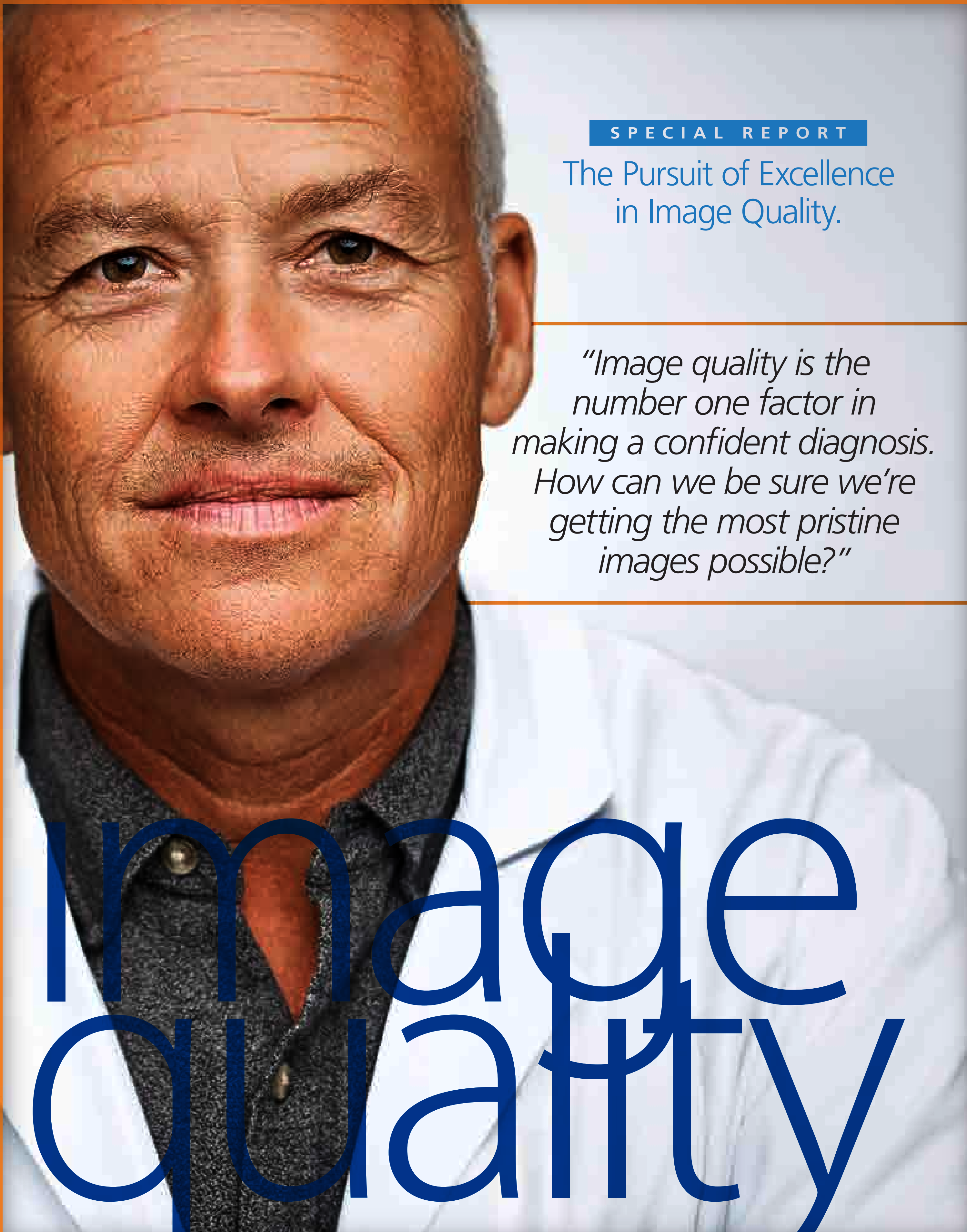


SPECIAL REPORT

The Pursuit of Excellence in Image Quality.

"Image quality is the number one factor in making a confident diagnosis. How can we be sure we're getting the most pristine images possible?"

Image quality

Quality Equals Confidence.

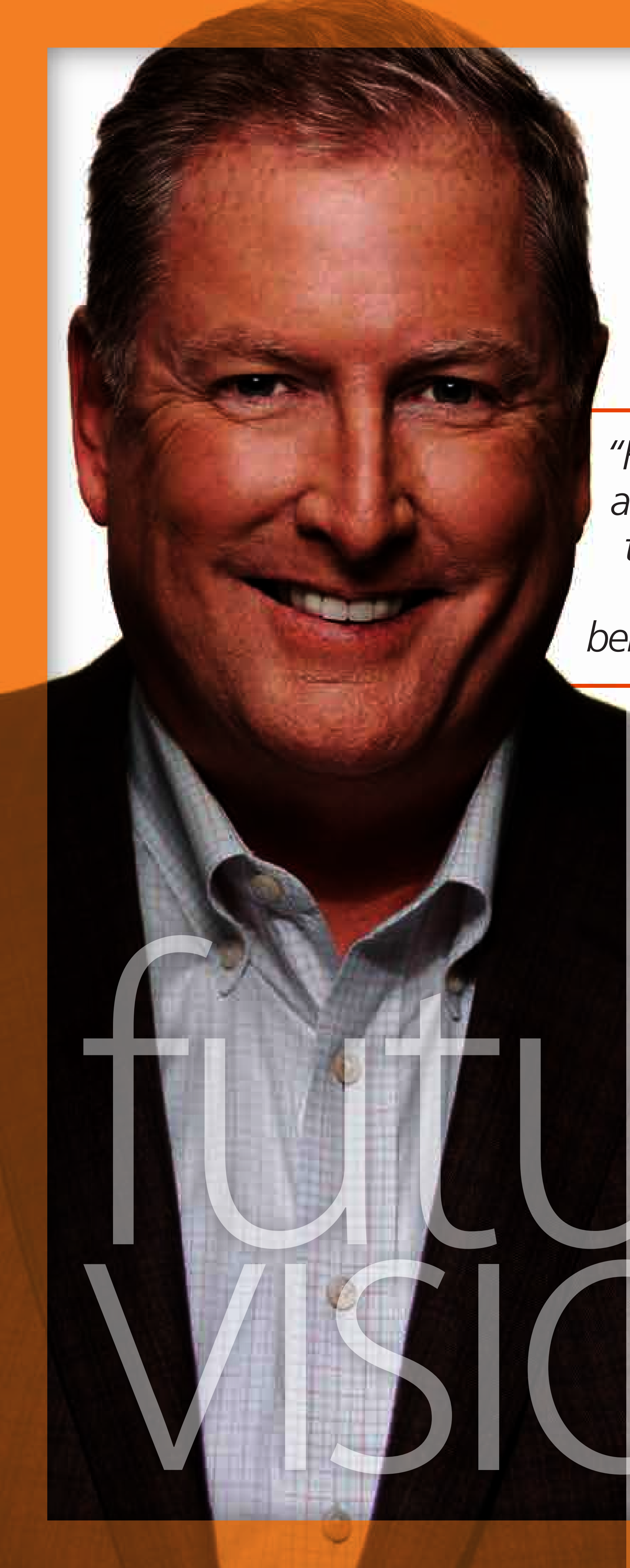
Let's face it: the accuracy of your diagnoses can only be as solid as the quality of your images – because only a sharp, clear radiograph can provide you with a complete picture of your patient's condition. This leads to diagnostic confidence and precision, which in turn helps support faster diagnosis, earlier commencement of treatment and better patient outcomes.

The effort to achieve ever-higher standards in image quality has been ongoing throughout the history of radiography. Today, many new technologies and strategies are available to help you meet this challenge.

In this Special Report, *The Pursuit of Excellence in Image Quality,* we'll look at some of ways you can improve your ability to acquire pristine radiographs. You'll read:

- *An article exploring the optimization of mobile chest image quality* through minimization of X-ray scatter.
- *A description of Carbon Nanotube technology* and how it benefits image quality.
- *A white paper on the advantages of true 3D* extremity imaging and weight-bearing exams.

pristine clarity



Today's hospitals and imaging facilities are striving to meet many critical objectives – such as increasing their productivity, managing their costs and accelerating their workflow. But at the end of the day, one goal remains paramount: the need to achieve the highest image quality possible. To support you, we've created this special report, The Pursuit of Excellence in Image Quality. We're confident you'll find its articles timely and informative.

"High-quality diagnostic images are crucial in your commitment to continuously enhance your standard of care. We are behind you 100% in this mission."

It is a privilege to lead and serve Carestream and, most importantly, to serve you – our valued customers. We will continue to build on our proven record of providing the best customer experience, and many new product development projects are well underway – all designed to support your commitment to excellence and your patients' well-being.

You can always count on our team to do the right thing to help you succeed. You have our promise on that, and of course, our gratitude for your business.

Dave

David C. Westgate
Chairman, President and CEO

future vision

Improving the Quality of Mobile Chest X-rays.

This article explores the use of specialized software that reduces the obscuring effects of scatter radiation in an image – without the need for a physical grid – to improve the quality and diagnostic value of portable chest X-rays.

> *"... in recent years, advances in mobile imaging have come a long way."*

Compensating for the Effects of X-ray Scatter Improves Contrast.

Mobile chest X-rays are often performed on acutely ill patients who are too critical or unstable to be transported to an X-ray imaging room. For these patients, bedside mobile X-rays can be the only option for medical imaging.

Fortunately, in recent years, advances in mobile imaging have come a long way. Many imaging professionals tout today's portable systems as "X-ray rooms on wheels" that help eliminate the risks, costs and delays of patient transport by bringing diagnostic technology directly to the bedside.

Recognizing the Disadvantages of Mobile Imaging.

Yet, mobile imaging still has potential drawbacks. In speaking about X-ray studies performed with mobile systems, Dr. David Levin, professor and chairman emeritus of the Department of Radiology at Thomas Jefferson University Hospital in Philadelphia, had this to say. "If you compare the quality of those studies with the quality of a study that was performed in a hospital in a radiology department or in a private radiology office, there is going to be no comparison," he told Reuters Health. "If a portable X-ray is absolutely necessary because of the patient's clinical condition, then it's justifiable."[1]

Other variables adversely affecting portable imaging, according to physicians Leif Jensen and Christopher Meyers, include "… patient factors such as obesity, hypoventilation and motion unsharpness."[2]

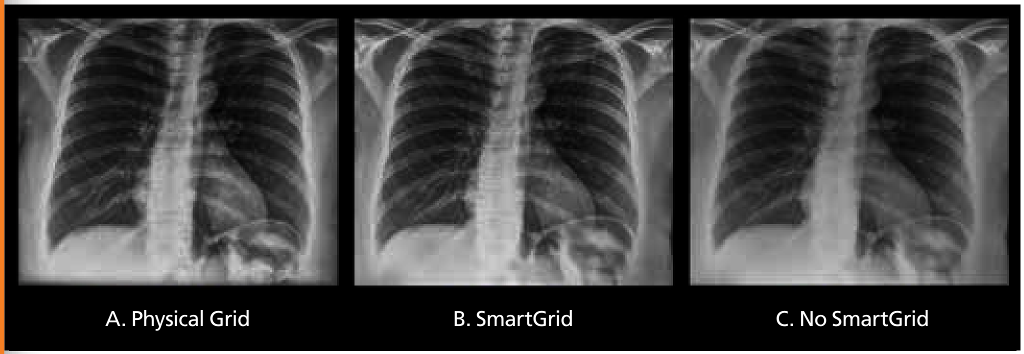


Figure A: Erect Portable Chest @ 105 kVp, 3.2 mAs with 6:1, 103 ln/in Grid.

Figure B: Same patient, same SID @ 95 kVp, 2.8 mAs, no Grid, processed with SmartGrid.

Figure C: Same capture as B, without SmartGrid. Click through to see a higher-resolution image.

Difficulties of Mobile Chest X-rays.

Concern over mobile image quality is perhaps greatest when it comes to X-rays of the chest. Ideally, chest studies are performed with the patient in a standing position. This is important for several reasons. One, it prevents blood engorgement of pulmonary vessels, which can compromise image clarity.

Two, upright positioning permits better visualization of air and fluids in the chest. When the patient is imaged while supine, fluids can diffuse themselves across the surfaces of the lung, producing a hazy image. So mobile imaging can be inherently problematic. If a patient must be X-rayed while lying in bed, the above-mentioned factors can compromise image quality from the get-go.

The Issue of Radiation Scatter in Mobile Chest X-rays.

Further complicating the situation is the potential degradation of image quality due to radiation scatter. This phenomenon occurs most frequently when imaging thicker areas of the body – such as the chest – particularly if collimation is not in close enough proximity. Specifically, when the X-rays penetrate the chest, a percentage of the photons engage in Compton interactions and cause radiation to scatter. This compromises image quality by introducing a noise-laden, low-frequency background signal that creates a haze. The result is an image with reduced contrast and detail, creating the potential for obscured vasculature, infiltrates and other pathology.[3]

Are Grids the Best Answer to Improve Chest X-ray Quality?

The traditional solution to reduce scatter has been the use of anti-scatter grids. Grid design uses parallel strips made of lead as well as strips composed of a radiolucent material. The technologist situates the grid in between the detector and patient. The beam, its path parallel to the radiolucent strips, passes freely between them. Radiation scatter is largely blocked by the angled lead strips before it can reach the detector and compromise the image. This helps preserve clarity and diagnostic value.

Grids can be highly effective in reducing scatter. But, it seems every solution has its disadvantages, and that is true here as well. Grids typically require a higher dose of radiation exposure, as the X-ray beam is attenuated by the lead strips. Also, grids are heavy and bulky. This can lead to misalignment during positioning, which can reduce the grid's efficacy. And, because they are inconvenient to handle, radiologic technologists might be discouraged from using grids altogether in some situations.

SmartGrid Provides Image Quality Comparable to Images Acquired with an Anti-Scatter Grid.

Recently, Carestream introduced software that reduces the damaging effects of scatter radiation in an image – helping to improve the contrast of the image when a physical anti-scatter grid is not used. Carestream's software, called SmartGrid, uses an advanced algorithm that estimates low-frequency scatter distributed throughout an image and reduces it.

Many physical factors affect the properties of scatter, including the energy spectrum of the beam, thickness and size of the object and collimation. But by using empirical modeling, SmartGrid software can accommodate these factors through estimation of algorithm parameters tuned to replicate anti-scatter grid visual performance.

SmartGrid is available for use with Carestream's flagship DRX-Revolution Mobile X-ray System and scaled-down, affordable DRX-Revolution Nano. (Available for commercial sale in the US and Canada. Dates in the European Union will be announced shortly.) SmartGrid also can be used with mobile systems from other manufacturers upgraded to digital with Carestream's DRX Retrofit Kits. In addition, it is available in all our modalities. This makes it a highly effective solution to the issue of compromised image quality in mobile chest X-exams.

SmartGrid processing provides image quality comparable to images acquired with an anti-scatter grid, lowering radiation dose in bedside chest imaging. The benefits of grid-like image quality without the use of an anti-scatter grid can lead to improved workflow and ease of imaging for radiographers, producing a win-win for a busy hospital. ■

[1]*Reuters Health News:* *Portable X-ray services becoming more common.*
[2]*Applied Radiology:* *Reducing Errors in Portable Chest Radiography.*
[3]*Perry Sprawls, Ph.D.,* *Scattered Radiation and Contrast.*

Authors: Lori Barski and Mary Couwenhoven are imaging scientists in the Carestream Health Research and Innovation Image Processing & Analysis group. Dong Yang also was a member of the Image Processing and Analysis Group during the research phase of the SmartGrid project.

Carbon Nanotube Technology in Medical Imaging.

Learn how this advanced technology is boosting the quality of X-ray studies – as well as making mobile imaging systems lighter, easier to transport and easier to position.

> *"Carbon nanotube technology will allow a further reduction in radiation doses."*

light-weight

Carbon Nanotube Technology Increases Portability and Image Quality and is More Energy-Efficient.

We are constantly bearing witness to important advances in the development and applications of medical technologies. However, it is not so common for there to be changes of a disruptive nature that lend a completely new orientation to a technology, either through new applications or through forms of use. However, this is happening now in medical imaging with the introduction of carbon nanotube technology (CNT).

Until the discovery of carbon nanotube technology, introduced worldwide by Carestream, X-ray devices used a vacuum ampoule. This is a device similar to a bulb with tungsten filaments that are heated to more than 1,000 degrees Celsius to generate the electrons necessary to produce the X-ray image.

"Cold" Carbon Nanotube Technology Yields Energy Efficiencies.

Although the historical contribution of the vacuum ampoule is priceless, it has limitations that carbon nanotube technology helps to solve. One is energy efficiency. Heating equipment at high temperatures uses an excessive amount of energy and requires the use of additional systems for cooling, such as fans (rotating anodes) or coolants. This contributes to the overall size and weight of the ampoule. Furthermore, because electrons are "boiled off," only about one percent of the energy produced by a vacuum ampoule is transformed into usable electrons.

Carbon nanotube technology, on the other hand, is a "cold" technology. The production of electrons is not achieved by heating the filament, but rather by the application of an electric field. Also, electrons are focused at the tips of the carbon nanotubes. There is a much higher percentage of electrons used toward the creation of an X-ray image. Finally, unlike vacuum ampoules, CNT does not need to be cooled, thus contributing to a much smaller, lighter-weight tube.

A

B

Carbon Nanotube Technology Yields 80 Percent Weight Reduction.

The benefits of this new technology are not limited to energy efficiency. They also are relevant in terms of the portability of digital X-ray equipment, image quality and, by extension, patient safety and comfort.

Carbon nanotubes weigh 75 percent less than current tubes. This reduction enabled Carestream to develop an extremely small and lightweight mobile digital imaging system, the DRX-Revolution Nano. It weighs only 100 Kg., 80 percent less than other mobile imaging equipment, such as the DRX-Revolution that uses a vacuum ampoule.

Like the DRX-Revolution, the DRX-Revolution Nano can become an X-ray room "on wheels". It can be transported manually, fits easily in an elevator, and has sufficient autonomy to perform a full day's work without needing to be plugged in to an electric source.

Figure A: *DRX-Revolution tube head and collimator assembly, ~56 cm (22 in.) in width and weighing 75 kg (165.3lb).*

Figure B: *DRX-Revolution Nano tube head and collimator assembly, ~32 cm(12.5in.) in width and weighing 7 kg (15.4 lb).*

Another important benefit – that goes beyond purely technological developments – is that these qualities allow imaging professionals to provide better care to patients, whether at their bedside, in the ICU or in paediatric wards.

It is likely that the cathode with an incandescent filament, which was the origin of all radiogenic production, has its days numbered. Carbon nanotube technology – which is totally disruptive – will begin to emerge as a replacement, allowing a reduction in the weight of the equipment, an improvement in ergonomics and, through the processing software, a further reduction in radiation doses received by patients.

High-Resolution Three-Dimensional Weight-Bearing Imaging of Lower Extremities Using Dedicated Cone-Beam Computed Tomography (CBCT).

True 3D X-ray technology has arrived. Here, you can read about its ability to reveal the full truth of injuries in orthopaedic extremity exams.

NOTE: This paper describes the CARESTREAM OnSight 3D Extremity System but was written prior to product availability. The system is now FDA approved and shipping to many countries around the world.

JOHNS HOPKINS MEDICINE

3D imaging

This paper addresses the benefits of a prototype cone beam computed tomography system (hereafter referred to as the "CBCT system") dedicated to extremity imaging. The CBCT system was co-developed by scientists at Carestream Health and John Hopkins University. The CBCT system has demonstrated spatial and contrast resolution beyond the limits of conventional multi-detector CT (MDCT) at a reduced radiation exposure.[1] The CBCT system was designed to image both upper and lower extremities, with the lower extremities also capable of being imaged in a weight-bearing configuration. This unique capability can unveil and better characterize certain pathologies in the knee and ankle joints such as meniscal extrusion, altered tibiofemoral joint space morphology, flatfoot deformity and distal tibiofibular syndesmosis insufficiency. According to an article published in European Radiology,[2] the prototype system has demonstrated adequate image quality for diagnostic tasks in extremity imaging. Specifically, CBCT system's images are "excellent" for bone and "good/adequate" for soft tissue visualization tasks. Additionally, the image quality was equivalent/superior to MDCT for bone visualization tasks.

Conventional radiography and MDCT have long been the modality of choice for diagnosing bone and joint injuries in lower extremities. But the complexity of the anatomy and biomechanical derangement that can occur during weight-bearing or other loaded conditions may not be detectable during non-weight-bearing conventional examinations.

In addition to the CBCT system advantages relative to MDCT stated above (dose reduction, weight-bearing), the CBCT system also provides advantages in reduced total cost of ownership, simplified site considerations and point-of-care access.

"The continued optimization of iterative-based reconstruction techniques is likely to further improve soft-tissue image quality relative to MDCT."

Initial experience with this system indicates that there are widely accepted deficiencies in current imaging modalities (e.g. MDCT) with relation to diagnosing common maladies. The weight-bearing capability of the system has shown the potential to improve the diagnosis of various maladies such as flatfoot deformity as discussed below.

In order to demonstrate the clinical feasibility of the CBCT system in an office-based orthopaedic practice, we examined patients with lower extremity pathologies, such as acute as well as chronic knee, foot and ankle injuries.

The findings in this study motivate areas of future work in improving the CBCT system performance and investigating potential future applications of the CBCT system. The continued optimization of iterative-based reconstruction techniques is likely to further improve soft-tissue image quality relative to MDCT. Furthermore, application to peripheral quantitative CT, where excellent bone visualization and isotropic spatial resolution (combined with high-quality scatter correction for improving the accuracy and precision of CT attenuation determination) could permit quantitative measurement of bone mineral density and subchondral bone/joint morphology. For instance, the presence of flatfoot and associated biomechanical derangements can be better evaluated using weight-bearing high-resolution CT examinations in order to differentiate between rigid versus flexible flatfoot, and to determine the underlying anatomical abnormality associated with such biomechanical derangement.

In knee imaging, weight-bearing 3D high-resolution CBCT can detect biomechanical derangements such as meniscal extrusion in patients who are at high risk for osteoarthritis. Further, weight-bearing 3D imaging of the knee and ankle (Fig. 1) could be used for diagnosis and treatment assessment of a number of other pathologies such as soft tissues or osseous impingements and/or malalignments in a functional weight-bearing state (Fig. 2, 3).

[1]*Carrino JA, Al Muhit A, Zbijewski W, Thawait GK, Stayman JW, Packard N, Senn R, Yang D, Foos DH, Yorkston J, Siewerdsen JH. Dedicated Cone-Beam CT system for extremity imaging. Radiology. 2014 Mar;270(3): 816-24.*

[2]*Demehri S, Muhit A, Zbijewski W, Stayman JW, Yorkston J, Packard N, Senn R, Yang D, Foos D, Thawait GK, Fayad LM, Chhabra A, Carrino JA, Siewerdsen JH. Assessment of image quality in soft tissue and bone visualization tasks for a dedicated extremity cone-beam CT system. Eur Radiol. 2015 Jun;25(6): 1742-51.*

Author: Shadpour Demehri, MD, John Hopkins University.

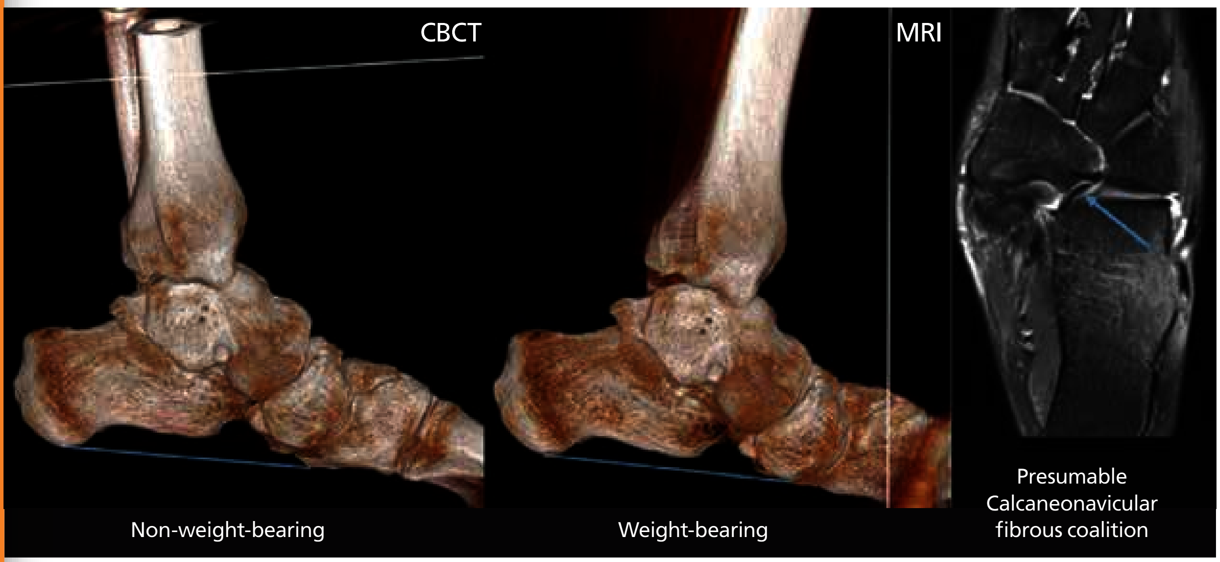


Fig. 1: *The MRI image (right) shows the presence of a fibrous band at the calcaneonavicular interface. CBCT 3D volumetric images (left) show the subtle flattening of the arch on the weight-bearing image associated with flatfoot.*

Fig. 2: *High-resolution 3D CBCT of the ankle demonstrates no osseous coalition at the Calcaneo-navicular interface.*

Fig. 3: *Weight-bearing and non-weight-bearing images show meniscal extrusion (small yellow lines) and biomechanical derangement in the weight-bearing image of this patient with osteoarthritis.*

Carestream's Solutions.

To acquire the pristine images so critical to diagnostic confidence and superb care, you need a partner who lives and breathes image quality. Carestream is that partner – our century-plus of imaging leadership is unsurpassed in the industry. The following hardware and software solutions are ideal for facilities that refuse to compromise when it comes to the quality of their radiographs.

3D Extremity Imaging

Ideal for orthopaedic practice and small hospitals, the CARESTREAM OnSight 3D Extremity System reveals the truth of injuries with true 3D X-ray imaging and weight-bearing exam capabilities.

Our Image-Processing Engine

Carestream's Eclipse Image Processing applies powerful, proprietary algorithms to provide automated and robust image processing that delivers superb image quality and consistent presentation – as well as the radiographic "look" of your choice.

Mobile Imaging Systems

Our CARESTREAM DRX-Revolution features a powerful 32kW generator, dual focal spot tube and EVP Plus image processing to deliver superb image quality. The CARESTREAM DRX-Revolution Nano is a scaled-down unit using Carbon Nanotube technology to reduce its size and optimize image quality. Both systems use SmartGrid software to minimize X-ray scatter.

An Advanced X-ray Room

Our flagship room, the CARESTREAM DRX-Evolution Plus, utilizes a wireless, shareable DRX Detector and EVP Plus image processing to deliver superb image quality, increased latitude and high-contrast image detail.

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"Rx only"