CLINICAL PERSPECTIVES ON

iU22 xMATRIX system

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INTRODUCTION

The role of the radiologist is rapidly changing. Clinical complexity is increasing, new applications for imaging are emerging, and pressure is mounting to streamline workflow and read examinations in a timely manner.[1] When 3,000 radiologists were asked how best to facilitate these advances, however, a need was identified for greater collaboration, better decision-making tools, seamless integration, and closer relationships with partners outside the hospital environment. In response to these concerns, Philips Healthcare released 'Imaging 2.0' in 2010.[2]

Imaging 2.0 was the umbrella term used to describe a range of products that were designed for any clinician involved in medical imaging – for example, radiologists, nuclear medicine physicians, and sonographers. The Imaging 2.0 concept offered a new approach to clinical collaboration, integration, patient focus, economic value, and safety; in short, Imaging 2.0 was developed to simplify everyday working for the medical imaging clinician. Now, the iU22 xMATRIX ultrasound system, coupled with the unique X6-1 xMATRIX transducer, extends the capability of Imaging 2.0 through its novel visualization tools and enhanced workflow (Figure 1).[3,4]

***Figure 1**. iU22 xMATRIX ultrasound system.*

An ongoing aim of Imaging 2.0 is to incorporate advanced technologies that enhance clinical collaboration and integration in healthcare, in order to provide efficient and personalized care for patients.[2] The iU22 xMATRIX ultrasound system is a seamless development within this concept that provides sonographers and radiologists with several improved features:[3–8]

- Exceptional image quality, and the capability to easily visualize structures rarely seen with conventional ultrasound, resulting in a correspondingly increased diagnostic confidence
- Increased diagnostic confidence from the ability to integrate xMATRIX isovoxel 3D data sets into workflow, following the CT/MR model
- Enhanced patient focus – enhancing workflow and the integration of clinical and radiological functions, such as the capability of imaging in multiple planes simultaneously, resulting in reduced user scanning fatigue and examination time
- An increased number of minimally invasive procedures, and improved accuracy of interventional ablations for oncology patients with PercuNav image fusion and instrument navigation
- An enhanced economic value, as systems are optimized for increased patient throughput.

FEATURES AND BENEFITS OF THE IU22 xMATRIX SYSTEM

There are several novel components of the iU22 xMATRIX system: xMATRIX transducer technology with live xPlane, the ability to view volume images on any picture archiving and communication system (PACS), and the development of single-button functions. Together, these specific features have enabled this ultrasound system to integrate into Imaging 2.0 and to meet the challenge of increased diagnostic confidence and efficiency.

xMATRIX transducer technology

The iU22 xMATRIX ultrasound system has been developed to enable the rapid execution of high-quality examinations in a wide variety of patients. A fundamental component of this development has been the introduction of the X6-1 xMATRIX transducer for general imaging.

Whereas a conventional abdominal transducer has a single row of approximately 128–256 elements, the X6-1 has a much higher total of 9,212 elements arranged in a true matrix. Behind the elements are integrated circuits containing 8 million transistors, providing each element with its own microbeam-forming channel, all located within the body of the transducer. Each element and its associated microchannel is only 0.25 mm in diameter. This configuration not only provides a very high line density, but also – by virtue of the iU22's xSTREAM architecture – uniquely allows dynamic electronic focussing in both azimuth and elevation planes (Figure 2). Consequently, a very narrow, high-resolution scan plane can be produced, which can be directed anywhere in the transducer's field of view.[9]

The X6-1 functions as a conventional transducer, with color, power, spectral Doppler, and harmonics. The sonographer also has easy access to the unique capabilities of live xPlane: near-instantaneous volume/3D ultrasound acquisition and live 3D (4D) imaging.[9]

Live xPlane allows clinicians to create two real-time, full-resolution images simultaneously (Figure 2). While the conventional scan plane is displayed, a second live image displays a parallel or orthogonal plane, and this second plane can be swept merely by using the control panel trackball. Thus, the operator does not have to flex or rotate the wrist in order to interrogate an organ or pathology.[3,6]

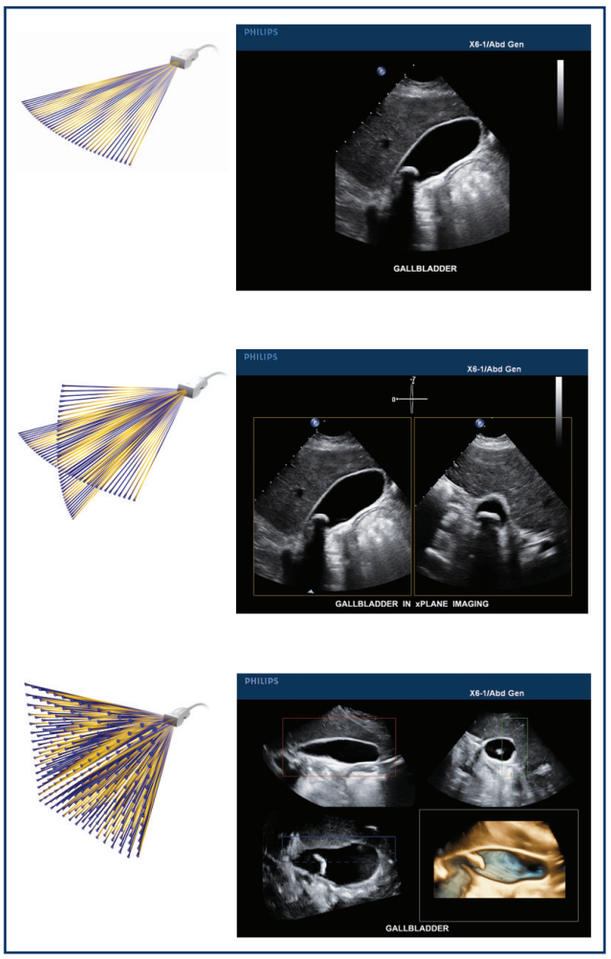


***Figure 2**. Single-plane imaging of the gall bladder with the X6-1 transducer (top); Live xPlane imaging creates two full-resolution planes simultaneously, with the x-1 transducer (middle); Live volume imaging allows the acquisition and rendering of full-volume data at true real-time frame rates with the transducer.*

Users of xPlane have found that it enables them to:[8–16]

- Reduce the examination time
- Enhance perception of anatomical relationships and tumor localization
- Significantly reduce upper-limb movements – and hence the potential of work-related musculoskeletal disorders (WRMSDs) – by reducing the number of orthogonal turns from 20–30 down to 0–5 in an abdominal examination.

xPlane ergonomics have been clinically assessed, whereby three operators performed abdominal examinations on four patients each. In the first instance, each operator carried out a conventional examination, which was then repeated using xPlane (Figure 3). Compared with conventional examination techniques, xPlane significantly reduced wrist excursions by an average of 70% (range 57–91%; n = 12). The only major wrist movement with xPlane occurred when changing target.[17]

Volume (3D) acquisition with the xMATRIX offers significant advantages over conventional mechanical 3D systems. First, being electronic, a full 90-by-90 degree volume can be rapidly obtained – typically in less than 1 second, resulting in fewer movement artifacts. This capability is particularly beneficial in the acutely ill patient, the elderly, or in pediatrics, since the patient does not have to suspend respiration while the scan is acquired. Secondly, and coupled with the short acquisition time, the high spatial and contrast resolution provided by the dynamic focussing and advanced XRES results in exceptional detail in all three planes, A, B, and C, during multiplanar reconstruction (MPR).[14]

The xMATRIX's electronic arrays also provide remarkable visualization of volume images. iSlice, for example, is a new volumetric display that allows the format to be adjusted to display 4, 9, 16, or 25 2D images, based on slices from the volume set. iSlice enables precision slicing of the volume to find images with the best views and content for review in making diagnoses (Figure 4).[18] QLAB software provides automated and objective methods for quantifying 2D ultrasound data, while QLAB's General Imaging 3D Quantification (GI 3DQ) feature supports the opening, viewing, and quantification of 3D data sets.[19,20] QLAB provides a high level of convenience for clinicians interested in rendering and advanced quantification; advanced image analysis, such as tissue analysis; color and power Doppler quantification; viewing, manipulating, and measuring 3D data sets; and creating graphic files for presentation purposes.[19]

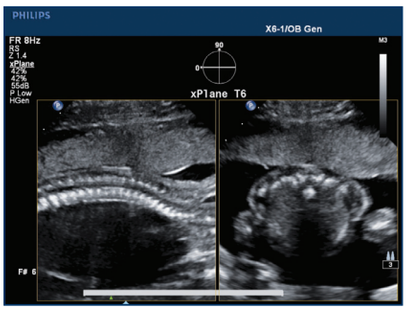


***Figure 3**. Imaging of the fetal spine with the X6-1 transducer.*

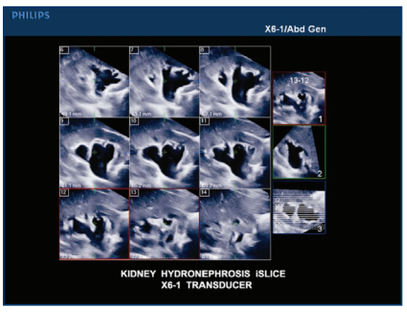


***Figure 4**. Kidney hydronephrosis imaging using iSlice.*

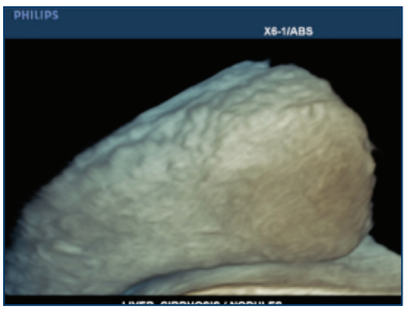


***Figure 5**. Ultrasound volume image of a cirrhotic liver with surface nodules.*

'Using volume ultrasound techniques, clinicians and sonographers are able to enhance perception and diagnosis by offering multiple image orientations'

Furthermore, 'virtual endoscopy' – for example in the bladder – is now possible, using high-resolution 3D/4D surface rendering with xMATRIX, which can also provide additional detail of surface structure, such as in micronodular cirrhosis (Figure 5).[3,16]

Consequently, using volume ultrasound techniques, clinicians and sonographers are able to:[13,14,16]

- Enhance efficiency by changing workflow patterns, e.g. time- and place-shifting functions such as simple measurements
- Enhance perception and diagnosis by offering multiple image orientations
- Store data for future analysis, audit, tele-radiology, or second reading.

These features mean that ultrasound methods of working are now becoming similar to those of conventional CT or MR.

One-button solutions

Ease of use is one of the key requirements for a high-performance ultrasound system. The iU22 xMATRIX is designed to operate using a number of single-button controls to optimize its use. A key one-button function controls the capability of the iU22 xMATRIX to switch seamlessly between 2D and 3D imaging. This is achieved as the X6-1 transducer provides the highest resolution for both 2D and 3D imaging, such that it is no longer necessary to switch transducers to acquire volume images. Thus, equipment operation is much simplified, requiring merely a single button press, and workflow is greatly enhanced, with a minimized risk of losing objects.[14]

The iU22 xMATRIX is also equipped with other modes that can be activated via single-button operations. For example:[14]

- iSCAN image optimization is a one-button operation that automatically adjusts multiple parameters to achieve optimal image quality in 2D, color, and Doppler examinations
- iFOCUS automatically computes beam characteristics for a selected region of interest, to provide superb detail resolution and tissue uniformity
- iOPTIMIZE instantly adjusts system performance for different patient sizes, flow states, and clinical requirements.

These features of the iU22 xMATRIX are designed to help sonographers obtain exceptional images with a decreased amount of effort. Ease of use is similarly provided by its ergonomic design.

Image transfer to PACS

Using the iU22 xMATRIX, it is now possible to send 3D multiplanar renderings to any PACS, such that volume images can be made available wherever they are needed for decision making, review, and storage. Once the volume data are acquired, a single-button command is used to capture the X, Y, and Z MPR cineloops and then send them to a PACS.[14]

VOLUME IMAGING IN THE REAL WORLD

The benefits of volume imaging – as provided by the iU22 xMATRIX system – have been demonstrated in numerous ultrasound applications, including imaging of the liver, kidneys, bowel, and breast. In 343 such cases, the use of volume imaging increased confidence in 57% of applications, led to a changed diagnosis in 29%, improved communication to the referring physician in 61%, and improved examination efficiency with a shortened examination time in 65% of cases.[16]

When used in liver ultrasound, volume imaging enabled the measurement of liver size, contour, lobe distribution, and echotexture in a single sweep. In patients with potential surgical disease, the relationship of pathology with the vital vascular structures of the liver can be optimally shown on a volumetric MPR series of images (Figure 6A).[16]

Ultrasound is a first-line image modality for suspected renal pathology. When applied to the kidney, volume imaging provided a more systematic and controlled review of renal architecture, with a more robust and potentially more accurate measurement of renal length (Figure 6B). When used to visualize the extent and activity of Crohn's disease, volume imaging established the presence, extent, and degree of activity of the inflammatory process. The presence of any complication in relationship to the bowel and surrounding tissue was also shown.[16]

In women's healthcare, volume imaging has been applied to breast ultrasound, gynecology, and fetal imaging. When used in the diagnosis, staging, and biopsy of breast tumors at the University of Kansas Medical Center, the enhanced image quality obtained 'has in some cases changed the diagnosis of a breast lesion' (Figure 6C).[10]

PREMIUM PERFORMANCE BEYOND xMATRIX

SmartExam decreases exam time throughput

The iU22 xMATRIX SmartExam feature enables the system to remember every stage of an ultrasound application, so that all required images for the study, annotation, body markers, mode changes, and quantification requirements

'Of the total abdominal examinations performed, 25–50% are on technically difficult patients'

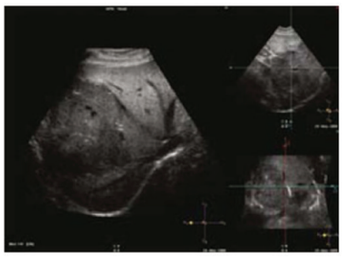
are saved. When the protocol is selected at a future date, annotation can be entered exactly the same each time without the need to stop scanning and make entries. Any required modes, such as Doppler, are automatically launched and measurements included in reports.[11] SmartExam protocols are designed to increase speed and provide consistency across ultrasound departments, from patient to patient,[14] and have other benefits also. In one study, SmartExam decreased the examination time by 30–50%, while enhancing the quality of exams.[11] The automatic annotation feature of SmartExam also reduces the need for repetitive motions on the part of sonographers, as they no longer need to look from monitor to control panel to keyboard.[14] Finally, in two studies – one of which was carried out at the University of Colorado Hospital – the time-saving SmartExam protocols allowed a 20% increase in the number of patients seen every day.[4,14]

When combined, PureWave, tissue aberration correction, coded beam-forming, and Advanced XRES reduce beam distortion, sharpen spatial resolution, and enhance image quality through the entire beam length, even in obese patients.[8]

A study at six sites in North America and Europe in technically difficult patients, using the iU22 xMATRIX system with these technologies, demonstrated the following advantages:[6,12,13]

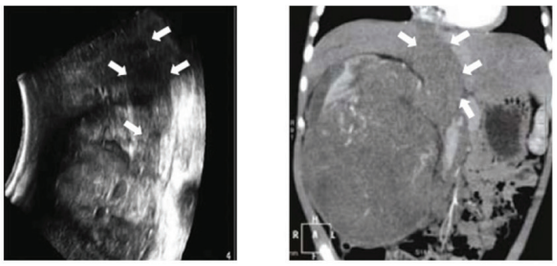
- Failed ultrasounds and the need for additional imaging studies are reduced by as much as 69%
- A marked improvement in color sensitivity is evident in up to 85% of cases
- Examination times are reduced by up to 38%
- A reduction in pain and fatigue from scanning is evident in 85% of sonographers
- Sonographers had to exert less pressure to achieve penetration of an organ or structure in as many as 93% of cases

Consequently, as the number of clinically challenging cases increases, sonographers require an ultrasound system that can provide the level of imaging, patient focus, and economic value required to meet the demands of modern healthcare.



***A**. Multiplanar reconstruction showing a large right-lobe liver mass in all three planes.[16]*

***B**. 3D imaging: coronal thick slice showing venous extension within the upper vena cava (left) and a CT scan coronal reformation confirming these findings (right).[16]*



***C**. Ultrasound image of a breast lesion obtained with tissue aberration correction (left) and standard speed of sound (right).[10]*

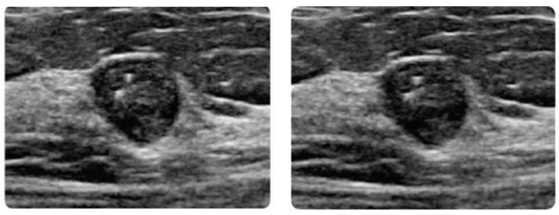


***Figure 6**. Volume imaging.*

Image quality and technically difficult patients

It has been estimated that of the total abdominal examinations performed, 25–50% are on technically difficult patients (as a result of increasing rates of obesity, fatty liver disease, and limited acoustical access).[5] This presents a significant challenge for the sonographer, particularly considering the increasing demand for a high throughput of examinations.

The abdominal organs of a large proportion of obese patients are more than 4–5 cm deep,[6] and in such cases, more time is required for an exam, image optimization may be problematic, and a high proportion of ultrasounds fail. Failed ultrasounds lead to higher healthcare costs because diagnosis is delayed, additional examinations (including CT or MRI) are required, and patient throughput is reduced.[5,6] Obesity can also affect the outcome of ultrasounds for other anatomical regions. Dense or fatty breast tissue, for example, can lead to difficultly in imaging suspicious, potentially cancerous lesions, thus delaying breast cancer diagnosis and staging.[7,8]

Performing ultrasound in obese patients can have a significant effect on sonographers themselves. WRMSDs have been reported by 90% of sonographers, which

can arise due to pressure applied to the transducer, abduction of the arm, and twisting of the neck and trunk.[9] The lengthier, more difficult procedures that obese patients necessitate are thought to be a key factor in the development of WRMSDs. Furthermore, staff shortages caused by WRMSDs can lead to increased medical bills, payouts for worker's compensation claims, and new staff recruitment and training.[6]

The iU22 xMATRIX system and its associated transducers provide additional options that are able to enhance the efficiency of everyday examinations. Firstly, its PureWave crystal technology uses pure uniform crystals to reduce clutter on images and provide excellent detail of fine structures.[8] The system also possesses tissue aberration correction, which accommodates the altered speed of sound waves as they pass through adipose tissue. Furthermore, coded beam-forming means that more tissue information is recovered for very high resolution of detail at extended depths. Finally, xMATRIX uses Advanced XRES – a special algorithm for high-resolution and high-speed adaptive image processing. Advanced XRES makes images virtually free of speckle noise artifacts, for sharp border deliniation.[8]

CONCLUSIONS

Development of the iU22 xMATRIX system has set a high standard for ultrasound imaging. The system's unique X6-1 xMATRIX transducer technology is able to provide exceptional image quality, with a decreased amount of input required by the sonographer. This not only increases diagnostic capability, throughput, and standards of care, but also offers significant changes in workflow, enhancements in efficiency, and the potential to reduce WRMSDs. The incorporation of SmartExam and single-button operations, in combination with the imaging capacity of the iU22 xMATRIX, means that the system is able to provide optimal clinical integration and collaboration, patient focus, and economic value. Novel features – such as live xPlane and the ability to view volume images on a PACS – are further enhancements that are meeting the increasing demand for precision image-guided therapies.

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