PHILIPS

Ultrasound

Automatic registration brings new levels of simplicity to image fusion – advancing patient care

Auto Registration on EPIQ Evolution 1.0

Fusion combines the strengths of multiple modalities

Ultrasound is a fast, high-resolution, and dynamic tool but can often lack the anatomical context provided by CT and MRI. Fusion allows specific regions of interest to be targeted for highly detailed analysis while benefiting from the anatomical detail provided by CT or MRI. This can be ideal for contrast-enhanced ultrasound (CEUS) examinations of indeterminate abdominal lesions, especially if there are multiple lesions that require interrogation, or if a lesion is unidentifiable on standard B-mode ultrasound.

Fusion imaging benefits are based on the ability to bring together innate advantages of various imaging modalities that helps to provide the best possible outcome for the patient, but registration of two imaging modalities can be time-consuming and technically challenging, often taking up to 10 minutes to achieve successful fusion with conventional registration techniques. Now with Evolution 1.0 the EPIQ platform has fully integrated fusion and navigation capabilities that helps clinicians achieve fast fusion of different modalities and high levels of clinical confidence.

Auto Registration in less than one minute

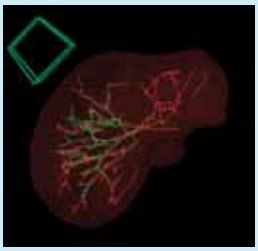
The Philips EPIQ ultrasound system features our most powerful Philips architecture ever applied to ultrasound imaging – touching all aspects of acoustic acquisition and processing, allowing ultrasound to evolve to a more definitive modality. Anatomical Intelligence Ultrasound (AIUS) allows EPIQ Fusion and Navigation Auto Registration to provide successful alignment of CT volumes to ultrasound in under one minute for the effective characterization of lesions. Performing automated fusion in less than one minute allows for more time to focus on the procedure ahead and less time on performing the registration necessary for accurate fusion.

Two methods for Auto Registration in the liver

To meet the demands of different clinical scenarios, Philips Auto Registration on EPIQ Evolution 1.0 uses either vessel-based or surface-based techniques to perform automated fusion in less than one minute.

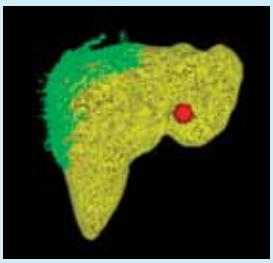
Registration using the liver vessels

Automatic CT/ultrasound liver vessel registration first extracts the 3D vessel trees of the entire liver from the contrast CT. Then an ultrasound sweep of the liver is acquired such that some vessels are captured in the sweep and automatically extracted. The registration algorithm then finds the best fit to align the 3D vessel trees within the liver CT volume and the 3D vessel trees acquired within the ultrasound sweep volume. This is analogous to matching fingerprints, where one is trying to match a complete fingerprint to a portion of another fingerprint of the same individual.



Registration using the liver surface

Automatic CT/ultrasound liver surface registration first extracts the 3D surface of the liver from the non-contrast CT scan. Then an ultrasound sweep of the liver is acquired such that part of the diaphragm touching the liver surface is captured in the sweep. The 3D shape of the diaphragm is automatically extracted from the ultrasound sweep. This 3D contour from the ultrasound can be considered as the partial 3D surface of the liver because they are adjacent to each other. The registration algorithm then finds the best way to align the 3D liver surface from the CT volume with the partial 3D liver surface from the ultrasound sweep volume. This is analogous to facial recognition, where one is trying to match a full picture with a portion of another picture of the same individual using the contour of the face.



Auto Registration case study 1

Prof. Yasuharu Imai, MD, FACP, FACG
Director, Department of Gastroenterology and Hepatology
Tokyo Medical University Hachioji Medical Center
Tokyo, Japan

A 1.5 cm recurrent hepatocellular carcinoma in the left lobe of the liver in a 79-year-old patient with a history of liver cirrhosis was examined under ultrasound using Auto Registration. This occult mass demonstrated well under contrast enhanced CT, but was previously undetected under ultrasound. Upon re-examination, this time using the Philips EPIQ ultrasound system, the occult mass was seen as a hypervascular region relative to the surrounding parenchyma with contrast ultrasound.

A previously acquired CT scan was imported into the Philips EPIQ system for fusion with contrast-enhanced ultrasound. The patient was positioned supine with the Philips patient tracker on the xiphisternum to maintain fusion accuracy despite patient motion throughout the procedure.

Traditional fusion techniques would have required the use of at least one internal landmark such as a vessel confluence as an anchor point for the fusion between the two modalities. Due to advanced cirrhosis, much of the portal tree in the liver had become very narrow and was poorly visualized in ultrasound. The lack of identifiable anatomy on ultrasound made traditional fusion methods impossible.

Prof. Imai performed Auto Registration between a prior contrast CT and ultrasound using the vessel-based technique. An ultrasound sweep volume was acquired to include optimal display of the portal vasculature.

The Auto Registration tool performed segmentation of vessels from the hepatic cell phase (although portal venous phase is also commonly used by other centers) image series from the CT scan, as well as the portal vessels that were included in the ultrasound volume acquisition. Despite a narrowing of the portal vasculature in this patient, Prof. Imai succeeded in assuring adequate vessels in this ultrasound volume.

Alignment of vessel maps took less than one minute to provide a clear demonstration of the mass on CT/ultrasound fusion. Correct alignment between the CT and ultrasound was validated by scanning in multiple planes over the liver and by reviewing the corresponding fused image.

Of note: when Prof. Imai can visualize sufficient vessels on the ultrasound image – as in this case – he performs vessel-based registration. In cases where visualization of vessels present a challenge, Prof. Imai starts with surface-based registration and focuses the sweep volume on the posterior surface of the liver.

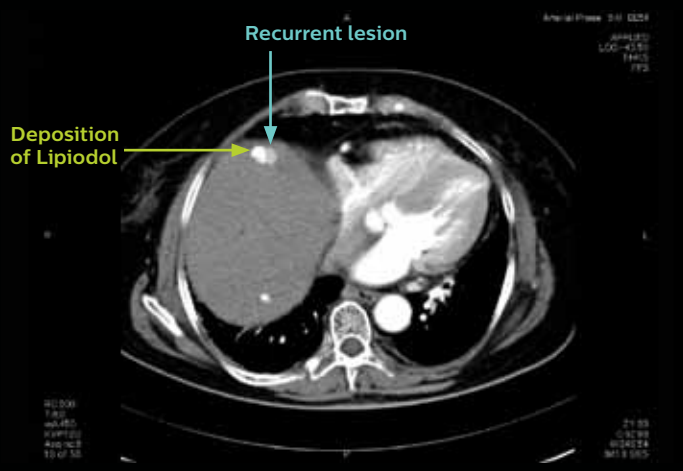
Once the images are fused, Prof. Imai typically checks from both the left and right lobes, consistently finding Auto Registration to be very accurate. Prof. Imai states, “There are significant advantages

to using other modalities with ultrasound. Lesion detection is simplified for further evaluation, and an opportunity exists for subsequent monitoring. The added clinical benefit of fusion imaging does not have to add additional time to the procedure."

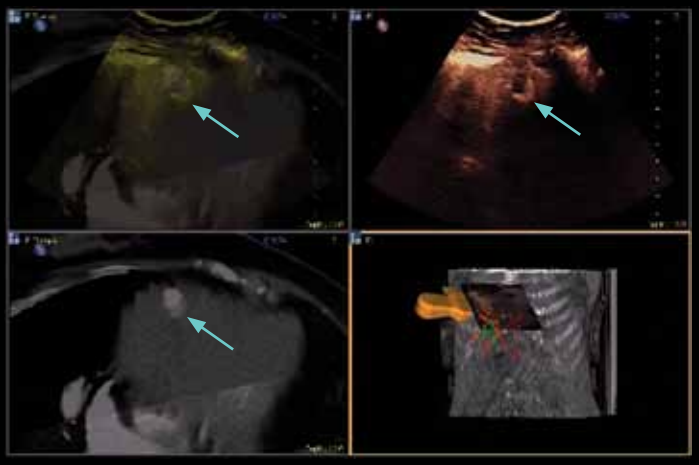
Follow-up care

In the case of this patient in which traditional approaches were not feasible, Auto Registration allowed the team to localize the lesion and further characterize it using CEUS with the goal to continue monitoring this lesion using ultrasound with CEUS.

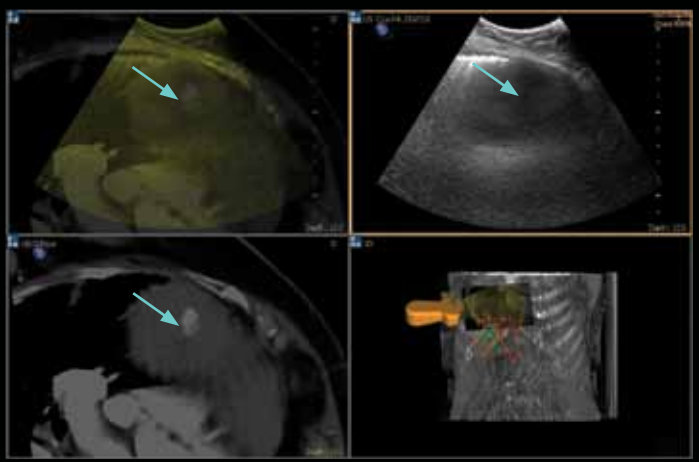
> "Traditional registration methods include a point or a plane match. It is not always easy to get good fusion results, depending on the system, operator, and patient. That is why we are so interested in Philips Auto Registration. 3D registration is much better than 2D registration."
>
> ***Prof. Imai**, Tokyo Medical University, Hachioji Medical Center*



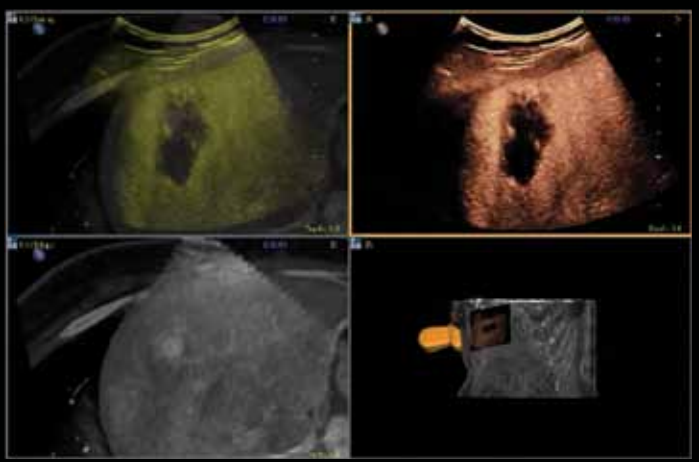
Case 1. Contrast enhanced CT demonstrates lipiodol deposition after chemoembolization.



Case 1. Sonazoid distribution on ultrasound fused with contrast enhanced CT for an anatomical reference.



Case 1. Fusion imaging assists in lesion localization under ultrasound, where clearly defined on contrast CT. The recurrent lesion was unclear on B-mode ultrasound.



Fusion imaging of CT and CEUS demonstrates HCC RFA post-treatment in reference to the CT of the pre-treated area, confirming successful treatment.

Auto Registration case study 2

Dr. MAF McNeill, MBBS FRCR
Dr. Ben Stenberg, PhD
Radiology Department, Freeman Hospital NHS
Newcastle upon Tyne, UK

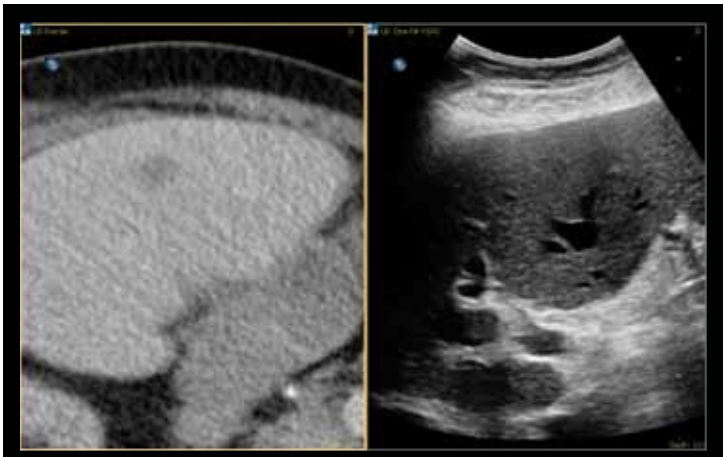
A 77-year-old patient with a history of previous Hartmann's procedure for pT3 N1 Dukes C adenocarcinoma of the distal sigmoid colon had a routine follow-up CT at one year which demonstrated no evidence of disease recurrence. However, a repeat CT six months later performed for increasing weight loss demonstrated a small nodule adjacent to the rectal stump and a new 1.5 cm segment 5 liver lesion in keeping with solitary metastasis

The patient's past medical history includes cardiovascular disease, previous ischemic stroke, and severe chronic renal impairment. In combination with marked spinal degenerative disease, the patient is wheelchair-bound and has mobility only with assistance. As a result he was unable to tolerate MRI for further evaluation of the surgical resection site, and the decision was that treatment of the solitary liver metastasis with liver resection carried too great a risk given these co-morbidities.

With surgery ruled out, percutaneous ablation of the liver metastasis was considered the best treatment option.
The radiology team felt that microwave ablation was technically feasible, using ultrasound guidance as the preferred imaging modality due to pre-existing renal disease, with an effort to avoid additional iodinated contrast injections that would be required with CT guidance.

> "Auto Registration simplifies fusion imaging so that more time can be spent evaluating pathology while optimizing the patient experience."
>
> ***Dr. McNeill**, Freeman Hospital NHS*

An initial ultrasound was performed at pre-assessment, but the lesion could not be identified. The patient was promptly referred for fusion-guided CEUS to further localize the lesion and assess suitability for ultrasound-guided percutaneous access.



A fused ultrasound and CT image confirms that the metastasis is truly invisible on B mode imaging, based on diagnosis; hence the need for contrast ultrasound assessment under fusion guidance.

This patient exhibited some discomfort while being positioned on the bed, and was unable to lie supine for an extended period due to discomfort in his lower back. Furthermore, he was unable to lie flat due to neck discomfort, and deliberate efforts were made to keep the scanning time minimal.

Fusion imaging using Auto Registration was performed using the C9-2 transducer under the general abdominal setting.
A manual sweep of the liver was acquired, with the focus on the liver surface. The diaphragmatic surface from the sweep acquisition was automatically aligned to that on the pre-acquired CT volume. Image fusion was achieved in less than a minute.

Fusion of the CT and ultrasound volumes provided the clinician with an immediate multi-planar reconstruction of the CT volume, offering a dynamic CT display that aligned to the real-time ultrasound image. Dr. McNeill scanned to locate the lesion on the reformatted CT display, to assist in finding the area to focus on the real-time ultrasound image for further evaluation with contrast.

A single bolus of 2.4 ml ultrasound contrast agent was injected via a peripheral cannula. The lesion demonstrated initial hypo-enhancement in the arterial phase, with peripheral wash out through the portal venous and late phase. This confirmed the lesion to be metastatic in nature, and as suspected on CT, appropriately sited for percutaneous access, and deep enough to the liver capsule to allow for microwave ablation.

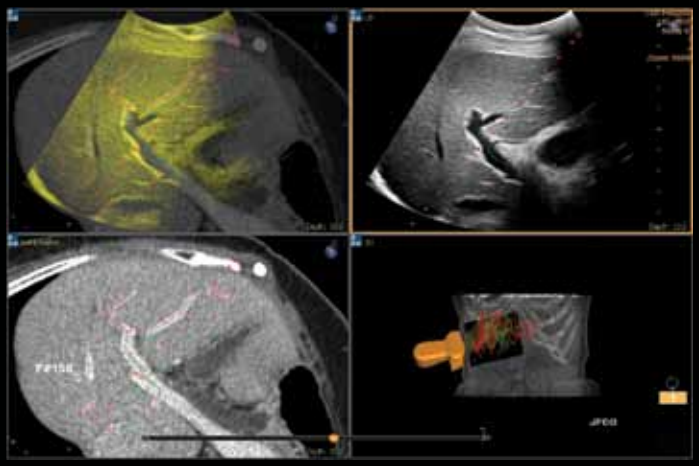
Progressive peripheral washout confirms the malignant nature of the lesion.

Subtle central vascularity seen in a predominantly hypo-enhancing lesion, appreciated on the initial arterial phase.

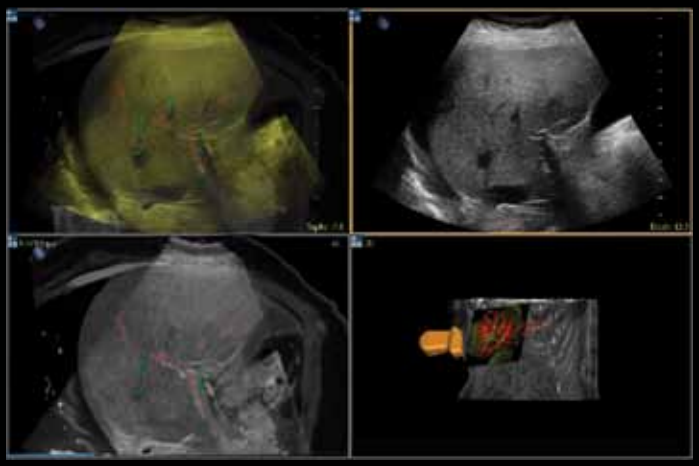
Dr. McNeill states, “Fusion imaging with Philips Auto Registration proved to be clinically relevant without shifting focus and time away from the patient’s needs. The clinical value of fusion in this case is self-evident, as it eliminated the need for additional iodinated contrast as used in CT, as well as offering a viable alternative for treatment planning.”

Follow-up care

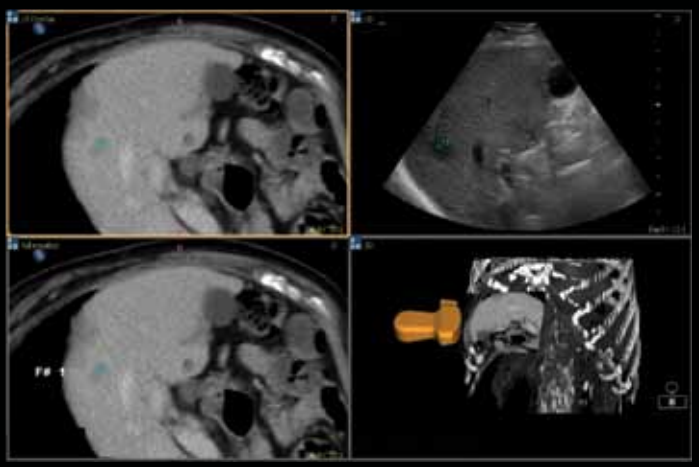
The general preference at this facility is to perform procedures under ultrasound guidance where possible. Furthermore, ultrasound-guided treatment is ideal for this patient because the iodinated contrast used in CT increases the chance of contrast-induced nephropathy in an already high-risk patient with chronic kidney disease. Percutaneous microwave ablation will be performed under general anaesthetic using fusion-guided CEUS to guide needle placement. Dr. McNeill states, “Percutaneous treatment is possible in this patient as fusion-guided CEUS allows a lesion not visible on B-mode ultrasound to be confidently targeted for microwave ablation. Co-morbidities make CT guided ablation or surgical resection unsuitable. Therefore with limited treatment options we are able to offer a potentially curative procedure rather than other higher-risk procedures, or possibly palliation/best supportive care.”



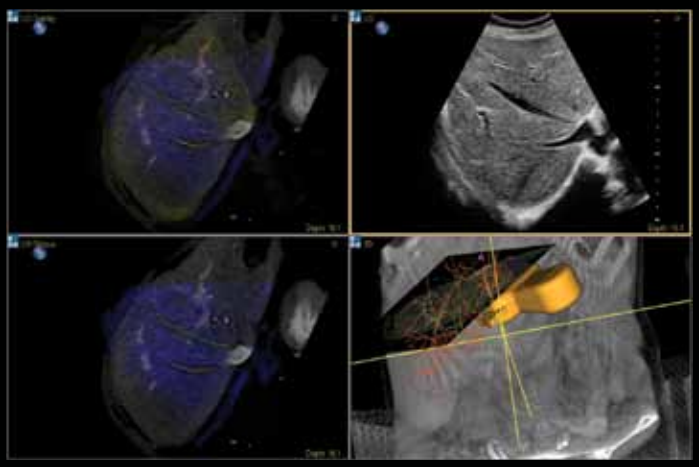
Auto Registration using a vessel based segmentation of the portal vasculature.



Auto Registration using a vessel based segmentation of the portal vasculature.



Fusion imaging – surface based Auto Registration. Visible target areas on CT and ultrasound confirm accurate alignment.



Auto Registration using a vessel based segmentation of the portal vasculature.

Keys to finding success with Auto Registration

The Freeman Hospital clinicians offer tips for making the most of fusion imaging, based on their own experiences.

While there are several methods of fusion registration, including point matching and plane matching, they have found Auto Registration to be quick and easy because it allows accurate registration with a simple sweep through the liver. The data auto-aligns with precision, without the need to perform additional fine manual adjustments. Fusion is performed in three planes, rather than in two dimensions (as with plane matching), which reduces error margins and makes registration more robust, particularly within the liver and kidneys. As might be expected, small error margins are unavoidable due to factors such as differing patient incline, position, and respiration, compounded by distance. They would routinely use Auto Registration for a study of the liver or kidneys, and reserve plane matching for examinations of EVAR grafts, which lends itself nicely to plane matching given the static graft material being readily identified on both CT and ultrasound.

Auto Registration typically reduces the registration process to less than one minute. A difficult point match registration can take between seven to ten minutes to adequately perform.

Clinical tips

1. There are several steps that can be taken to increase the chances of success with Auto Registration. Because the Auto Registration function works by detecting and matching specific anatomical landmarks (for example, vessels or diaphragm), it only works if those structures are available on the 3D ultrasound sweep acquired during the registration process. Therefore a high-quality image is important, and a good acoustic window to access the liver is key, preferably at paused, neutral respiration. This is likely to be an intercostal view of the liver hilum for a vascular match, and a subcostal or intercostal view with as much diaphragm visible as possible for the surface match. The greater the volume and the better optimized the image, the greater the success rates.
2. It is also important to realize that the success of Auto Registration is patient-dependent, in much the same way a standard B-mode ultrasound is affected by patient factors. A patient who is unable to breath-hold or cooperate for a reasonable period of time may significantly reduce the chance of successful Auto Registration.
3. Quality of the cross-sectional study to be fused should also be high, as imaging degraded by artifacts will make the process more challenging. Similarly, if there has been a significant change in the internal abdominopelvic structures, fusion may not be possible (for example, reduction or increase in volume of ascites).
4. Ultrasound fusion is a dynamic study performed with patients who are moving and breathing, which means that motion discrepancies occur between the two fused images at various phases during the respiratory cycle. As long as the practitioner is aware of this, it does not greatly affect contrast studies where a close fusion (<10 mm discrepancy) is sufficient. The team initially spent time attempting to achieve perfect fusion, before realizing that this was unnecessary in the majority of cases because close fusion was sufficient to provide them with the clinical benefits of the examination.
5. Of course, great importance should be given to more accurate fusion during interventional procedures, and initial care should be taken to register the ultrasound and cross-sectional dataset at the point of respiration at which the procedure is likely to be performed, allowing the greatest accuracy of registration at the required point.

Applications for fusion imaging at Freeman Hospital, Newcastle upon Tyne

Endovascular aneurysm repair (EVAR) graft assessment

Microbubble studies of EVAR grafts have been dramatically improved with the addition of fusion technology, allowing clinicians to combine the high sensitivity of CEUS with the anatomical data provided by CT for greater overall detection and evaluation of endoleaks, where CT findings are often equivocal.

Percutaneous ablation of liver lesions

The team is now able to treat lesions in the liver that are difficult to identify and target with any single imaging modality. Fusion-guided CEUS provides far greater confidence in the ability to perform percutaneous therapy, and allows for treatment that may otherwise not be possible. They feel this impact is one of the greatest strengths of the system for them.

Focal liver biopsies

Targeting active tumors, particularly in previously ablated liver lesions, is becoming increasingly important in the context of developing percutaneous treatment of primary or secondary liver tumors. Lesions that develop recurrence often have active tumor in their periphery. This can be difficult to appreciate on B-mode ultrasound, and may be subtle or indeterminate on CT. Combining CEUS with CT allows accurate definition of potential sites of recurrence and enables accurate targeting for tissue sampling.

Head and neck applications

Targeting lesions and PET hotspots in the head and neck using linear probe fusion is a direction the clinicians at Freeman Hospital would like to explore in the future as this has the potential to be of great benefit, ensuring PET-positive nodules or nodes are targeted for biopsy and not adjacent reactive lymphadenopathy.

Additional benefits of the Philips approach to fusion

Philips fusion imaging has the capability of free hand Auto Registration with C5-1, C9-2, S5-1, and electronic Auto Registration with X6-1 to provide clinicians access to quick and easy fusion.

The Philips system features a separate patient tracker, which allows the magnetic field generator to be moved during an examination without having to reset the whole procedure or perform a new registration process. In the view of Dr. McNeill “This is particularly useful in the theatre setting in our practice where the registration is performed before the patient is prepped and the field generator can be moved and reinstated during the sterilization process without interfering with the accuracy of the registration.

There are other instances where this is useful, such as moving the field generator for access for cannulation during a contrast study, or during percutaneous biopsies where the field generator may not be optimally positioned having started the procedure.

The other standout feature with the Philips system is the depth of functionality. Not only are there multiple ways to register, adjust, and display the fusion imaging, but there are multiple applications such as ultrasound-ultrasound fusion, multiple target planning, and needle tracking functions. This allows the system to grow with the needs of your service instead of limiting it.”

Philips Auto Registration marks a significant evolution of fusion imaging, bringing new levels of simplicity even in the most complex procedures.

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Printed in The Netherlands.
4522 991 11011 * JUN 2015