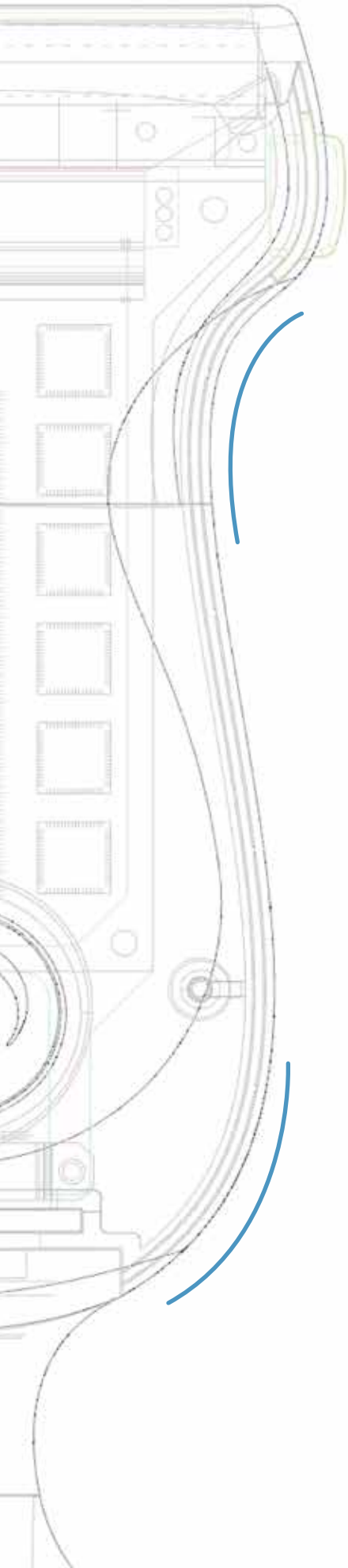


iQProbes



“Transducers are the core of Ultrasound technology. Integrating physics, electronics and geometrics in their design is the greatest engineering challenge of the signal processing chain.”

Francesca Gelli, R&D - Transducer Projects, Esaote, Florence, Italy

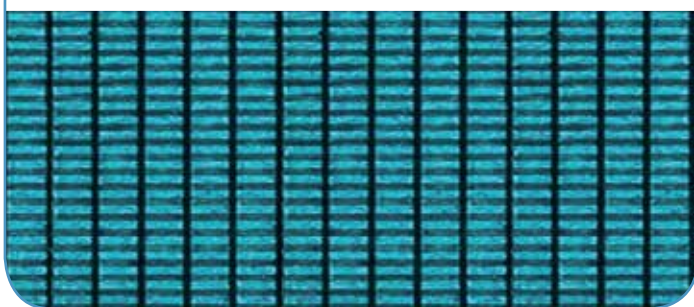
Ultrasound Transducers The First Element of the Chain

Transducers are the primary components of the Signal Processing Chain that leads to the final ultrasound diagnostic image. Even though much effort has been made to optimize scan converters, post processing algorithms and sophisticated speckle reduction technologies, ultrasound transducers remain ultrasound scanners' first and main interface between patient and user. Ultrasound transducer's design, material and manufacturing technology are the fundamental determinants of an ultrasound system's image quality. Thanks to the innovation of Quality gold standard ultrasound transducers, iQProbes are state-of-the-art Esaote Technology.

Active Matrix Composite Material

A piezoelectric opportunely doped in order to attain a good conversion efficiency both in terms of transmission and reception, is the active material (transducer's component that effectively produces ultrasound signal) that is currently available for cardiovascular probes. The introduction of Active Matrix Composite Material represents a huge breakthrough in improving transmission power's efficiency aiming at: reducing high electric impedance, electric issues between probe head and ultrasound transducer along with consequent transmission power loss, minimizing the extremely high acoustic impedance of PZT material (20 times greater than human tissue) and improving ultrasound wave propagation within the PZT material through the tissue.

Microscopic view of the Active Matrix Composite Material

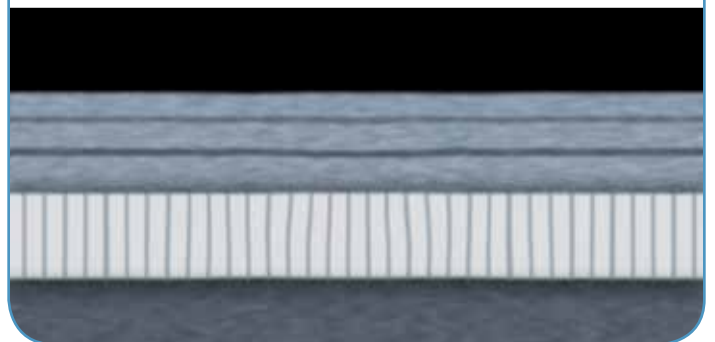


Active Composite Material is made of PZT and resin. It is a consolidated block that is subject to a coherent vibration efficiency which provides minor acoustic impedance and increases signal propagation. The latter delivers an extremely high quality pulse, resulting in a unmatched sensitivity thanks to the extraordinarily wide band pulse (greater than 100% bandwidth at -6 dB)

Multiple Adaptive Layers

In order to provide increasingly improved acoustic impedance, iQProbe Technology adopts the intelligent design of Multiple Adaptive Layers. These multiple matching (very thin) layers placed between the Active Matrix Composite Material and the patient's tissue have different acoustic impedance degrees, applied with decreasing value from the Matrix Composite elements towards the tissue. Multiple Adaptive Layers Technology reinforces target achievement with further improved sensitivity based on an extraordinary pure pulse signal and an extended bandwidth greater than 100%.

Microscopic view of the Multiple Adaptive Layers Technology



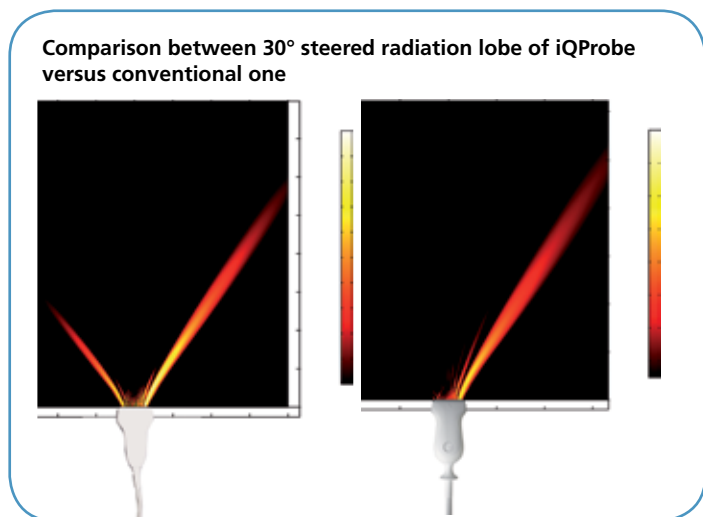
Radiation Lobe

iQProbe Technology is supported by sophisticated array cutting equipment (located at the Florence Italy plant) able to operate with incredible precision and tolerance (2 micron) to yield a greater element size reduction adapting to the relevant cut size of inter-spatial area between the elements. To provide the necessary acoustic decoupling, the currently available manufacturing

technology leaves this inter-spatial area empty, assuming it to be free from any spurious elements. iQProbe Technology introduces in the manufacturing process a Structure Filling Material which provides greater stability of the array structure, maximizing the highest decoupling level between array elements.

These two pictures clearly display the results brought by this technology and the effect achieved within single element radiation lobe by using conventional and state-of-the-art processing.

Properly activated within the transmission delay chain, lobe radiation circular patterns will be essential for beam focusing and consequently to deliver superb Images, Colour, Spectral Doppler and CEUS sensitivity.

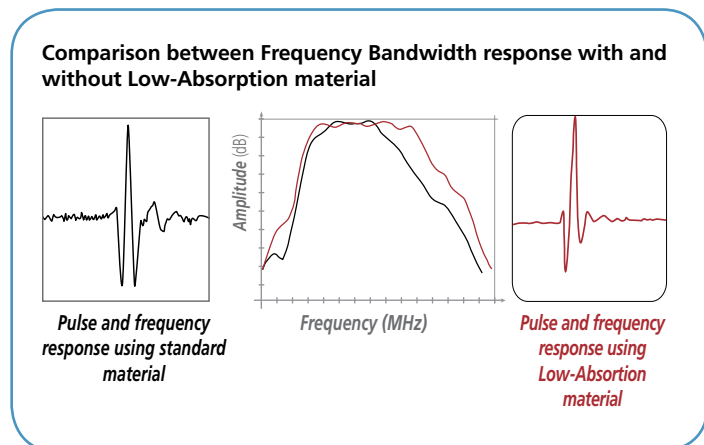
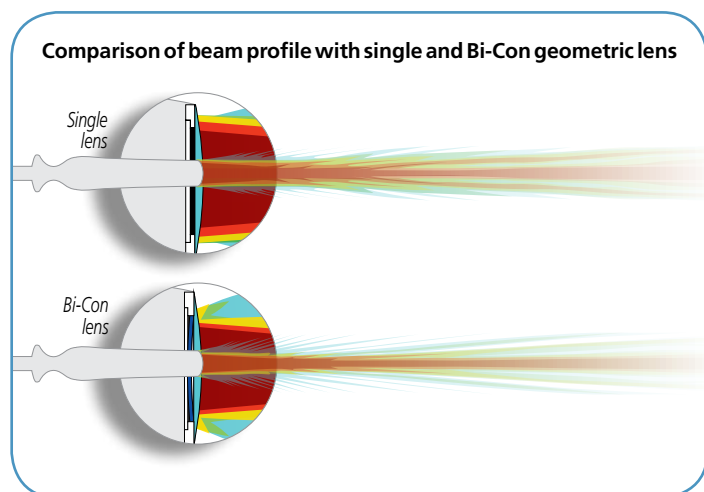


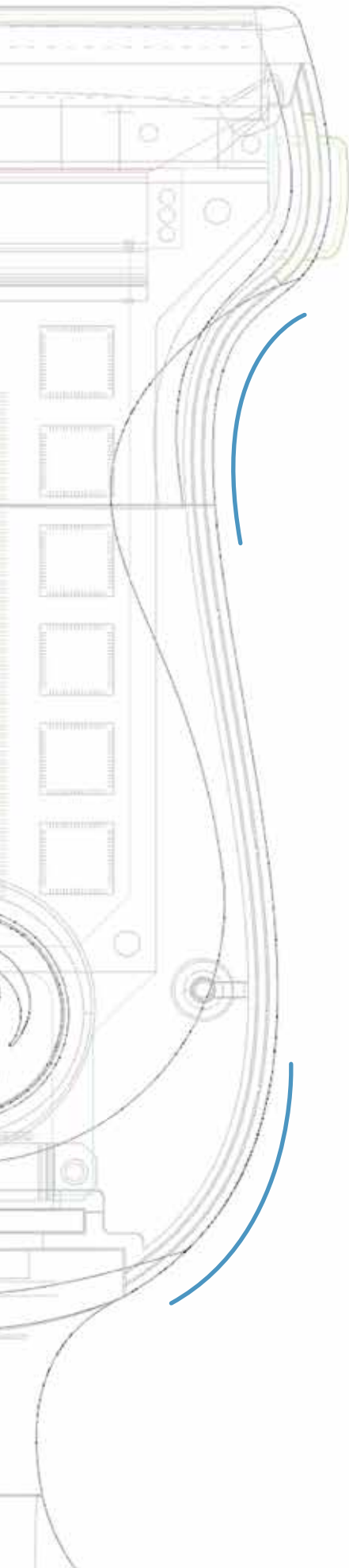
Bi-Con Geometric Lens

Transducer's design plays a key role in supporting focusing processes. Until now "converse shape effect" materials have been commonly adopted. Based on the recent research carried out by Esaote's R&D for iQProbe, we have introduced an innovative design using more than a single lens which are interacting each other. This intelligent idea represents an innovative technical solution which delivers an extraordinarily focused beam profile within the entire field of view.

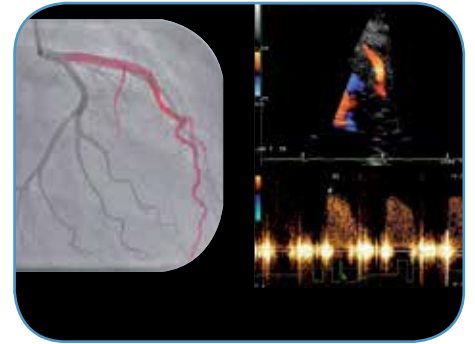
The material used to produce Geometric Lenses is crucial for the transducer's efficiency and uniform sensitivity. The use of conventional materials may be affected by a high absorption coefficient, which jeopardises achieving high frequency resolution in vascular applications.

To assure high homogeneous sensitivity over the whole transducer bandwidth, iQProbe Technology employs an extraordinary low-absorption material in the Geometric Lens Manufacturing Process.





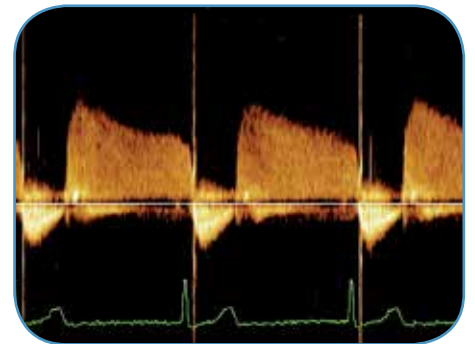
CEUS (Contrast Enhanced Ultrasound) is an important additional tool in the hands of physicians to support diagnostic confidence and improved patient management. Beam focalization and very wide bandwidth are key elements for the best insonation of ultrasound contrast agent bubbles resulting in an extraordinary discrimination of their relevant signal contribution through front-end CnTI algorithms.



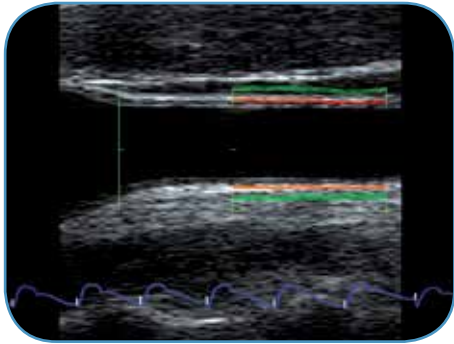
The contribution provided by iQProbe Technology in the detection of coronary artery flow derives mainly from the adoption of Active Matrix Composite Material and Multiple Adaptive Layers. iQProbe Technology assures both Color and Spectral Doppler enhanced sensitivity for an easy and fast detection, as well as precise quantification, of flow velocity.



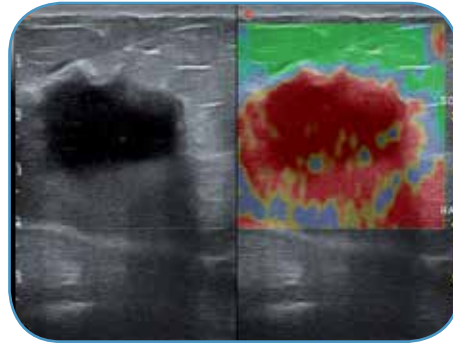
Deep abdominal investigations may represent a problem with difficult patient examinations. iQProbe technology offers a combination of key factors that enhance "deep region in difficult patient" imaging based on high adaptive impedance and wide bandwidth. This allows the proper management of fundamental and harmonic frequencies through sophisticated Front-End image processing algorithms.



CW Doppler is fundamental to detect and quantify high-speed flow velocity. iQProbe's cutting and manufacturing process offers a solid assurance that maximises the highest decoupling level between array elements and offers an extraordinarily focused beam profile to provide superb Spectral Doppler resolution and flow sensitivity.



Having an extremely wide transducer bandwidth is very important to properly analyze radio-frequency signal. iQ^{Probe}'s technology delivers an extended bandwidth that is greater than 100% thanks to the Active Matrix Composite Material and Multiple Adaptive Layers technologies that are employed.



When a mechanical compression or vibration is applied, some tissues generally get deformed less than others. The difference in tissue responses are detected and displayed in real time through elastography processing algorithms with different graphic representations. iQ^{Probe} technology (with its Active Matrix Composite material) offers an extraordinary bandwidth capability and sensitivity that covers the widest frequency spectrum linked with tissue elasticity properties.



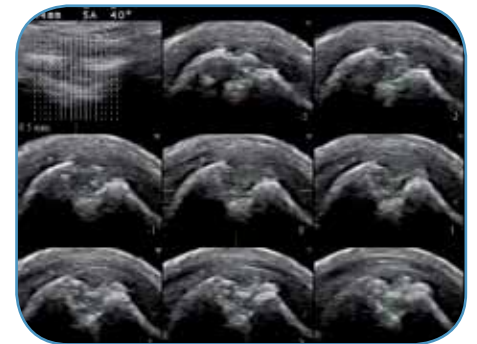
The characteristics (frequency, size, format, etc...) of transducers employed for superficial imaging examinations are very different from those of transducers used for deep region investigations. Thanks to a higher frequency range, there is an axial resolution imaging improvement, while specific management of beam focalization is required due to a short field of view. iQ^{Probe} technology applied to Linear transducer provides extraordinary results thanks to its array characteristics, electronic beam focusing and Bi-Con Geometric lens.



State-of-the-art Obstetric Ultrasound aims at achieving extraordinarily early detection capabilities during the first trimester scan. By combining both penetration and resolution imaging, iQ^{Probe} technology offers a superbly wide bandwidth compared to conventional convex and array probes. Thanks to this technology's features (Active Matrix Composite Material, Multiple Adaptive Layers, etc...) this platform is able to focus beyond normal viewing ranges to discover a new universe of clinical information even under a millimeter of size.



Transducers are subjected to overheating due to the high transmission power required for far field/difficult patient applications. Overheating also occurs in superficial imaging where for higher PRF rate the transmission power is applied more frequently per fraction of time. Thanks to Array Heating Efficiency Maximization technology, iQ^{Probes} are able to offer the great advantage of achieving both optimal imaging results as well as extended probe working life.



High Frequency Volumetric probe are today's state-of-the-art technology. iQ^{Probes} offers the extraordinary characteristics of this technology and volumetric design, supplying the operator with a fast and easy volume acquisition tool, several new imaging formats and rendering/calculation package.



Ergonomic innovation: working with natural alignment

We were aware of the health issues associated with probes and sonographers and we believed that a new probe design could reduce these issues.

In our research we found studies that supported our idea that the change in grip was necessary. One of these studies by the University of Wisconsin-Madison, from December 8, 2004, explained the problem of the grip, what health issues are associated with the traditional pen grip, and what action could be taken to prevent it.

One of the most interesting facts from the study highlights the occupational hazards associated with the use of probes, "Roughly 80% of sonographers report that they have some sort of musculoskeletal complaint of the hand and wrist and neck and back in conjunction with use of the probe and specific to the limb used to examine a patient."

The study also showed that beyond the personal health issues of the sonographers, the problems associated with the use of the probes affected the hospitals and patient care.

"Many of the workers reporting injury stated that they had to use sick time, vacation time, and workers' compensation benefits to deal with the time lost due to injury. Sick time and workers' compensation costs for thirteen work sites using ultrasound imaging reached levels upwards of \$180,000 because of injuries during 2001-2002. [...]"

Finally, the call to action by the study (see below) addresses what needs to change specifically in the hand-held transducer. "While manufacturers have made many ergonomic modifications to the ultrasound machines as a whole, the client wanted a design that focused on the hand-held transducer. The design needs to address the pinching and pushing associated with transducer use by sonographers. The design would need to alleviate the stress put on the sonographer when they are required to grasp the probe and apply pressure with it onto the patient. The main goal is to improve the well being and safety of the sonographer, especially their wrists, elbows and shoulders.

Ultrasound imaging relies on very small adjustments of the transducer head during exams for quality imaging; therefore a new design must give the sonographer a good amount of fine movement ability. In addition, good sonography is a learned skill that technicians work at to become proficient, so drastically changing probing procedures should be avoided. A design that can assist for long periods of time would also be ideal because of the large variation in exam times (from 30 minutes up to 8 hours).

Sometimes the probe must be held in only one spot with constant pressure for a long exam, and this can be very taxing on the sonographer. Regular exams are also getting longer as newer scanning technologies are being utilized, and sonographers are only being put under a bigger burden."

We believe that with the appleprobe we have changed the way transducers are held, creating a new way to grip the probe and respecting the traditional grip of the probe that so many have become accustomed to. It is our hope that the appleprobe will better the lives of sonographers making their work less painful and allow them to focus on their patients.

appleprobe: a new path

Esaote has designed a number of ultrasound probes over the years, each time trying to make them more comfortable and more ergonomic, yet something more drastic needed to be done. The design needed to address the pinching and pushing associated with transducer use by sonographers. And at the same time alleviate the stress put on the sonographer when they are required to grasp the probe and apply pressure with it onto the patient. After looking into the various changes that could be made it became clear that the way the probe is held could be re-designed.

The pen grip was the accepted way to hold and design the probes, yet it causes stress on the hand and wrist. It was decided to find a new way to hold the probe using a more natural grip. Through various studies, mock-ups and models our design team tested sonographers and doctors alike to best understand what kind of grip would be comfortable and natural for the hand and wrist and allow the small adjustments necessary for the ultrasound exam. During the studies the palm grip was discovered. It is new to probe handling, yet very intuitive.

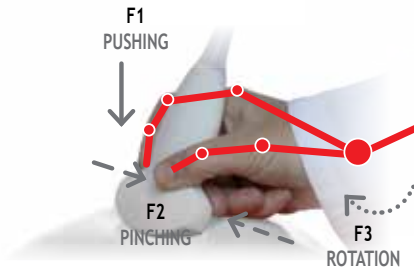
The palm grip is achieved by holding the cord end between the index and middle fingers and cupping the probe with the palm of the hand. This allows for the user to move the fingers and wrist during an exam without compromising the ultrasound image. With this new grip the pressure needed to create the ultrasound image could come from the upper arm and elbow, this would alleviate the pressure on the wrist. A new probe could allow for this new grip to be used as well as the traditional pincer grip. Allowing for both grips gives the user the power to decide how to hold the probe.

By having two different grips for one probe, the user can switch from one grip to another, reducing the stress created by the constant repetition of the traditional grip. The palm grip aligns the

wrist and the hand and allows the user to avoid the pressure associated with the pinching in the pincer grip. Yet the pincer grip may be more comfortable for certain exam positions. Switching between the grips increases the range of movement and limiting the time spent in one single grip. Doctors and sonographers have used the palm grip now, and the feedback is positive. They say that they find the new palm grip natural and comfortable. Sometimes something innovative is very instinctive.

Conventional grip

USE POSITION



**F1
PUSHING**

**F2
PINCHING**

**F3
ROTATION**

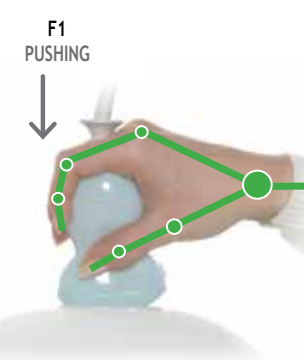
NO RELAX POSITION

as in the other probes on the market

The muscles, tendons and nerves remain in constant tension, caused by two necessary movements to keep the probe in the hand Pinching and to scan Pushing.

appleprobe grip

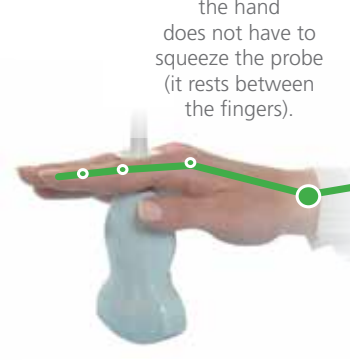
USE POSITION



**F1
PUSHING**

RELAX POSITION

the hand does not have to squeeze the probe (it rests between the fingers).





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CnTI™: The use of Contrast Agents in the USA is limited by FDA to the Left Ventricle opacification and visualization of the Left ventricle endocardial border.*