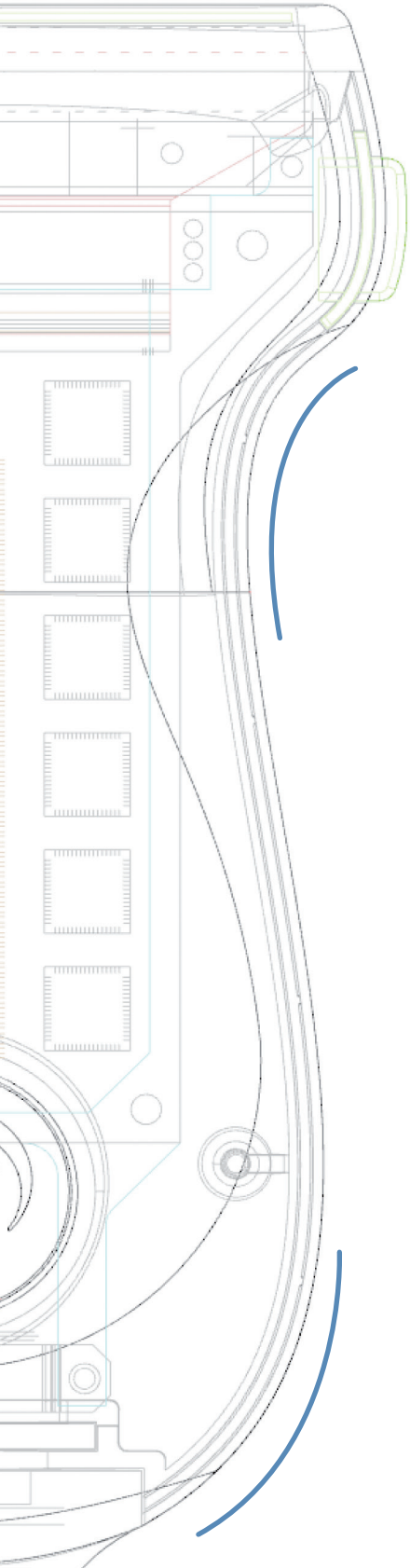
White Paper



iQ³Probes

PRELIMINARY

esaote
Creativity in Healthcare

iQ³Probes

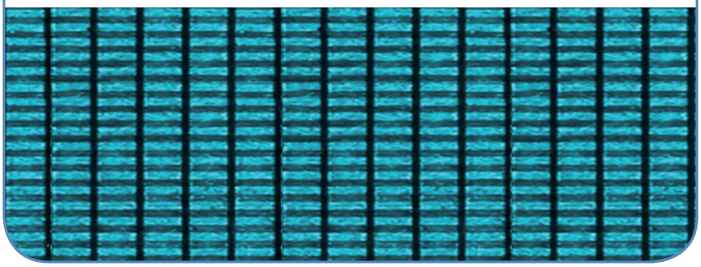
Ultrasound Transducers The First Element of the Chain

The transducer is the primary component in 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, the first and the main interface between the patient and the user of the ultrasound scanner still remains the ultrasound transducer. The design of the material and the manufacturing technology of an ultrasound transducer is a fundamental determinant of the system image quality. The iQ³Probe represents state of the art Esaote Technology due to the innovation of Quality gold standard ultrasound transducers.

Active Matrix Composite Material

In the existing family of cardiovascular probes, the active material (which is the part of the transducer that effectively produces the ultrasound signal) is a piezoelectric opportunely doped in order to have good conversion efficiency both in transmission and reception. The introduction of the Active Matrix Composite Material represents a huge breakthrough in improving the efficiency of transmission power with the aim to: reduce the high electric impedance, the origin of the electric issues between the probe head and ultrasound transducer and the consequent loss of transmission power minimize the extremely high acoustic impedance of PZT material (20 times greater than human tissue) and improve the ultrasound wave propagation generated within the PZT material through the tissue. The Active Composite Material which is made by PZT and resin represents a consolidated block subject to a coherent vibration efficiency which overall provides minor acoustic impedance and increases the signal propagation. The latter delivers an extremely high quality of the generated pulse, resulting in unmatched sensitivity thanks to an extraordinarily wide band pulse (superior to a 100% bandwidth value at -6 dB).

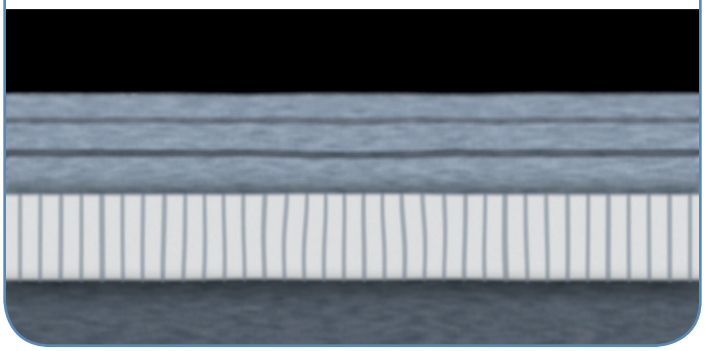
Microscopic view of the Active Matrix Composite Material



Multiple Adaptive Layers

In order to provide additional improvements to the acoustic impedance, the iQ³Probe Technology has adopted the intelligent design of Multiple Adaptive Layers. These multiple matching (very thin) layers placed between the Active Matrix Composite Material and the patient tissue have different acoustic impedance degrees, applied in decreasing value from the Matrix Composite elements towards the tissue The Multiple Adaptive Layers Technology reinforces the target achievement with a further improvement of sensitivity based on an extraordinary pure pulse signal and an extended bandwidth greater than 100%.

Microscopic view of the Multiple Adaptive Layers Technology

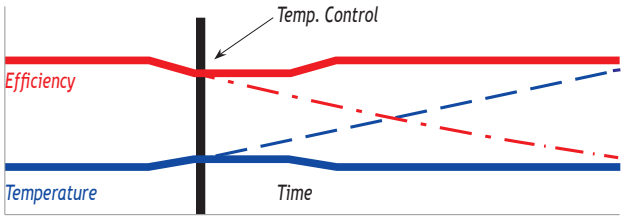


Radiation Lobe

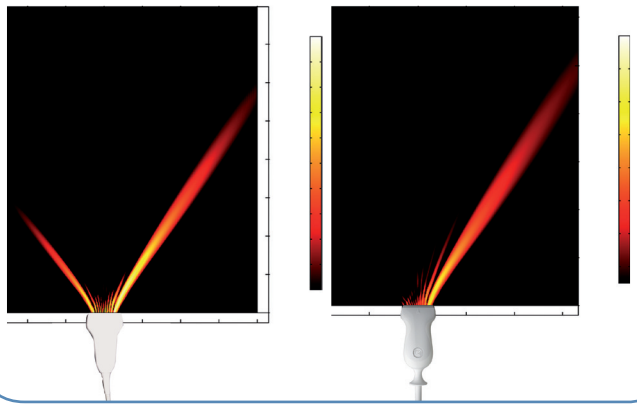
iQ³Probe Technology is supported by sophisticated array cutting equipment (located at the Florence Italy plant) able to operate with incredible precision and tolerance (2 micron) to yield a greater element size reduction adapting to the relevant cut size of inter-spatial area between the elements. To 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.
iQ³Probe 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.

Array Heating **Efficiency Maximization**

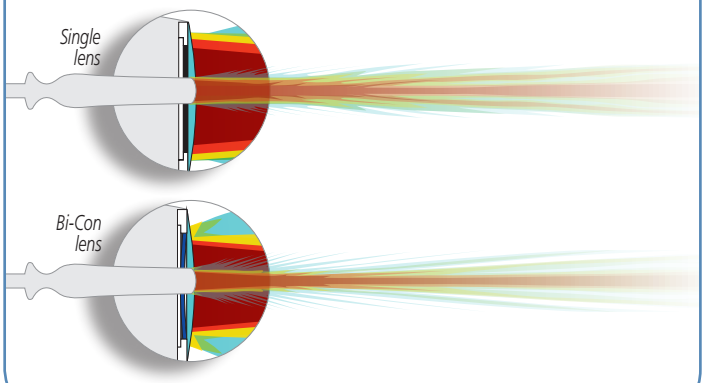
The extensive use of transducers in clinical daily workload may determine their efficiency loss and represent the main cause for a decrease in the probe's useful lifetime. This problem is generally caused by array overheating. iQ³Probe Technology provides the capability to measure transducer's head internal heating (through a system monitoring process) and to automatically control transmission power thereby preventing overheating. This capability is clearly operator-independent and is constantly adjusted for efficiency maximization. Thanks to this feature, the transducer will operate in the best conditions, always delivering its maximum power and with an extended useful lifetime.



Comparison between 30° steered radiation lobe of iQ³Probe versus conventional one



Comparison of beam profile with single and Bi-Con geometric lens



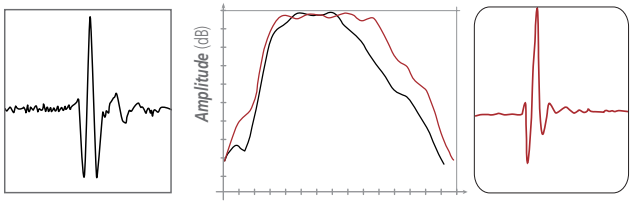
Bi-Con Geometric Lens

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 iQ³Probe, 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.

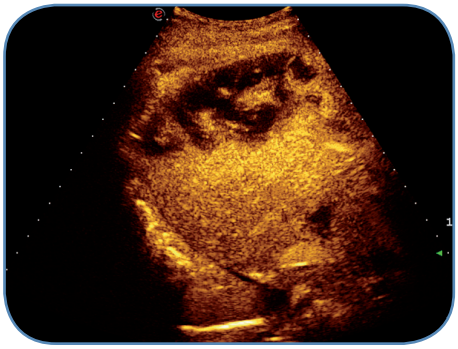
To assure high homogeneous sensitivity over the whole transducer bandwidth, iQ³Probe Technology employs an extraordinary low-absorption material in the Geometric Lens Manufacturing Process.

Comparison between Frequency Bandwidth response with and without Low-Absorption material

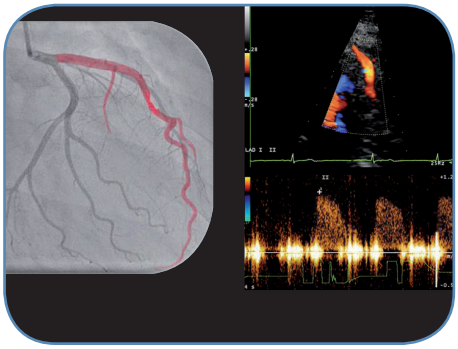


Pulse and frequency response using standard material

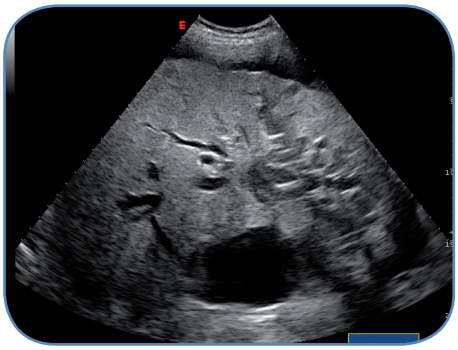
Pulse and frequency response using Low-Absortion material



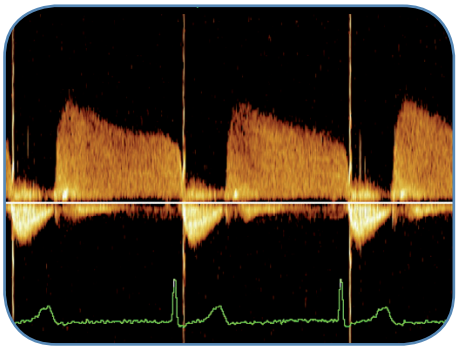
In the detection of coronary artery flow, the contribution provided from the iQ³Probe Technology is mainly derived from the adoption of the Active Matrix Composite Material which in combination with Multiple Adaptive Layers. This to ensure both Color and Spectral Doppler sensitivity to make easy and fast detection, precise quantification of the flow velocity.



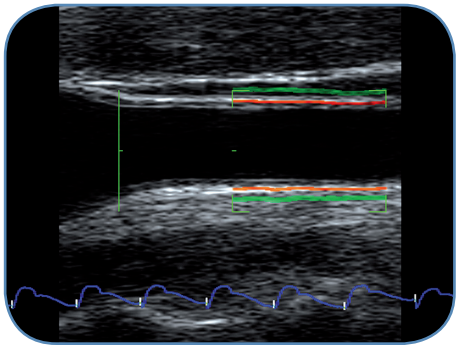
In order to make a proper radio-frequency signal analysis it is extremely important to have an extreme large transducer bandwidth. iQ³probe technology delivers an extended bandwidth greater then 100% thanks to both Active Matrix Composite Material and the Multiple Adaptive Layers technologies.



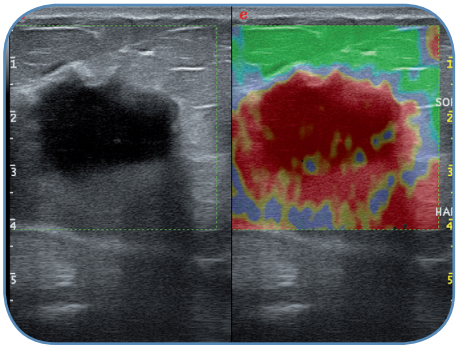
CW Doppler is a fundamental function for the detection and quantification of high-speed flow velocity. The cutting and manufacturing process of the iQ³Probe is a solid guarantee of maximization in the highest decoupling level between array elements, the latter in combination with the extraordinary focused beam profile provides superb Spectral Doppler sensitivity and flow profile resolution.



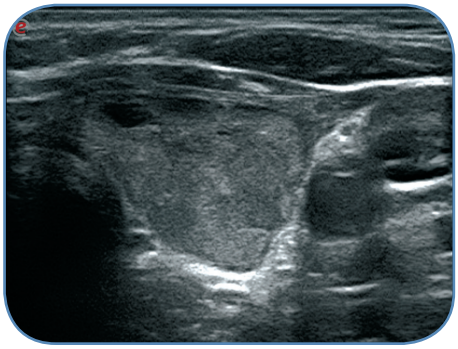
Deep abdominal investigations may represent a problem in difficult patient examination. The iQ³Probe technology offers a combination of key factors to enhance "deep region in difficult patient" imaging based on high adaptive impedence and large bandwidth. This allows the proper management of fundamental and harmonic frequencies in sophisticated algorithms located in the Front-End image processing.



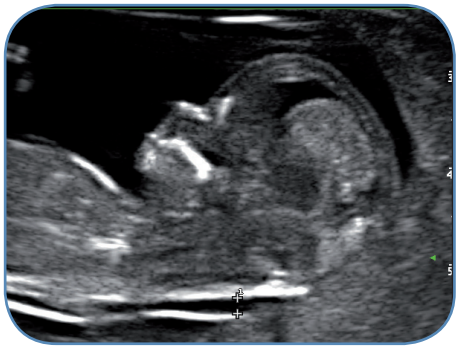
CEUS (Contrast Enhanced Ultrasound) represents an important additional tool in the hand of the physician to support confidence in diagnosis and improve patient management. Beam focalization and very wide bandwidth are the fundamental keys for the best insonation of the ultrasound contrast agent bubbles resulting in the extraordinary discrimination of their relevant signal contribution throught the front-end CnTI algorithms.



In superficial imaging examinations the transducer characteristics (frequency, size, format, etc…) are very different from deep region investigations. Thanks to the higher frequency range there is a physical improvement of axial resolution imaging, while on the other side it is required a specific management of the beam focalization due to the short field of view. iQ³Probe technology applied to Linear transducer provides extraordinary results thanks to its array characteristics and to both electronic beam focousing Bi-Con Geometric lens.

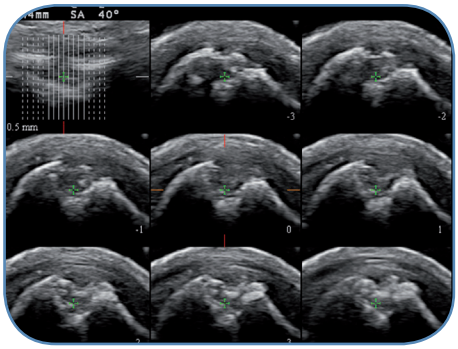


The overheating of the transducer is subjected to the high transmission power needed in far field/difficult patient applications, but also in superficial imaging where for higher PRF rate the transmission power is applied more frequently per fraction of time. With Array Heating Efficiency Maximization technology, iQ³probe offers a great advantage to achieve both optimal imaging result and longer probe working life.



State of the art Obstetric Ultrasound is looking at extraordinary early detection capability during the first trimester scan. iQ³Probe technology offers in addition to conventional Convex a superb wide bandwidth Linear array combining both penetration and resolution imaging. Thanks to its characteristics (Active Matrix Composite Material, Multiple Adaptive Layers, etc…) such technological platform has the ability to focus over normal viewing range as well as look below the millimeter to discover a new universe of clinical information.

When a mechanical compression or vibration is applied, generally some tissues get deformed less than others. The differences in tissue responses are detected and visualized in real time by elastosonography processing algorithms through different graphical representation on the display. iQ³Probe technology (with its Active Matrix Composite material) offers an extraordinary bandwidth capability and sensitivity to cover the widest frequency spectrum related to tissue elasticity properties.



High Frequency Volumetric probe is state of the art available technology today. iQ³Probe technology offers in this case its extraordinary characteristics in combination with a volumetric design, to provide the operator fast and easy volume acquisition, 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).

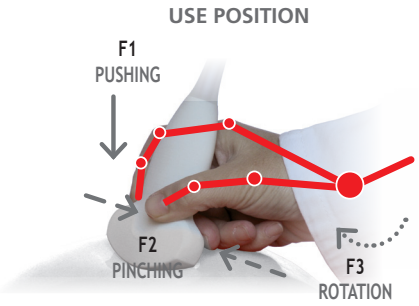
Sometimes the probe must be held in only one spot with constant pressure for a long exam, and this can be very taxing on the sonographer. Regular exams are also getting longer as newer scanning technologies are being utilized, and sonographers are only being put under a bigger burden."

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. The main goal is to improve the well-being and safety of the sonographer, with specific attention to their wrists, elbows and shoulders. 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

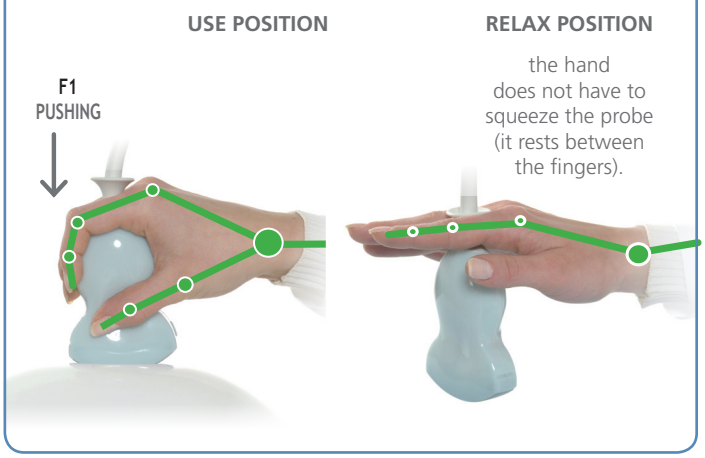


NO RELAX POSITION

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



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

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