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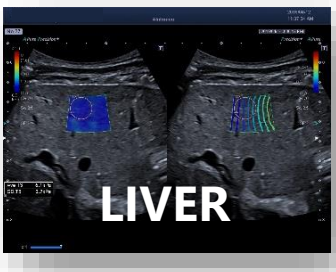
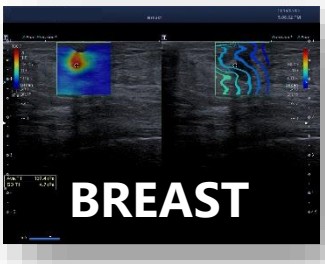
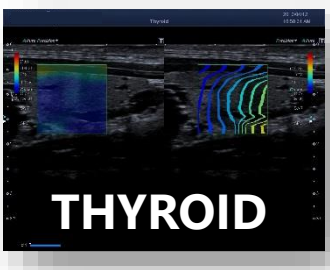
Shear Wave Elastography

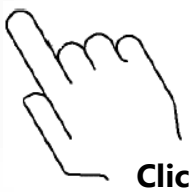
Aplio i-series

Technique









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Physics

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Compatible Probes

Acquisition Modes

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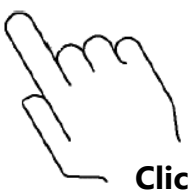

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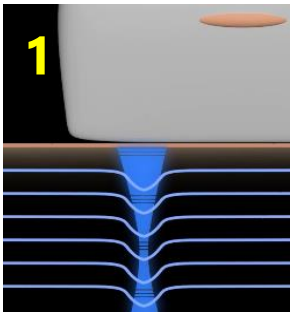
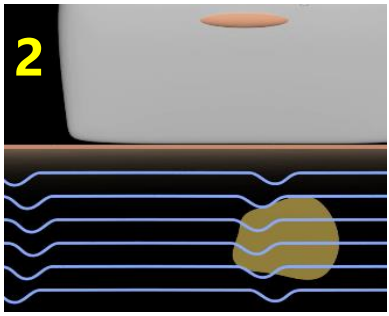
Physics

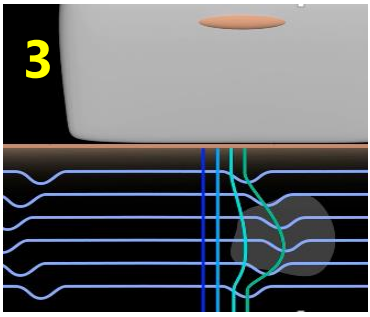
- High power focused ultrasound pulse generates a lateral tissue displacement. It is called shear wave.
- Shear wave speed is related to tissue stiffness. Waves tracking and analysis allows to calculate tissue stiffness by Young Modulus.



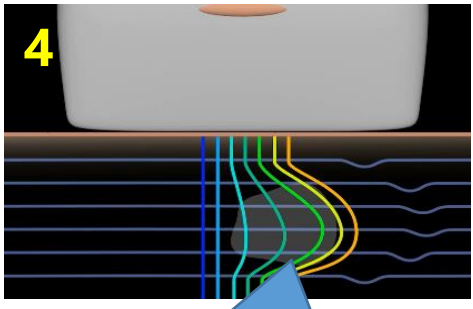
Focused Wave Generates Shear Wave



Propagation of Shear Wave in tissues



Shear wave velocity changed following



Lesion harder than the surrounding tissue : fast shear wave

Important Notes

- **Values :**
  Elasticity values must be used only by trained users, aware of the technology and its limits.
  Moreover, these results should never be used alone and always correlated with clinical or other imaging techniques.

- **Compression :**
  Excessive pressure on the probe can compress superficial tissues. Elasticity values measurements could be overestimated

- **Attenuation :**
  Insufficient tissue displacement by the push pulse may make it difficult to generate the shear wave amplitude required to measure the shear wave speed and elasticity. It may be caused by phase aberration, refraction or tissue attenuation: Excessive wall thickness or steatosis liver.

- **Anisotropy :**
  Some structures such as tendons have different propagation properties. Waves speed can be different along the axis studied . Be sure that the reference values correspond to the orientation analyzed.

- **Reverberation :**
  Shear waves are also affected by reverberation artefacts that can display false stiff areas on superficial interfaces.

- **Liquids :**
  The shear waves do not propagate in non- viscous liquids. However diffraction artifacts from adjacent structures can be observed in cystic structures (especially small cysts) .

- **Lesions :**
  Shear waves propagation is uniform in homogeneous tissue. The propagation mode allows to evaluate the quality before making a measurement. However in the case of a rigid and / or heterogeneous lesions , the analysis of this propagation profile does not provide any information about the quality of this acquisition.
  In the case of extremely stiff lesions, if it exceeds 200 kPa , unencrypted areas can occur without affecting the quality of the acquisition.

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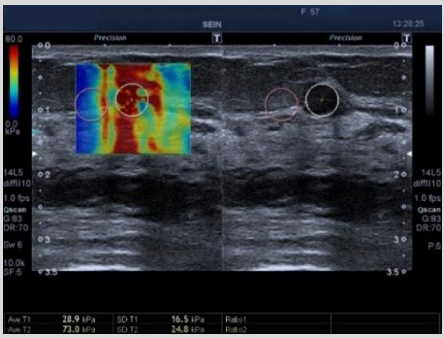
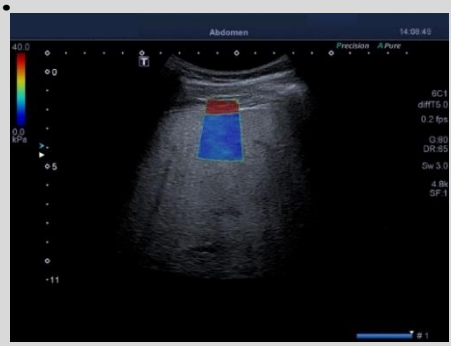
Artifacts

- **Excessive probe pressure:**
  Excessive pressure on the probe can create tissue pre compression and increased elasticity values



- **Liver Capsula stiff artifact :**
  Area under the liver capsula can be very stiff and not representative about the global liver stiffness.



- **Stiffness out of range:**
  Mapping can be incomplete case of very stiff lesions out of scale range

- **Calcifications**
- **Muscular interfaces**

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Compatible Probes

Abdominal Probes

PVT 375 BT/SC

PVI 475 BT/BX

Superficial Probes

PLT 1005 BT

PLI 1205 BX

Endocavity Probe

PVT 781 VT/VTE

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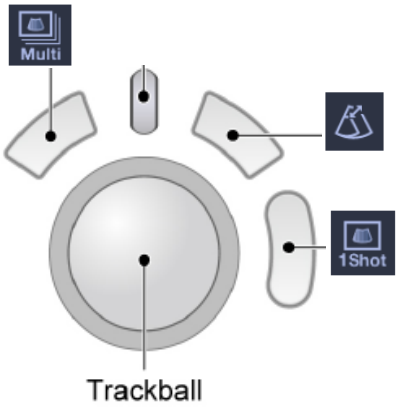
Acquisition Modes



Start Shear Wave mode by displaying the ROI on the screen

Adjust ROI size (resize with trackball)

Disable Shear Wave Mode and back to B mode

Press following button to activate one of the 2 acquisition modes available:

Real Time Shear Wave acquisition

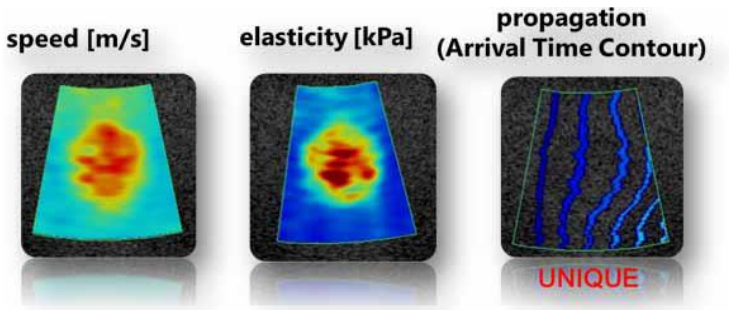
(Recommended)

Single One Shot acquisition with maximum power and resolution

Note , After an acquisition, **OneShot** mode requires a cooling time during which the probe is automatically frozen for 5 seconds.

Mapping

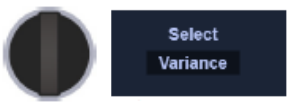
- **Map Types:**
  - **Speed:** Shear wave velocity map (m/s)
  - **Elast:** Elasticity map (kPa)
  - **Prop:** Mapping of the shear wave propagation profile.
  - **Select:** Variance mapping



Switch from elasticity to speed mapping via the dial Map Type . This setting is possible in real time and frozen image.

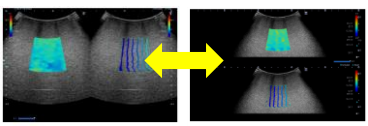
Scale is adjusted by the dial Range Max (speed : max 10 m/s / Elast : max 200 kPa) This setting is available in real time and frozen image.

Recommended scales :	
Breast:	0 – 180 kPa
Thyroid:	0 – 85 kPa
Muscle:	0 – 65 kPa
Liver:	0 – 45 kPa



Display or remove Variance Mapping

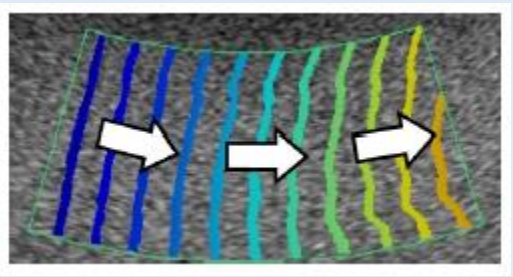
Change display from Left/Right to Up/Down



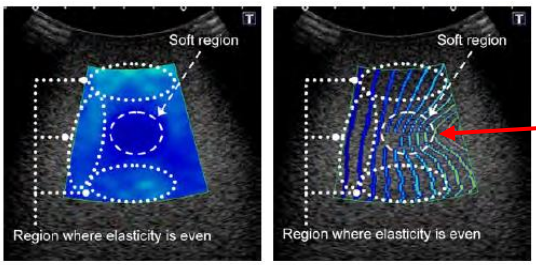
Propagation Mode

- The propagation mode is an exclusive mode for representing the profile of Shear Waves.
- This propagation profile is useful to evaluate propagation quality in uniform tissues (Liver)

- Propagation tracking starts from dark blue to warm colors



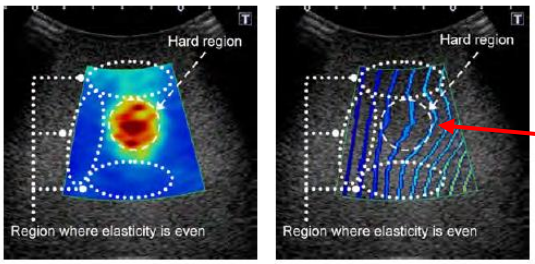
Soft lesion :



Elasticity display Propagation display

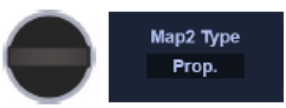
The Shear Waves are "slower" in the softer lesion.

Stiff lesion :



Elasticity display Propagation display

The Shear Waves are " accelerated" in the stiffer lesion.



Display (Prop) or remove (B) Propagation Map

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Settings

	LIVER	BREAST	THYROID	MUSCLE	TENDON
Preset	Fibrosis	Breast	Thyroid	Muscle	MSK
One Shot		No	No	No	
Range Max	**45 kPa**	**180 kPa**	**85 kPa**	**65 kPa**	**12 m/s**
FR Control	3	3	3	3	3
Smoothing	2	3	3	3	2
Time Smoothing	4	4	3	3	3
Diff Pitch	2	2	2	2	2
Color Map	0	0	0	0	0
Opacity	0,5	0,5	0,5	0,5	0,5
Resolution	2	3	3	2	0
Focus	75%	75%	75%	75%	75%
Track Freq	2.2	6	6	6	2.2
ROI Measure	10 mm	2 mm	4 mm	3 mm	3 mm
Position	Parenchyma	Stiffest area (lesion or peri- lesional)	Lesion	Lesion	Injured area

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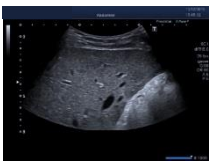
Liver Protocol

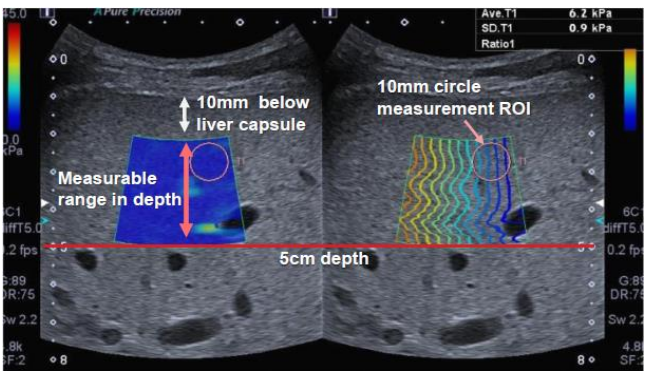
- **Acquisition Protocol:**

1. Patient fasted for > 4 hours
2. Patient supine position
3. Right liver Intercostal approach (segment VII/VIII predominantly)
4. Probe perpendicular to the liver surface

5. Liver surface (capsule) displayed horizontally



6. High quality B-mode image free of vessels or any shadowing/reverberation artifact
7. SW box placed 1 cm below the liver capsule



8. Complete the acquisition on a "block" of breathing (No deep apnea)

- **Measurement Protocol:**

1. ROI Shape/Size: circle/10mm diameter
2. Center of the ROI shouldn't be placed at a depth greater than 5cm
3. Place ROI on most parallel propagation map area
4. Use median value after 10 acquisitions

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Liver Fibrosis Assessment

- **Indicative values for Hepatic Fibrosis***

- **Ultrasound Shearwave for Staging Liver Fibrosis: Preliminary Results of a Prospective Multicenter European Study**

  Lim,A, Ronot,M, Ferraioli,G, Mueller,H, Friedrich-Rust,M, Cosgrove,D, Filice,C, Vilgrain,V

  Radiological Society of North America 2016 Scientific Assembly and Annual Meeting, November 27 - December 2, 2016, Chicago IL. archive.rsna.org/2016/16009227.html Accessed November 30, 2016

- A total of 5 measurements is sufficient.
- ToSWE can distinguish patients with Normal/Mild Fibrosis and Cirrhosis

Stage	Fibrosis Stage	Speed (m/s)	**Elasticity (kPa)**
F0-F1	Non significant	< 1,54	**< 7.1**
≥ F2	Significant	1,54 - 1,78	**7,1 – 9,5**
≥ F3	Advanced	1,78 – 1,87	**9,5 – 10.5**
F4	Cirrhosis	> 1,87	**> 10.5**

*IMPORTANT: This study is ongoing and data are not been published.
This report is for INTERNAL use only until this MC study is published.

The values described in this document are indicative and not exhaustive., according to current scientific literature .

Toshiba Medical cannot be responsible for the consequences from the use or interpretation based on these values.

Healthcare professional is the only guarantor of the diagnosis in particular safety and patient information in accordance with the acquired data science.

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References
Liver Fibrosis

- **Elastography assessment for Liver Fibrosis :**

- **(1) EFSUMB Guidelines and Recommendations on the Clinical Use of Liver Ultrasound Elastography, Update 2017 (2017)**
  - Christoph F. Dietrich, Jeffrey Bamber, Annalisa Berzigotti, Simona Bota, Vito Cantisani, Laurent Castera, David Cosgrove, Giovanna Ferraioli, Mireen Friedrich-Rust, Odd Helge Gilja, Ruediger Stephan Goertz, Thomas Karlas, Robert de Knegt, Victor de Ledinghen, Fabio Piscaglia, Bogdan Procopet, Adrian Saftoiu, Paul S. Sidhu, Ioan Sporea, Maja Thiele

- **(2) Elastography assessment of liver fibrosis : Society of radiologists in ultrasound consensus conference statement (2015)**
  - G. Barr, G. Ferraioli, L. Palmeri, D. Goodman

- **(3) Superiority of a new shear wave elastography in evaluation of liver fibrosis (2015)**
  - *Hiroko Iijima, Masahiro Yoshida, Mariko Hashimoto, ChikageNakano,Tomoko Aoki, Kenji Hashimoto, Hironori Tanaka, NobuhiroAizawa, Akio Ishii, TomoyukiTakashima, Yoshiyuki Sakai,Yoshinori Iwata, Naoto Ikeda, HirayukiEnomoto, Masaki Saito, SyuheiNishiguchi, Seiichi Hirota, JiroFujimoto, Hirohisa Yano, Osamu Nakashima, Masayoshi Kage*

- **(4) Principles and clinical application of ultrasound elastography for diffuse liver disease (2013)**
  - Woo Kyoung Jeong, Hyo K. Lim, Hyoung-Ki Lez, Jae Moon Jo, Yongsoo Kim

Exam Report

- **Exam report:**

- Press report button on left side row of touch command screen to displays a summary of measurements

  - Mean
  - Standard deviation
  - Median
  - Interquartile range IQR

- The more robust result of the examination is given by the median parameter

	Speed[m/s]		Elasticity[kPa]		Depth[cm]
	Average	SD	Average	SD	
1	1.86	0.09	10.3	1.0	2.6
2	1.90	0.16	10.8	1.9	2.6
3	2.09	0.12	13.1	1.5	2.5
4	1.77	0.12	9.3	1.3	2.7
5	1.87	0.14	10.4	1.6	2.7
6	1.81	0.12	9.8	1.4	2.9
7	1.76	0.08	9.2	0.8	2.5
8	1.80	0.07	9.6	0.8	2.8
9	1.75	0.13	9.1	1.4	2.9
10	1.69	0.13	8.5	1.3	2.8
Mean	1.83		10.0		
SD			1.2		
Median	1.81		9.7		
IQR					

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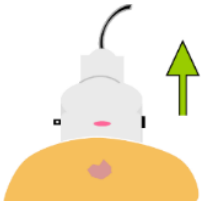
Breast Protocol

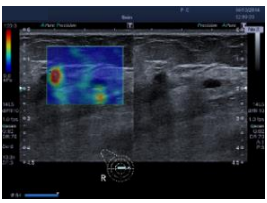
1. Reduce probe pressure to the minimum as to get acceptable 2D image



2. Display the shear wave ROI

3. Adjust ROI wide enough to analyze the entire lesion and a normal gland area

4. Start Shear Wave in Multi mode (real time)



5. Control lesion position on the lesion . Wait few seconds for image stabilization (several successive images with stable mapping) and freeze the image.

6. Place the T1 ROI of 2 mm first in the normal gland : the value must be <25 kPa (except in very glandular) without validating it.

7. Then move the ROI T1 on stiffest area inside **lesion or in direct surrounding area**.

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References Breast

- **(6) Value of shear wave arrival time contour display in shear wave elastography for breast masses diagnosis (2017)**
  - Bang-Guo Zhou, Dan Wang, Wei-Wei Ren, Xiao-Long Li
- **(7) Qualitative and quantitative analysis with a novel shear wave speed imaging for differential diagnosis of breast lesions (2016)**
  - Yu-Ping Yang, Xiao-Hong Xu, Le-Hang Guo, Ya-Ping He
- **(8) Shear-wave elastography in breast ultrasonography: the state of the art (2017)**
  - Ji Hyun Youk, Hye Mi Gweon, Eun Ju Son
- **(9) Shear-wave Elastography improves the specificity of brest US – BE1 (2012)**
  - A. Berg , D. O. Cosgrove , J Doré , K. W. Schäfer , E. Svensson, R. J. Hooley , R. Ohlinger , E. B. Mendelson , C. Balu-Maestro , M. Locatelli , C. Tourasse , C. Cavanaugh , V. Juhan , A. Thomas Stavros , A. Tardivon , J. Gay , JP. Henry , Cl. Cohen-Bacrie ,
- **(10) Shear-wave elastography for breast masses: local shear wave speed (m/sec) versus Young modulus (kPa) (2014)**
  - Ji Hyun Youk, Eun Ju Son, Ah Young Park, Jeong-Ah Kim

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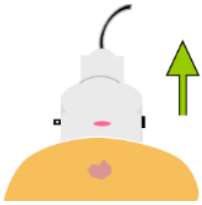
Thyroid Protocol

1. Select longitudinal probe orientation

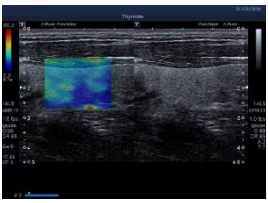


2. Reduce probe pressure to the minimum as to get acceptable 2D image

3. Display the shear wave ROI

4. Adjust ROI wide enough to analyze the entire lesion and a normal gland area

5. Start Shear Wave in Multi mode (real time)



6. Control lesion position on the lesion . Wait few seconds for image stabilization (several successive images with stable mapping) and freeze the image.

7. Place the T1 ROI first in the normal gland : the value must be <25 kPa (except in case of thyroiditis) without validating it.

4. Then move the ROI T1 on the lesion

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References Thyroid

- **(11) Elastography of the Thyroid (2013)**
  - H.Montpeyssen, J. Tramalloni, S. Poirée, O. Hélélnon, JM. Corréas
- **(12) Ultrasound elastography for thyroid nodules recent advances (2014)**
  - F. Jin Young Kwak, Eun-Kyung Kim
- **(13) Shear Wave Elastography: A New Ultrasound Imaging Mode for the Differential Diagnosis of Benign and Malignant Thyroid Nodules (2010)**
  - F. Sebag, J. Vaillant-Lombard, J. Berbis, V. Griset, J. F. Henry, P. Petit, and C. Oliver
- **(14) Shear wave elastography of thyroid nodules for the prediction of malignancy in a large scale study. (2014)**
  - Ah Young Park, Eun Ju Son, Kyunghwa Han, Ji Hyun Youk, Jeong-Ah Kim, Cheong Soo Park