Imperial College London

QIBA Elastography a Clinical Perspective

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Breast and Liver

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Strain Elastography Breast

- extensively studied
- essentially qualitative
- quantitation of stiffness relative to adjacent fat
- concern on reproducibility

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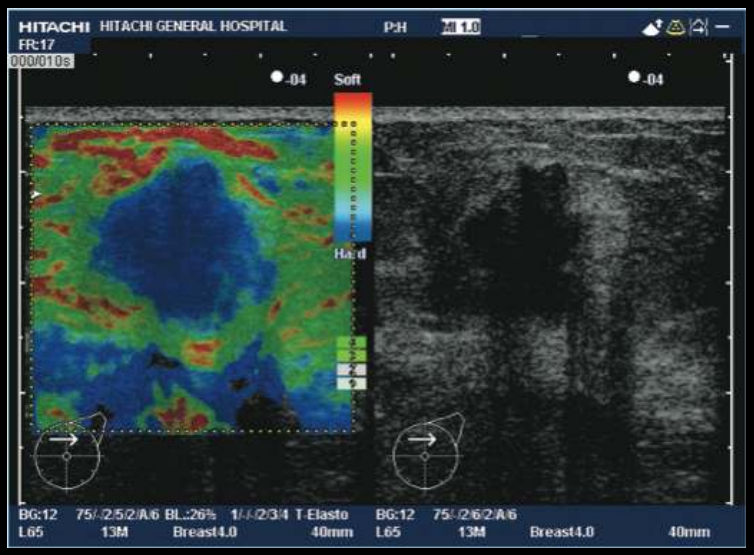

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Hitachi

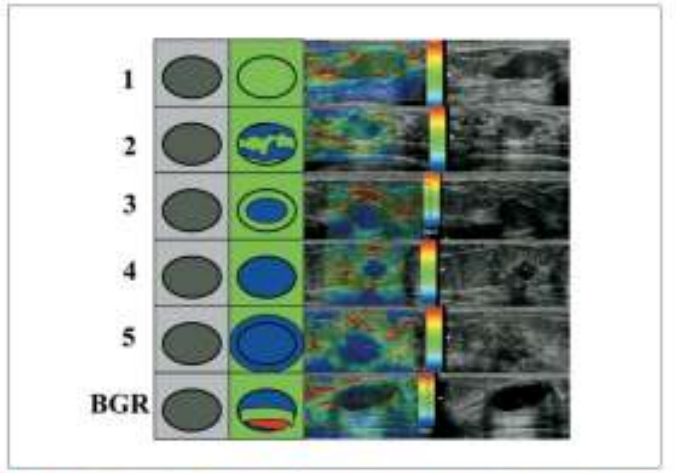

Fig. 1 : Tsukuba Elasticity Score patterns and clinical cases

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Kiel Group
129 B, 64 M

- Hitachi system
  - Tsukuba score 1–5
- FNA cytology
- M 4.1±0.9
- B 2.1±1.0
- Spec 96%
- Sens 58%

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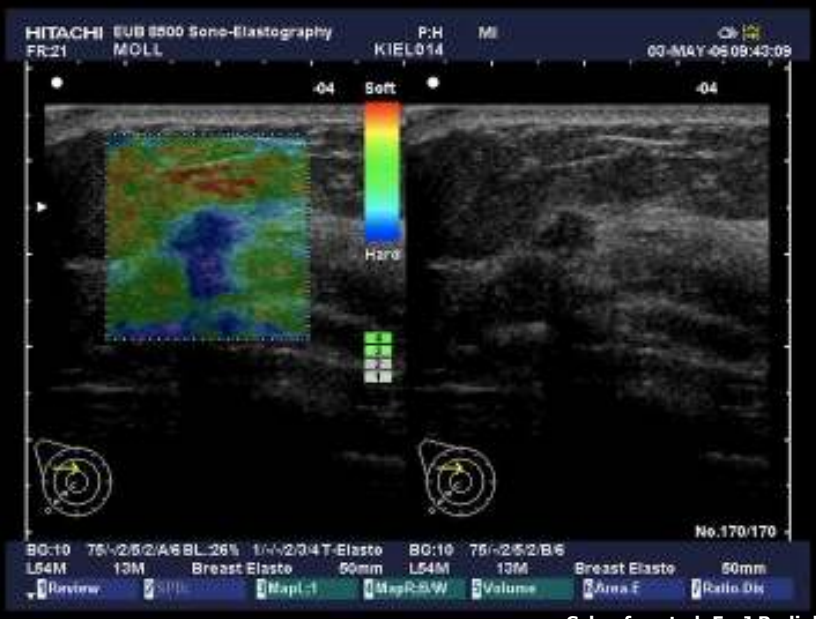
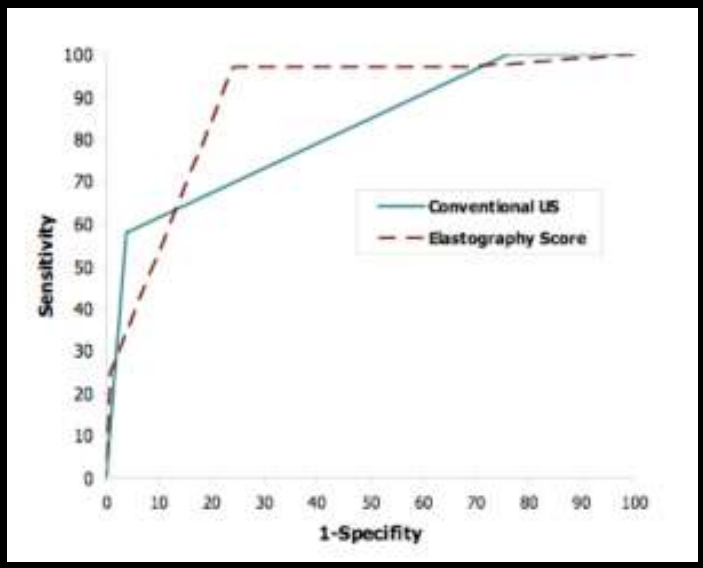
Schaefer et al, Eu J Radiol 2009

Carcinoma



Schaefer et al, Eu J Radiol 2009



Elasto A_z 0.884

B-mode A_z 0.820

(p<0.001)

Schaefer et al, Eu J Radiol 2009

Conclusion

- "elastography has not the potential to replace conventional B-mode for the detection of breast cancer, but can complement conventional US to improve the diagnostic performance."

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Schaefer et al, Eu J Radiol 2009

SWE Breast

- images are quantitative
  - ROI give values in m/s or kPa
- minimal operator input
  - good reproducibility
- currently SuperSonic Imagine only
  - Siemens liver system in beta
  - other companies have work in progress

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BE 1 Study

- 1800 patients
- multicentre, USA and Europe
- initial analysis for reproducibility and power to regrade BI-RADS 3 and 4a
- rich data base for additional analysis

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Carcinoma

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Fibro-cystic Change
ANDI

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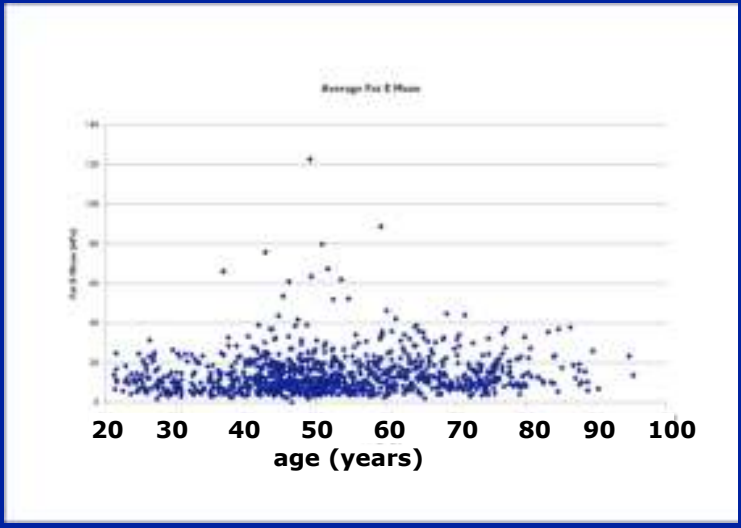
Scatterplot of E Mean



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Fat Stiffness Changes

- trend to an increase in stiffness with age
  - *c* 10% per decade
- small increase close to cancers
  - *c* 3%

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BE1 Reproducibility 758 masses

- qualitative: 3 images ≥ "reasonably similar" for 88%
- intra-observer reliabilities for mass diameter, perimeter, and area "almost perfect" (ICC ≥ 0.94)
- intra-observer reliability for Emax and Emean "almost perfect" (ICC = 0.84 and 0.87) and "substantial" for the mass-to-fat SWE ratio (ICC = 0.77)
- inter-observer agreement "moderate" for SWE homogeneity (κ = 0.57) and "substantial" for visual assessment of maximum elasticity (κ = 0.66)

Caroline Doré, biomedical statistician

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BE1 Results
single SWE features added to BI-RADS scores

SWE feature	A_z
BI-RADS alone	0.7159
SWE shape	0.8103
SWE vs B Shape similarity	0.8196
SWE homogeneity	0.8473
SWE/B size ratio	0.8286
SWE ratio	0.8647
SWE Min value	0.8559
SWE Max value	0.8647
SWE Mean value	0.8660

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Berg et al. Radiol 2012

Reproducibility of E Mode measurements

Measurement (log tranformed)	Measurement (log tranformed)
Distance	0.89
Perimeter	0.85
Area	0.91
E Min	0.78
E Max	0.87
E Mean	0.90
E ratio	0.81

all measurements but E Min have almost perfect agreement

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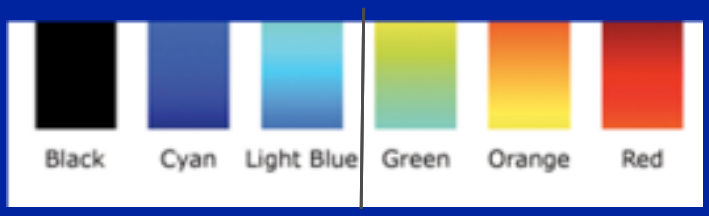
BE1 Main Study
939 masses, 289 Ca

- use visual colour SWE to upgrade BI-RADS 3 and downgrade 4a masses



- AUC BI-RADS:US 0.950 ↑ 0.962, p = .005 without loss of sensitivity
- specificity ↑ from 61.1% to 78.5%, p<.0001

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BE1 Subjective Results
939 masses, 289 Ca

- AUC BI-RADS:US AUC 0.950
- use visual blue/green threshold
  - upgrade BI-RADS 3 and downgrade 4a: specificity ↑ from 61.1% to 78.5% (p<.0001)
  - AUC ↑ to 0.962 (p= .005)
  - no loss of sensitivity

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Berg et al. Radiol 2012

Liver diffuse diseases

- most experience with Fibroscan
- non-imaging
- m/s readout
- quality control
- 12% failure rate

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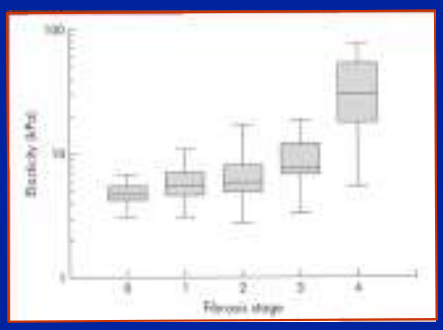
Fibroscan *vs.* Histology

- prospective study
  - 711 patients chronic liver disease
- correlates with METAVIR fibrosis stage
  - r = 0.73; P < 0.0001



	Fibrosis Stage		
Liver stiffness	Moderate (F ≥ 2)	Severe (F ≥ 3)	Cirrhosis (F = 4)
Cut-off values (kPa)	7.2	12.5	17.6
A_z	0.80	0.90	0.96

Courtesy of Prof Taylor-Robinson

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Fibrotest and FibroScan

183 Prospective Patients with Chronic HepC

Agreement with Liver Biopsy

Fibrosis Stage	Fibrotest %	Fibroscan %	Fibrotest + Fibroscan %
F≥ 2	80	73	84
F≥ 3	81	83	95
F = 4	80	90	94

Castera L, et al. Gastroenterology 2005;128:343

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Comparison TE, RTE and ARFI

45 biopsied mixed diffuse liver disease and 27 controls

- **TE with Fibroscan**
  - **readout in kPa**
- **Real Time Elasto with Hitachi**
  - **multivariate anlaysis for Elasticity Index**
- **ARFI with Siemens 2000 virtual touch**
  - **readout in m/s**
- **Metavir fibrosis and necro-inflammatory score**
  - **F1 = normal, F2 & 3 = increasing fibrosis, F4 = cirrhosis**

Colombo et al. J Gastroenterol, 2012

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Haed-to-head Comparison

- all performed well for severe fibrosis
  - poor for necro-inflammatory score
- TE marginally best

Colombo et al. J Gastroenterol, 2012

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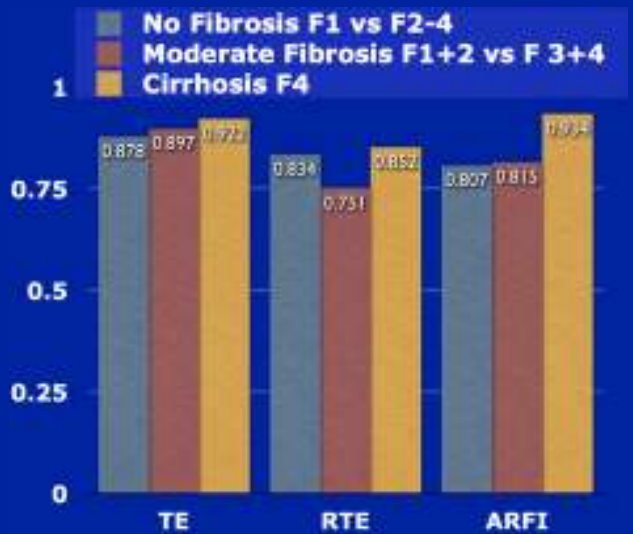
Fibrosis
A_Z of ROCs F1 vs F2-4



Colombo et al. J Gastroenterol, 2012

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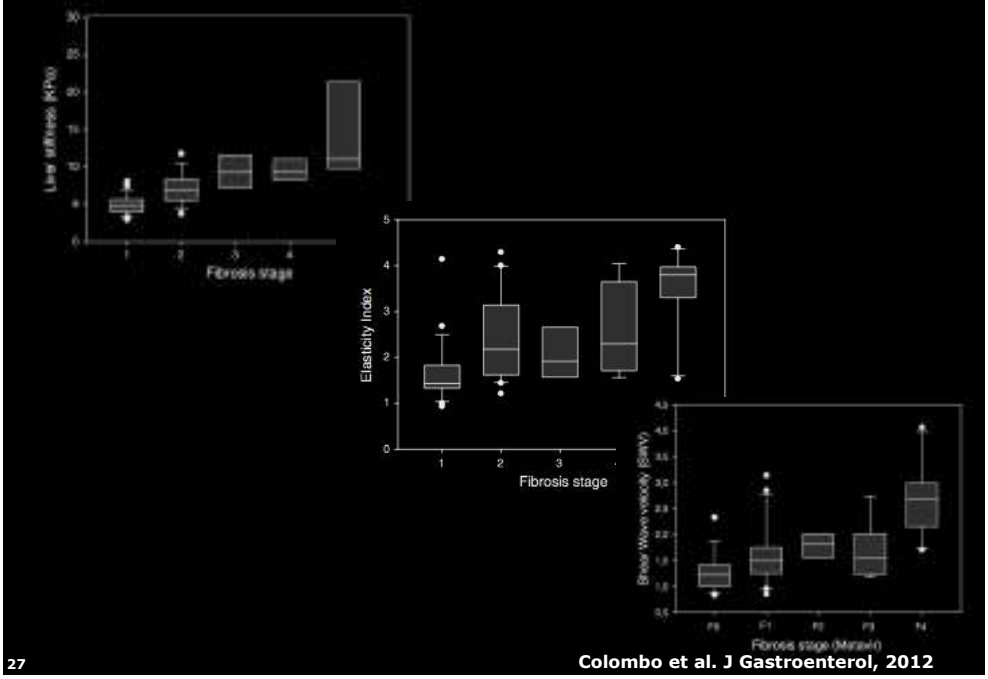
Comparisons



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Colombo et al. J Gastroenterol, 2012

Caveat re Fibroscan Meta-analysis

- 40 of 1280 studies selected
- QUADAS tool for report quality

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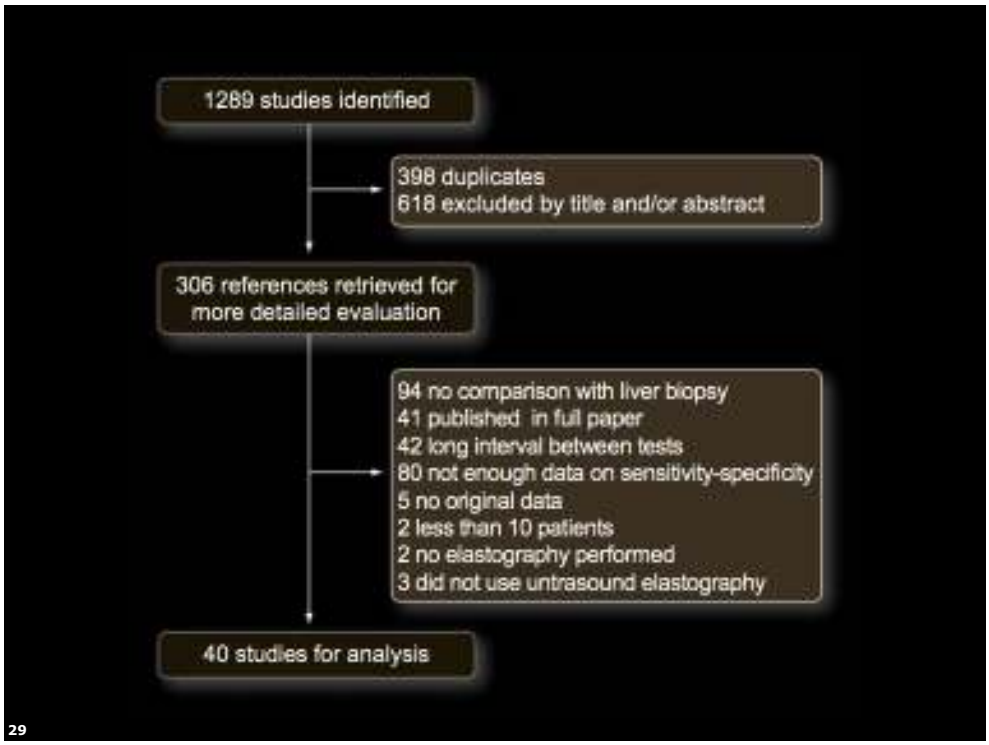
Tsochatzis et al. J Hepatol 2011, 54:650–659



Caveat re Fibroscan Meta-analysis

Fibrosis	# Studies	Sensitivity	Specificity
≥1	10	0.78	0.83
≥2	31	0.79	0.79
≥3	24	0.82	0.86
4	30	0.83	0.89

Tsochatzis et al. J Hepatol 2011, 54:650–659

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Criteria for Fibrosis

- cut offs varied widely
  - for F4, 9–26.5 kPa
- no prospective study
- negative TE of limited value
  - F2 in 20%
  - F4 in 16%

Tsochatzis et al. J Hepatol 2011, 54:650–659

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Fatty Livers
NASH (non-alcoholic steato-hepatitis) and NAFLD (non-alcoholic fatty liver disease)

- 61 biopsy-proven cases
- fat and fibrosis score
- Fibroscan
- ARFI Siemens S-2000

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Fibroscan XL in Obesity

210 patients with chronic liver disease, BMI >28 kg/m²

- **liver biopsy**
  - **viral hepatitis 45%**
  - **non-alcoholic fatty liver disease (NAFLD) 55%**
- **XL probe wider piston with greater excursion, lower interrogating frequency**
- **11% overestimated by ≥ 2 F levels**
  - **~ "poor quaity acquisitions"**
  - **~ BMI**
  - **~ stiffness > 7 kPa**

Myers et al., J Hepatol 2012, 56:564

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Siemens ARFI
Quantification

- **acoustic radiation force push**
  - **high MI (but within AIUM limits)**
- **shear wave travels laterally**
  - **multiple pulses track shear wave**
- **velocity converted to kPa**
  - **quantitative readout**

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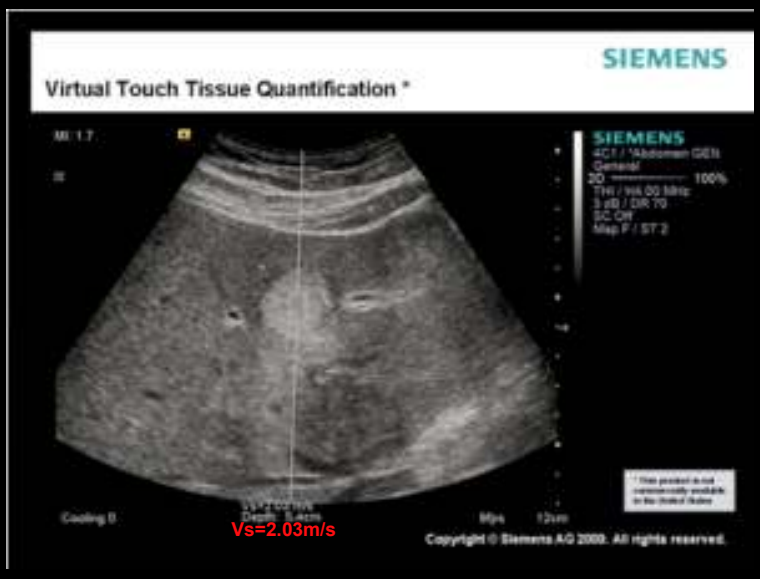
ARFI Quantification

siemens.com/strain

Quantitative ARFI



siemens.com/strain

ARFI vs Fibroscan

606 patients, mixed chronic liver disease; 69 biopsied

- success rate ARFI 99.7%; TE 79.5%
- good correlation
  - *r* 0.92 *p* < 0.001
- different cut-offs for each pathology

Kircheis et al., World J Gastroenterol. 2012, 18:1077

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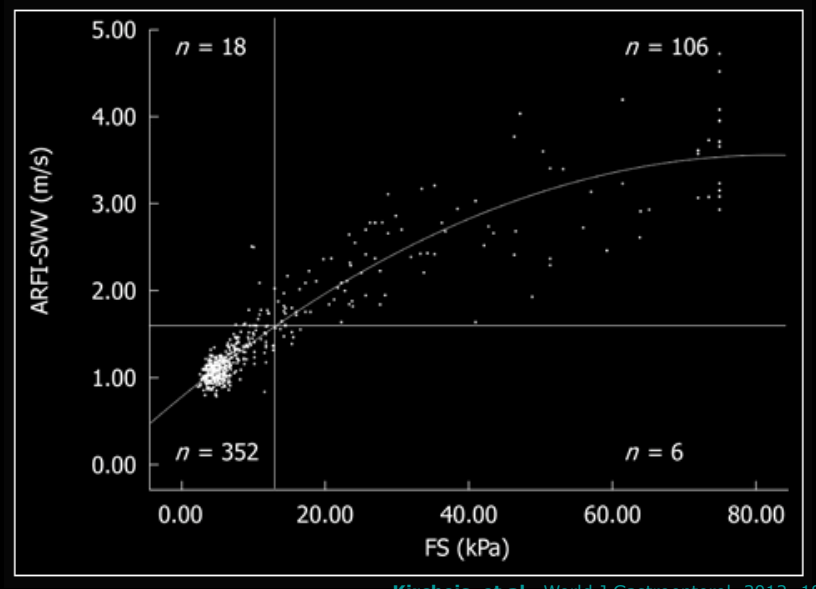
Correlation between ARFI and TE



Kircheis et al., World J Gastroenterol. 2012, 18:1077

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ARFI vs TE biopsied cases

- Comparison with liver biopsy [ARFI-SWV (*n* = 68) and FS-LS (*n* = 59)]

- Non significant liver fibrosis
- ARFI (*n* = 23)
- 0.929
- 1.32 m/s
- 0.83
- 0.91
- 87.0
- 80.0

Kircheis et al., World J Gastroenterol. 2012, 18:1077

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qARFI in Chronic Liver Diseases
Prof. Bill Lees

- **300 subjects**
  - **100 normal**
  - **mainly HBV, HCV and fatty livers**
  - **75 biopsied**
- **1 technical failure**
  - **morbid obesity**

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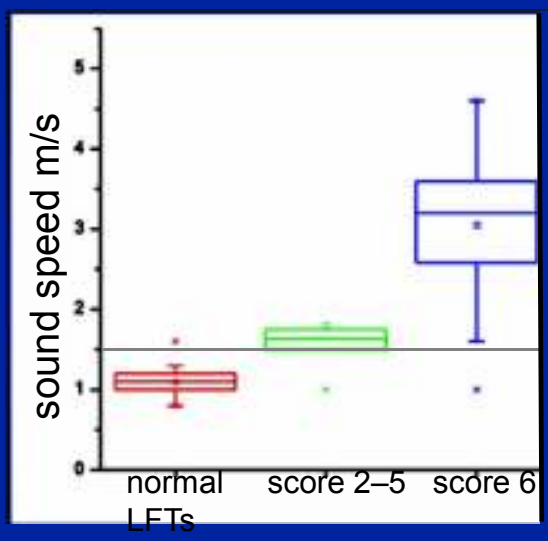
ARFI in Chronic Liver Disease
Prof. Bill Lees



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ARFI

- elasto alongside B-mode
- mainly for liver
- fast and simple to learn
- user independent
- can be quantitative

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ARFI

- transducer heats up
  - intermittent imaging
- small elasto box
  - 8cm depth limitation
- abdomen only

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SWE in Liver Fibrosis
113 HBC patients

- Fibroscan, SWE and blood tests
  - 39 had biopsies also
- 2.5 MHz curved array
  - C2-4
  - prototype of Aixplorer
- 7 excluded Fibroscan/SWE unreliable

Bavu et al. UMB 2011, 37, 1361-1538

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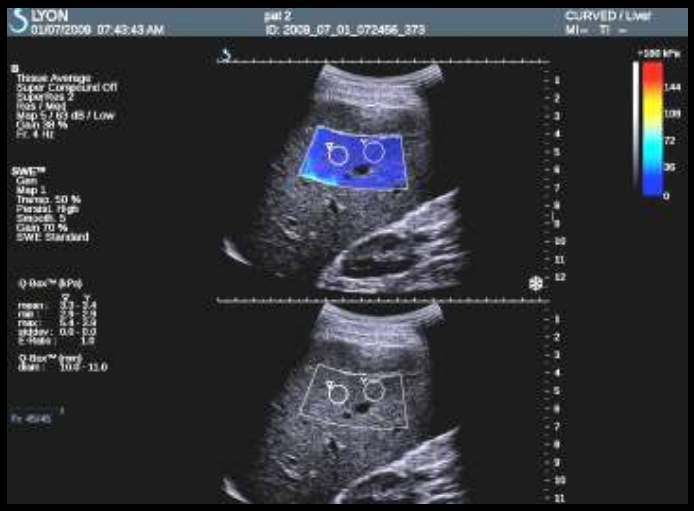
Normal Liver



liver 3.4 kPa

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Fibrosis

liver 30 kPa

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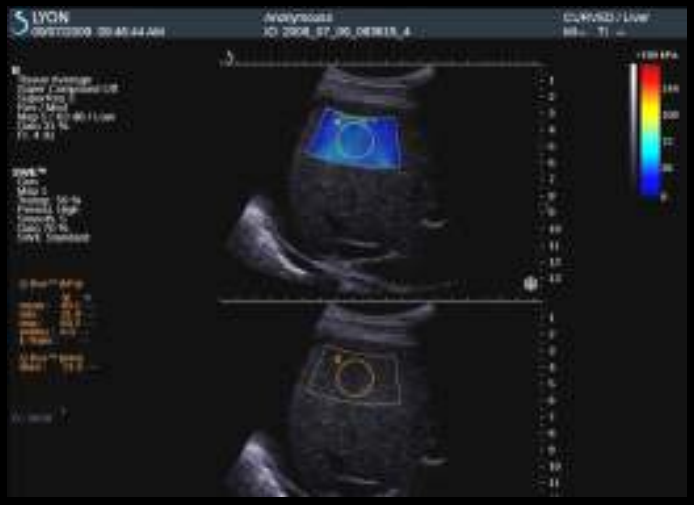
Cirrhosis Portal Hypertension



liver 43 kPa

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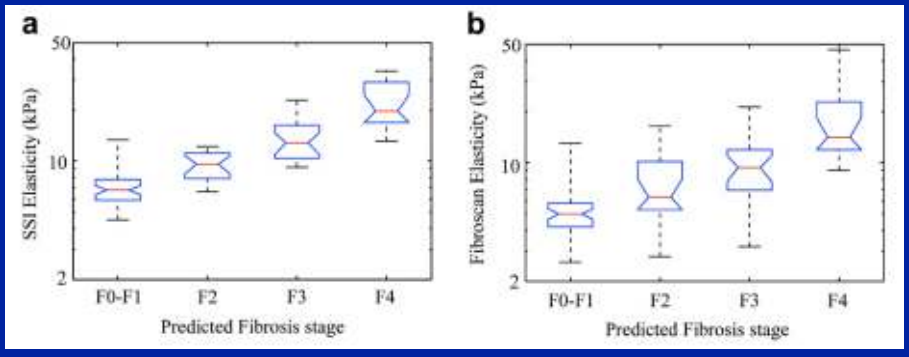
Mean SWE and Fibroscan vs Metavir Score



Good Agreement p<0.0001

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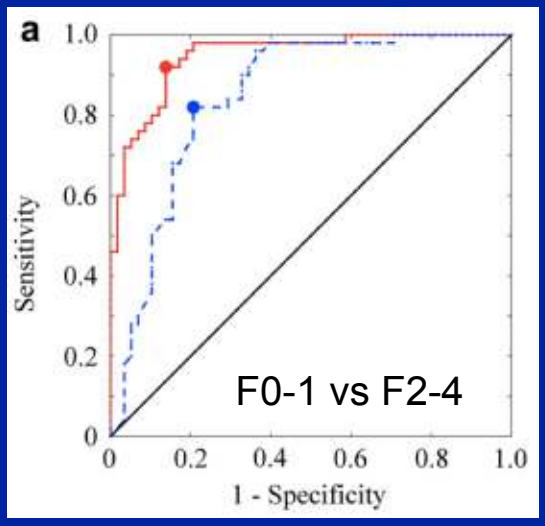
Bavu et al. UMB 2011, 37, 1361-1538

ROC curves
Red = SWE, Blue = Fibroscan



Bavu et al. UMB 2011, 37, 1361-1538

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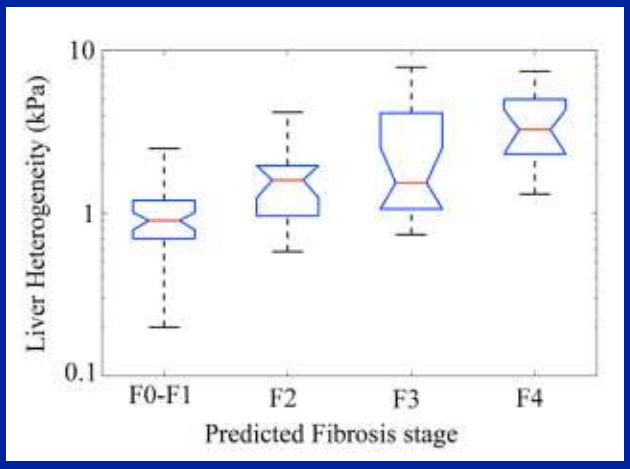
SWE Heterogeneity
σ, kPa



Bavu et al. UMB 2011, 37, 1361-1538

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QIBA Criteria: Breast Masses

- degree of fit
  - transformative √
  - translational √
  - feasible √
  - practical √
  - collaborative √
- numbers: potentially large
- QUALYs: could be large
- implementation: only one but certain to change
- clinical demand: great

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QIBA Criteria: Diffuse Liver Disease

- degree of fit
  - transformative √
  - translational √
  - feasible √
  - practical √
  - collaborative √
- numbers: potentially large
- QUALYs: could be large
- implementation: several
- clinical demand: great

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