


Dept of Clinical Sciences
Malmö Sweden

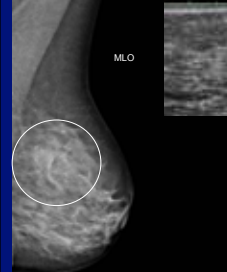
Digital Breast Tomosynthesis

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D. Förnvik, T. Svahn, P. Timberg
A. Tingberg, S. Zackrisson

Acknowledgements

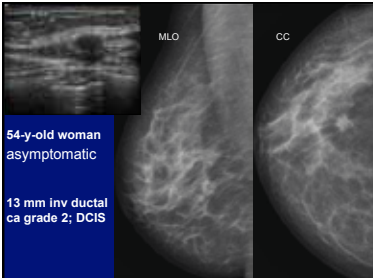
A. Lindahl MD
M. Löfgren MD
C. Wattsgård MD
B. Ziemecka MD



MLO

Palpable tumour

Pathology:
17 mm inv ductal carcinoma grade 3



MLO CC

54-y-old woman asymptomatic

13 mm Inv ductal ca grade 2; DCIS

Mammography is less than perfect

Mammography Reasons for non-detection

- **Anatomic noise** (dense breast tissue)
- **Tumour growth pattern**

Digital vs. screen-film mammography

”The 10 studies comparing FFDM with SFM in screenig have shown divergent and rather conflicting results”

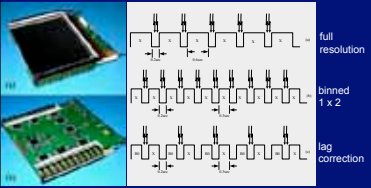
Skaane, ACTA RADIOL 2009

Digital mammography: Why not a more dramatic improvement?

Hypothesis:

- The detector is not the limiting factor
- **The anatomical background of the breast is the limiting factor**
- Tomosynthesis will reduce the anatomical noise

Tomosynthesis - Detector & Readout



24 cm x 30 cm
2816 x 3894 pixels
Pixel pitch 85 µm


cycle time 0.5 ... 1.0 s

full resolution
binned 1 x 2
lag correction

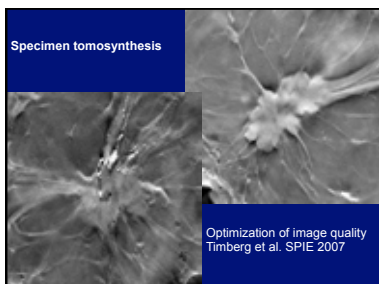
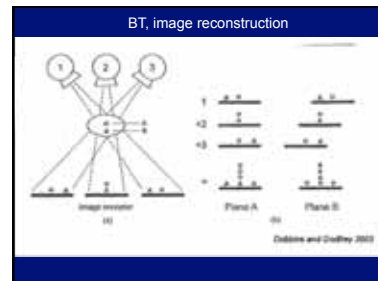


MAMMOMAT Inspiration

- Mammography platform
- Screening
- Stereotactic biopsy on FD
- Tomosynthesis



USA: CAUTION – Investigational Device. Limited by U.S. Federal law to investigat



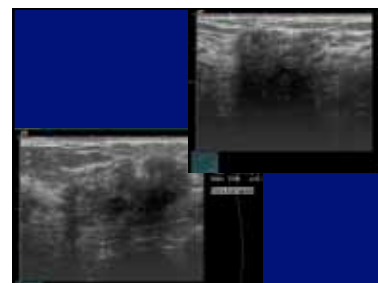
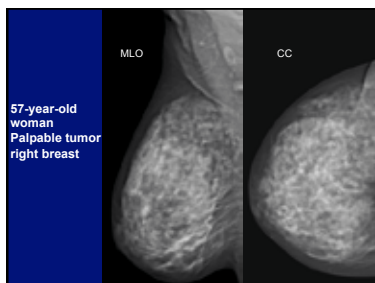
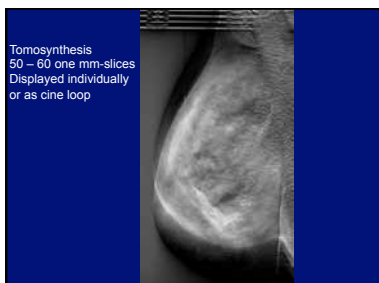
Optimization of image quality in breast tomosynthesis

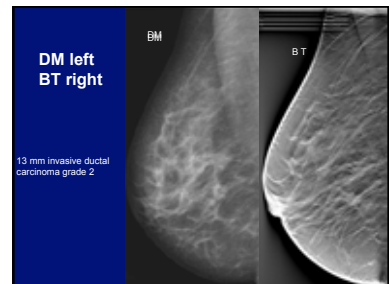
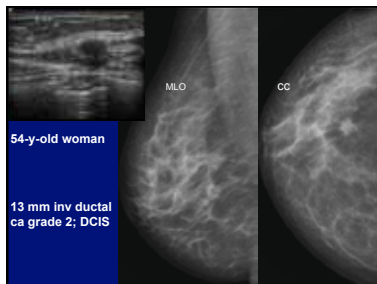
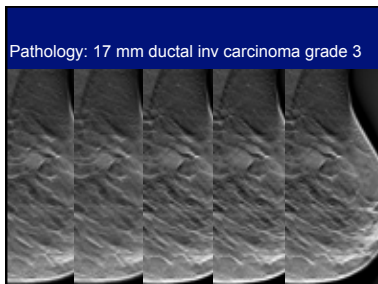
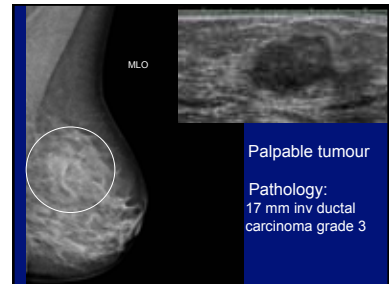
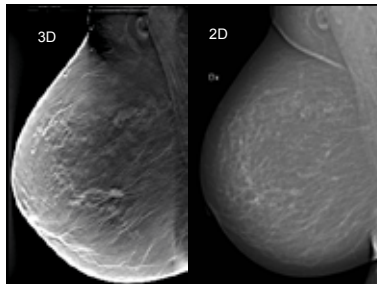
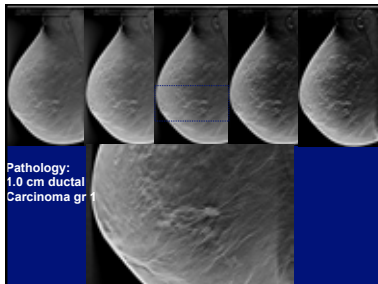
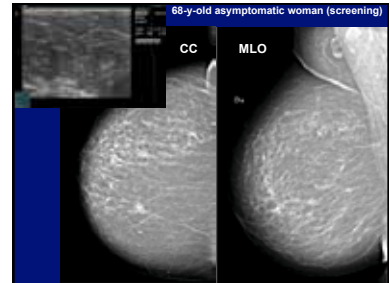
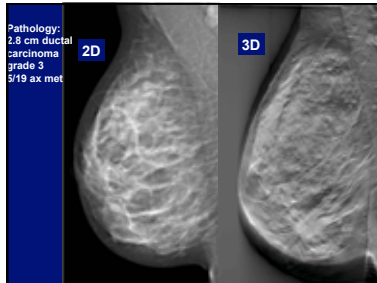
- Image quality increased with
 - number of projections
 - angular range
 - binned collection mode (less noise but reduced resolution)

• Timberg et al
SPIE 2007

Tomosynthesis

- No. of projections 25
- Angular range 50 degrees
- Scanning time 20 seconds
- Absorbed dose twice that of 2D
- W/Rh. No grid

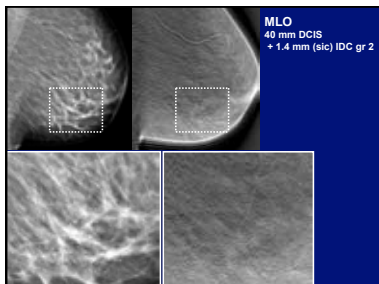
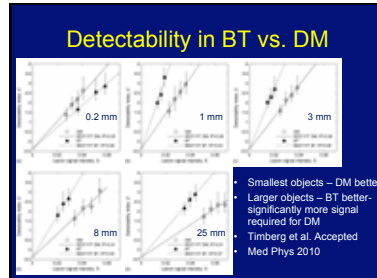
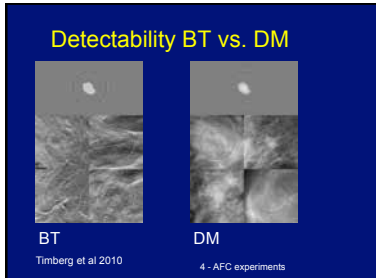




Improved in-plane visibility of tumors using breast tomosynthesis

- Tomosynthesis requires only about one fourth of the signal (contrast) compared with 2D mammography

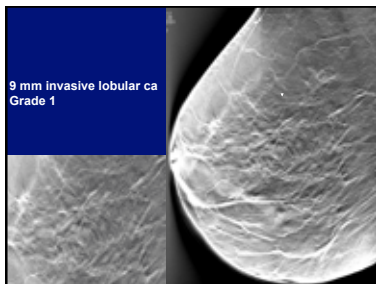
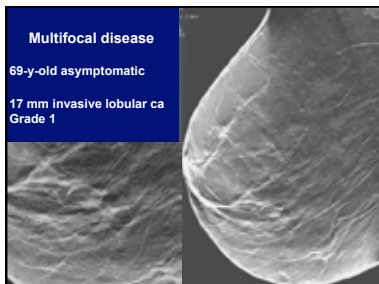
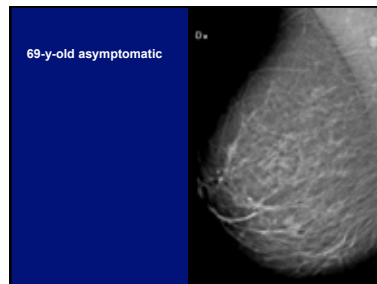
Ruschin et al 2007



Tomosynthesis

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Multifocal disease



Visibility (1-view BT vs 2-view DM)

• Better by BT	11 cases
• Equally well by BT and DM	24
• Seen by neither one	4
• Better by DM	1

Andersson et al. Eur Radiol 2008

BIRADS upgrading on BT
1-view BT vs 2-view DM (40 cases)

- BIRADS 1/2 to 3/4/5 4 cases
- BIRADS 3 to 4 or 5 8 cases
- Clinically significant upgrading in 30%

Diagnostic accuracy of 1 view tomosynthesis versus 2 view digital mammography

- Blinded free response study
- 90 b.c. cases, 110 benign/normal
- DM (MLO & CC) + BT (MLO)
- 4 experienced radiologists
- Svahn et al. RSNA 2009

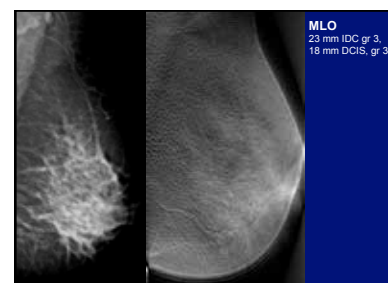
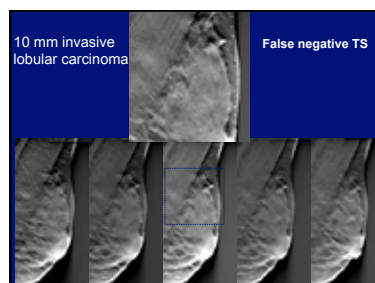
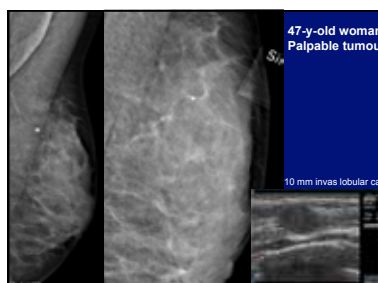
JAFROC study. Results.

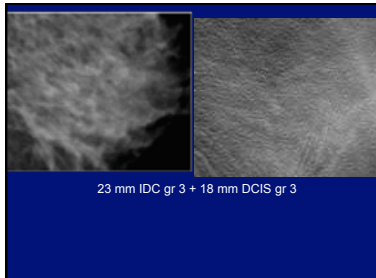
- JAFROC FOM, BT 0.81 DM 0.72 (p=0.007)
- Conclusion: Suggests higher diagnostic accuracy of BT
- Svahn et al. RSNA 2009

Tomosynthesis. Limitations.

- No tumor edge characteristics (not spiculated)
- Embedded in homogeneously dense tissue
- Other non-specific growth patterns (diffuse or non-specific, multifocal)

- Cancers seen by BT but not by US tended to be spiculated and of histologic grade 1 or 2
- Cancers seen by US but not by BT tended to be rounded and located in dense tissue and of histologic grade 2 or 3

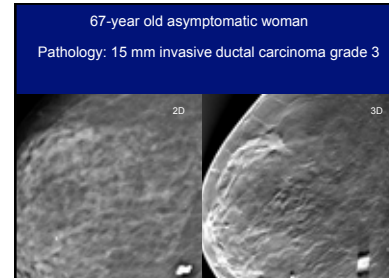




Tumor measurement and staging

more accurate with tomosynthesis

Förnvik et al. ACTA RADIOL 2010



Assessment of tumour size: BT versus DM

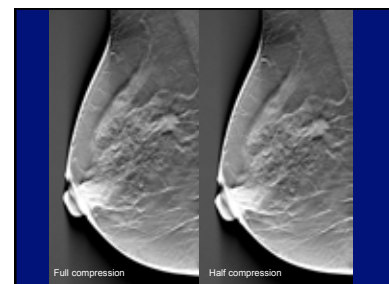
- More tumours could be measured
- Correlation with pathology better
- Preop. staging more accurate

Förnvik et al. ACTA RADIOL 2010

Breast Tomosynthesis

Breast compression can be reduced

Förnvik et al To be published in RPD 2010



Conclusions BT versus DM

- Sensitivity superior
- Tumour measurement and
- Staging more accurate
- Less compression possible

How should BT be used?

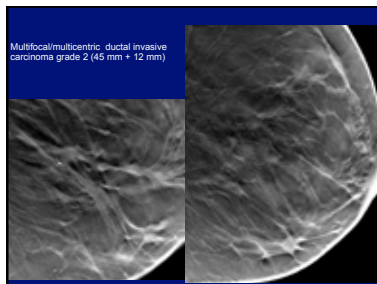
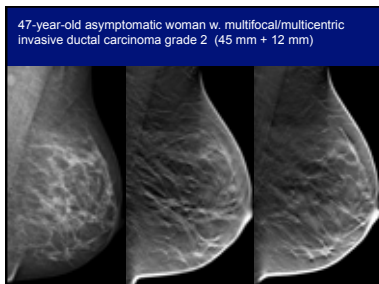
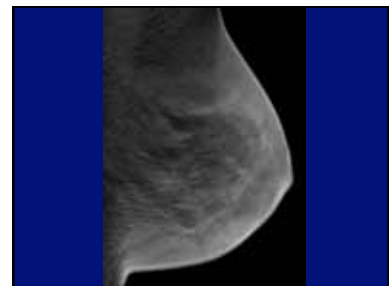
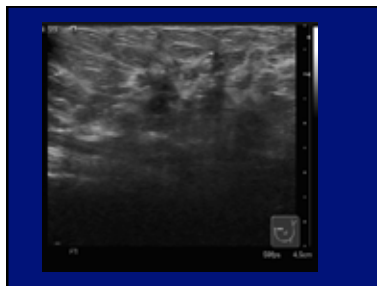
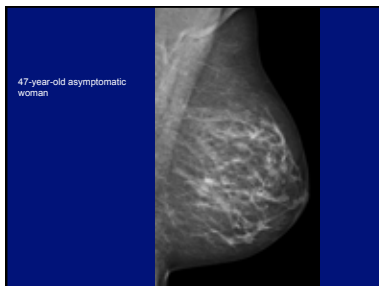
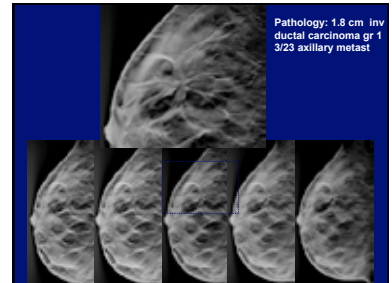
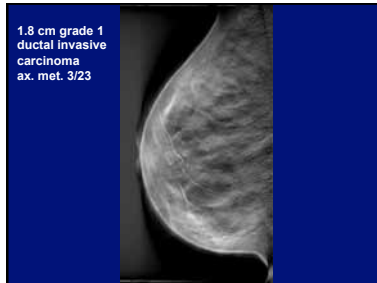
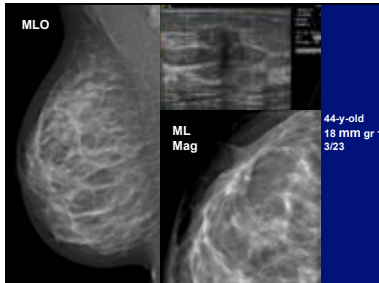
BT represents improved digital mammography

Valuable adjunct to clinical mammography

Potential screening modality

BT as adjunct to clinical mammography

- Lesion localisation
- Confirmation of lesion
- Exclusion of lesion
- Characterisation of lesion incl staging
- Demonstration/exclusion of multifocality



What is the future of BT?

- Potential screening modality
- Optimal device for biopsy localisation
- Contrast enhanced imaging

BT – a potential mass screening modality


- Current barriers
- Efficiency not known
- Examination time
- Reading time
- Work stations
- CAD not available

Feasibility study of BT as a screening modality

- Population based – city of Malmö, Sweden
- 15 000 women aged 40 – 74
- Single armed study – study women will undergo DM (CC and MLO) and BT (MLO)
- Sensitivity, specificity, JAFROC analysis
- Characterize BT- only detected cancers
- Cost – benefit analysis

Main message

- BT represents a significant step forward in mammographic technique
- Some issues have to be further investigated



Thank you!
 Diagnostic Center for Medical Imaging
 Malmö University Hospital
 Malmö, Sweden

Uelab

A combined digital tomosynthesis-breast ultrasound system: Initial results : coverage and mass visibility

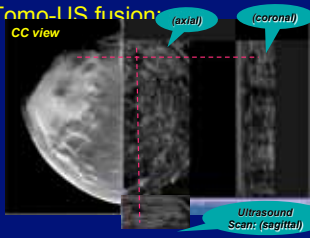
Marilyn A. Roubidoux, MD
 Mark A. Hevia, MD
 Gerald Laccapellieri, PhD
 Mitch Goodst, PhD
 Hsiang Ping Chen, PhD
 Paul L. Carson, PhD
 Sumedha Sinha, MS
 Alexis Nees, MD
 University of Michigan Health Systems
 Andrea Schmitz, MS
 Cynthia E. Landberg, PhD
 GE Global Research
Supported in part by NIH Grants R01 CA117112 and P01 CA126784

Tomosynthesis-US Fusion

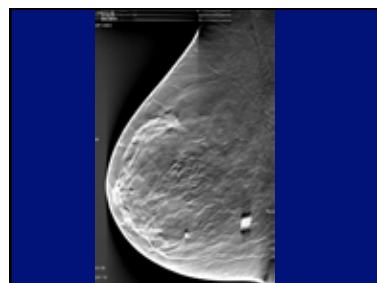
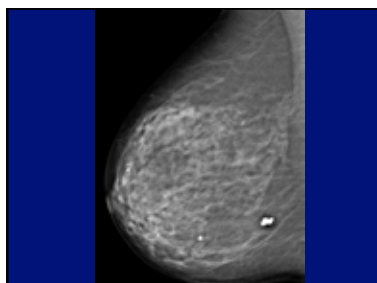
- Prototype system: GE Digital Breast Tomosynthesis + GE Logic 9 Ultrasound
- Images acquired in same mammographic view; Facilitates 3D geographic correlation of lesions



Tomo-US fusion



CC view (axial) (coronal)
 Ultrasound Scan: (sagittal)



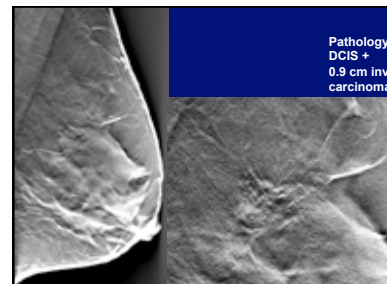
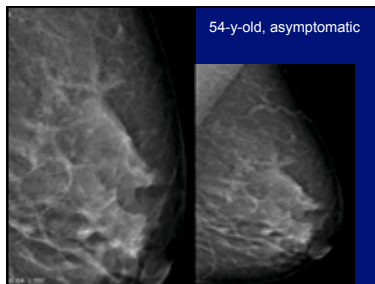
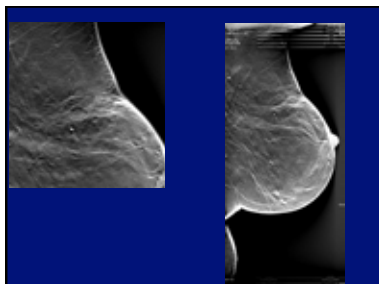
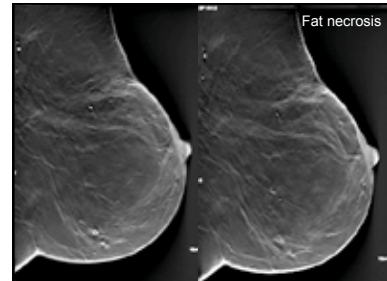
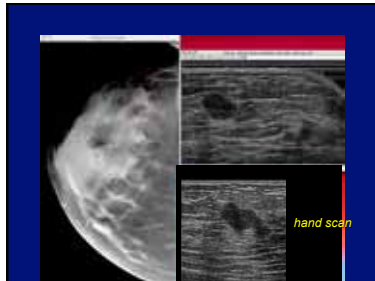
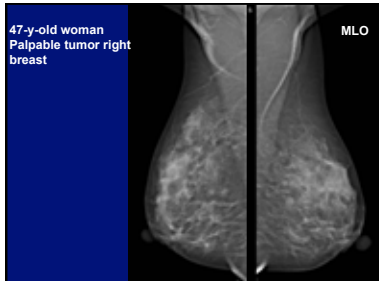


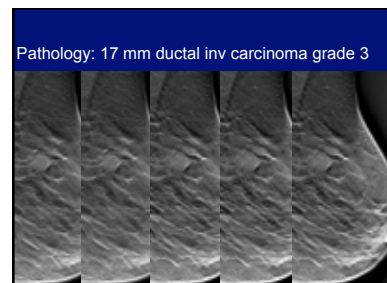
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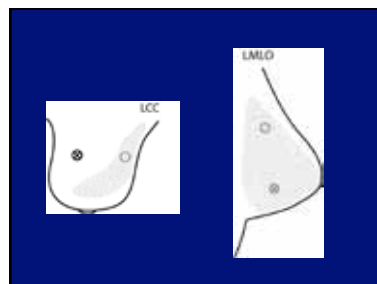
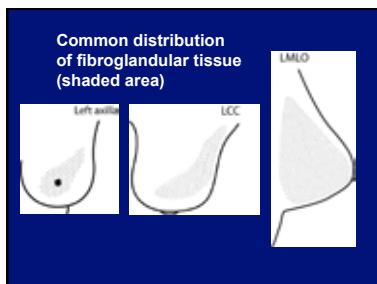
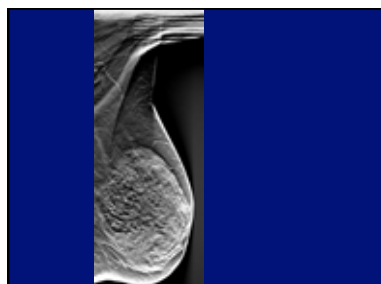
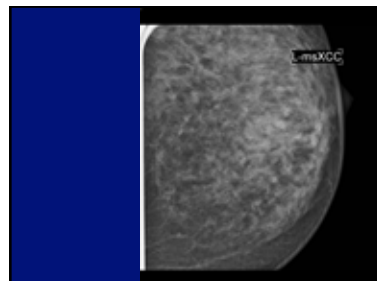
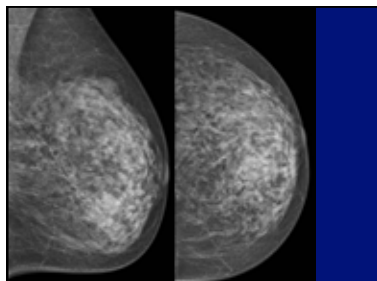
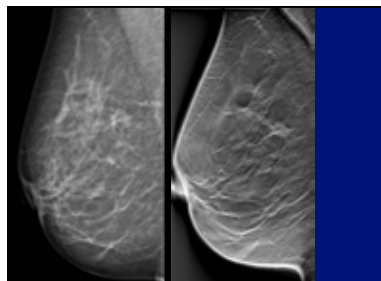
- Patients seated
- Tomosynthesis performed CC and lateral/ MLO
- Then automated ultrasound scanning immediately after second tomo view
 - Scanning through special mammogram compression plate, CC or Lateral view
 - 1-3 ultrasound probe sweeps, whole surface or area of interest
 - Compression time for tomoview + US = ≤ 10 minutes

Screening Mammography

15 – 30 % of the cancers are not detected at screening

Laming D. and Warren R. 2000
Bassett et al 1987
Baines et al 1986





Grading of visibility

- Not visible
- Questionably visible
- Visible
- Clearly visible

Visibility (1-view BT vs 1-view DM)

- Better by BT 22 cases
- Equally well by BT and DM 13
- Seen by neither one 4
- Better by DM 1

Breast cancer visibility

was ranked higher for BT than for

- 1-view DM in 22/40 (55 %)
- 2-view DM in 11/40 (28 %)

BIRADS upgrading on BT
(1-view BT vs 1-view DM N=40)

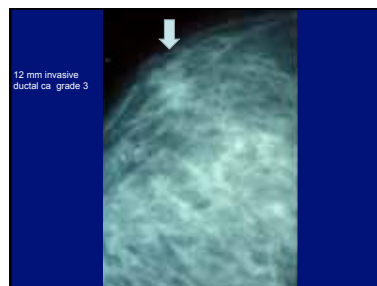
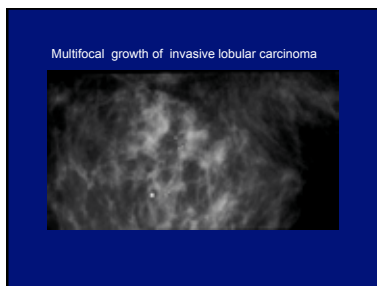
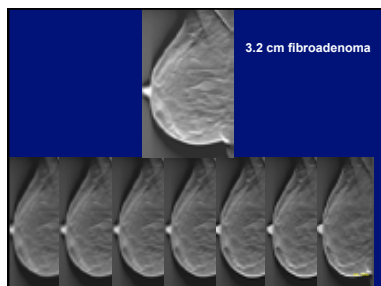
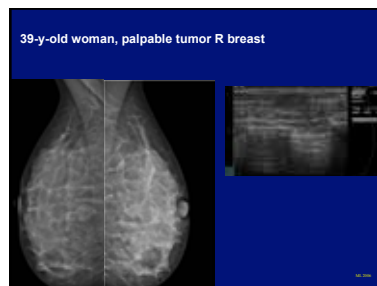
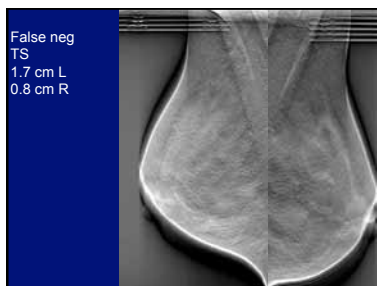
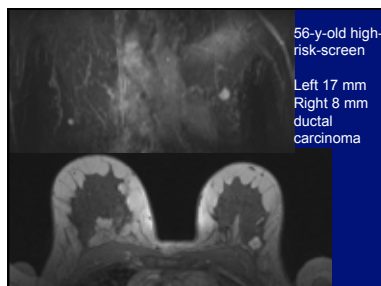
- BIRADS 3 to BIRADS 4 10 cases
- BIRADS 1/2 to 3/4/5 11 cases
- Total upgrading 21 cases

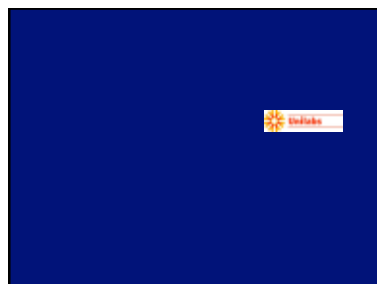
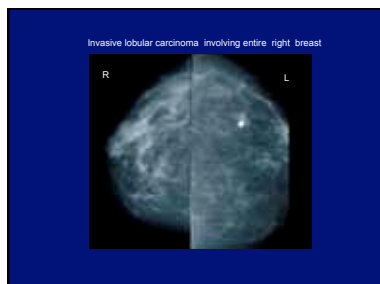
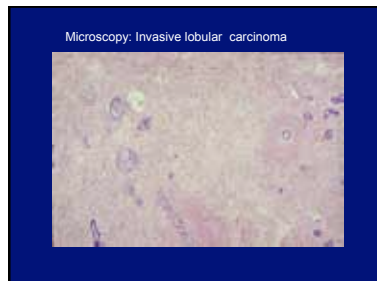
On-going/future research

- "Detection study" (comparison 2D – 3D)
- Compression force
- Dose
- Contrast enhancement

Tomosynthesis

- Acquisition of multiple projection images over an angular range with mathematical reconstruction of slices parallel to the detector plane





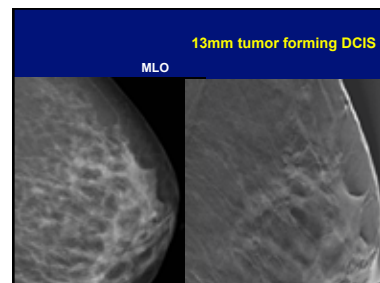
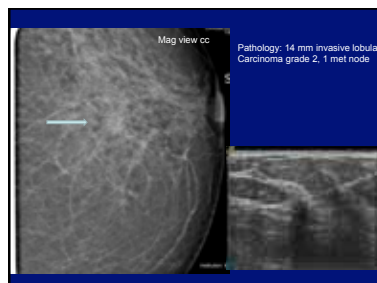
Tomosynthesis
Preliminary conclusions

- Sensitivity of TS superior to DM
- Main application probably screening
- Also valuable in the diagnostic setting

Breast tomosynthesis
Selection criteria

The projection where the lesion was least/not visible on 2D mammography was chosen for tomosynthesis

Andersson et al; Eur Rad 18:2817; 2008

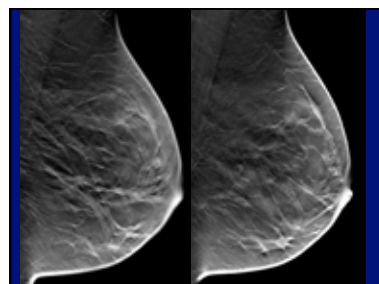
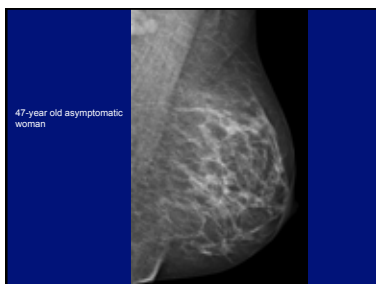
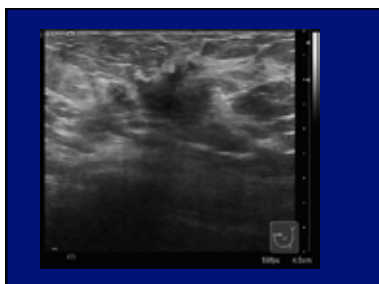
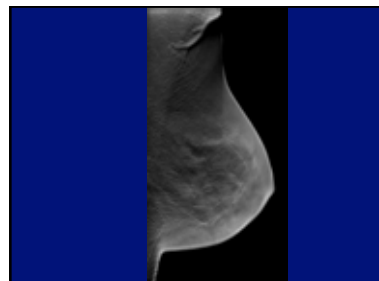


Parenchymal density (36 breasts)
BIRADS categories

- **Mostly dense (3,4)** 24
- **Less dense (1,2)** 12

Tomosynthesis

The generation of a set of slice images from the summation of a set of shifted projection images acquired at different angles of the tube



Digital tomosynthesis in breast imaging

Niklason et al. Radiology 1997

BT is an advancement of digital mammography

Digital breast tomosynthesis versus digital mammography

Clinical performance of tomosynthesis in one view not significantly different from digital mammography in two views

Gennaro et al: Eur Radiol Dec 2009

Breast tomosynthesis in clinical practice: initial results

The sensitivity of DM and BT identical

Conclusion: the role of BT is not yet established

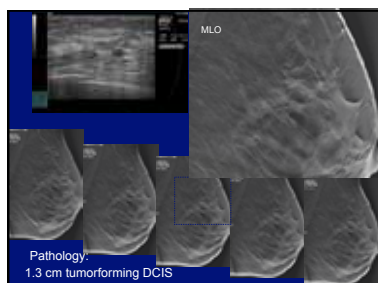
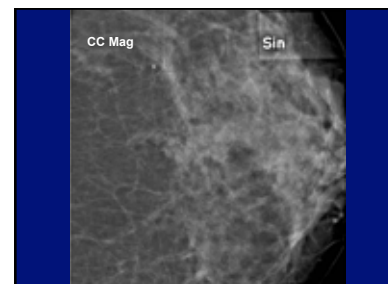
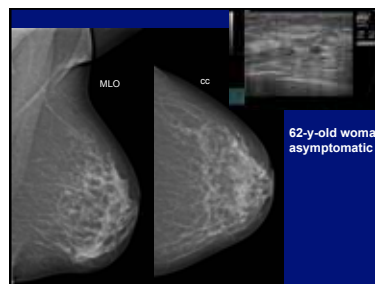
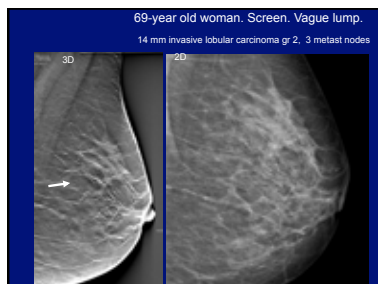
Teerstra et al: Eur Radiol 2009

Feasibility study of BT as a screening modality

- Population based – city of Malmö, Sweden
- 15 000 women aged 40 – 74
- Single armed study – study women will undergo DM (CC and MLO) and BT (MLO)
- Sensitivity, specificity, ROC analysis
- Cost – benefit analysis

Resultat och slutsatser

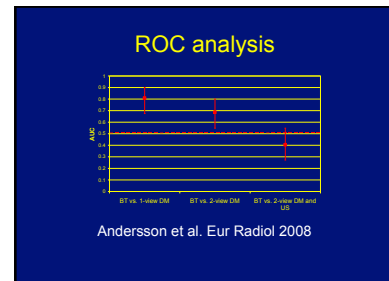
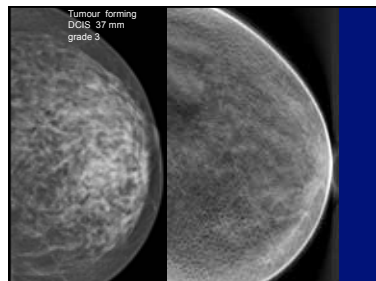
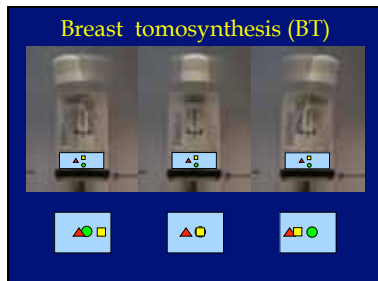
- BT mindre systematiskt och stokastiskt fel än DM och US
- BT stämmer väl överens med PAD
- Storleksbedömning möjlig redan vid screeningundersökning med BT
- Förnvik et al. Acta Radiol 2010



Tomosynthesis

- Reduces or eliminates the negative effects of tissue overlap and anatomic noise

Tomosynthesis



Screening Mammography

15 – 30 % of the cancers are not detected at screening

Laming D. and Warren R. 2000
Bassett et al 1987
Baines et al 1986

Noise sources degrading image quality

- Anatomic noise is much more important than system noise (e.g. quantum noise)

Bochud et al Med Phys 1999
Burgess et al Med Phys 2001

Digital tomosynthesis in breast imaging

Niklasson LT et al: Radiology 1997

Tomosynthesis

The generation of a set of slice images by shifting and adding a number of projection images acquired at different angles



