Physics of stereo vs. tomosynthesis-guided breast biopsy

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Outline

• Clinical background
• Principle of
  • Stereo imaging
  • Tomosynthesis imaging
• Imaging during a biopsy procedure
• Pitfalls
• Summary & Conclusion
Follow-up Testing Risks of Mammography Screening

Out of every **100** women who get a screening mammogram:

- **90** will be told that their mammograms are normal
- **10** will be asked to return for additional mammograms or ultrasounds
- **6** will be reassured that their mammograms are normal
- **2** will be asked to return in 6 months for a follow-up exam
- **2** will be recommended to have a needle biopsy

Mammography Saves Lives®
... one of them may be yours

To learn more about mammography benefits and risks visit mammographysaveslives.org
Biopsy needle

Performing a biopsy

Stroke Margin

Breast biopsy ~ 1990

Image-based target localization in the breast becomes available
- enables use of a biopsy gun for breast biopsy

-> stereotactic breast biopsy

Second Stereo Image

-15°  +15°
Z-coordinate

To x-ray tube
Tomosynthesis Basics
Tomosynthesis Basics

View 1

View 2

View 3

Sum
Tomosynthesis Basics

Depth-resolution in DBT depends on detail size, and is poor except for small targets or sharp margins.
Imaging during the biopsy procedure

Stereo guidance

• Pre-procedure mammogram

• Lesion targeting
  ➢ Stereo scout
  ➢ +/- 15 degree stereo pair

• Tissue sampling
  ➢ Pre-fire stereo pair
  ➢ Post-fire stereo pair

• Biopsy clip confirmation (stereo)

• Post procedure mammogram

• Specimen images
Imaging during the biopsy procedure

Stereo guidance

- Pre-procedure mammogram
- Lesion targeting
  - Stereo scout
  - +/- 15 degree stereo pair
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  - Pre-fire stereo pair
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Stereo guidance

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**Stereo guidance**

- Pre-procedure mammogram
- Lesion targeting
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  - Pre-fire stereo pair
  - Post-fire stereo pair
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- Specimen images
Target is marked, system calculates target coordinates

Coordinates are transmitted to needle guidance system
Imaging during the biopsy procedure

Stereo guidance

- Pre-procedure mammogram
- Lesion targeting
  - Stereo scout
  - +/- 15 degree stereo pair
- Tissue sampling
  - Pre-fire stereo pair
  - Post-fire stereo pair
- Biopsy clip confirmation (stereo)
- Post procedure mammogram
- Specimen images

If target is lined up with needle, fire needle
Imaging during the biopsy procedure

**Stereo guidance**

- Pre-procedure mammogram
- Lesion targeting
  - Stereo scout
  - +/- 15 degree stereo pair
- Tissue sampling
  - Pre-fire stereo pair
  - **Post-fire stereo pair**
- Biopsy clip confirmation (stereo)
- Post procedure mammogram
- Specimen images

**Lesion should “within” needle trough**

If needle location is good, obtain samples
Imaging during the biopsy procedure

**Stereo guidance**

- Pre-procedure mammogram
- Lesion targeting
  - Stereo scout
  - +/- 15 degree stereo pair
- Tissue sampling
  - Pre-fire stereo pair
  - Post-fire stereo pair
- **Biopsy clip confirmation (stereo)**
- Post procedure mammogram
- Specimen images
Imaging during the biopsy procedure

Stereo guidance

• Pre-procedure mammogram

• Lesion targeting
  ➢ Stereo scout
  ➢ +/- 15 degree stereo pair

• Tissue sampling
  ➢ Pre-fire stereo pair
  ➢ Post-fire stereo pair

• Biopsy clip confirmation (stereo)

• **Post procedure mammogram**

• Specimen images
Imaging during the biopsy procedure

Stereo guidance

• Pre-procedure mammogram
• Lesion targeting
  ➢ Stereo scout
  ➢ +/- 15 degree stereo pair
• Tissue sampling
  ➢ Pre-fire stereo pair
  ➢ Post-fire stereo pair
• Biopsy clip confirmation (stereo)
• Post procedure mammogram
• Specimen images

Calcifications must be seen in tissue samples to confirm successful biopsy
Imaging during the biopsy procedure

**Stereo guidance**

- Pre-procedure mammogram
- Lesion targeting
  - Stereo scout
  - +/- 15 degree stereo pair
- Tissue sampling
  - Pre-fire stereo pair
  - Post-fire stereo pair
- Biopsy clip confirmation (stereo)
- Post procedure mammogram
- Specimen images

**DBT guidance**

- **DBT** scout
- Pre-fire **DBT or stereo pair**
- Post-fire **DBT or stereo pair**
- Biopsy clip confirmation (**DBT**)
Case 1: DBT image guidance (DBT pre/postfire)
Case 1: DBT image guidance (DBT pre/postfire)
Case 2: DBT/Stereo image guidance
Case 2: DBT/Stereo image guidance

- Stereo Scout
- Pre-fire Stereo
- Post-fire Stereo
Case 2: DBT/Stereo image guidance
Pitfalls

• Uncertainty
Uncertainty - Stereo

\[ \Delta z \approx \frac{\Delta x}{2 \tan(15^\circ)} \]

\[ \Delta z \approx 2 \cdot \Delta x \]
Error due to uncertainty

Lesion more shallow than calculated (+3/-3mm error on +15/-15 views)

Lesion deeper than calculated (-3/+3mm error on +15/-15 views)

Error due to uncertainty

• Can affect targeting of small masses
Pitfalls

• Uncertainty

• Erroneous measurement
Failed stereo localization

Pitfalls

- Uncertainty
- Erroneous measurement
- Non-visualization of lesion due to positioning
Non-visualization of lesions

Stereo acquisition with rotating system

Pivoting point

±15 deg
Deep lesion
Proximal lesion off-centered on scout
## Potential pitfalls

<table>
<thead>
<tr>
<th></th>
<th>Stereo imaging</th>
<th>DBT imaging</th>
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<tbody>
<tr>
<td><strong>Targeting uncertainty</strong></td>
<td>Significant depth uncertainty</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Multiple lesions</strong></td>
<td>Lesions might be missed if not marked correctly</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Field-of-view limitations</strong></td>
<td>More severe for rotating detector</td>
<td>Less severe (no significant detector rotation)</td>
</tr>
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</table>
When to use DBT guidance?

• DBT-guidance used when lesion is seen on DBT only, particular architectural distortions
Summary & Conclusion

Both stereotactic and tomosynthesis imaging can be useful for biopsy guidance:

• DBT guidance allows biopsy of lesions that are only seen in tomosynthesis, such as architectural distortions

• Lesion targeting in the tomosynthesis scout eliminates depth uncertainty, and reduces the potential to mis-target lesions

• Tomosynthesis artifacts due to biopsy needle in pre/post-fire images are severe
  ➢ Use stereo imaging if lesions are visualized
  ➢ Lateral arm produces fewer artifacts

• Both DBT and stereo guidance are available as upright add-on and with prone biopsy tables
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Thank You!