Can AI support mammography image quality improvement?

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Image Quality

Poor mammography positioning has negative implications:

- **Overtreatment**
  - Increased technical recall rate [Salkowski, 2019]
  - Increased radiation dose [O'Leary, 2011]
- **Breast cancer detection**
  - Decreased sensitivity in cancer detection drops almost 20% [Taplin, 2002]
  - Increased # of interval-detected cancers [Taplin, 2002]

Factors contributing to poor positioning

- **Physics acquisition parameters**
  - Compression pressure
- **Patient factors**
  - Breast density
    - As density decreases, positioning failures increase [Bassett, 2000]
  - Breast volume
    - As BMI increases (relates to breast volume), compression thickness increases [Guest, 2000]
    - As the breast enlarges, the position of the IMF descends [Hudson, 2019
    - As the breast enlarges, the nipple position deviates from breast meridian [Hudson, 2019]
  - Breast Area

Factors contributing to poor positioning (sagging)

Inadequate compression, sagging

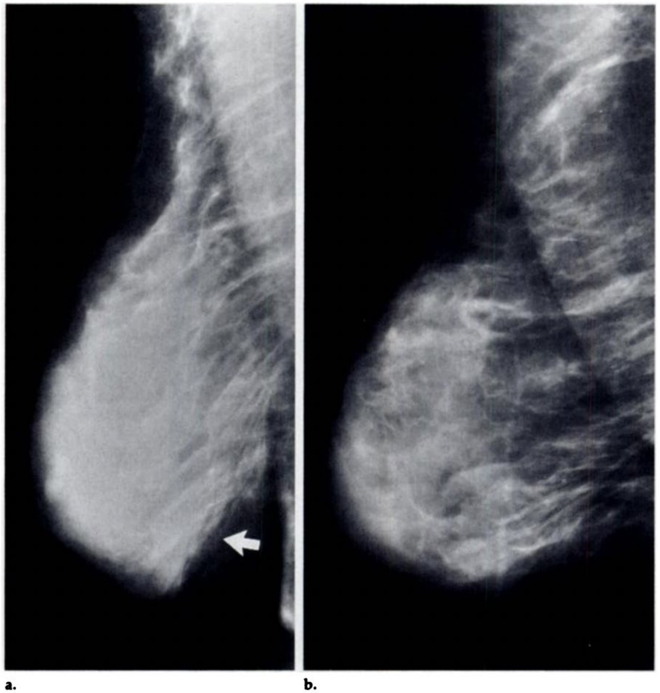


Figure 2. Evaluation of breast compression on MLO mammogram. (a) Inadequate compression. Nonuniform exposure and inadequate separation of fibroglandular tissues, sagging of the breast contour, and blurring of linear structures (arrow) inferiorly due to motion are seen. (b) Adequate compression of the same breast as in a. Dense breast tissue is uniformly exposed and well separated, the breast contour is upright, and no motion unsharpness is seen.

Adequate compression, no sagging

[Bassett, 1993]

Why Baseline Positioning Rates Are Necessary?

- ✓ To evaluate, educate, train and take corrective action interventions for technologists, and evaluate mammography facility processes
  - ✓ The first step in continuous mammography quality improvement is to assess baseline performance
  - ✓ Establish baseline positioning error rates and set performance benchmarks

Current Practice @ NorthShore University Health System

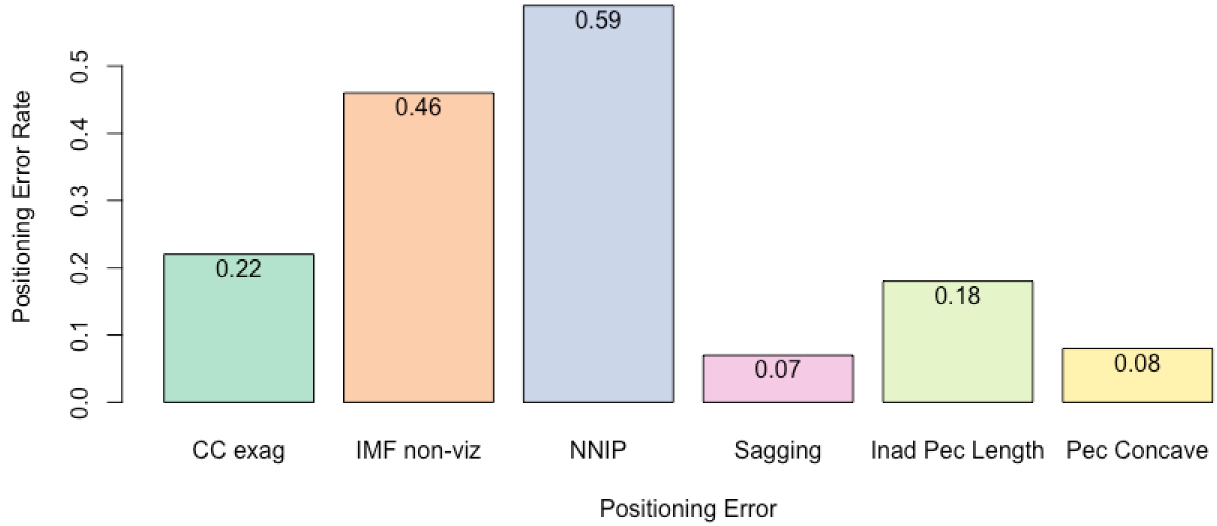
- Positioning errors are evaluated subjectively (not standardized) [Sweeney, 2017]
- Positioning errors are evaluated manually (resource-intensive)
- Only small samples of mammography studies are comprehensively evaluated for positioning errors
- No visibility into health system wide positioning quality

OBJECTIVE:
Demonstrate how an Artificial Intelligence (A.I.) decision support tool can help establish population-level mammography quality positioning error benchmarks at NorthShore University HealthSystem as an important step in quality improvement

Methods

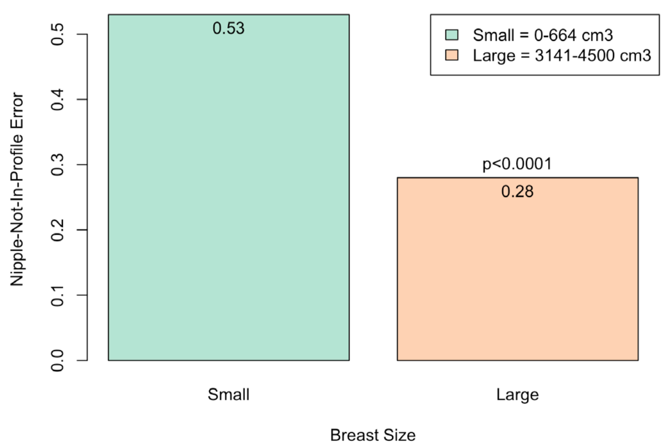
Sample	Assessments	Analyses
Size: n=188,609 _Location:_ NSUHS _Date range:_ Sept 1, 2021 to Apr 15, 2022	Positioning error rates measured using automated mammography quality A.I. software (densitas® intelliMammo™) ● CC exaggeration ● IMF missing ● Nipple not in profile ● Sagging ● Inadequate pectoralis muscle length ● Pectoralis muscle concave	A. Establishment of overall baseline error rates B. Establishment of error rates stratified by: i. Laterality ii. breast density iii. breast volume iv. compression pressure v. breast area

Baseline Error Rates

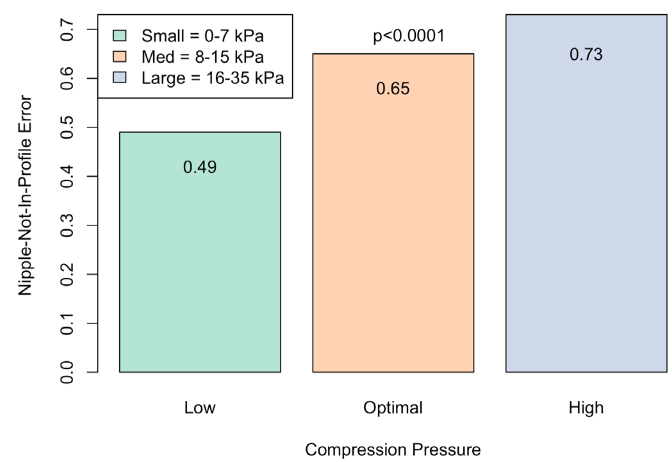


Nipple Not in Profile (NNIP) Error

Small breasts were associated with higher NNIP errors than large breasts (p<0.0001)

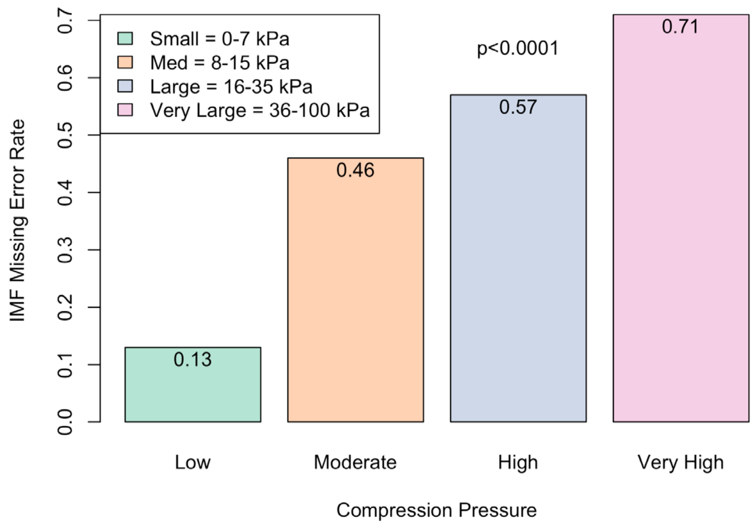


Higher compression was assoc. with higher NNIP errors than lower compression (p<0.0001)

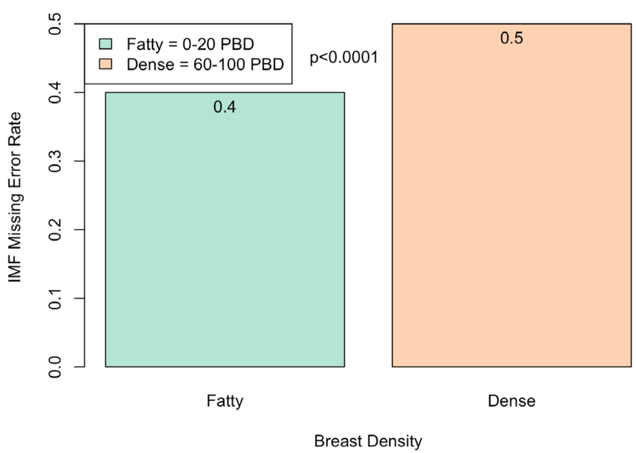


IMF Missing Error

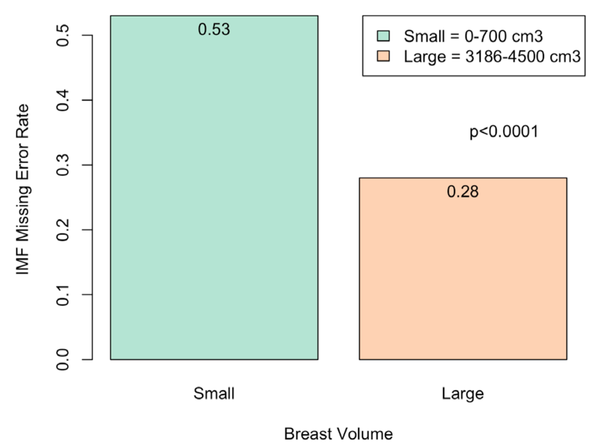
Higher compression was associated with higher IMF Missing errors than lower compression (p<0.0001)



Dense breasts were associated with higher IMF Missing errors than fatty breasts (p<0.0001)

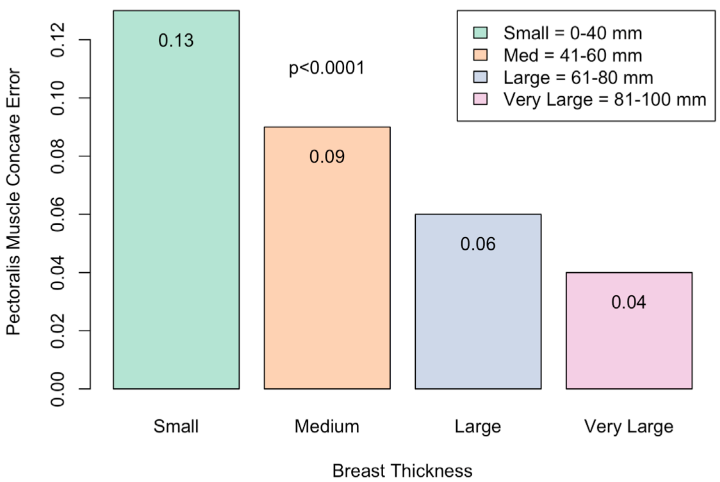


Small breasts were associated with higher IMF Missing errors than large breasts (p<0.0001)

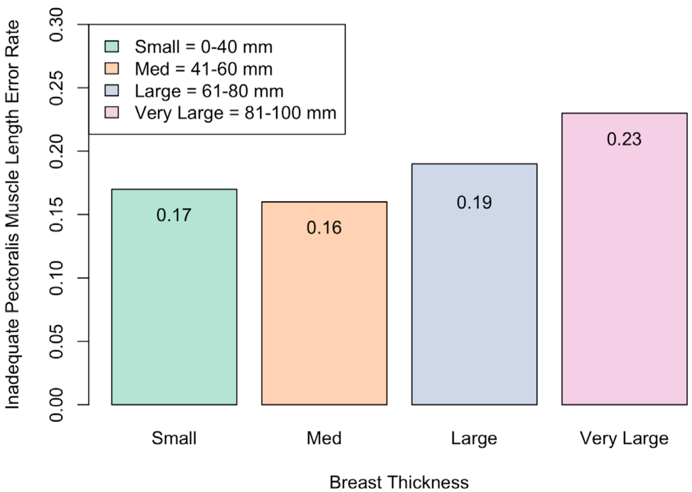


Other Positioning Errors

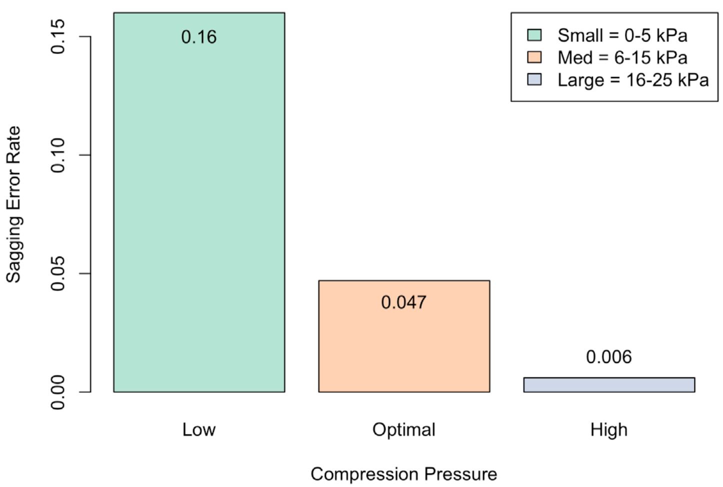
Thinner breasts were associated with higher **Pec Muscle Concave errors** than thicker breasts (p<0.0001)



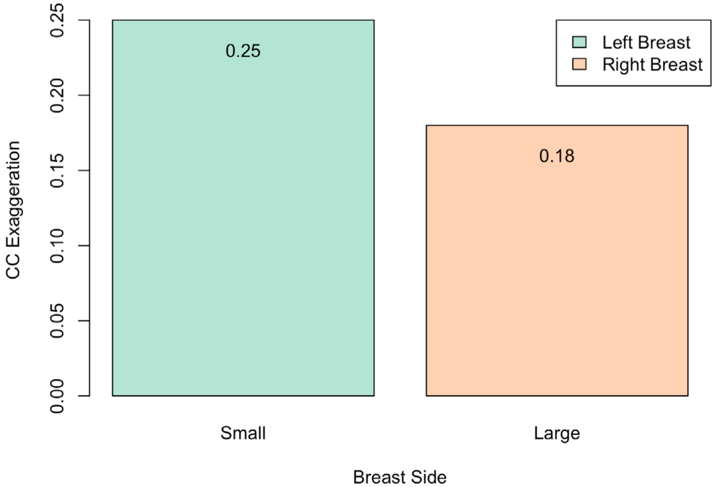
Thicker breasts were assoc. with higher **Inadequate Pec Muscle Length errors** than thinner breasts (p<0.0001)



Lower compression was associated with higher **Sagging errors** than higher compression (p<0.0001)



Left breasts were assoc. with higher **CC Exaggeration errors** than large breasts (p<0.0001)



Discussion

- **A.I. decision tools may provide a feasible solution for continuous quality control and mammography quality improvement**
  - ✓ Fully automated
  - ✓ No added burden on the clinical care team
  - ✓ Standardized
  - ✓ Validated by association between error rates and patient & physics acquisition parameters
  - ✓ Baseline error rates provide a reference against which to evaluate performance improvements
  - ✓ Health system wide visibility into mammography quality performance

- **Distinguishing between technologist's technique, patient limitations and other factors impacting positioning**
  - provides greater insight into addressable and non-addressable root causes
  - informs training/educational interventions
  - establishes benchmarks for performance

Limitations: Did not stratify analyses by root causes such as technologist, mammography unit, hospital site, technologist experience, patient limitations

Future Directions

Collect longitudinal data to determine if implementation of A.I. for mammography positioning quality can detect changes in technologist performance to target training/educational interventions and monitor improvements the technologists performance result from such interventions

Stratify positioning error rates by patient limitations versus no limitations to establish addressable (i.e. technologist technique) root cause

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