

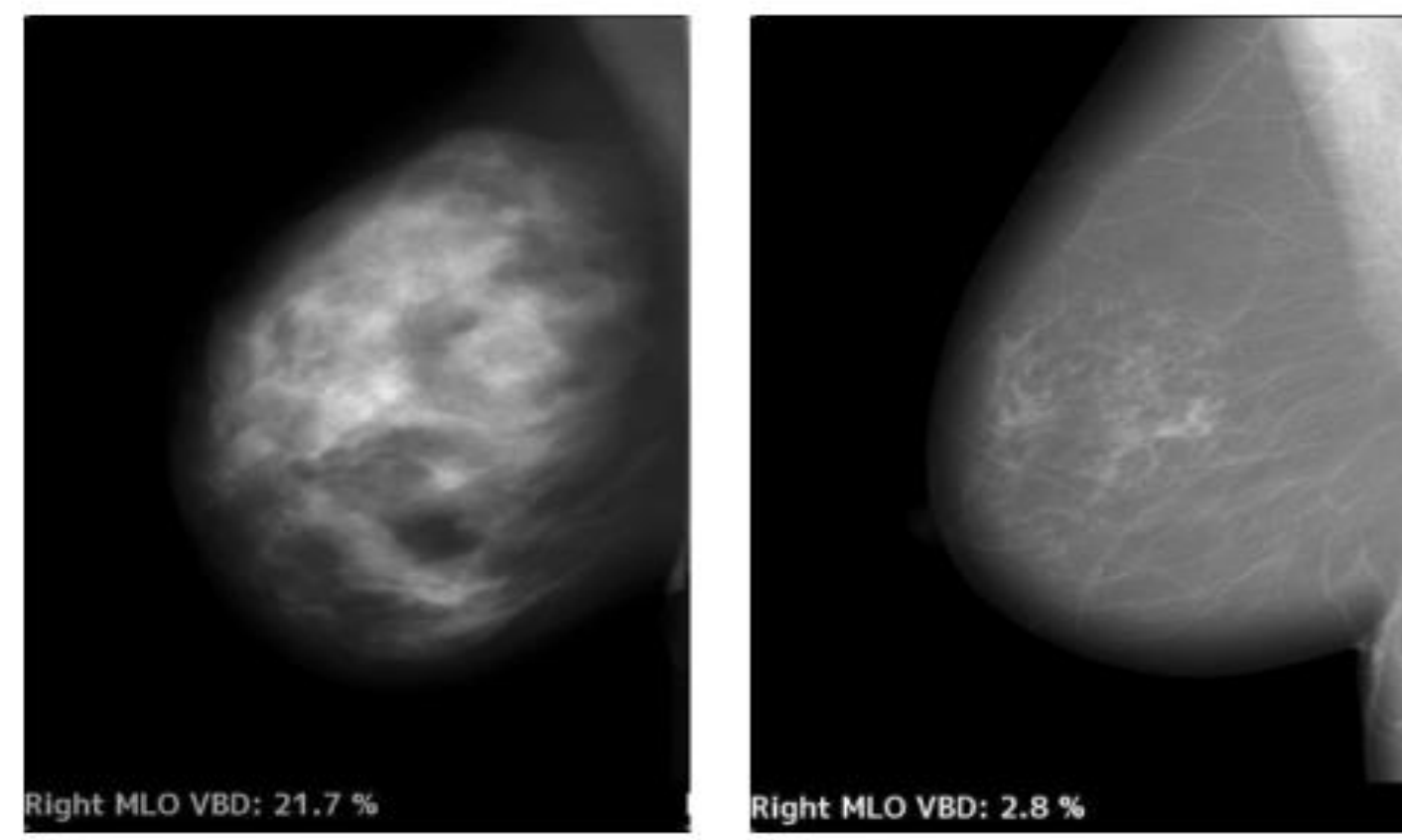
# Patient-Specific Dose for Mammography and Tomosynthesis using Volumetric Breast Density

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## Introduction

- Important to keep mean glandular dose (MGD) as low as reasonably achievable [1,2]
- MGD breast density-dependent [3-9]
- Without per-patient density measurement, crude assumptions often made for MGD estimation [7]
- Patient-specific MGD previously proposed, but only compared to manufacturer-reported dose [10]
  - vendors may use one of a variety of accepted dose models [3-6]
    - use of density for MGD estimation often unclear



**Fig. 1.** Mammograms for women with the same breast thickness, but different VBD. Model in [7] assumes these breasts have the same glandularity.

## Objective:

Compare patient-specific mean glandular dose (MGD) using volumetric breast density (VBD) measurements to MGD calculated according to population-average glandularity.

## Method

### Dose Model

- MGD for digital mammography (DM) and tomosynthesis (DBT) estimated by Dance et al. model [6-9]:

$$MGD(mGy) = K g c s T$$

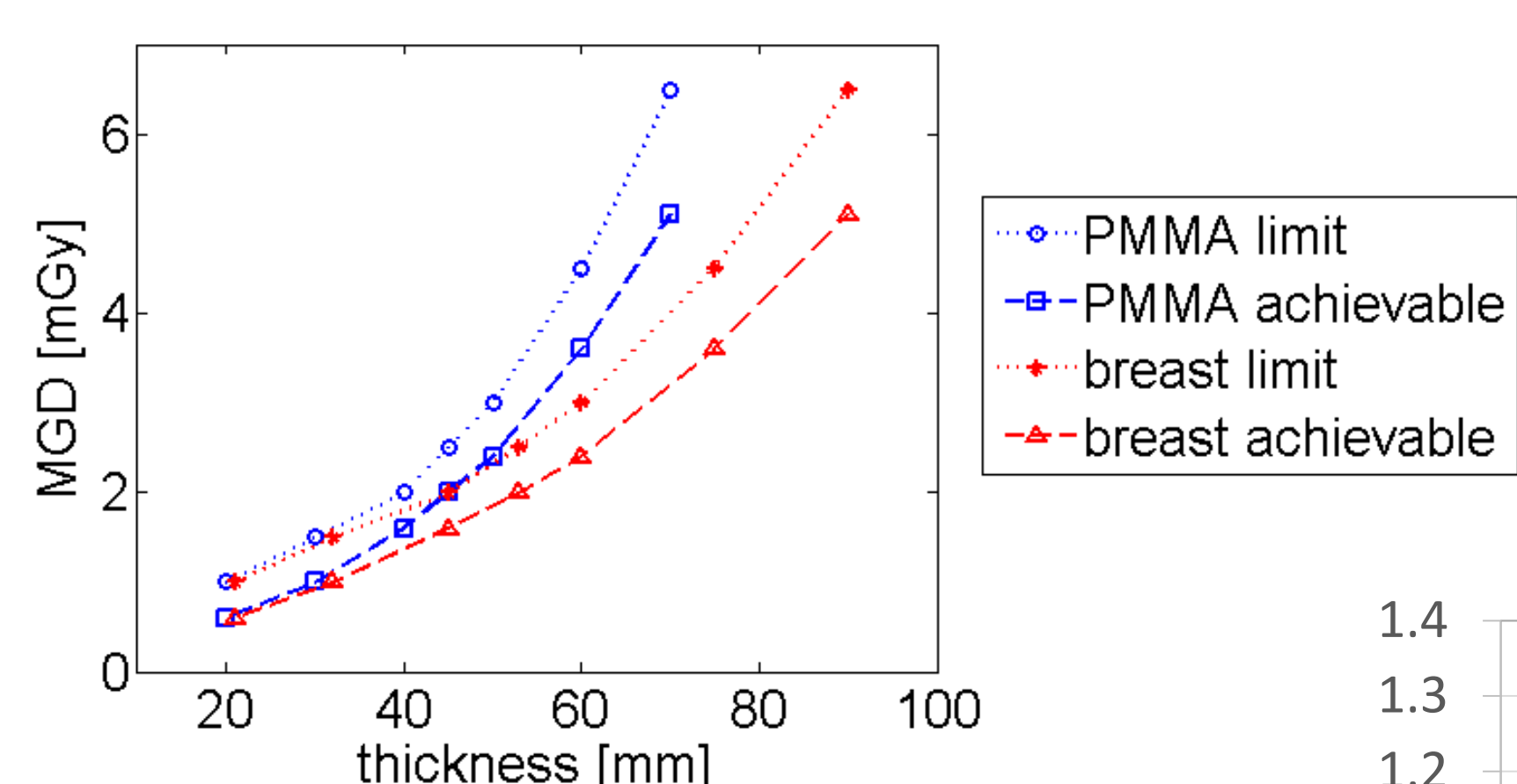
- widely accepted model [11], which incorporates corrections for breast glandularity, according to the 'c-factor'

**K:** incident air kerma (mGy)  
**g:** fraction of K absorbed by a 50% glandularity breast  
**c:** correction for glandularity compared to 50%  
**s:** correction for x-ray spectrum different than Mo/Mo  
**T:** correction for total dose from all tomosynthesis projections

- NHSBSP software v2.4 estimates DM and DBT by Dance et al. model [12]
  - typically used for patient dose surveys [13]
  - output compared to patient-specific MGD for over 1400 anonymized DM, and 500 DBT exams
  - dosimetry data (tube output, HVL, per anode/filter/kVp) used to calibrate MGD for both patient-specific and NHSBSP-estimated values

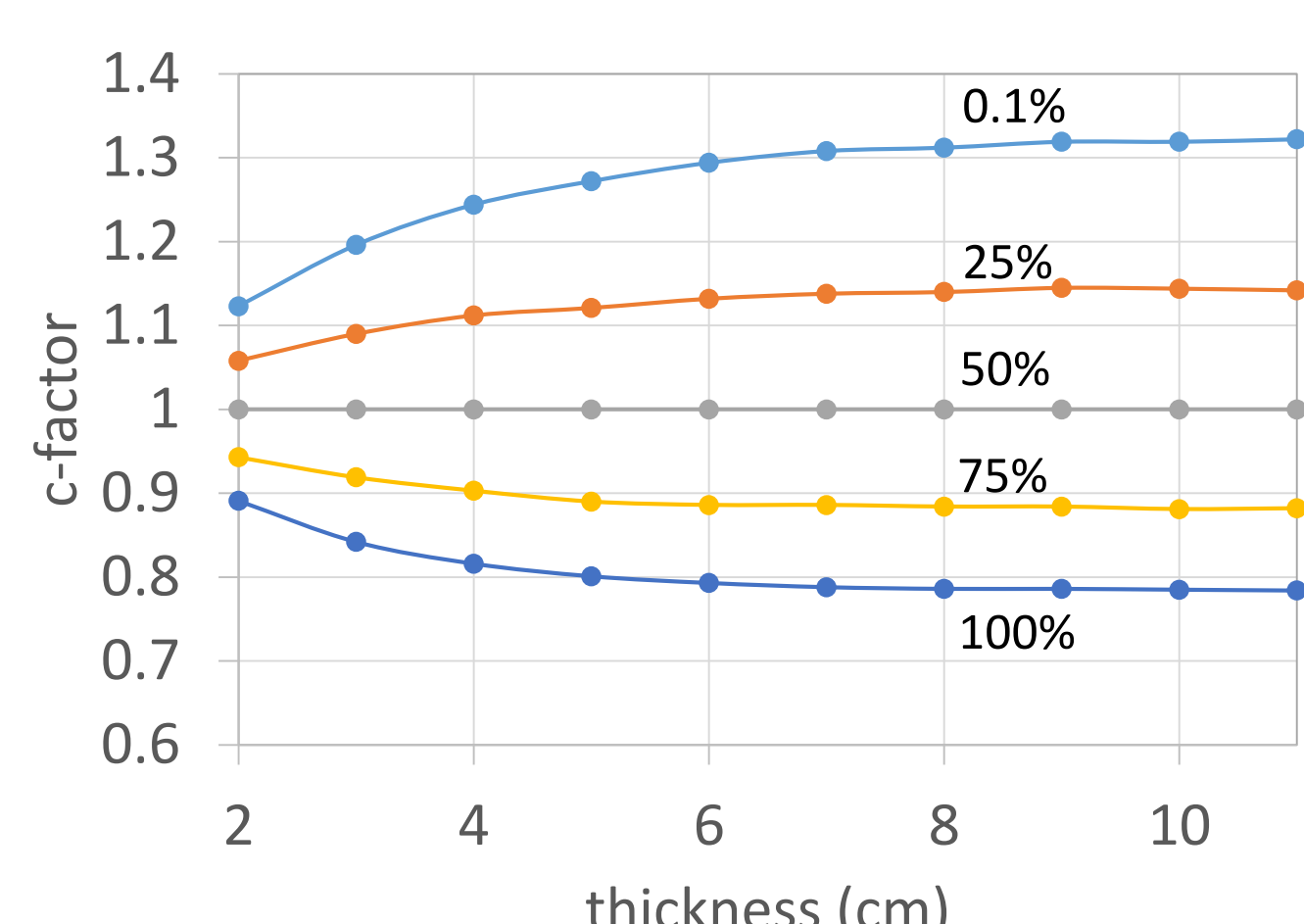
## Breast Glandularity

- VBD measured using Volpara algorithm v1.5.2.0 [14]
- Glandularity estimated in NHSBSP software by Dance model, according to age and breast compressed thickness [7, 11]
- VBD transformed to % glandularity by weight to match Dance breast model conditions [6, 10]



**Fig. 3.** Figure 3 of Ref [7] reproduced to demonstrate how MGD varies with % glandularity via the c-factor. MGD increases with decreasing glandularity. Data for fixed HVL of 0.35 mm Al.

**Fig. 2.** EUREF achievable and acceptable radiation dose limits [11]. A 50% glandularity assumed for the breast. Achievable limits give reasonable estimate of clinical MGD [11, 13]

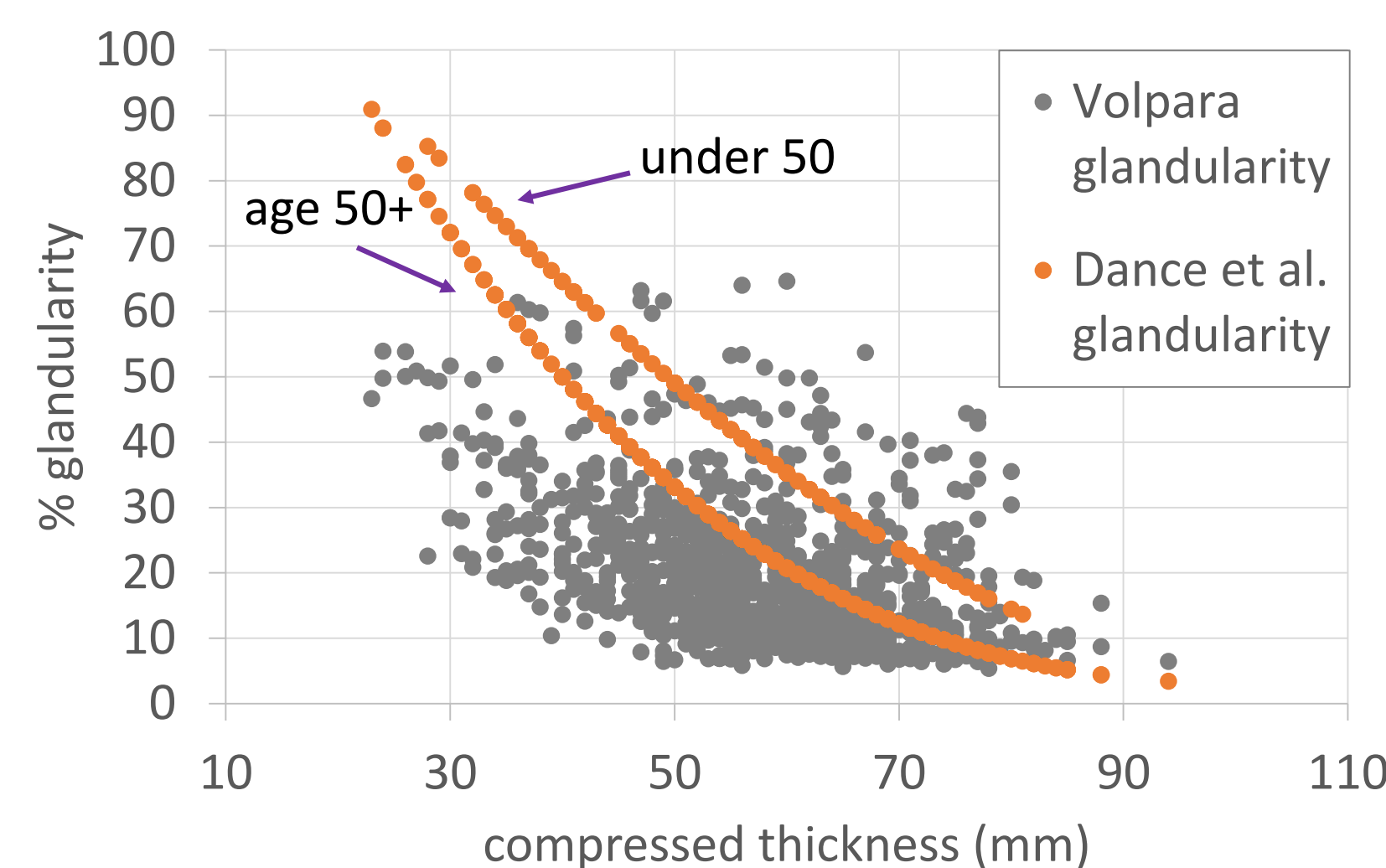


## Results

**Table 1.** Patient dose calculated using Volpara v1.5.2.0 vs NHSBSP v2.4. All differences were significantly different than zero, p<0.05.

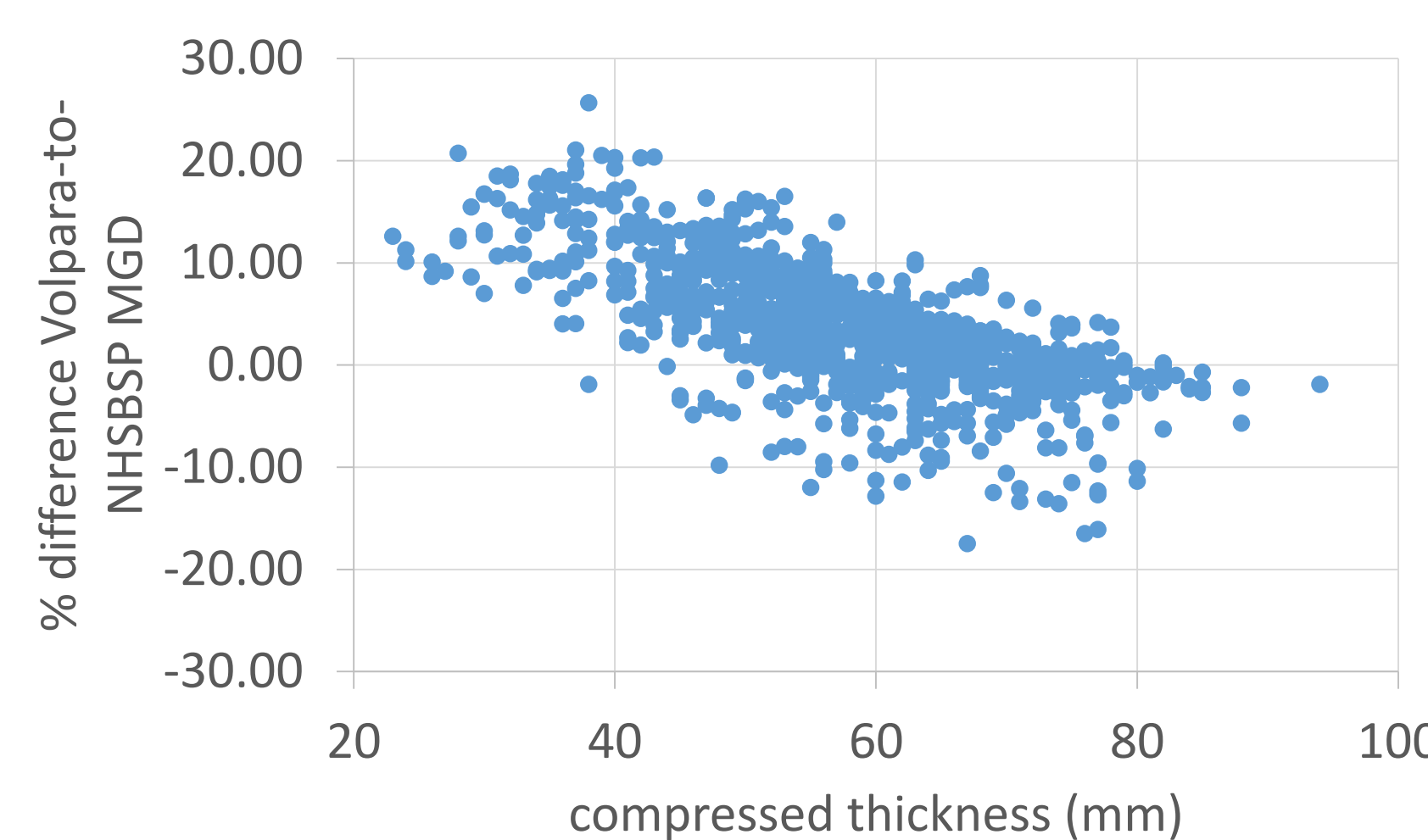
- Excellent correlation found between MGD using our method and NHSBSP software
- The MGD values vary based on c-factor

vendor	imaging system	DM / Tomo	# images	mean age	mean VBD	Volpara-to-NHSBSP Pearson correlation	mean MGD difference [min, max] (%)
GE	Senographe DS	DM	392	62	10.4	0.99	3 [-15, 17]
	Mammomat	DM	46	63	8.2	0.99	7 [-9, 18]
Hologic	Lorad Selenia	DM	992	63	10.6	0.99	4 [-17, 26]
GE	Senographe Essential	Tomo	93	57	9.8	0.97	10 [-10, 34]
	Mammomat	Tomo	230	48	12.8	0.99	3 [-17, 32]
Siemens	Inspiration	Tomo	230	48	12.8	0.99	3 [-17, 32]
Hologic	Selenia	Tomo	177	51	13.8	0.98	5 [-13, 22]
	Dimensions	Tomo	177	51	13.8	0.98	5 [-13, 22]



**Fig. 4.** Volpara (grey) and Dance et al. [7] (orange) estimated glandularity vs compressed breast thickness for 992 Hologic DM.

- Volpara glandularity calculated from VBD
- Dance glandularity estimated from patient age and breast thickness [7]



**Fig. 5.** The % difference between patient-specific MGD estimated using Volpara glandularity, and that calculated using NHSBSP software vs compressed breast thickness for 992 Hologic DM.

## Conclusions:

Compared to using population averages, personalized MGD estimates that incorporate breast density measurement can result in substantially different dose estimates.

- MGD calculated using patient-specific breast density ranged from about ±20% of that via population averages
- MGD tended to be underestimated for low thickness breasts by population-based model
- Practical to estimate patient-specific MGD with automated VBD measurement
- Patient-specific MGD could be important for accurate radiation risk estimation, stratification to different screening modalities

## Disclosure

- Melissa Hill provides scientific consulting services for Volpara Health Technologies Ltd.

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