La qualità della prestazione mammografica nei seni densi

Stefano Pacifici

"La mammografia non ammette mediocrità"(Gros)

La mammografia combina "la scienza dell'imaging e l'arte del posizionamento"
(Eklund, Cardenosa)

È difficile ottenere mammografie di alta qualità.
Le caratteristiche peculiari del seno, come la forma, le dimensioni, la densità e il basso contrasto, si combinano con fattori del paziente come ansia, dolorabilità e paura delle radiazioni per sfidare le capacità del tecnico più esperto.
(Eklund)

L'abilità di posizionamento influisce sulla sensibilità e specificità della mammografia.
La sensibilità della mammografia può ridursi drasticamente quando non vengono soddisfatti i criteri di correttezza.
(Buist, Taplin)

Un posizionamento errato può provocare la sovrapposizione del tessuto ghiandolare, causando sia falsi negativi che falsi positivi che influiscono direttamente sulla specificità della mammografia.
Sebbene il mantenimento di un'elevata sensibilità in mammografia sia fondamentale, è la specificità che influisce sui costi finanziari, sull'ansia della paziente e sul successo del programma di screening.
(Drukteines et al.)

Breast Positioning during Mammography: Mistakes to be Avoided

Manju Bala Popli, Rahul Teotia, Meenakshi Narang

Breast positioning is the key factor affecting a mammogram. If care is taken during positioning, it maximizes the amount of breast tissue being imaged, eliminates most of the artifacts, and increases sensitivity of the mammogram.

Article
Automated Assessment of Breast Positioning Quality in Screening Mammography

Mouna Brahim [1], Kai Westerkamp [1], Louisa Hempel [2], Reiner Lehmann [3], Dirk Hempel [4] and Patrick Philipp [1,*]

Inadequate breast positioning quality is the main cause behind misdiagnosis of breast cancer in screening mammography.

Image evaluation and breast density categories as a function of mammary positioning in full-field digital mammography

Irene Tomoko Nakano, Gabriel Lucca de Oliveira Salvador, [...], and Silvio Tacara, (+3)

Appropriate mammary positioning is an important factor in optimizing image quality in mammography (MMG).

Dense MMG presented less visibility of the lateral tissue compared with other categories.

Several factors influenced in the MMG process, but we find that breast parenchyma has a substantial role in affecting these criteria and therefore a correct position for diagnosis, which could compromise MMG diagnostic performance.
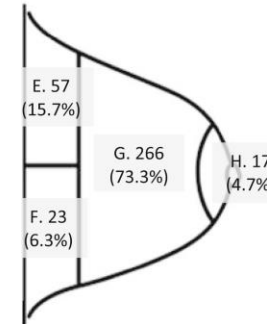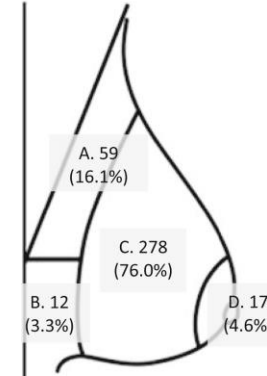
MILKY WAY
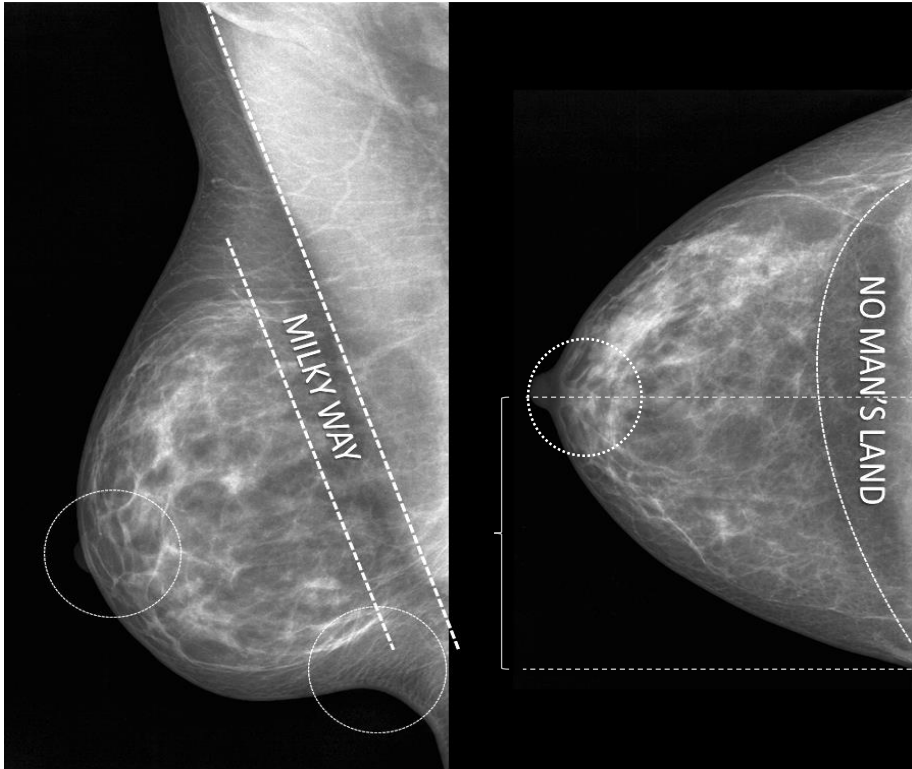
NO MAN'S LAND

"FORBIDDEN AREAS"

MLO

spazio retroghiandolare *(milky way)*
spazio retroareolare
angolo sottomammario

CC
Metà mediale
Spazio retroghiandolare *(no man's land)*
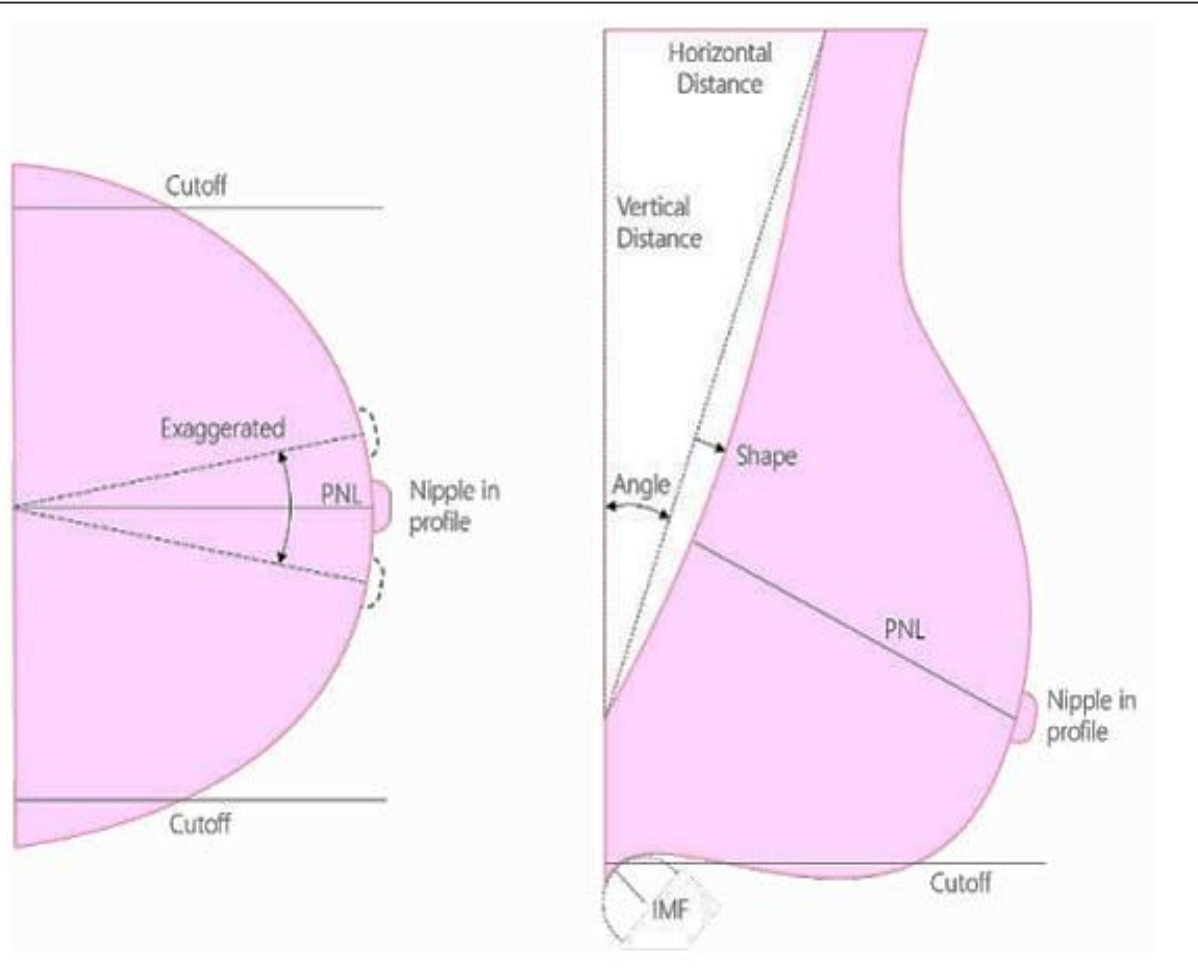
L Tabár, 2001

Screen-detected cancers

A. 59 (16.1%)
C. 278 (76.0%)
B. 12 (3.3%)
D. 17 (4.6%)
E. 57 (15.7%)
G. 266 (73.3%)
H. 17 (4.7%)
F. 23 (6.3%)

Interval cancers

A. 45 (17.2%)
C. 185 (70.6%)
B. 16 (6.1%)
D. 16 (6.1%)
E. 40 (15.5%)
G. 181 (70.2%)
H. 18 (7.0%)
F. 19 (7.4%)
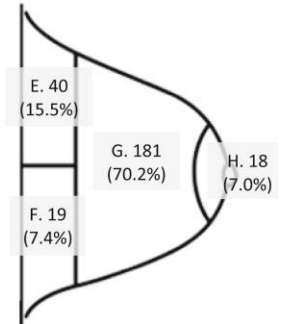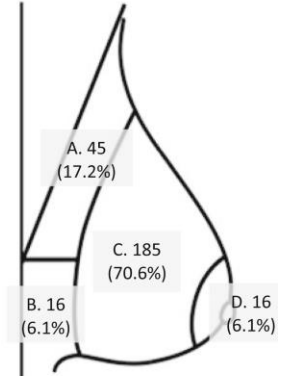
I. Théberge, 2019

Positioning criteria

	Breast positioning criteria	Measurement
CC view	Nipple in profile	Yes
		No
	Pectoral nipple line	mm
	Rotation of the breast	Nipple is central (no rotation of breast)
		Nipple is rotated 5-10°, lateral or medial
		Nipple is rotated >10°, lateral or medial
MLO view	Nipple in profile	Yes
		No
	Pectoral nipple line	mm
	Angle of pectoral muscle	≤20°
		>20°
	Fold in pectoral muscle	Yes
		No
	Length of pectoral muscle to posterior nipple line	Sufficient: Pectoral muscle reaches 1 cm or more below pectoral nipple line
		Insufficient: Pectoral muscle does not reach 1 cm below pectoral nipple line
	Shape of pectoral muscle	Straight
		Concave
		Convex
	Inframammary fold visibility	Open and free of skin folds
		Open with skin fold
		Not included

GG Waade et al, 2021
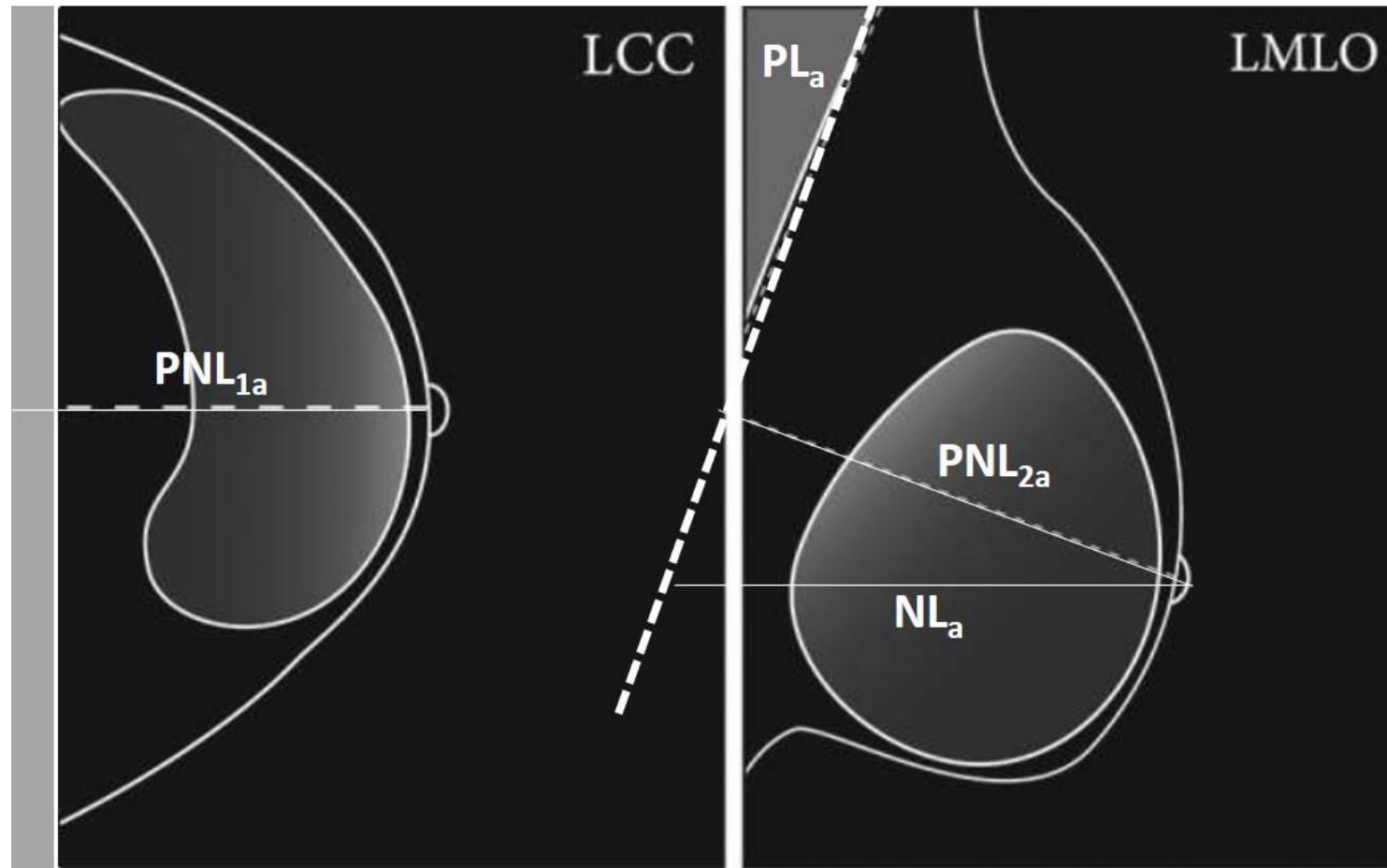
Positioning criteria
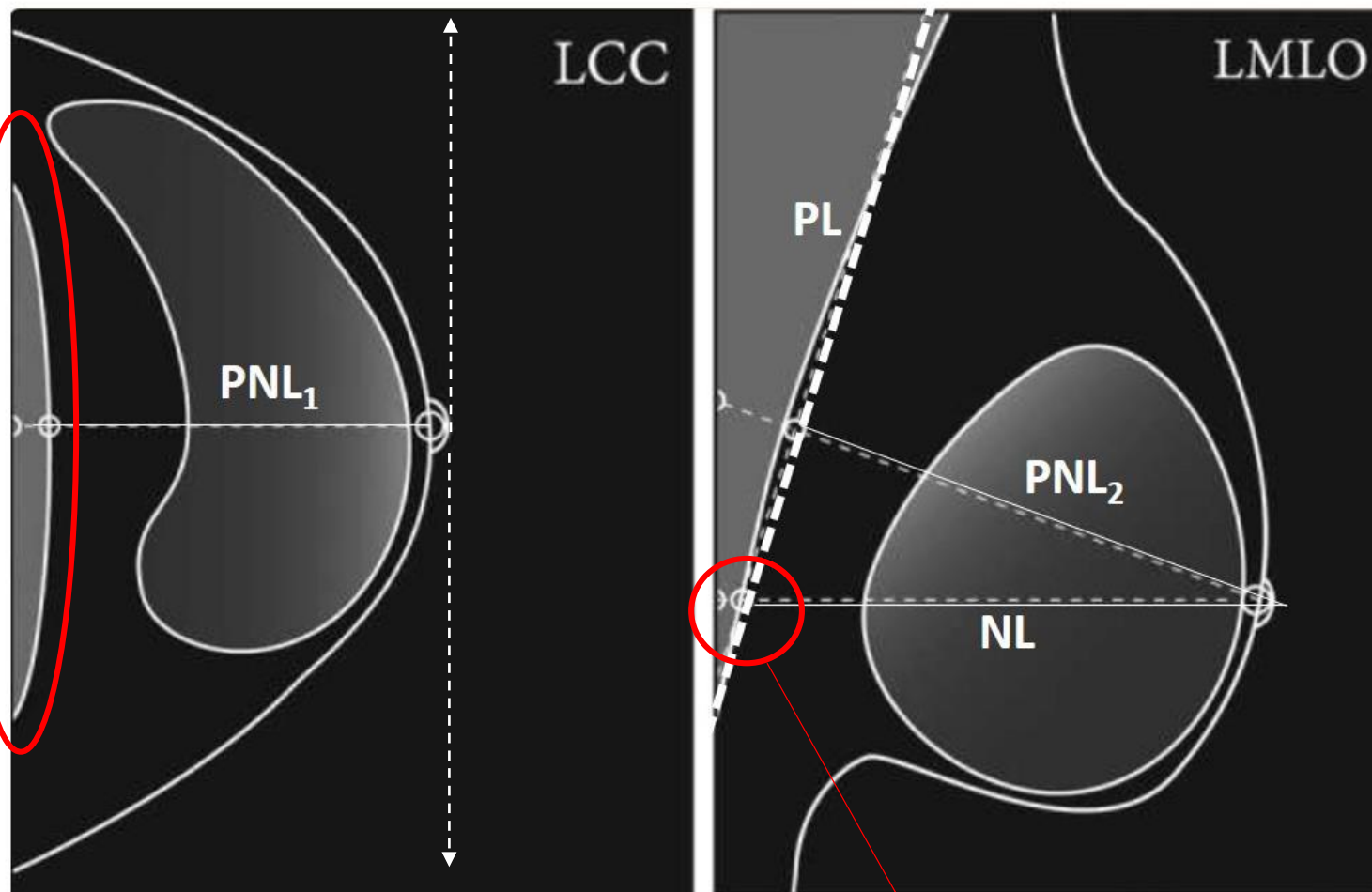
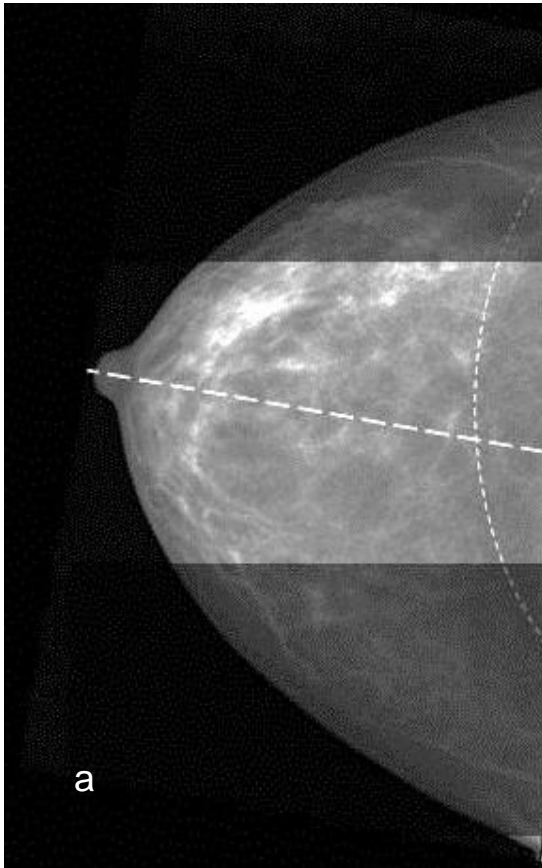20%*- 40%**

*Hendrick, Bassett, Dodd, 1992
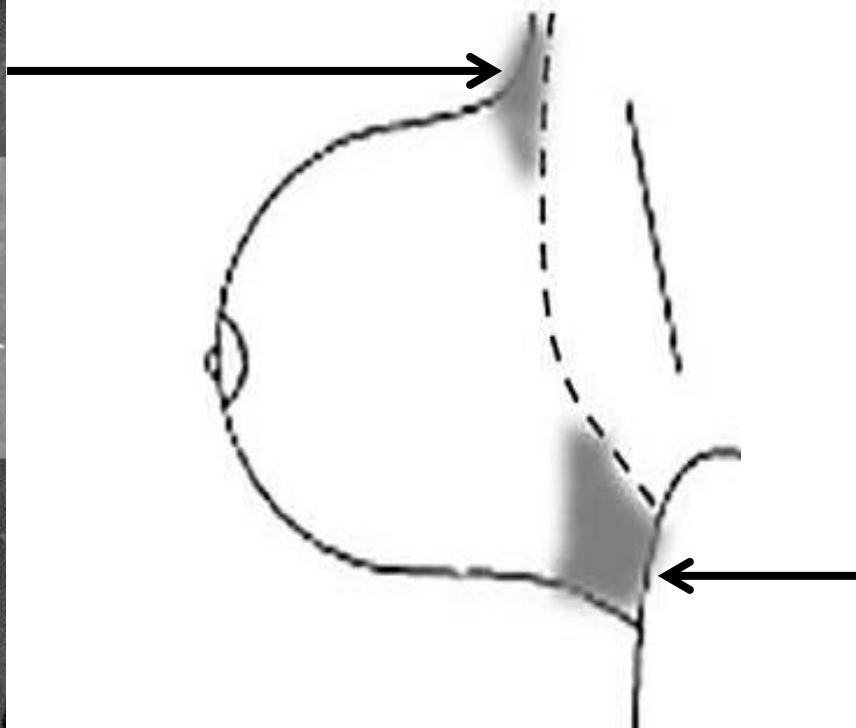**Eklund, 1994; ACR, 1999
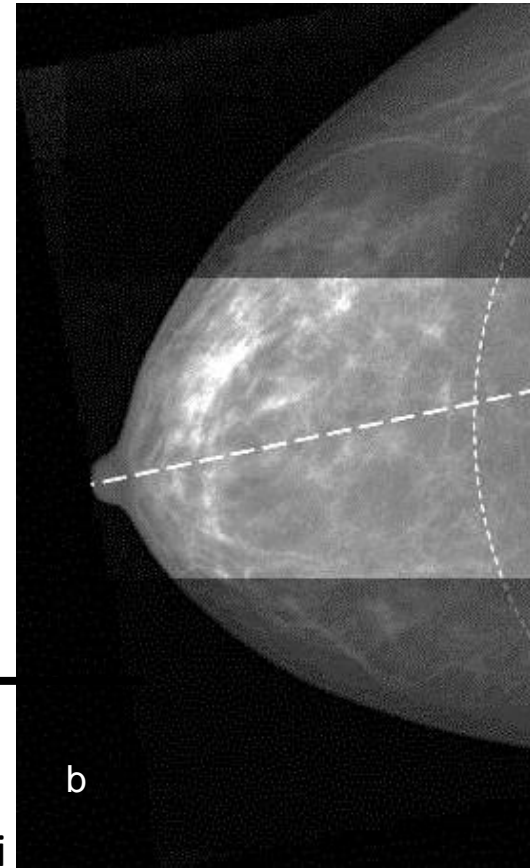
80%

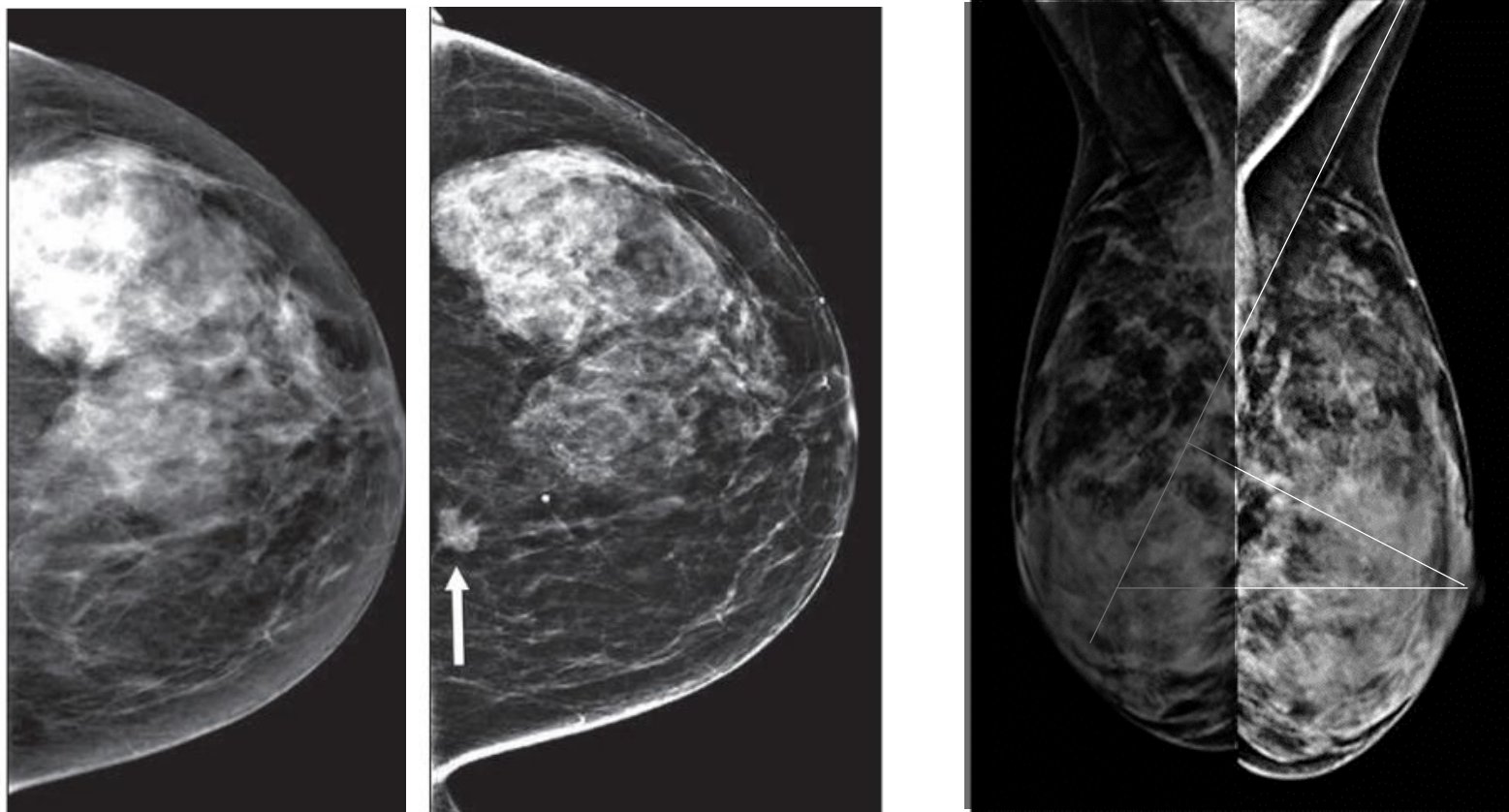# Positioning criteria failures

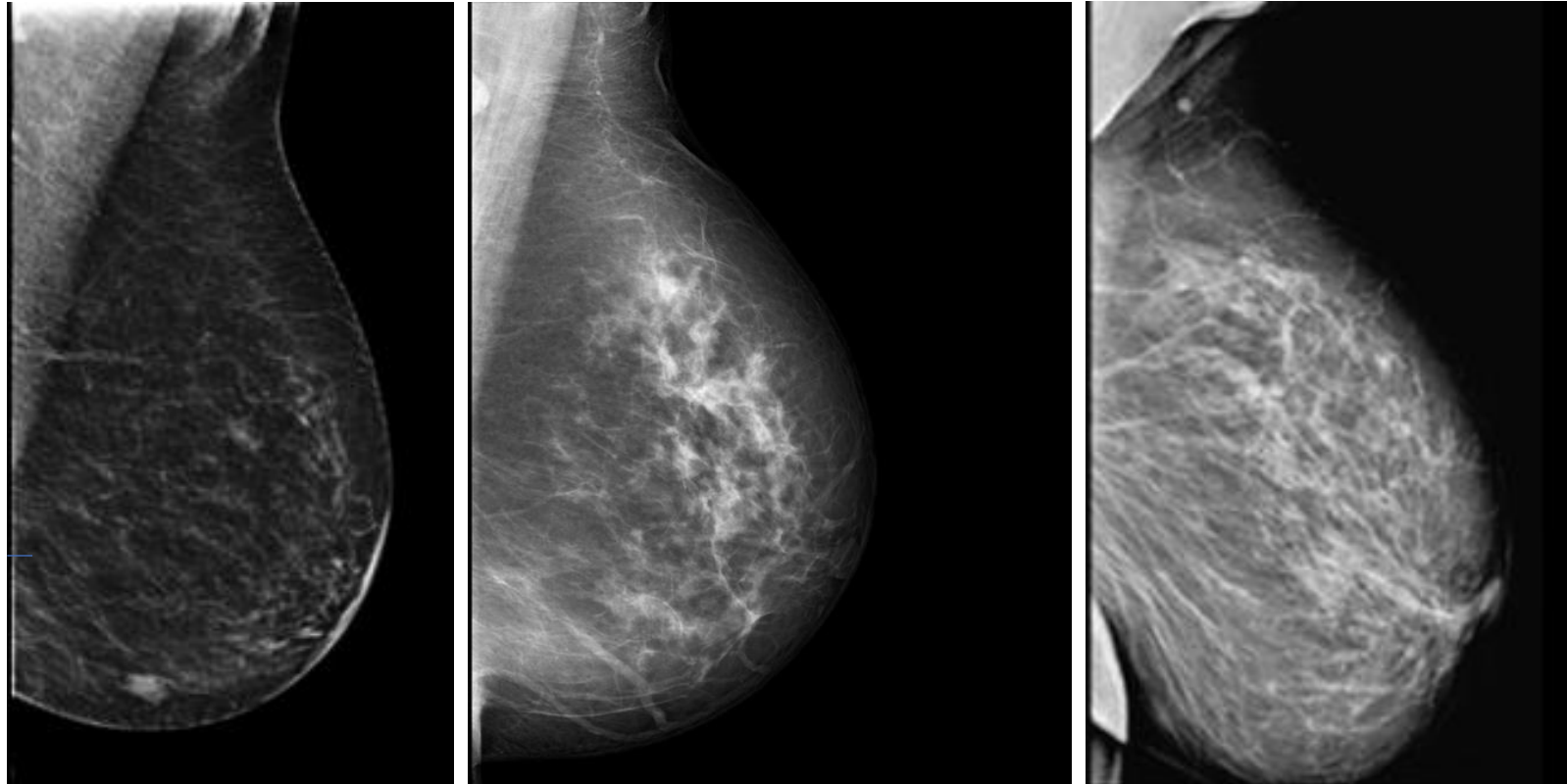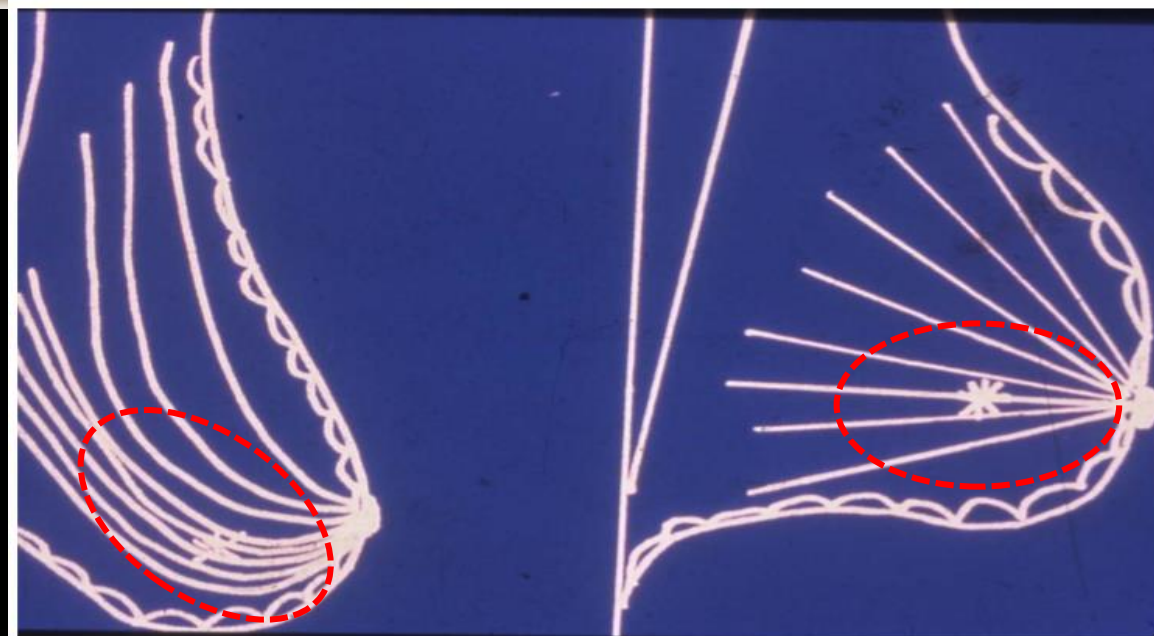# Positioning criteria failures

a) cut-off dei tessuti esterni profondi

b) cut-off dei tessuti interni profondi

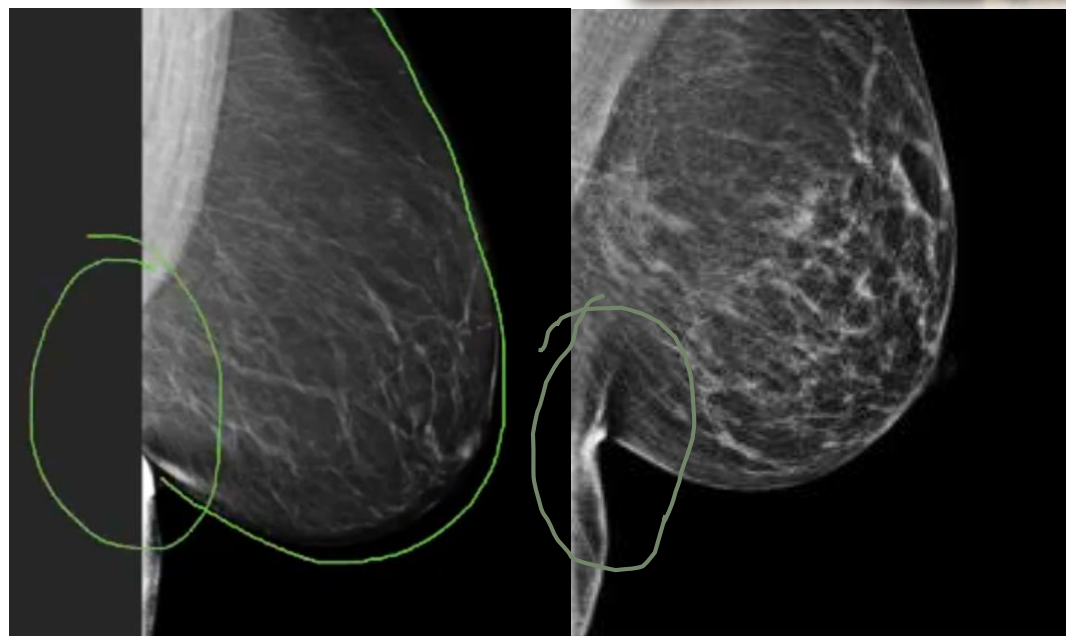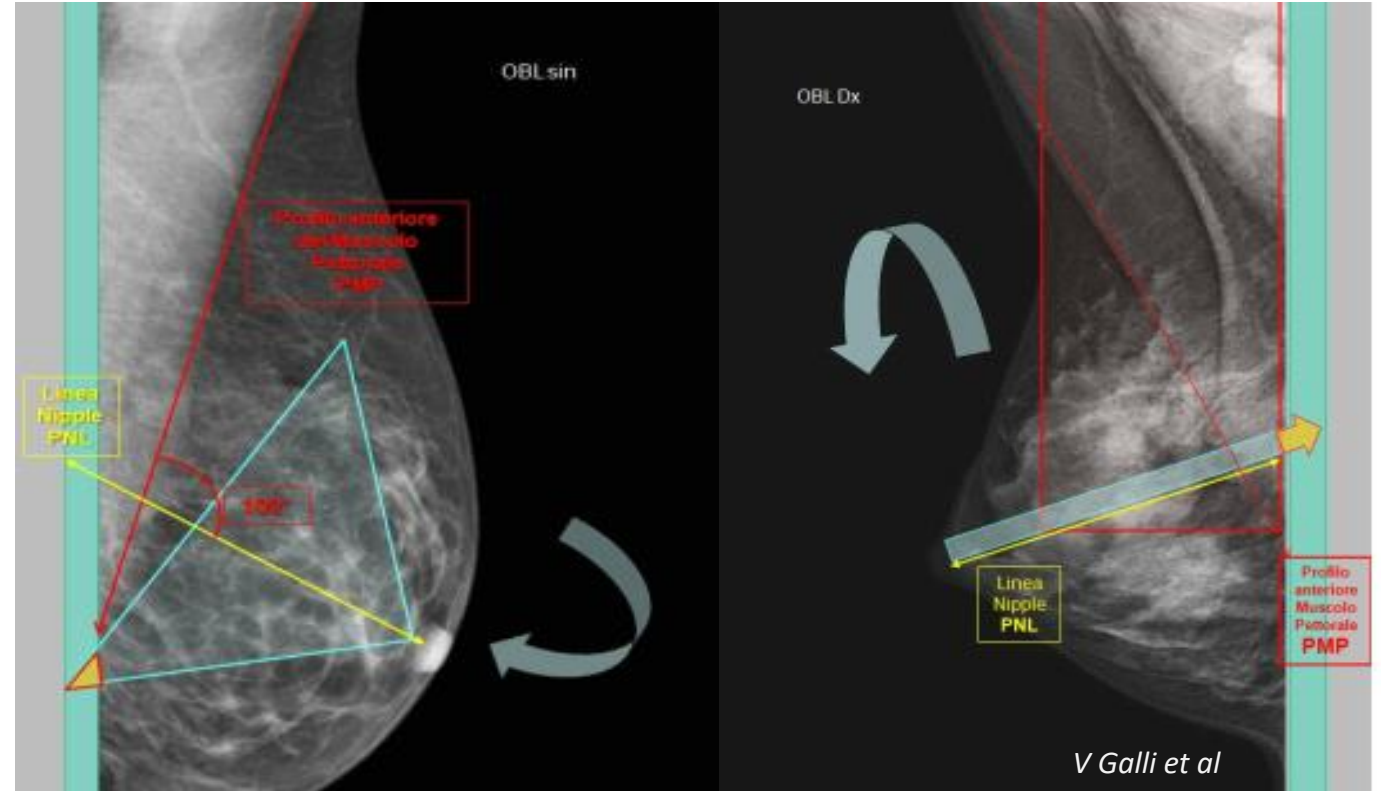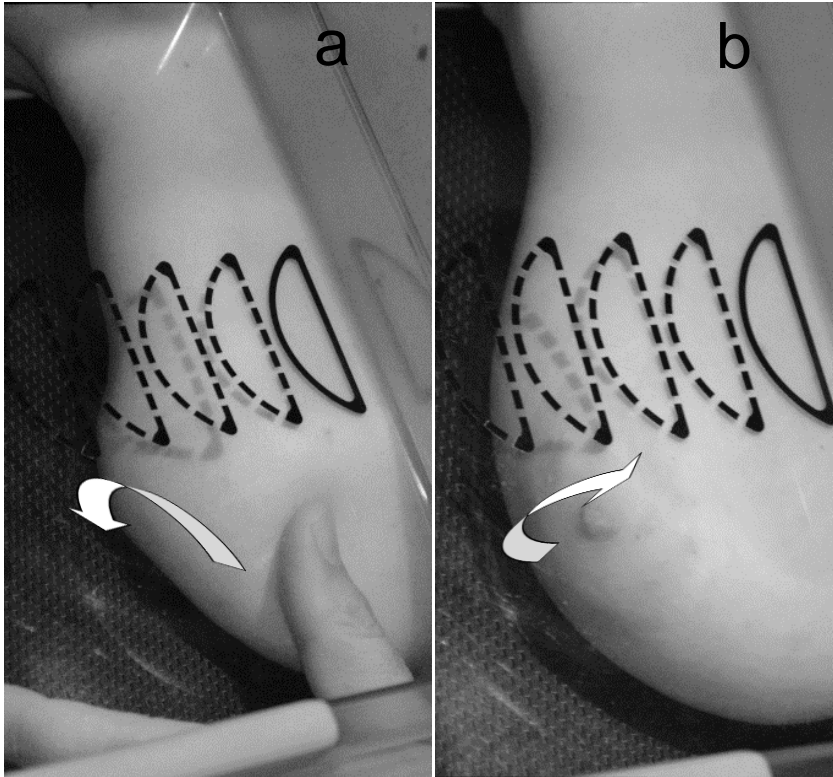# Positioning criteria failures

Positioning criteria failures
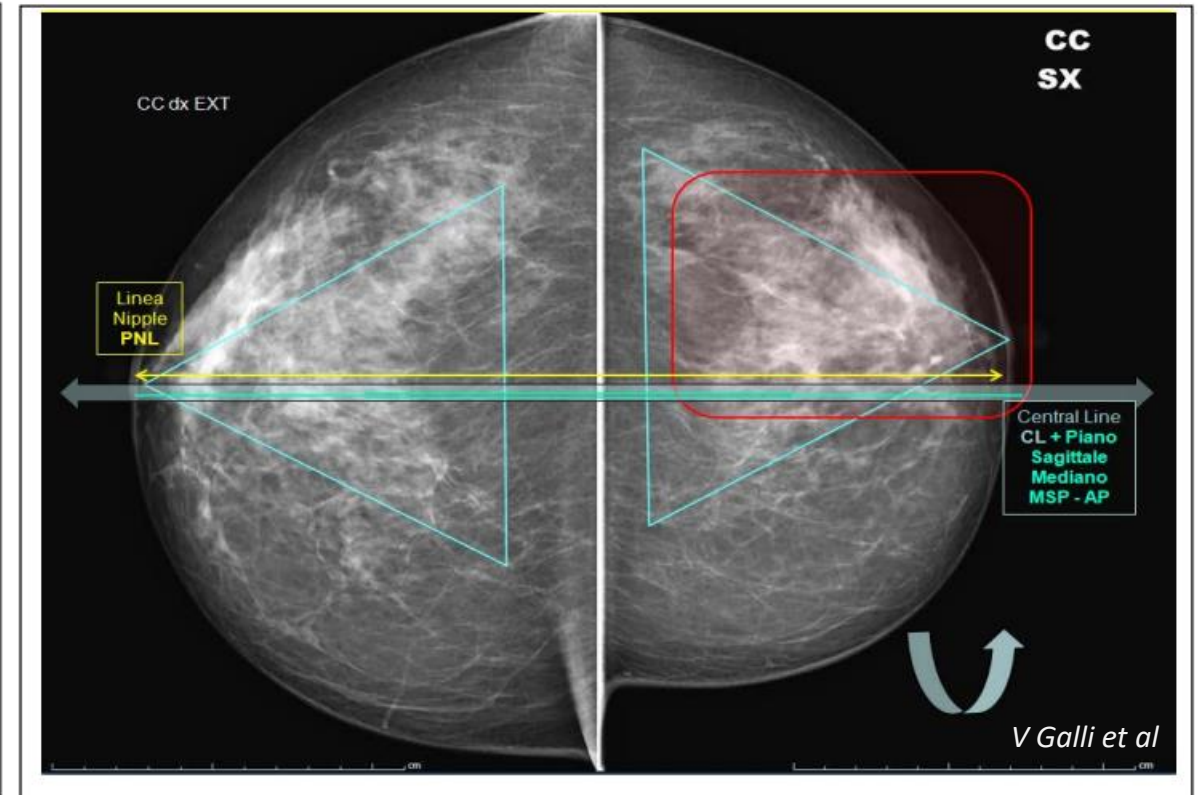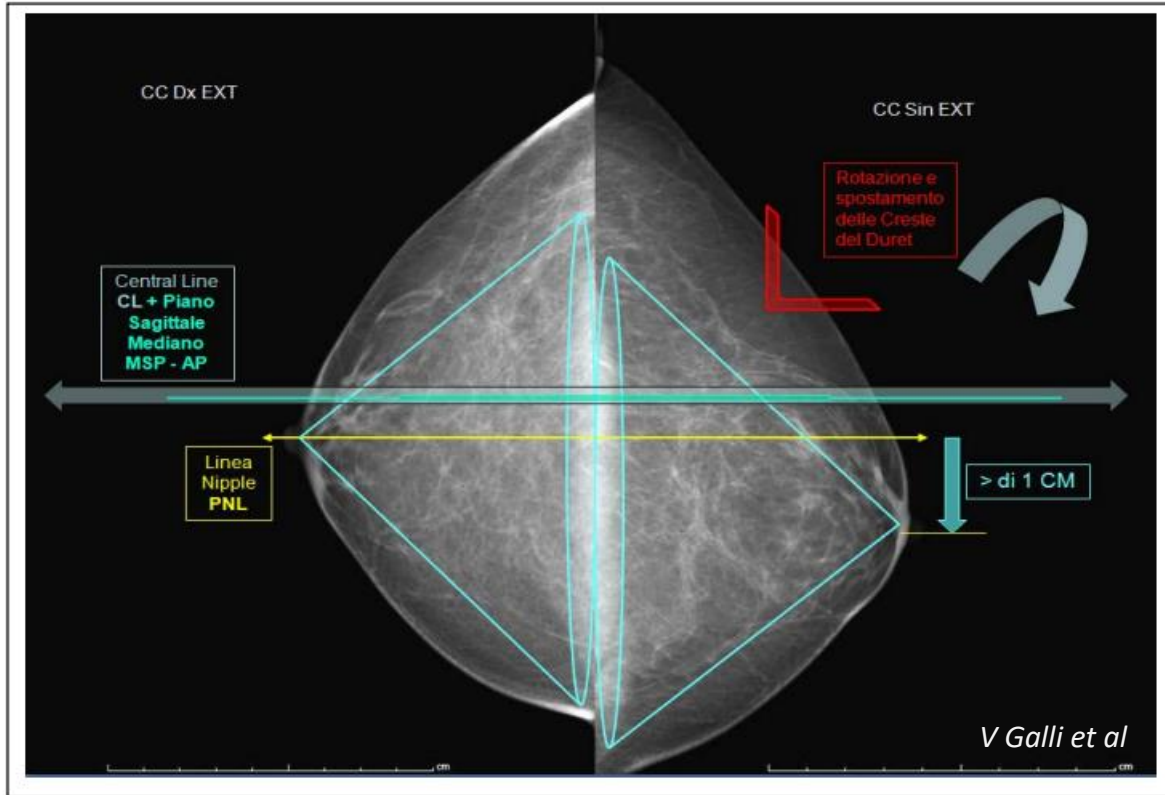
Positioning criteria failures

Positioning criteria failures

V Galli et al

Positioning criteria failures

V Galli et al

V Galli et al

Positioning criteria failures

1127 MGs performed by certified mammographers (Quebec-wide representative sample)

Evaluation of the quality of breast positioning by CC view, MLO view and overall

Assessment category	Overall CC view		Overall MLO view		Overall mammographic examination	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Adequate	816	72.4 (68.6 to 76.0)	834	74.0 (69.2 to 78.4)	635	56.3 (51.2 to 61.4)
Critical failure	310	27.6 (24.0 to 31.4)	293	26.0 (21.6 to 30.8)	492	43.7 (38.6 to 48.8)
Total	1127	100.0	1127	100.0	1127	100.0

Note: CC = craniocaudal, CI = confidence interval, MLO = mediolateral oblique.

J Rouette et al, 2021
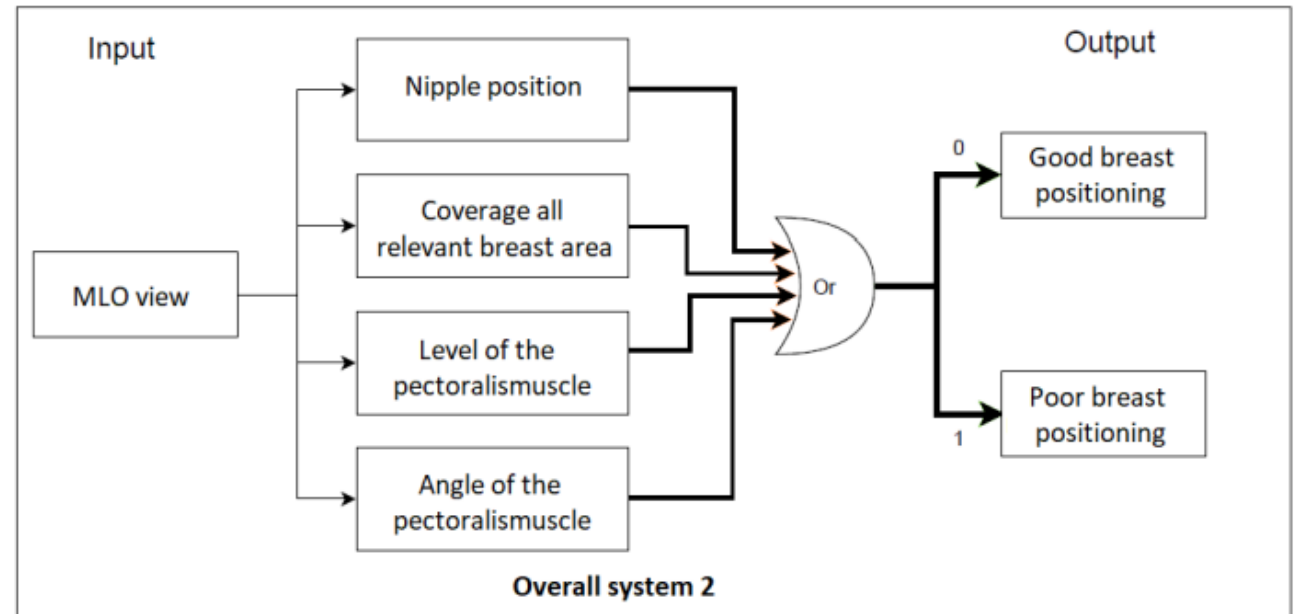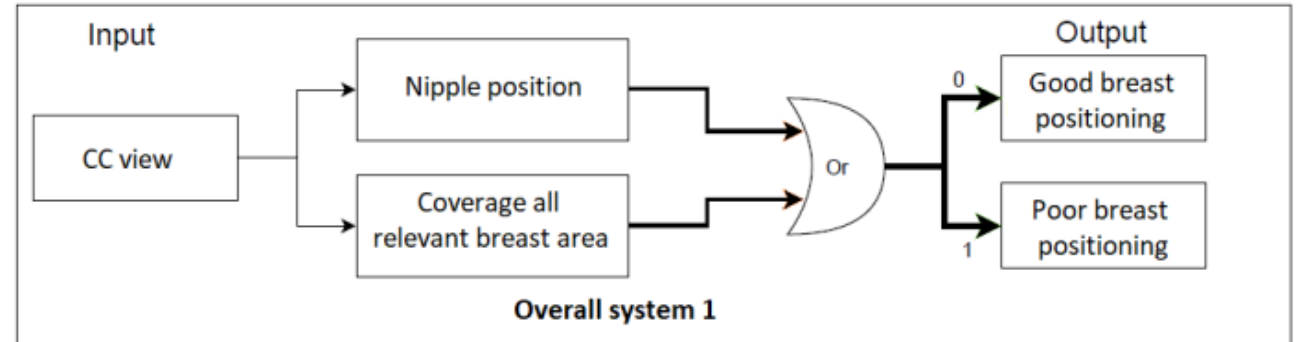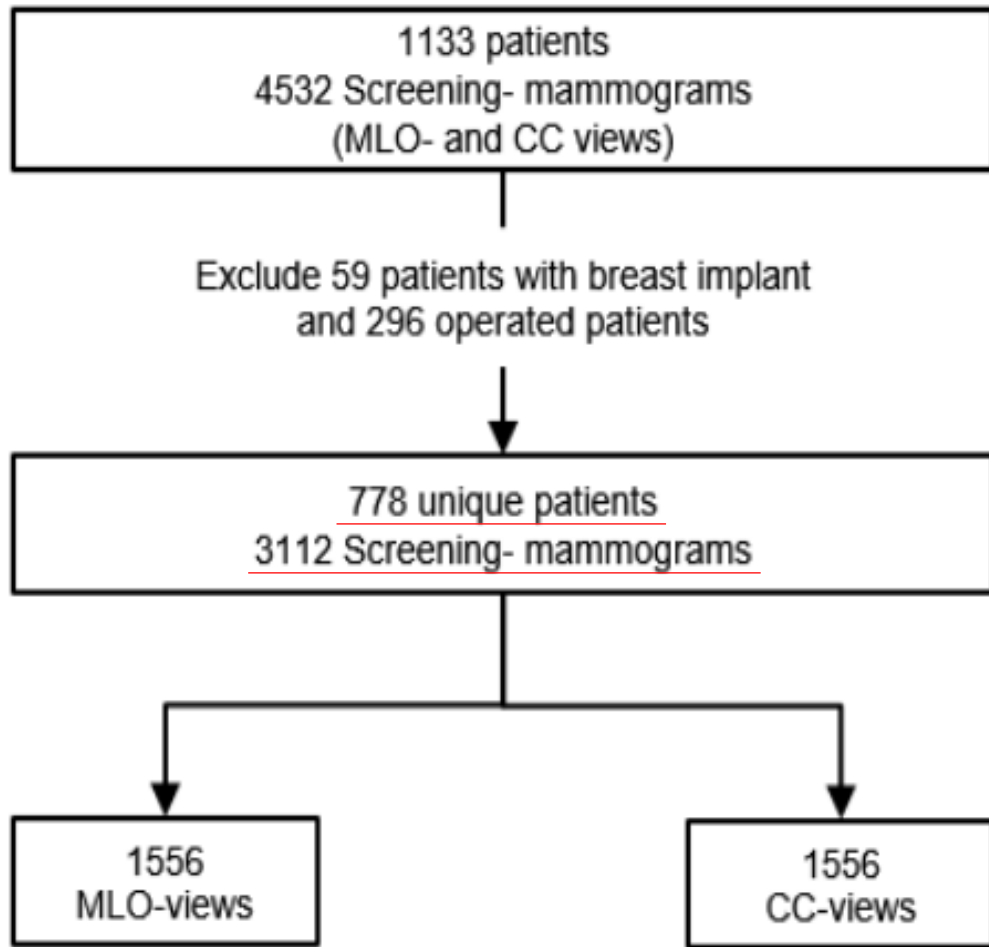
Positioning criteria failures

Specific Deficiencies of Image Quality Categories in Failed Mammograms According to ACR Standards

Category	Deficiency	Frequency*	Category	Deficiency	Frequency*
Positioning	Inadequate pectoralis major muscle on MLO view	28.7	Exposure	Generalized underexposure	75.8
	Poor visualization of posterior tissue in MLO view	23.9		Inadequate penetration of dense area	19.7
				Generalized overexposure	4.5
	Breast sagging in MLO view	12.4	Compression	Poor separation of parenchymal densities	88.1
	Posterior nipple line in CC view	11.5			
	Poor visualization of posterior tissue on CC view	9.6		Patient motion	6.8
				Non-uniform exposure level	5.1
	Breast cut-off	6.2	Contrast	Inadequate contrast	100
	Skin folds	5.7		Excessive contrast	0
	Breast positioned to high on image receptor	1.4	Sharpness	Poor delineation of linear structures	51.3
				Inadequate delineation of features margins	28.2
	Nonstandard angulation	0.5		Blurring of microcalcifications	20.5

Note.— *Numbers in parentheses are percentages.

E Gourd, 2018

Positioning criteria failures

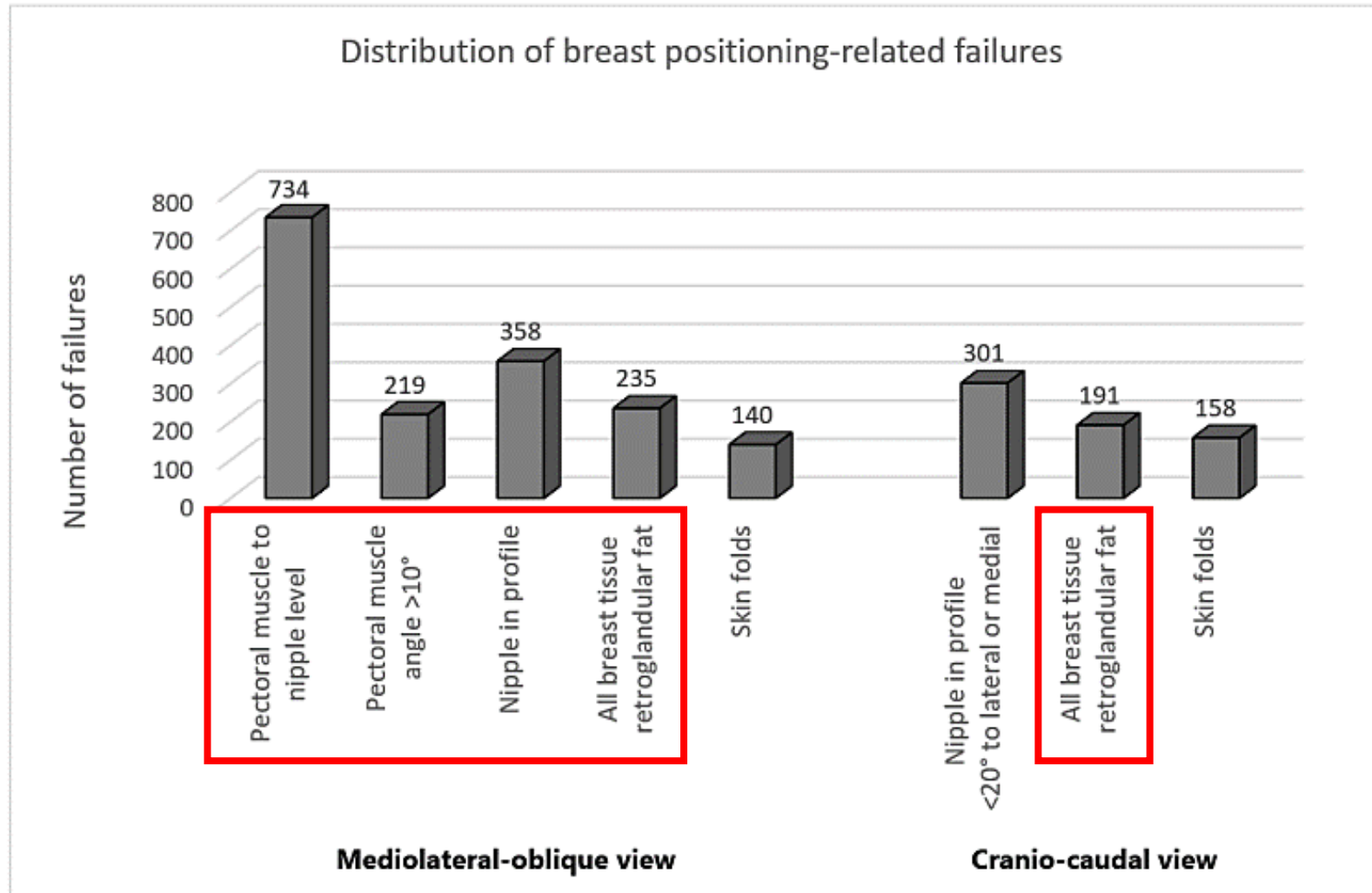*M Brahim et al, 2022*

Positioning criteria failures

Table 1. Classification results of the collected 1556 MLO views according to ACR categories and quality of breast positioning.

ACR Category	Breast Positioning Quality	
	Good	**Poor**
ACR1	241 (52,7%)	213 (47,3%)
ACR2	387 (49,7%)	291 (51,3%)
ACR3	113 (36,7%)	195 (63,3%)
ACR4	78 (67,2%)	38 (32,8%)

Table 2. Classification results of the collected 1556 CC views according to ACR categories and quality of breast positioning.
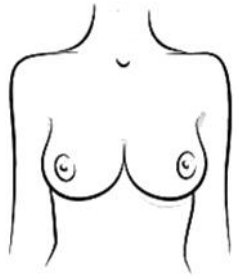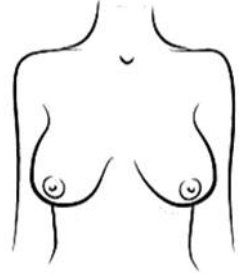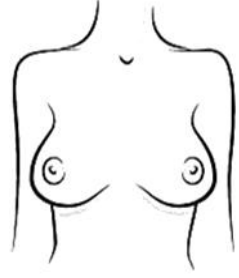
ACR Category	Breast Positioning Quality	
	Good	**Poor**
ACR1	312 (68,7%)	142 (31,3%)
ACR2	472 (69,6%)	206 (30,4%)
ACR3	206 (66,8%)	102 (33,2%)
ACR4	84 (72,4%)	32 (27,6%)

M Brahim et al. 2022

Positioning criteria failures

Distribution of breast positioning-related failures

M Brahim et al, 2022

Ectomorfo   Mesomorfo   Endomorfo

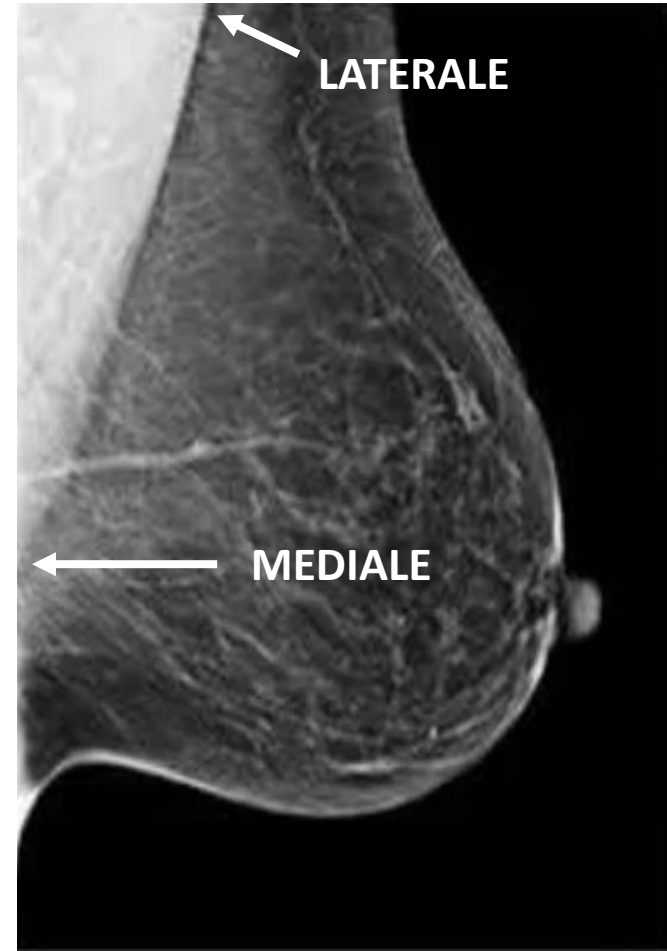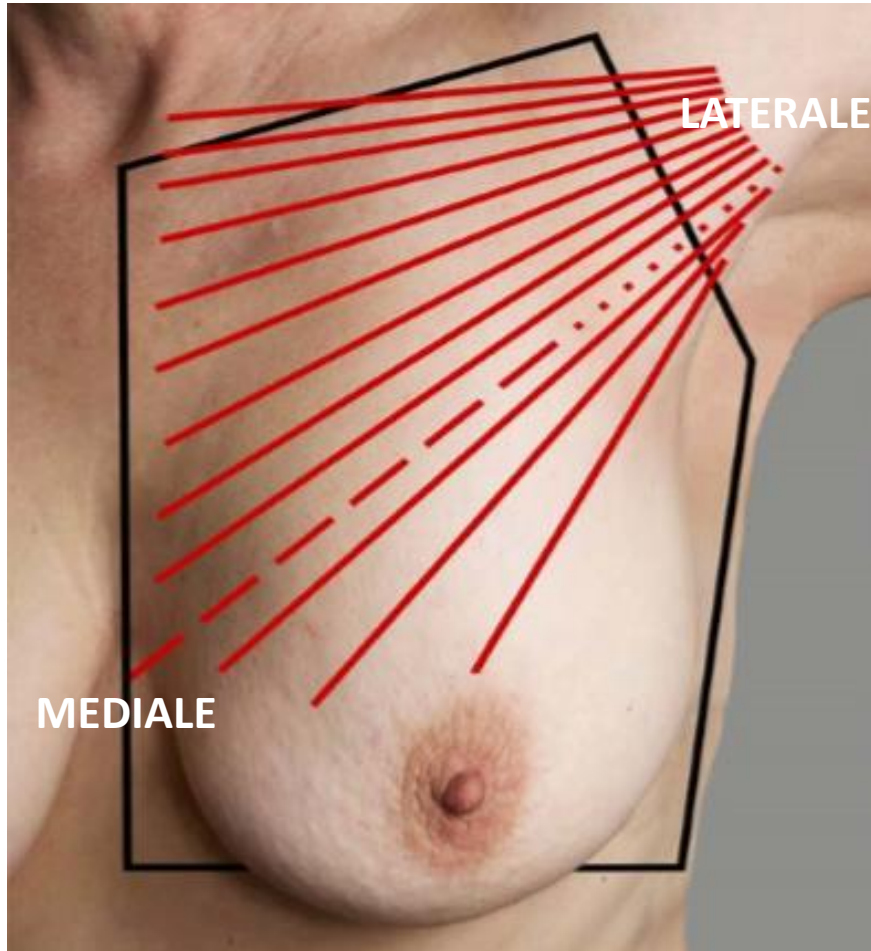Corretto angolo di inclinazione

Angolo di inclinazione eccessivo
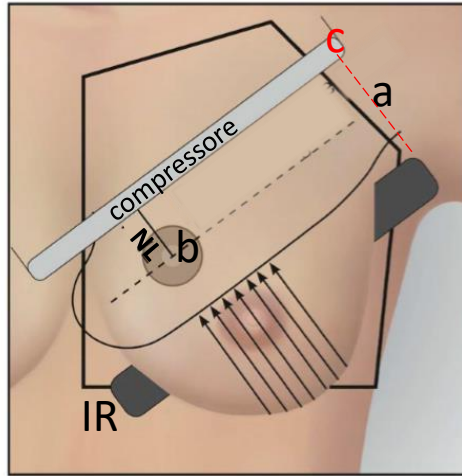
a-b = Lunghezza del muscolo sull'immagine
c-d = Larghezza del muscolo sull'immagine

Porzioni di muscolo e tessuto mammario non visualizzati sull'immagine

Muscolo visualizzato nell'intera lunghezza
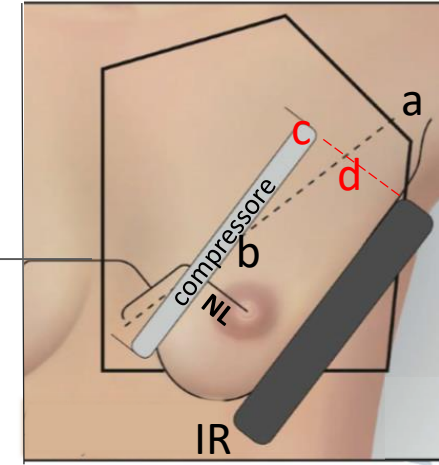
Porzione di muscolo non visualizzata
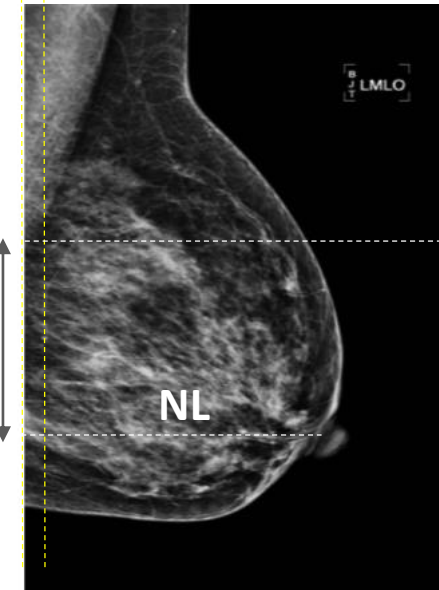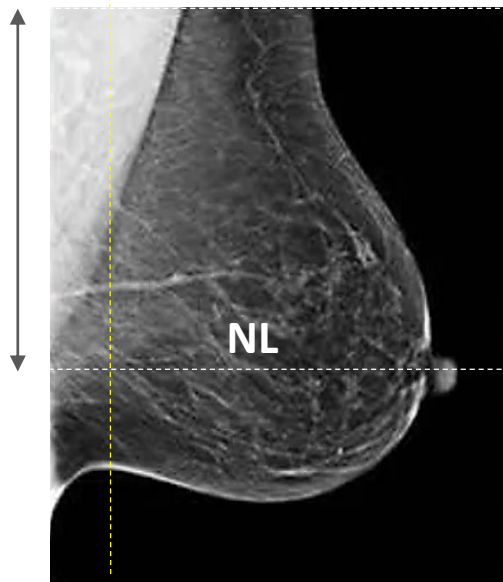
Differenza di quantità di tessuto posteriore visualizzata
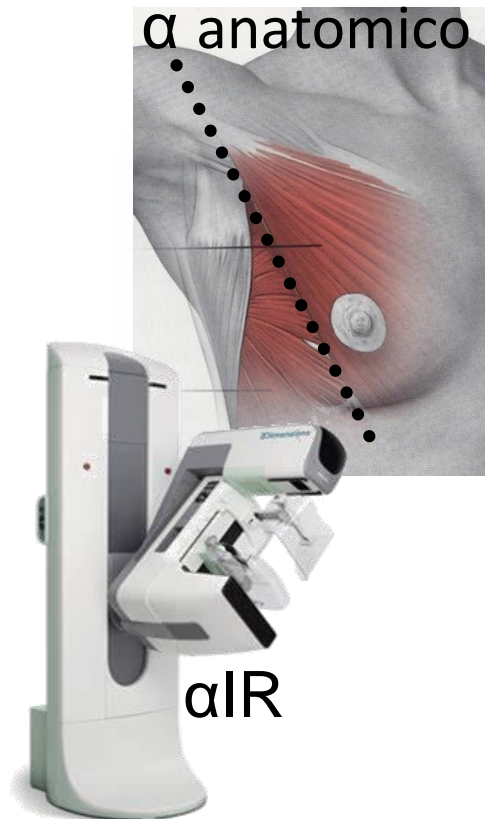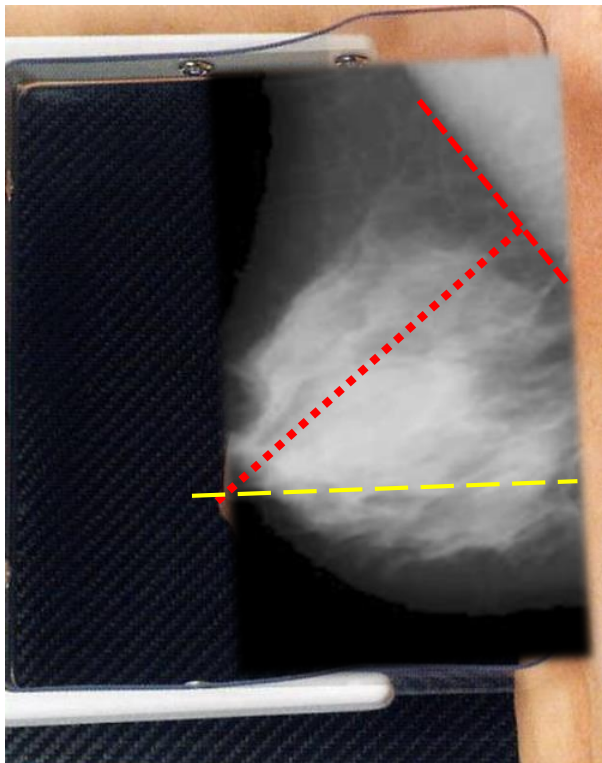
αIR 45° > αPETTORALE
(αIR eccessivo rispetto ad αPEC)

αIR 45° < αPETTORALE
(αIR eccessivo rispetto ad αPEC)

α anatomico

αIR

M.PETTORALE

PROL.ASC.

QSI   QSE

QII   QIE

M.PETTORALE

PROL.ASC.

QSI   QSE

QII   QIE
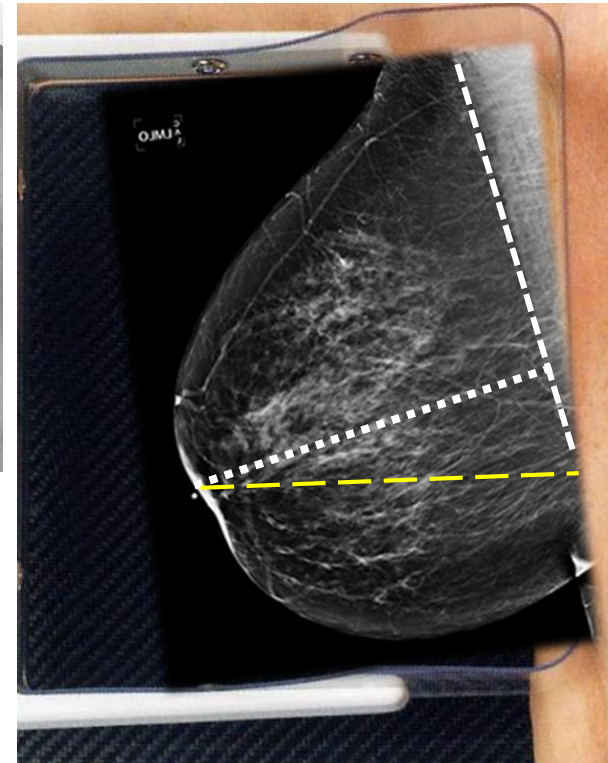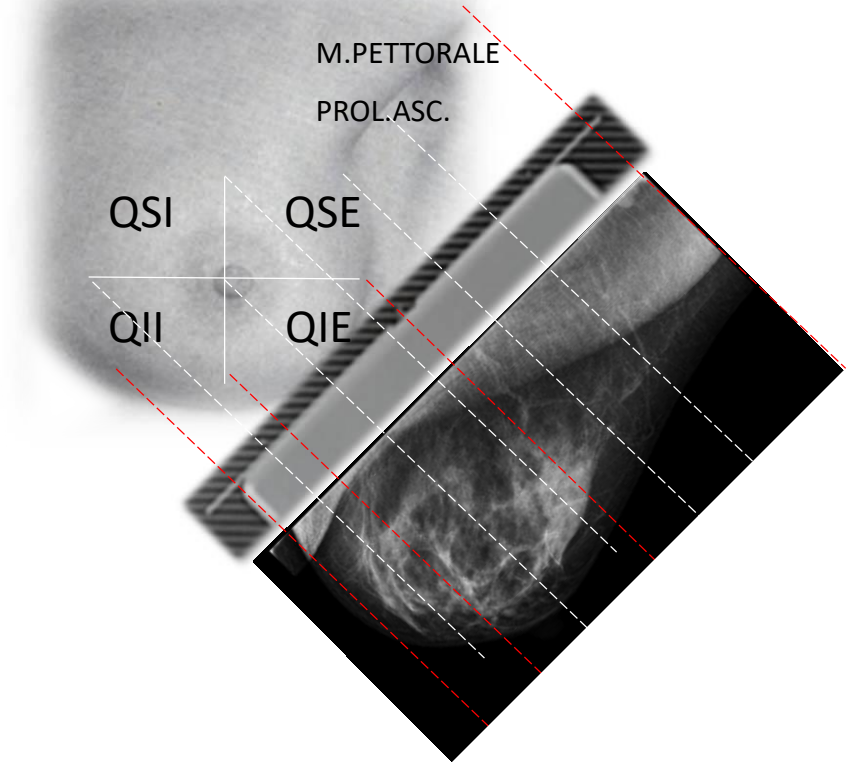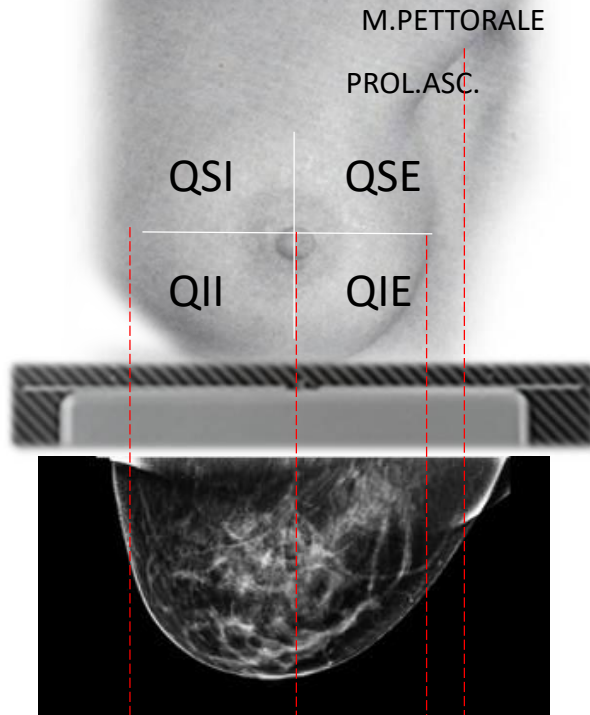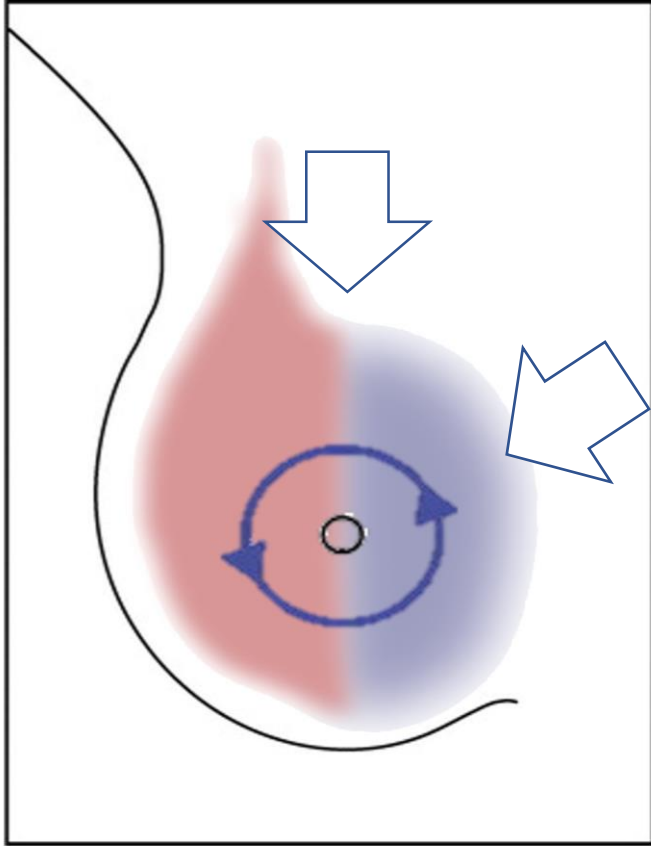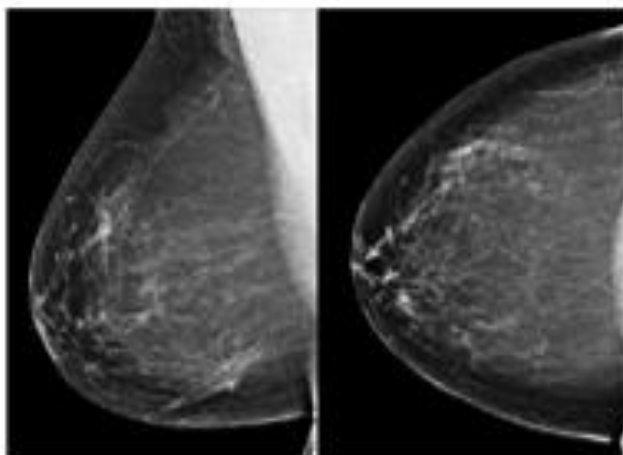
BI-RADS Category A   BI-RADS Category B   BI-RADS Category C   BI-RADS Category D

Plop

Pull

Differenza di lunghezza della PNL

Completa rappresentazione del tessuto ghiandolare

Completa visualizzazione dello spazio retroghiandolare
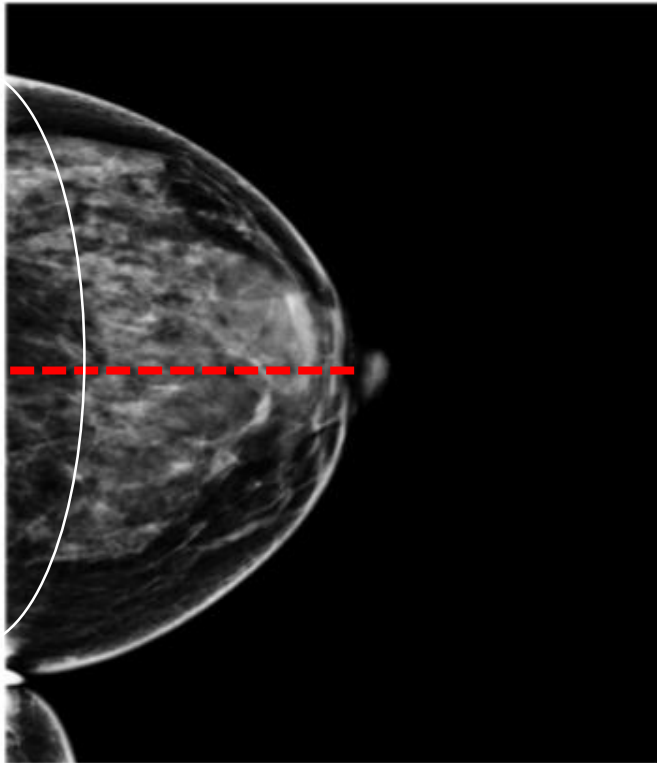
NON CORRETTO

Margine dell'IR davanti all'IMF

CORRETTO

Margine dell'IR dietro all'IMF

The effect of breast positioning on breast compression in mammography: a pressure distribution perspective

Magnus Dustler; Ingvar Andersson; Daniel Förnvik; Anders Tingberg

La **compressione effettiva** applicata alla mammella
equivale al **rapporto tra forza applicata e superficie di applicazione**

$$p = \frac{F}{S}$$

$$kPa = N/cm^2$$
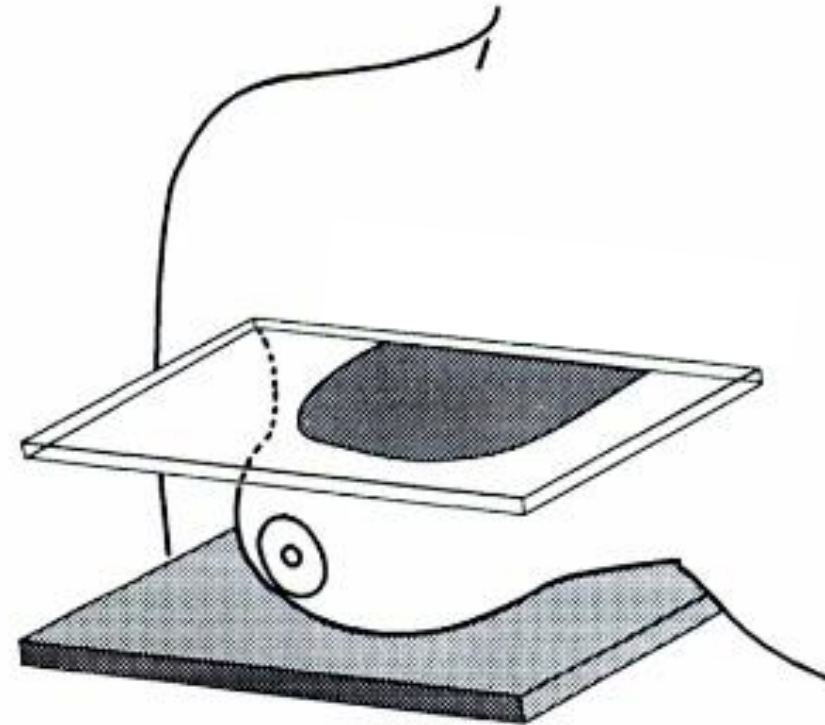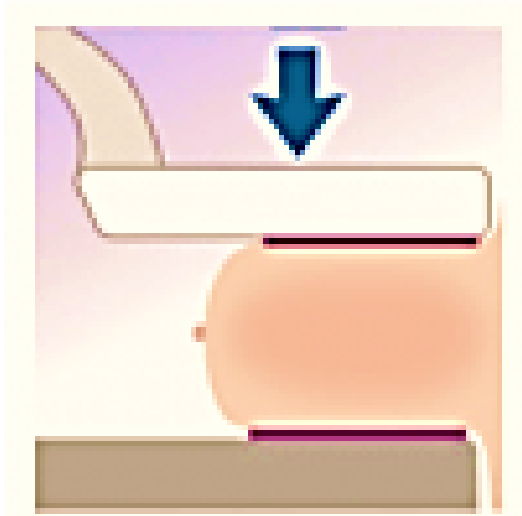
- Mammella grande (superficie di contatto = 180cm^2)

- Forza = 180N

- Pressione = 10 kPa (75 mmHg)

- Minor dolore
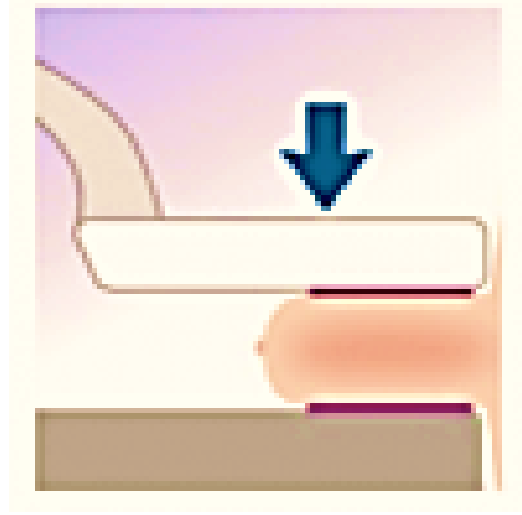
- Mammella piccola (superficie di contatto = 110cm^2)

- Forza = 180N

- Pressione = 16 kPa (120 mmHg)

- Maggior dolore

(a)

10 daN   10 daN

＊
CENTRO DI MASSA

(b) Maggior dolore

10 daN   20 daN

＊
CENTRO DI MASSA

(a)

Medio-laterale

Antero-posteriore

Y

＊

X

(b)

Medio-laterale

Antero-posteriore

Y

＊

X
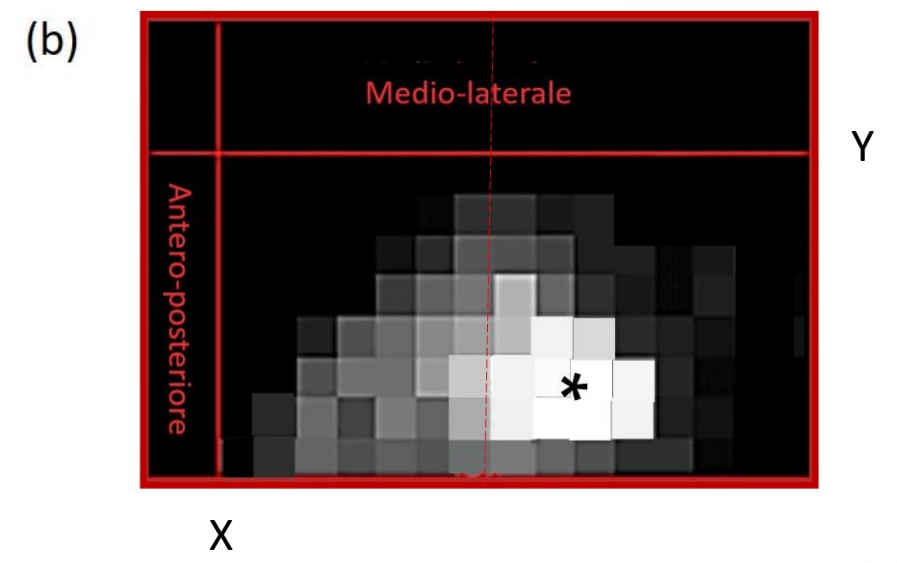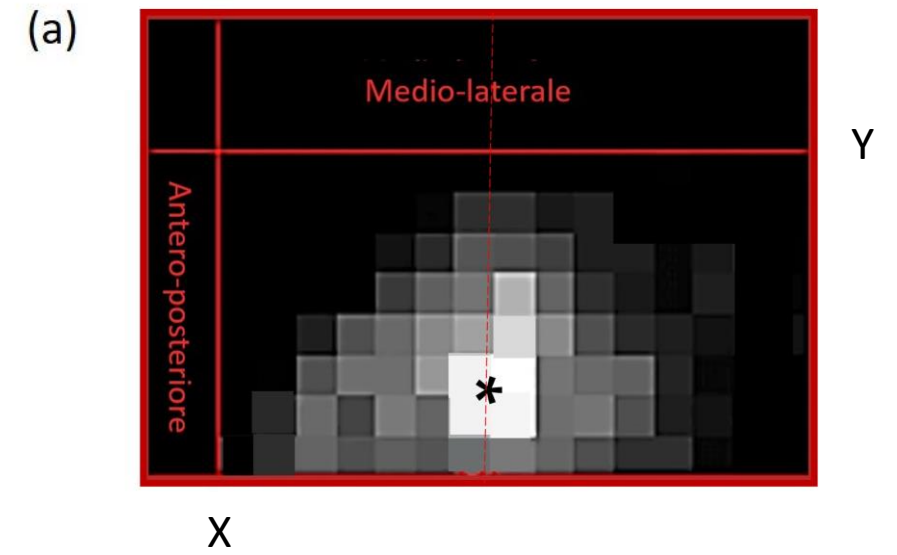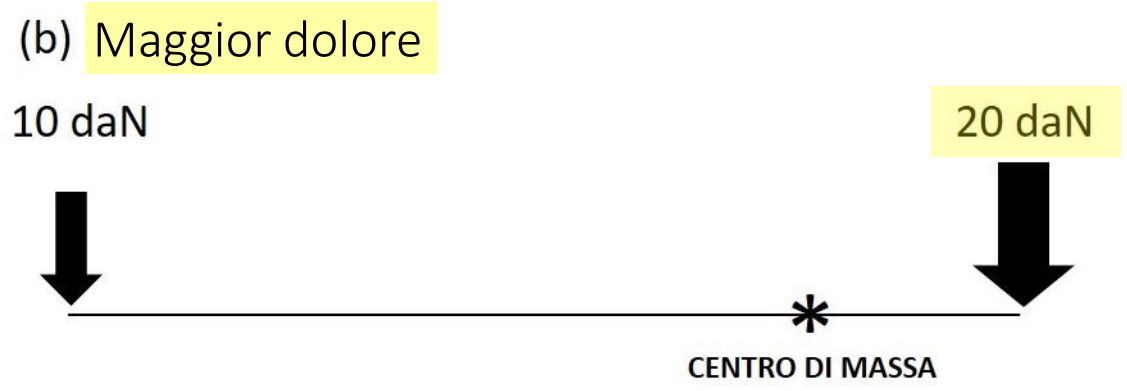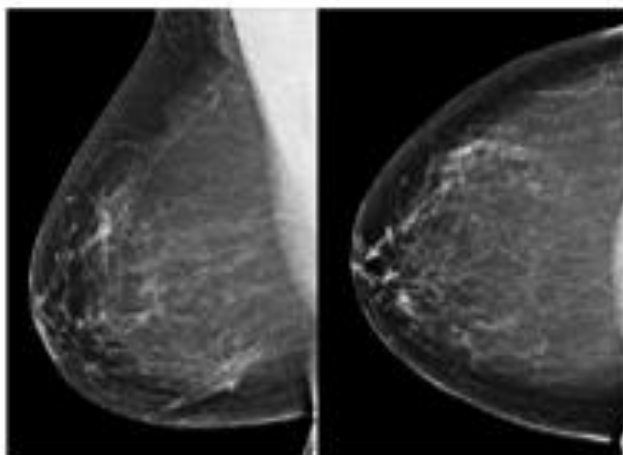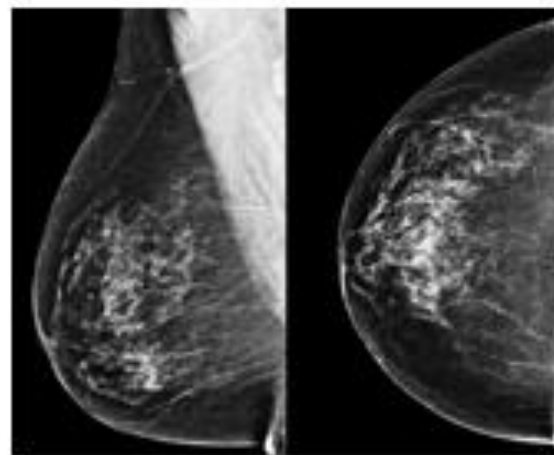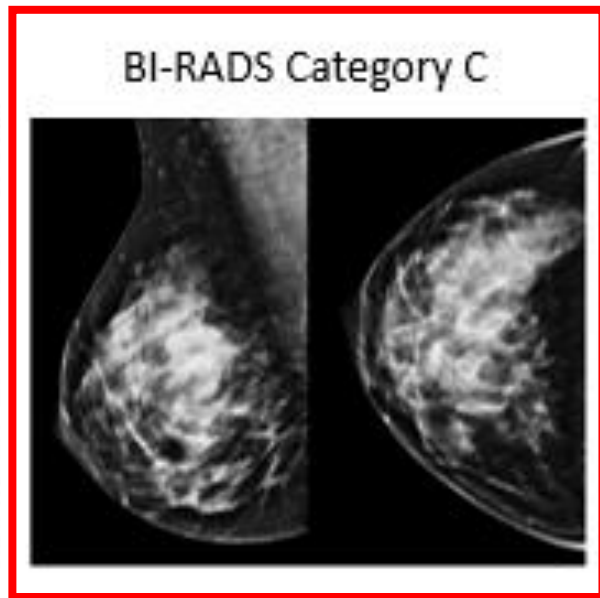
BI-RADS Category A   BI-RADS Category B   BI-RADS Category C   BI-RADS Category D
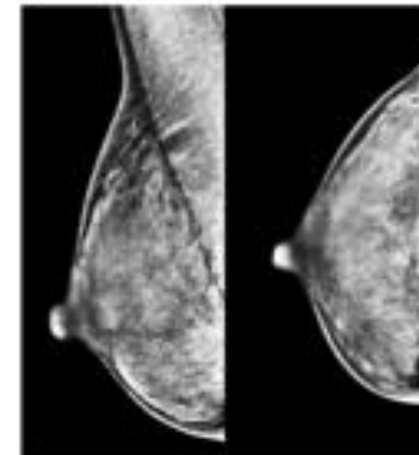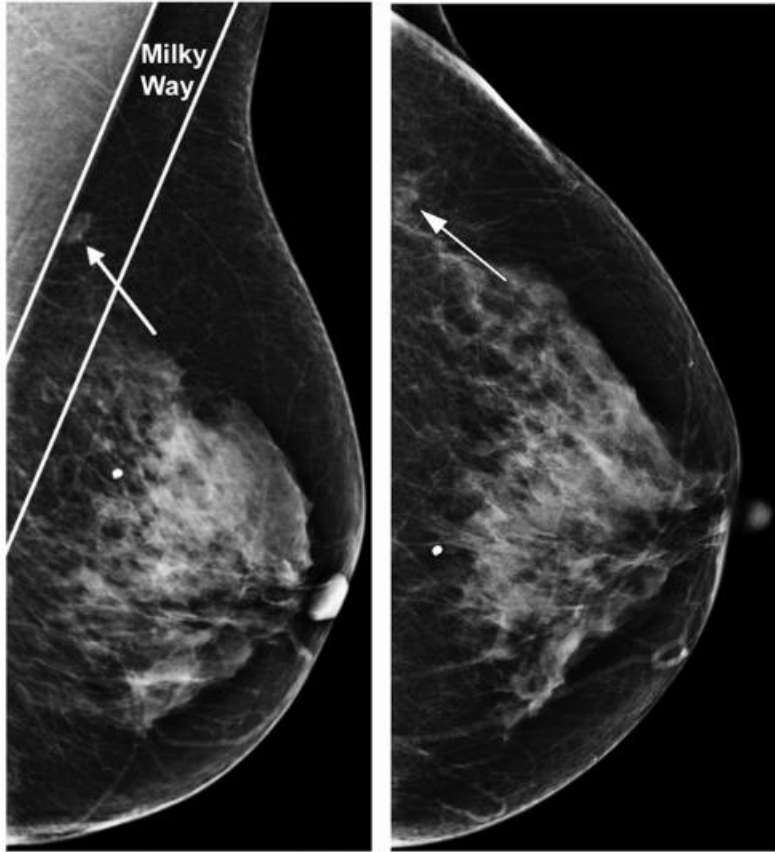
Tabar Classification

	I	II	III	IV	V
Mediolateral views					
Craniocaudal views					

(a)

Subdivision of Pattern I

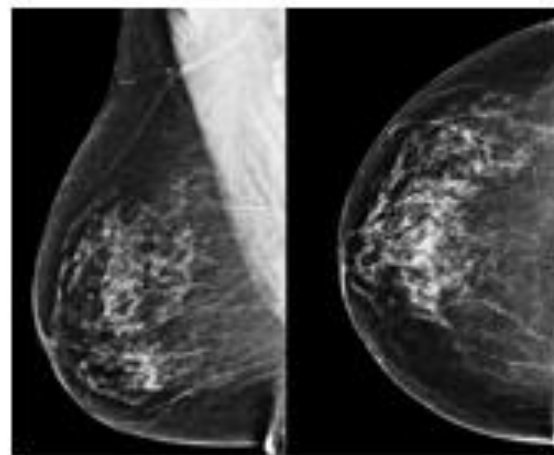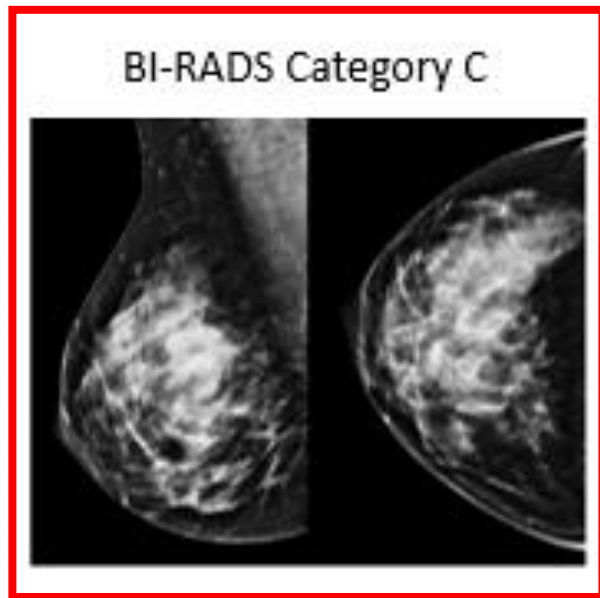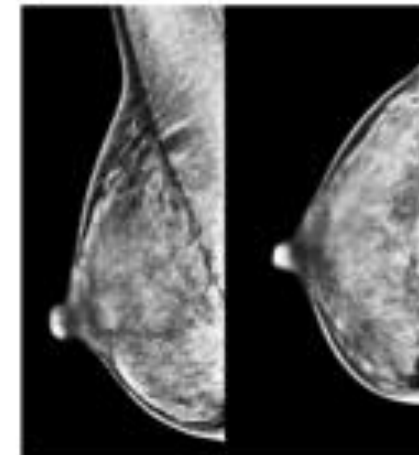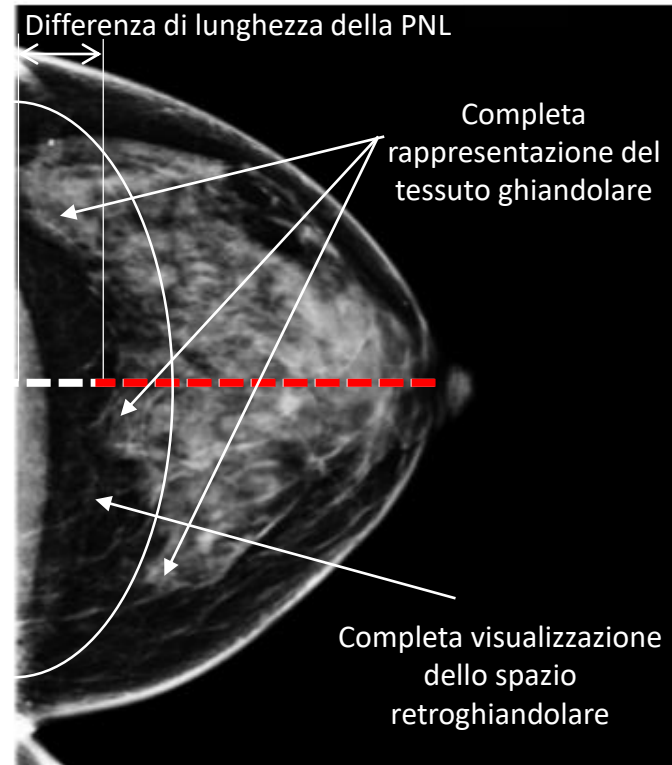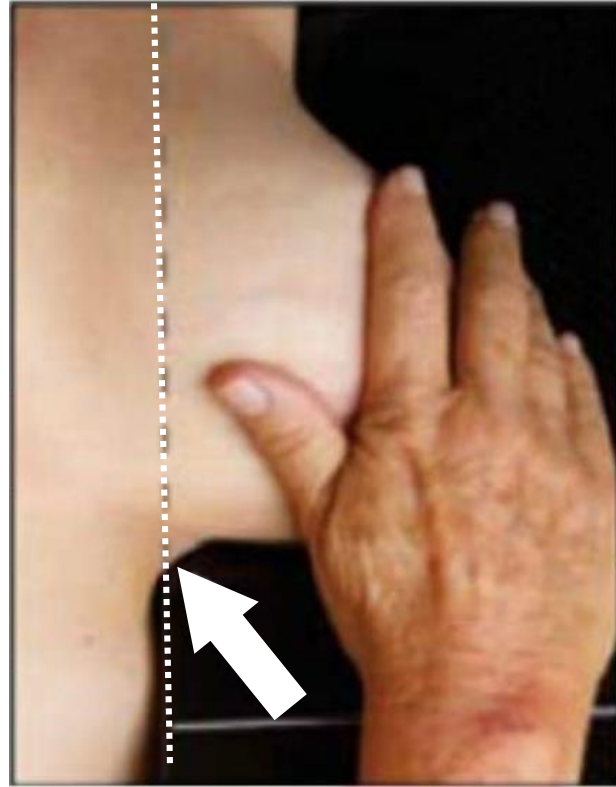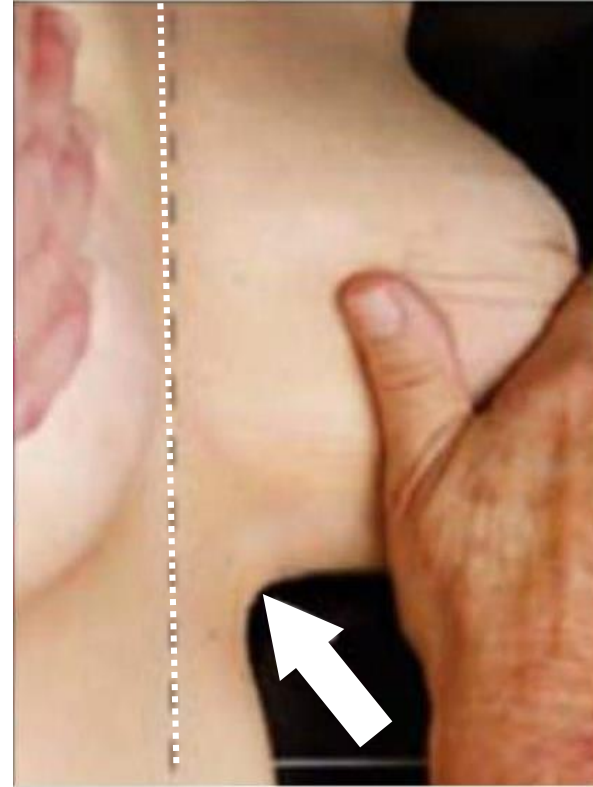| IA	IB	IC
Mediolateral views		
Craniocaudal views		
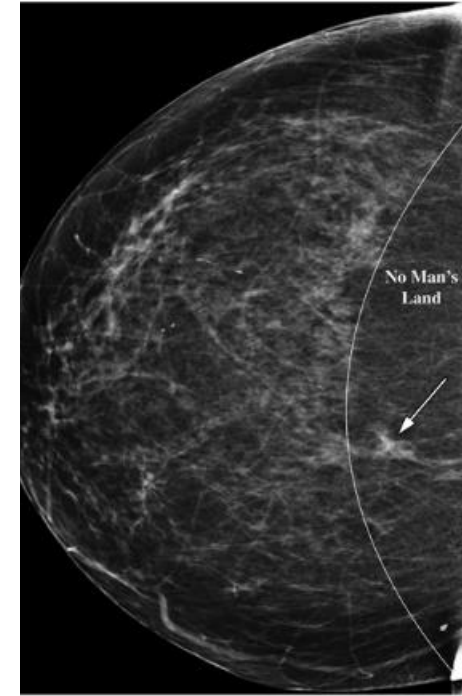
Breast compression in mammography: How much is enough?

Performance of Breast Cancer Screening Depends on Mammographic Compression

Katharina Holland[1](✉), Ioannis Sechopoulos[1], Gerard den Heeten[2], Ritse M. Mann[1], and Nico Karssemeijer[1]

The results suggest that high pressure reduces detectability of breast cancer. The best screening results were found in the groups with a moderate pressure.

Influence of breast compression pressure on the performance of population-based mammography screening

Katharina Holland[1]*, Ioannis Sechopoulos[1], Ritse M. Mann[1], Gerard J. den Heeten[2], Carla H. van Gils[3] and Nico Karssemeijer[1]

In conclusion, this study shows a relation between the applied pressure and the performance of screening mammography even when taking into account confounding effects. The recall rate, false positive rate, and specificity were affected negatively in the compression category with the lowest pressure, while the sensitivity was reduced in the categories with high pressure.

Cute (0,5cm x 2)

Tessuto adiposo (FAD)

Tessuto ghiandolare (FGL)

European guidelines for quality assurance in breast cancer screening and diagnosis *Fourth Edition*

RADIOGRAPHICAL GUIDELINES

3.8 Radiographic quality standards

The radiographic quality objectives are:
- More than 97% of the women should have an acceptable examination, whether this is single view or double view mammography. A good diagnostic image meets the criteria laid down in the previous paragraphs.
- Less than 3% of the women should have a repeated examination, either a repeated mediolateral or cranio-caudal view. Audit must be carried out to monitor this.
- More than 97% of the women should be satisfied with their screening visit and feel the radiographer has met their needs.
- 100% of the women should be informed by the radiographer of the method and time scale for receiving their results.

PGMI: >97% P+G+M (>50%G); <3% I

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National guidelines for image quality

Country	Guideline
Australia	PGMI adapted from UK version
Denmark	PGMI (adopted 1995)
New Zealand	PGMI adapted from UK version
Norway	Norwegian Breast Cancer Screening Program (NBCSP) criteria expanded from PGMI
UK	PGMI standard
Italy (RER)*	POGMIIR
Ebreast*	IQAS

Comparison of positioning criteria included in guidelines across various countries

	Country	United States	United Kingdom	Australia	Netherlands	Belgium
	Guidelines maintained by	American College of Radiology (23)	National Health Service (13)	BreastScreen Australia (14)	LRCB, Dutch Expert Centre for Screening (24)	European Commission (25)
Criteria (CC/MLO views)	Skin folds	✔	✔	✔	✔	✔
	Asymmetry left vs. right		✔	✔	✔	✔
	Nipple is not in profile		✔	✔	✔	✔
	PNL>1cm between CC and MLO views	✔		✔		
	Breast tissue cutoff	✔		✔		✔
	Absence of artifacts/other body parts	✔	✔	✔	✔	✔
	Fibroglandular disc/ triangle				✔	
Criteria (CC view only)	Medial tissue not visualized		✔	✔	✔	✔
	Lateral tissue/axillary tail not visualized		✔		✔	✔
	Posterior tissue not visualized	✔	✔			✔
	Pectoral muscle/shadown visualized		✔		✔	✔
	Excessive exaggeration	✔				
Criteria (MLO view only)	IMF not well demonstrated/visualized	✔	✔	✔	✔	✔
	IMF skin folds of IMF obscured					✔
	Pectoral length to level of nipple/PNL		✔			✔
	Pectoral angle		✔			✔
	Full width/sufficient amount of pectoral muscle			✔	✔	
	Breast too high on receptor	✔				
	Breast sag/droop	✔	✔			✔
	Posterior tissue not visualized	✔	✔	✔		

EBreast

Education and training in early detection of breast cancer for health care professionals

Funded by the Erasmus+ Programme of the European Union

Breast cancer detection should be carried out by a team involving a number of health professionals from various medical, nursing and allied health disciplines. Interprofessional training provides students with the knowledge of different professional roles as well as with the interpersonal skills needed for liaison and communication.

Image quality assessment system

Quality level	PGMI	EBreast	POGMIIR (RER)
The mammogram totally meets the considered criteria	P		P
The mammogram meets the considered criteria. Some minor faults are accepted.	G	G	O
			G
The mammogram partially meets the considered criteria. It is acceptable for diagnostic purposes.	M	SO	M
The mammogram is not readable because of a significant part of the breast is not imaged, or because a part of the breast is obscured or blurred due to improper positioning, compression or imaging parameters. It is necessary to reject and retake the image.	I	L	I
			IR

Classification of the criteria related to "good", "sub-optimal", "repeat"

	Criteria	Good [G]	Suboptimal [SO] If there are several criteria classified as suboptimal then you should think about reject and retake	Low [L] Necessary to estimate if the low quality is due to improper positioning. If the answer is "yes" then it is necessary to reject and retake the picture
Criteria relevant for CC - View	**Shadow of the pectoral muscle**	• Shadow of pectoral muscle is visible or • Retroglandular fat tissue is visible all along the posterior part and the length of the PNL is within 1 cm of the PNL on the MLO-View	• Retroglandular fat tissue is visible all along the posterior part but the length of the PNL is longer than 1 cm of the PNL on the MLO-View	• The dense breast tissue is sagged and the length of the PNL is longer than 1 cm of the PNL on the MLO-View
	Medial part of the breast tissue	• The intermammary fold is visible or nearly visible and retroglandular fat tissue is visible	• Retroglandular fat tissue is visible but the intermammary fold is absent	• The medial breast tissue is sagged and there is a medial deviation of the nipple (> 10°)
	Lateral part of the breast tissue	• The lateral breast tissue is visible as much as possible and there is no lateral deviation of the nipple	• Part of the lateral breast tissue is not visible • There is no lateral deviation of the nipple • The superior and lateral breast tissue is clearly visible on the MLO-View	• Important part of the lateral breast tissue is sagged
	Breast tissue	• Cutis, subcutis, fibroglandular tissue and retroglandular tissue are visible all along	• Deviation of the nipple or the length of the PNL is longer than 1 cm of the PNL on the MLO-View	• Part of the breast tissue is sagged because of improper positioning

Classification of the criteria related to "good", "sub-optimal", "repeat"

	Criteria	Good [G]	Suboptimal [SO] If there are several criteria classified as suboptimal then you should think about reject and retake	Low [L] Necessary to estimate if the low quality is due to improper positioning. If the answer is "yes" then it is necessary to reject and retake the picture
Criteria relevant for MLO - View	Length of the pectoral muscle	• Inferior edge of the pectoralis muscle at the nipple line	• Inferior edge of the pectoralis muscle at the PNL level but retroglandular fat tissue is visible	• Pectoralis muscle shorter than PNL and retroglandular fat tissue not visible
	Width of the pectoral muscle	• Angle > 20° • Enough cranial breast tissue	• Angle < 20° but cranio-lateral breast tissue is visible all along	• Cranio-lateral breast tissue is sagged
	Inferior breast tissue	• Cutis, subcutis and fat tissue visible		• Inferior breast tissue sagged
	Inframammary angle	• Clearly visible • Without any superimposition	• Not visible or • Superimposition with folds	• Not visible • Inferior and posterior breast tissue sagged
	Breast tissue	• Cutis, subcutis, fibroglandular tissue and retroglandular tissue are visible all along	• Pectoralis slightly too short or • Angle of pectoralis muscle or • Inframammary angle not clearly visible	• Breast tissue is sagged because of improper positioning

Criteria relevant for both views	Criteria	Good [G]	Suboptimal [SO] If there are several criteria classified as suboptimal then you should think about reject and retake	Low [L] Necessary to estimate if the low quality is due to improper positioning. If the answer is "yes" then it is necessary to reject and retake the picture
	Nipple	• Nipple in profile, clear of overlying breast tissue (transection of the nipple by the skin is acceptable)	• Nipple in superimposed by breast tissue	
	Compression	• Sharp reproduction of the breast tissue • Breast tissue spread out • Sharp reproduction of the skin structure (rosettes from pores)		• Blurred or partially blurred image
	Contrast	• Correct exposure	•	• Inadequate exposure
	Skin folds	• No skinfolds	• Discrete skinfolds that do not interfere with the diagnosis	• Skinfolds that obscure breast tissue or transparent folds that interfere with the diagnosis
	Artefacts	• No artefact	• Discrete artefacts that do not interfere with the diagnosis	• Artefacts that obscure breast tissue, interfering with the diagnosis
	Symmetrical images	• Symmetrical images	• Images not symmetrical	

Actually, there is no complete consensus how to assess mammography quality based on the criteria. Slight differences exist between different countries. Check existing guidelines in your country.

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RADIOGRAPHICAL GUIDELINES

3.8 Radiographic quality standards

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- 100% of the women should be informed by the radiographer of the method and time scale for receiving their results.

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POGMIIR: >97% P+O+G+M; >85% P+O+G; >12% M; <3% I+IR; <1% IR

EBreast: >97% P+SO; <3% I

Grazie per l'attenzione

Stefano Pacifici