Intra-operative Imaging of Breast Lesions

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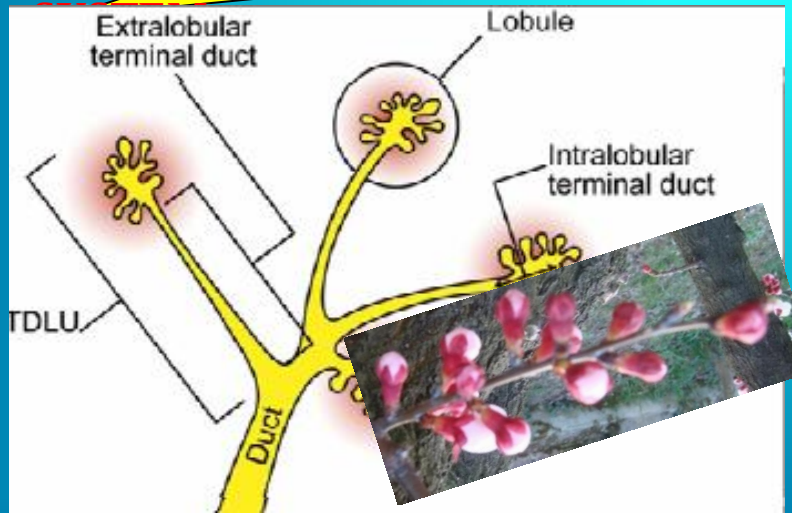
From pathological point of view we adopted the principles of lobar anatomy and the concept of sick lobes that states: breast carcinoma develops within a single lobe

- Breast composed of 15-20 lobes as many as the ducts
- each lobe is a sector or a segment
- major ducts come from periphery to the nipple

BREAST DISEASES ARE DISEASES OF DUCTAL



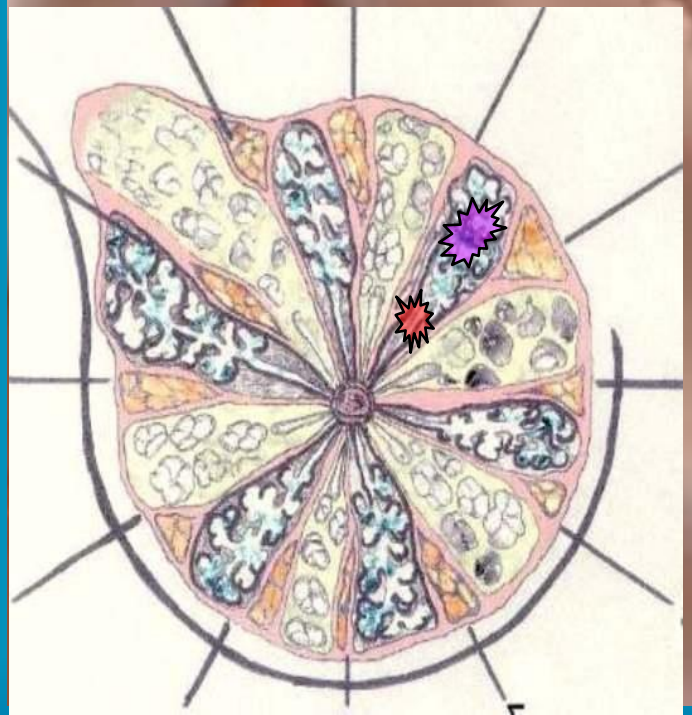
CLINICAL SYMPOSIA

CIBA

Vol. 32; N° 2; 1980

Lobar Anatomy described by Townsend, illustrated by Craig

The breast is not one gland but many, each with its own central milk-collecting duct in the nipple and several orders of branching tributary ducts draining the secretory glandular tissue



BREAST DISEASES ARE DISEASES OF DUCTAL SYSTEM EPITHELIUM

More recently the principle of lobar disease has been recognized by others authors

Virchows Arch (2005) 447: 1–8
DOI 10.1007/s00428-005-1274-7

REVIEW ARTICLE

Tibor Tot

DCIS, cytokeratins, and the theory of the sick lobe

Received: 24 February 2005 / Accepted: 12 April 2005 / Published online: 31 May 2005

We hypothesize that carcinoma in situ, and consequently breast carcinoma in general, is a lobar disease

Tibor Tot

International Journal of Surgical Pathology
Volume 15 Number 4 October 2007; 369-375

Breast Cancer Research and Treatment (2006) 97: 285–291
DOI 10.1007/s10549-005-9122-7

Preclinical study

Human breast duct anatomy, the 'sick lobe' hypothesis and intraductal approaches to breast cancer

James J. Going[1] and Timothy J. Mohun[2]
[1]*Division of Cancer Sciences and Molecular Pathology, University of Glasgow, Glasgow, Scotland, UK;* [2]*Developmental Biology Division, National Institute for Medical Research, Mill Hill, London, UK*

Author's paper presented at World Surgical Week – Milano July 1988

Surgical echography as diagnostic and staging tool in breast pathology.

Thoracic Surgery , Monduzzi Ed., 1988, pp.301-308.

Intraoperative imaging technique has become fundamental tool for breast surgeons specially for the most early-stage non-palpable cancer.

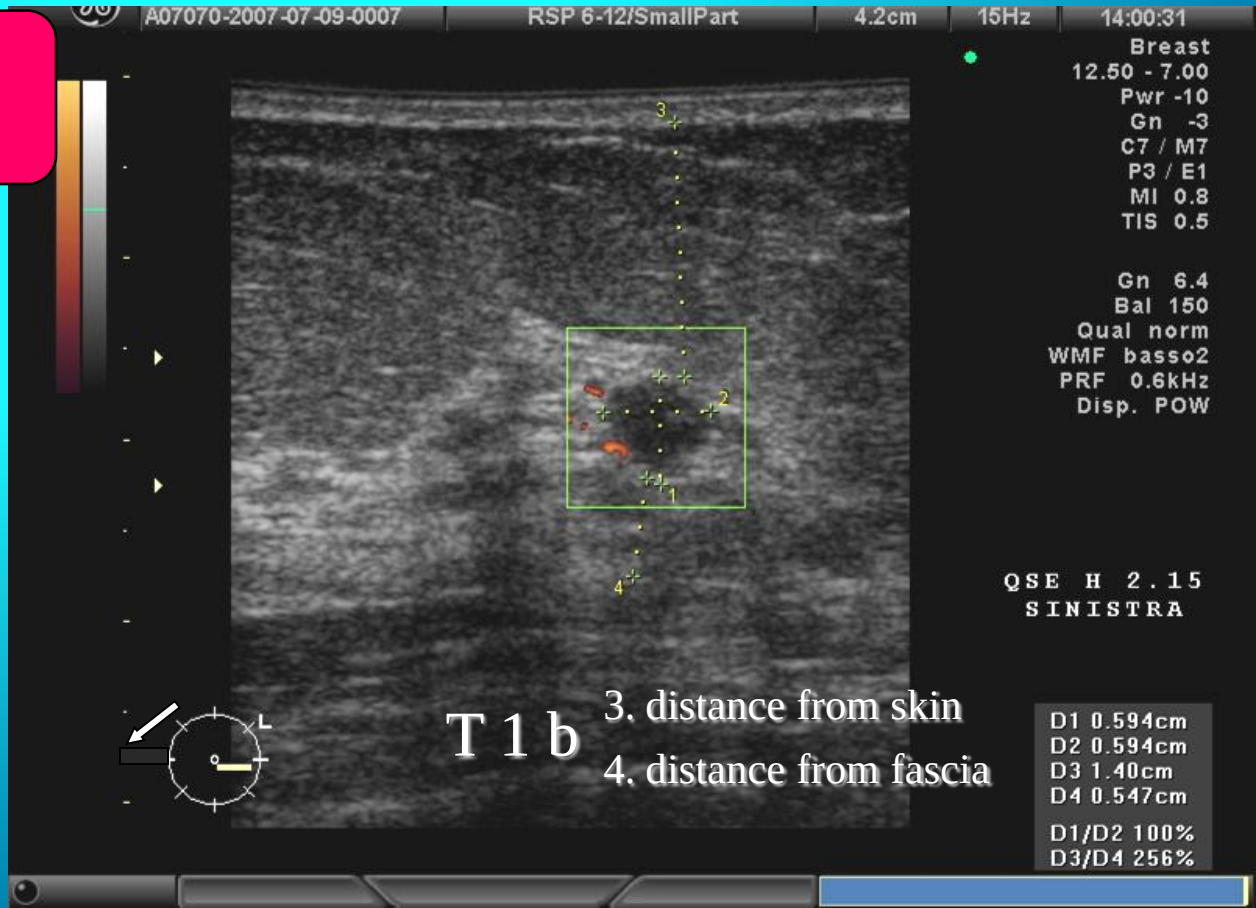
For non-palpable lesions the surgeon need an intraoperative imaging guide in order to:

- **visualize and localize the lesion,**
- **to evaluate its extension,**
- **to measure the distance from the skin, from the fascia, from the nipple,**
- **to evaluate the tumor-to-breast relation in order to decide if conservative surgery is cosmetically adequate,**
- **to choose the best incision site according the Langer‘s lines,**
- **to select the margins resection,**
- **to evaluate the resected specimen.**

For therapeutic, oncologically radical and anatomically correct surgery, preliminary parameters of lesions are necessary:

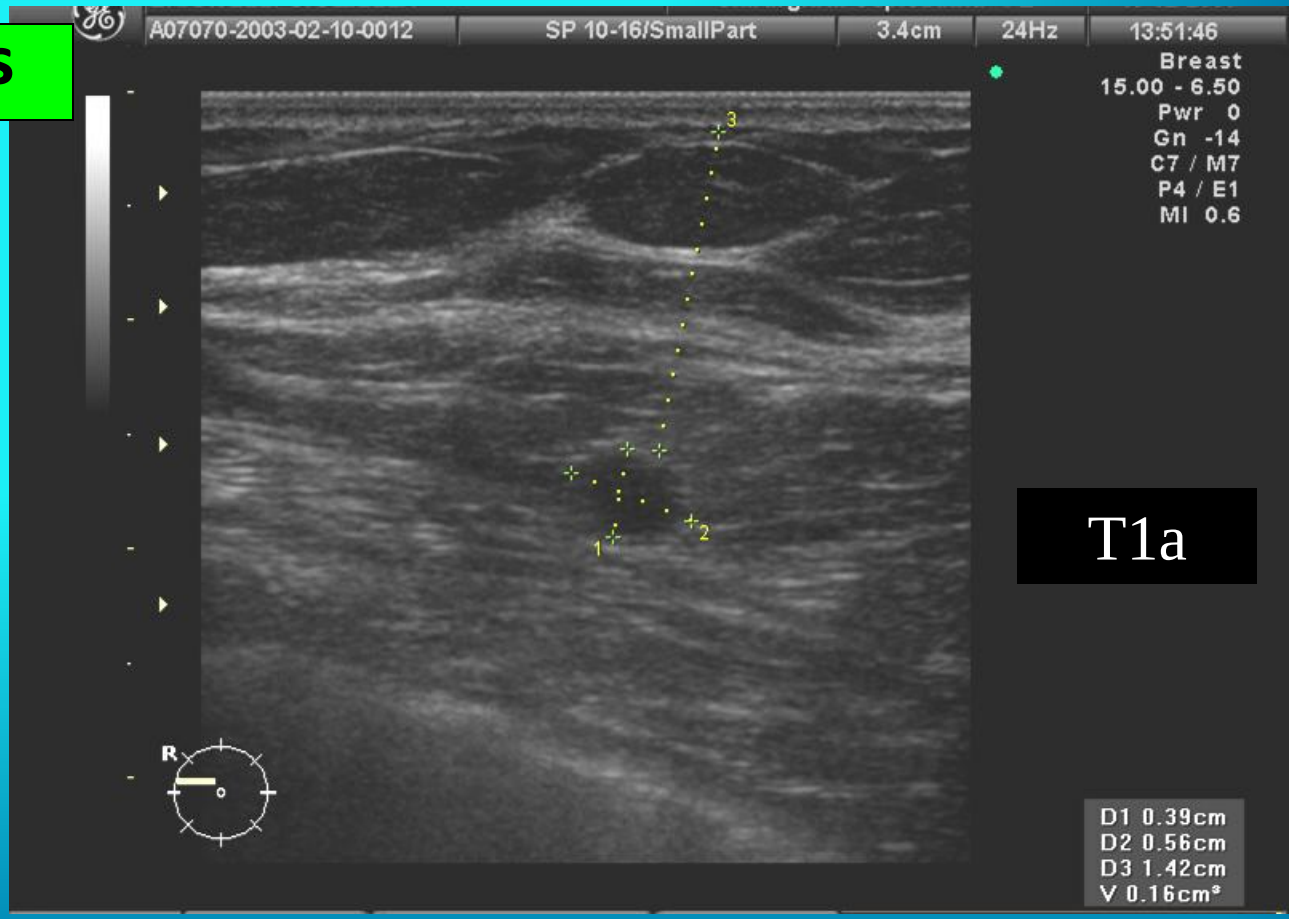
Stage the lesions

Dimensions



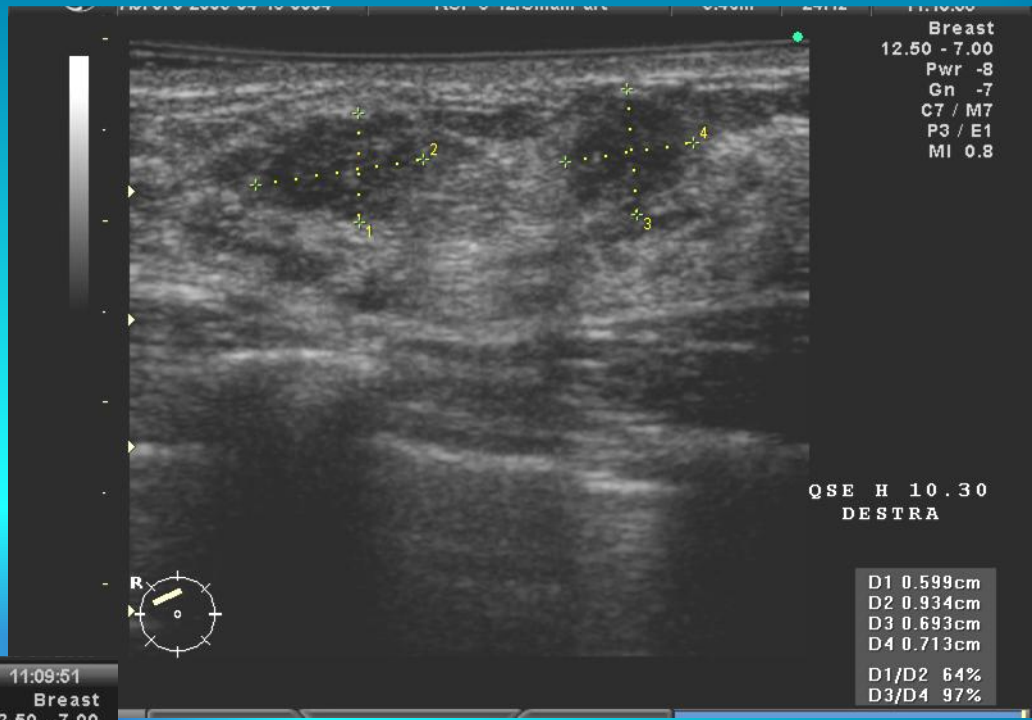
- **Dimensions**

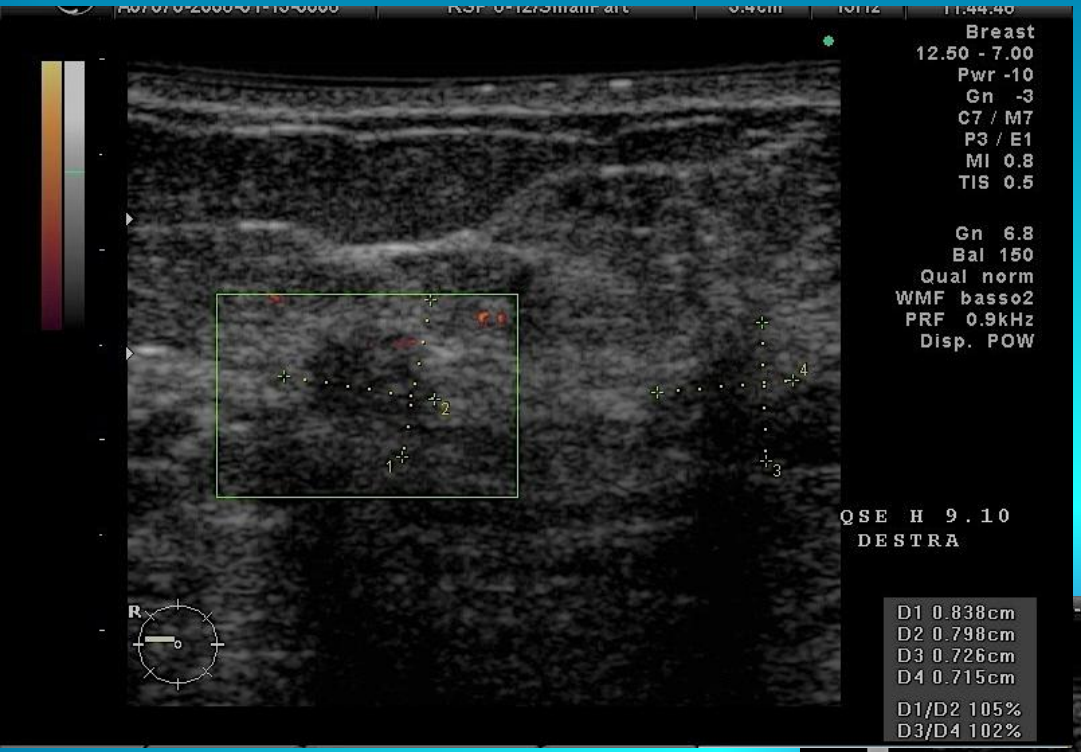
- **Stage the lesions**

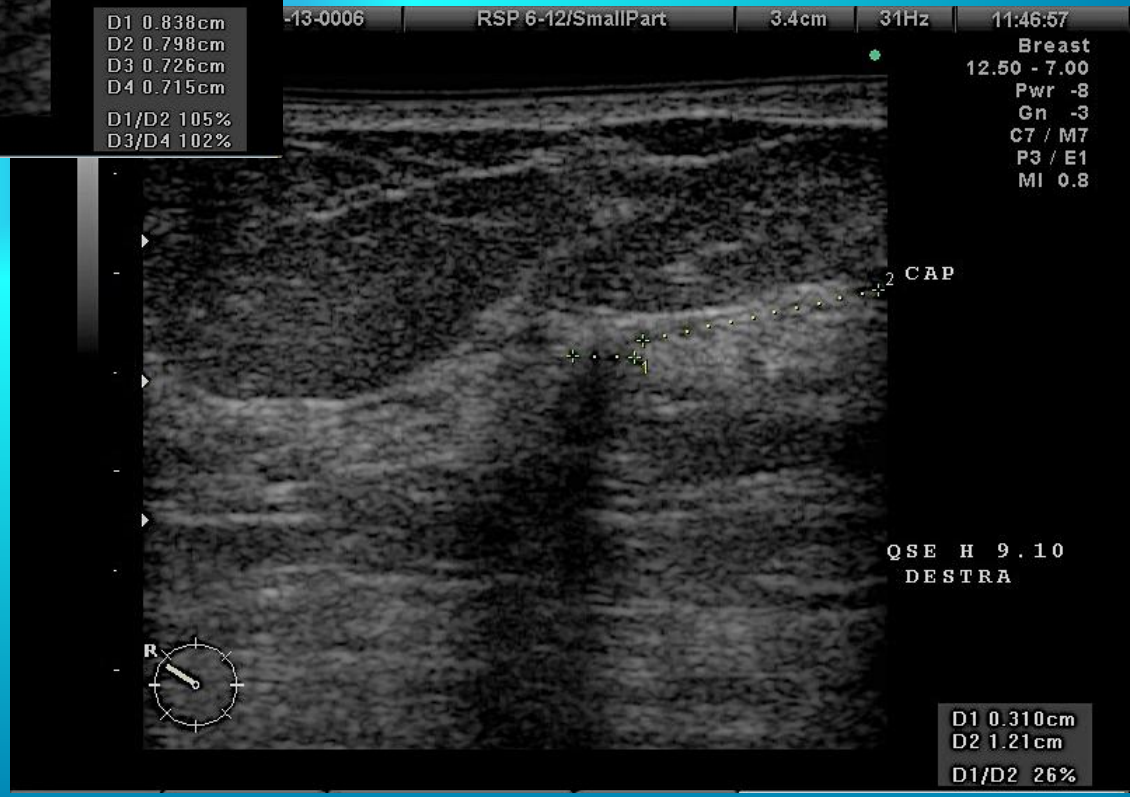


- Dimensions
- Ductal Extension

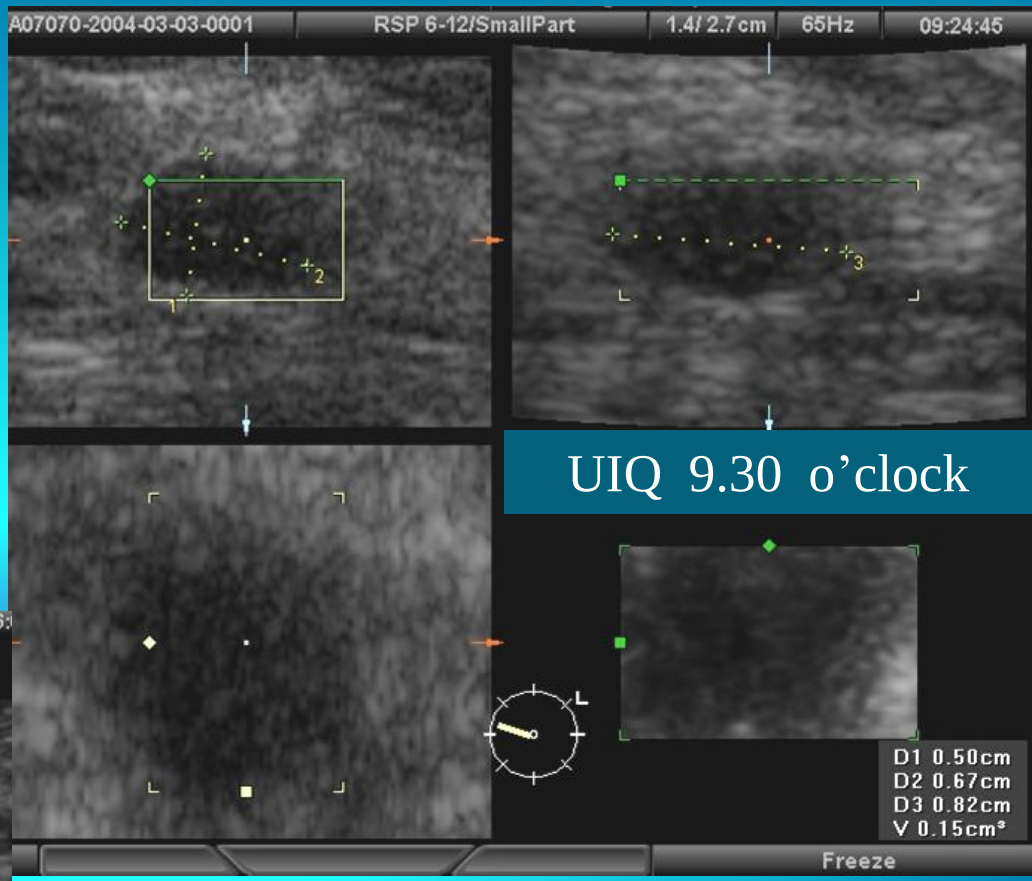
- Dimensions
- Ductal Extension
- **Multifocality**



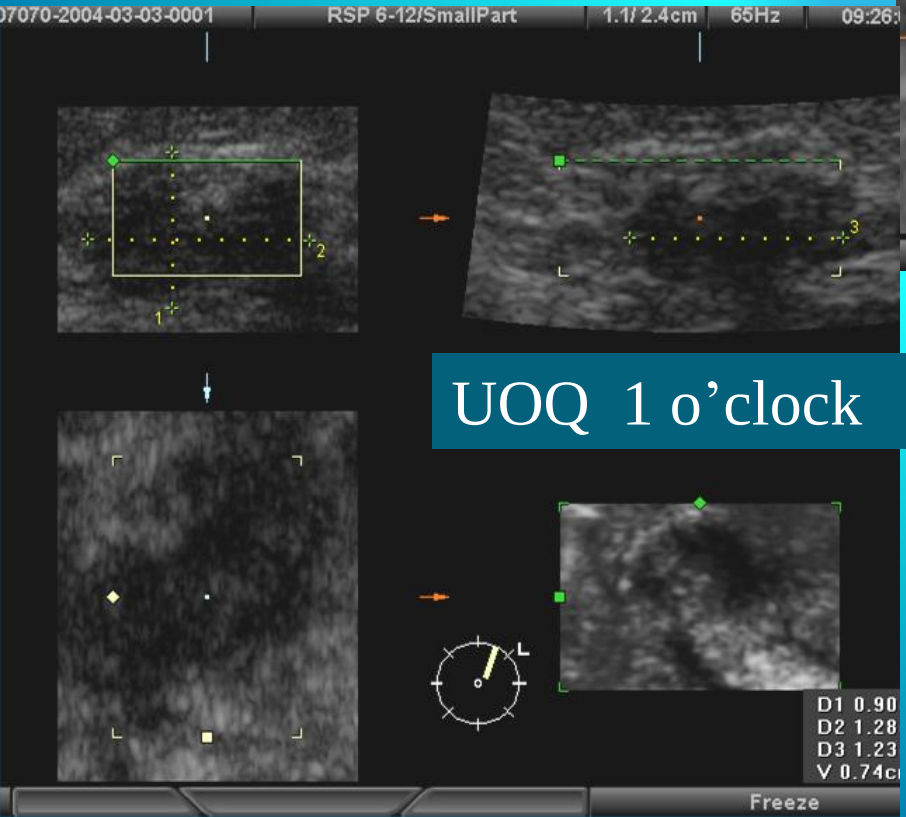

Breast
12.50 - 7.00
Pwr -10
Gn -3
C7 / M7
P3 / E1
MI 0.8
TIS 0.5
Gn 6.8
Bal 150
Qual norm
WMF basso2
PRF 0.9kHz
Disp. POW
QSE H 9.10
DESTRA
D1 0.838cm
D2 0.798cm
D3 0.726cm
D4 0.715cm
D1/D2 105%
D3/D4 102%


RSP 6-12/SmallPart
3.4cm
31Hz
11:46:57
Breast
12.50 - 7.00
Pwr -8
Gn -3
C7 / M7
P3 / E1
MI 0.8
CAP
QSE H 9.10
DESTRA
D1 0.310cm
D2 1.21cm
D1/D2 26%

- Dimensions
- Ductal Extension
- Multifocality
- Multicentricity



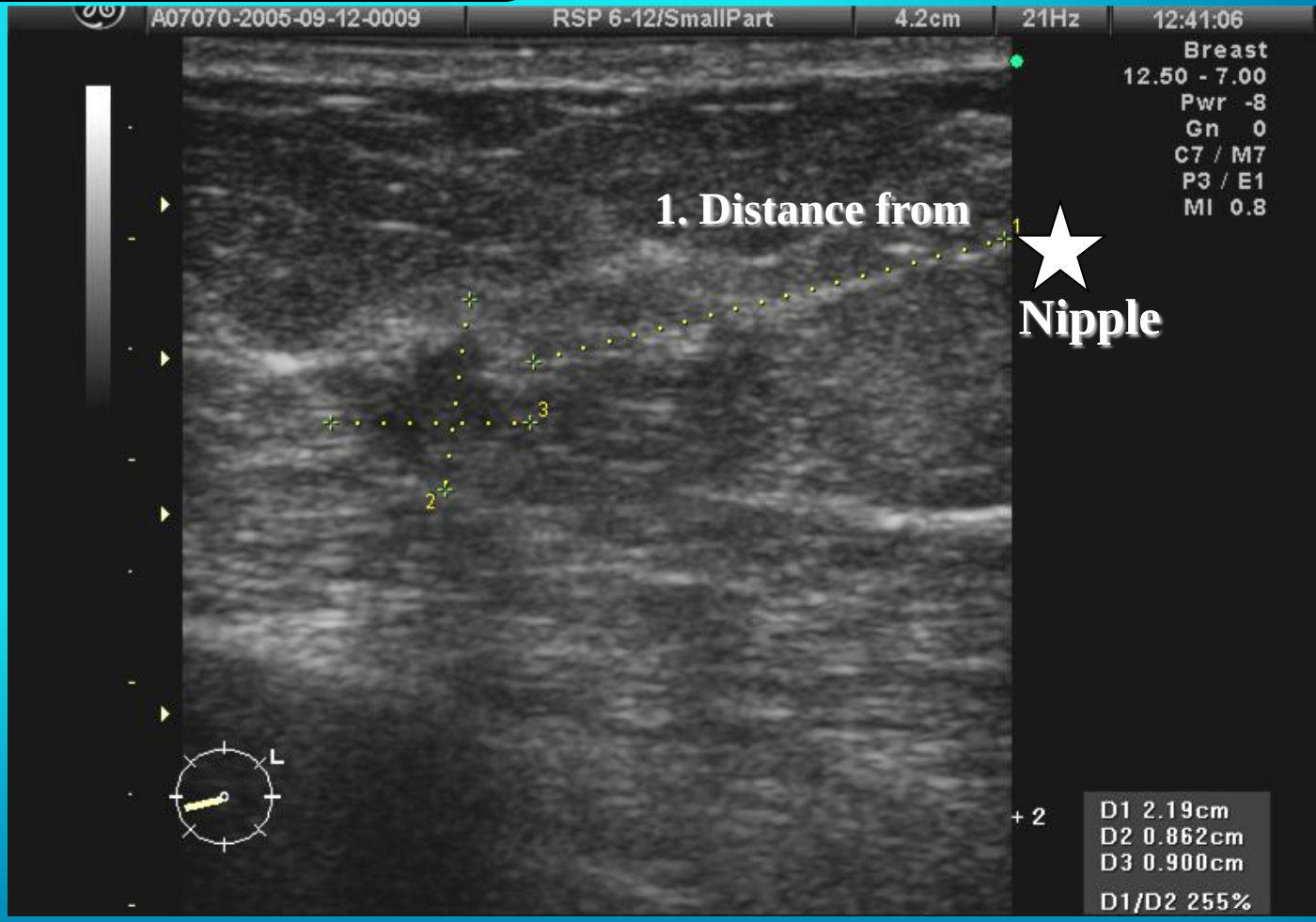
UIQ 9.30 o'clock



UOQ 1 o'clock

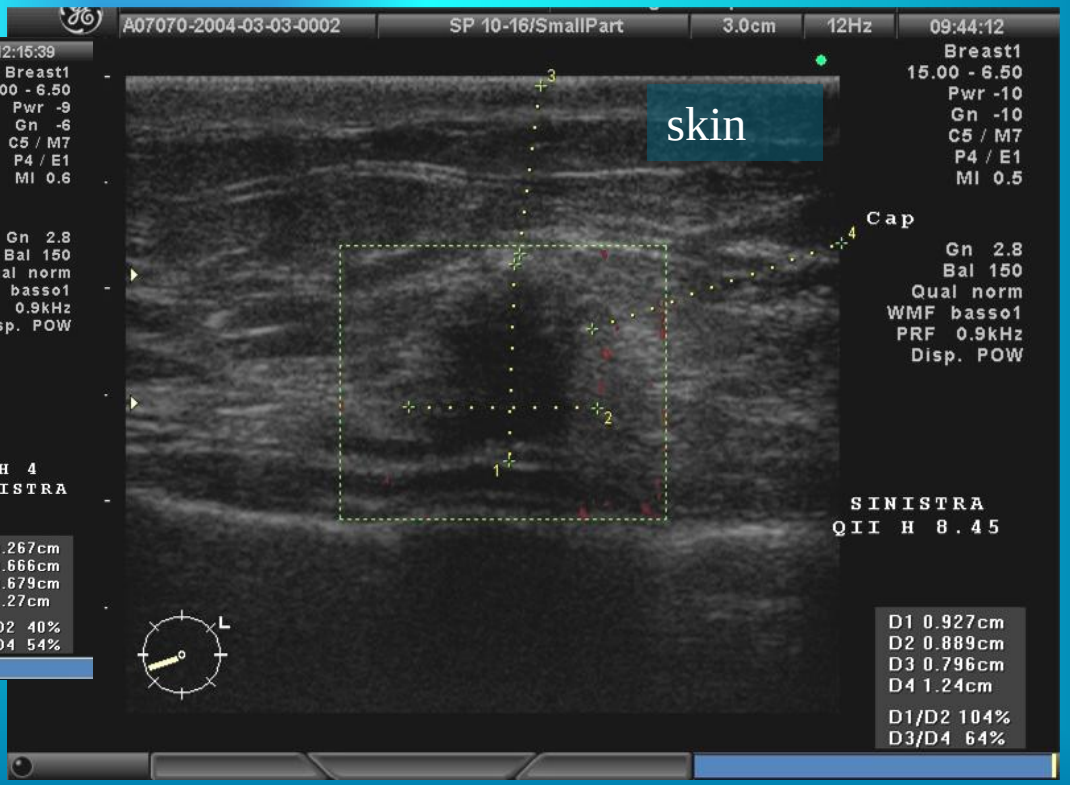
Secondary parameters for conservative, oncologically radical, cosmetic surgery :

Distance from the nipple



Secondary parameters for conservative, oncologically radical, cosmetic surgery :

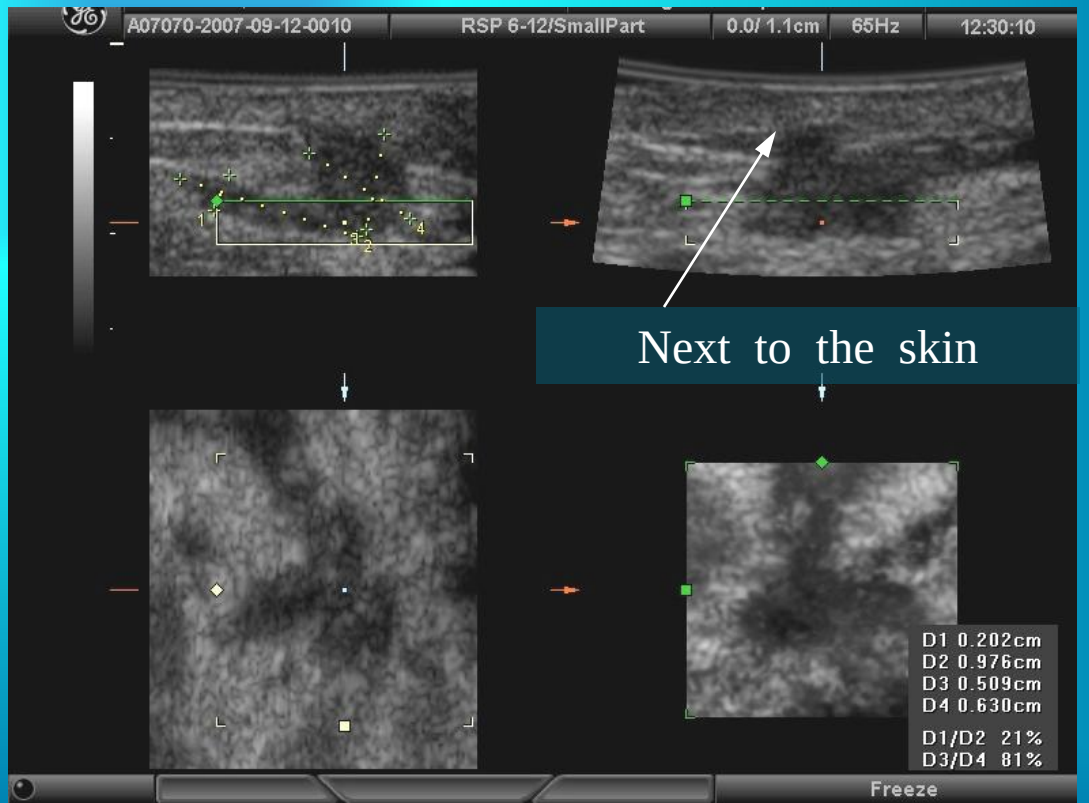
- **Distance from the nipple**
- **Distance from the skin**



Secondary parameters for conservative, oncologically radical, cosmetic surgery :

- **Distance from the nipple**
- **Distance from the skin**

When the skin is very near to the tumor we must remove the skin in front of the tumor using mostly a double curvilinear incision according the Langer lines.



Secondary parameters for conservative, oncologically radical, cosmetic surgery :

- Distance from the nipple
- Distance from the skin

Distance from the fascia

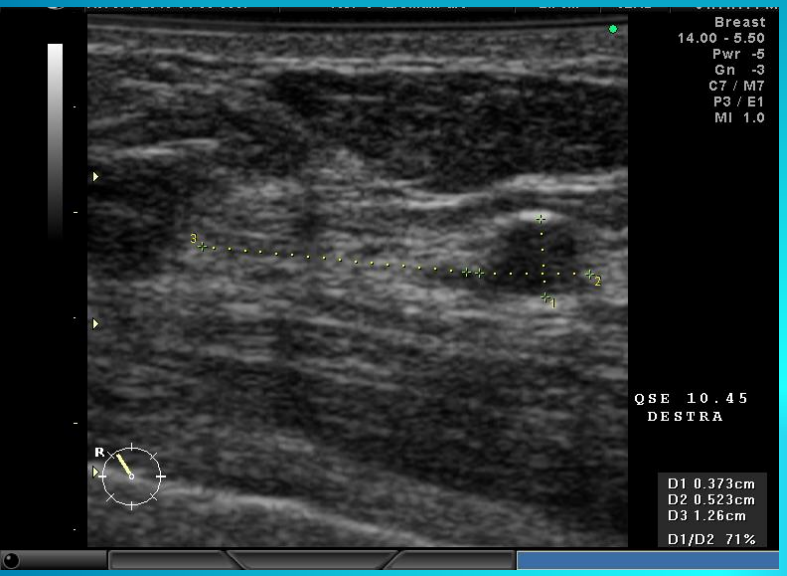
Secondary parameters for conservative, oncologically radical, cosmetic surgery :

- **Distance from the nipple**
- **Distance from the skin**

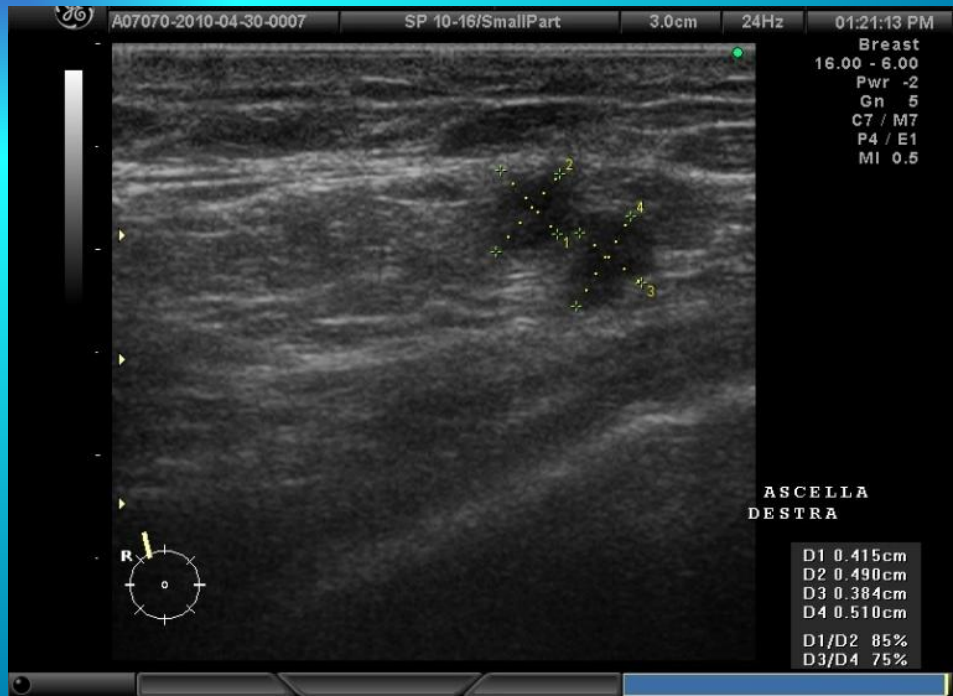
- **Distance from the pectoralis fascia**

Pectoralis fascia is a different anatomic entity from the deeper layer of superficial fascia that envelop the breast tissue. Behind this there is a retromammary fat layer and than the pectoralis fascia

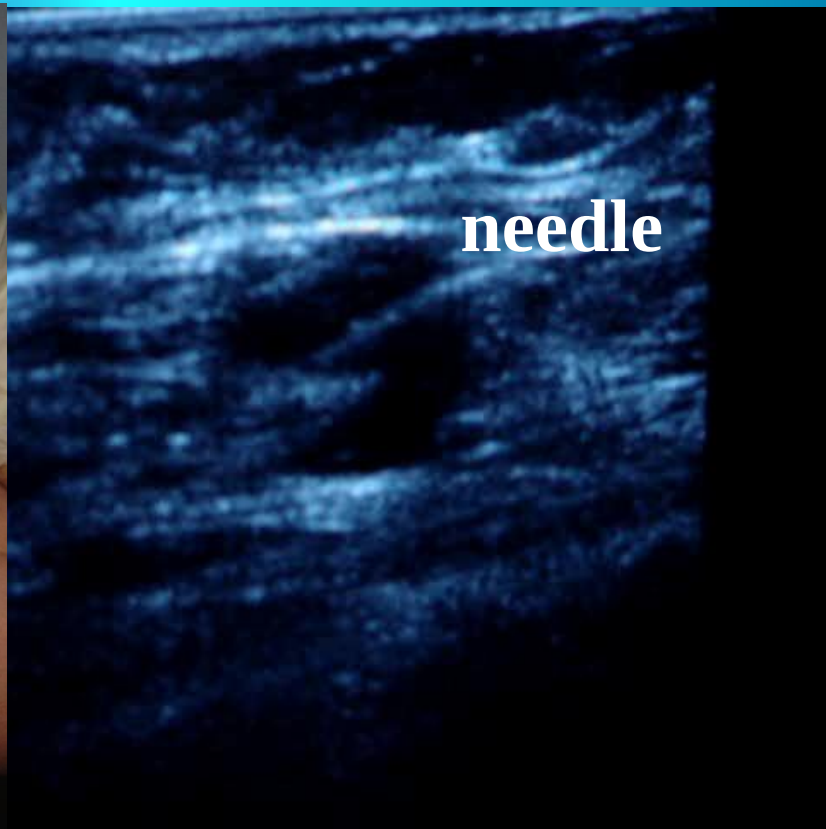
Lymph node staging



Small lesion with involved lymph nodes

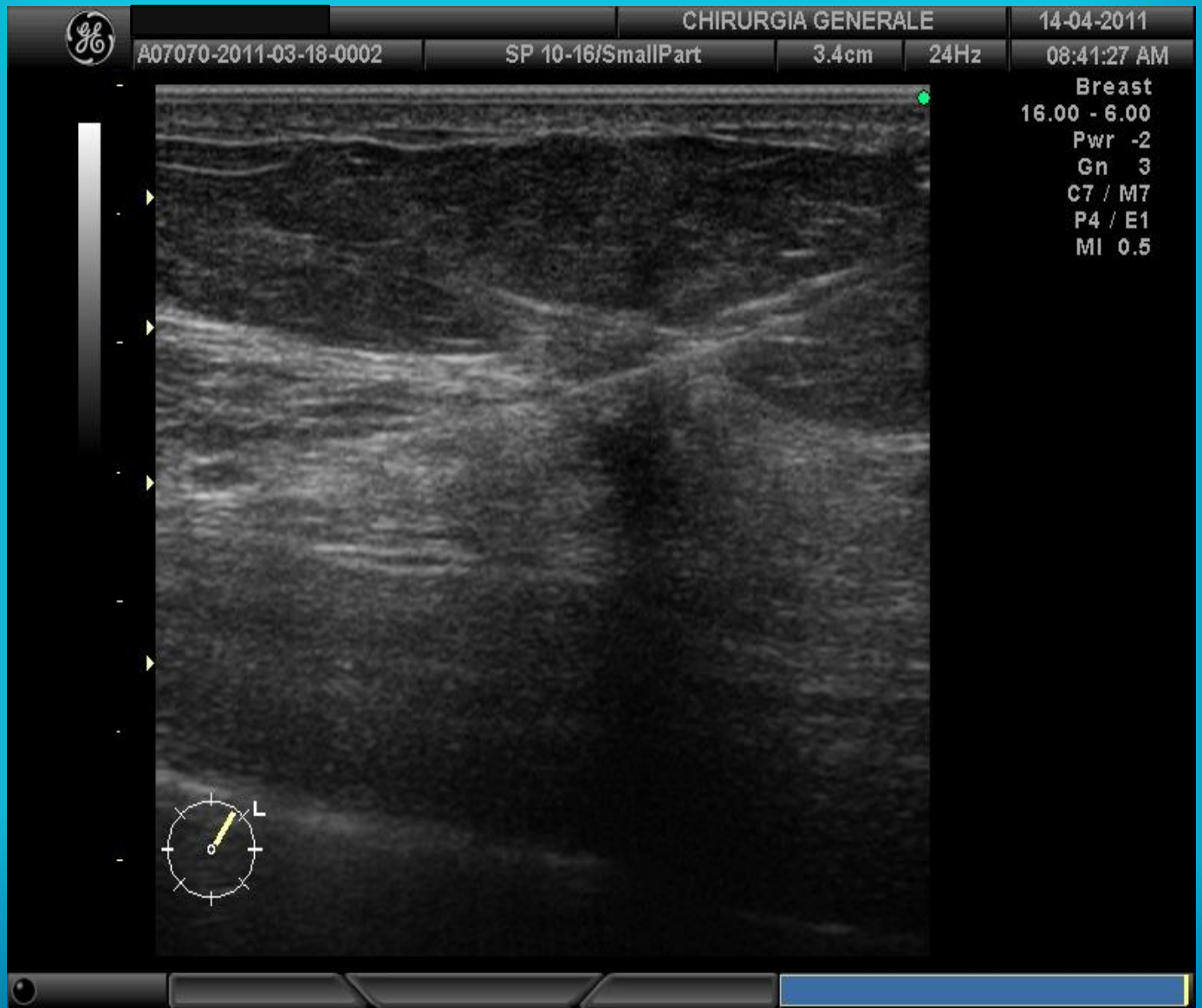


FNA of axillary lymph node



Intraoperative Ultrasound seem to be the method of choice for guiding all the above mentioned procedures thanks to its handiness, moreover there is a benefit of greater surgical autonomy in performing all these procedures in the operating room with patient in supine position and under anaesthetic.

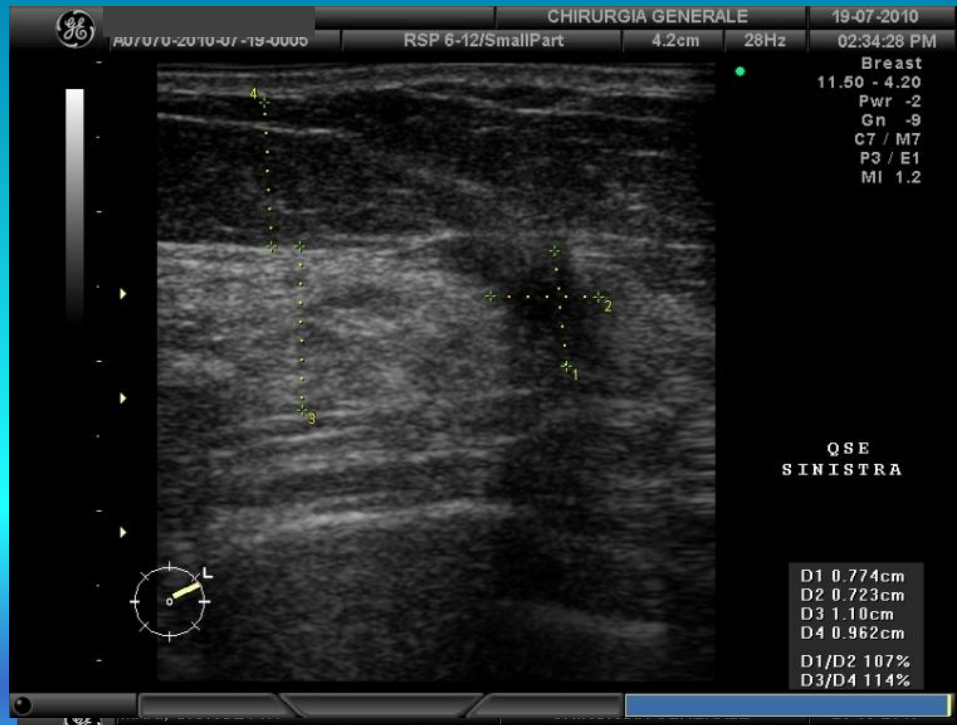
In the excision of small lesion we prefer wire localization more useful also for pathologist



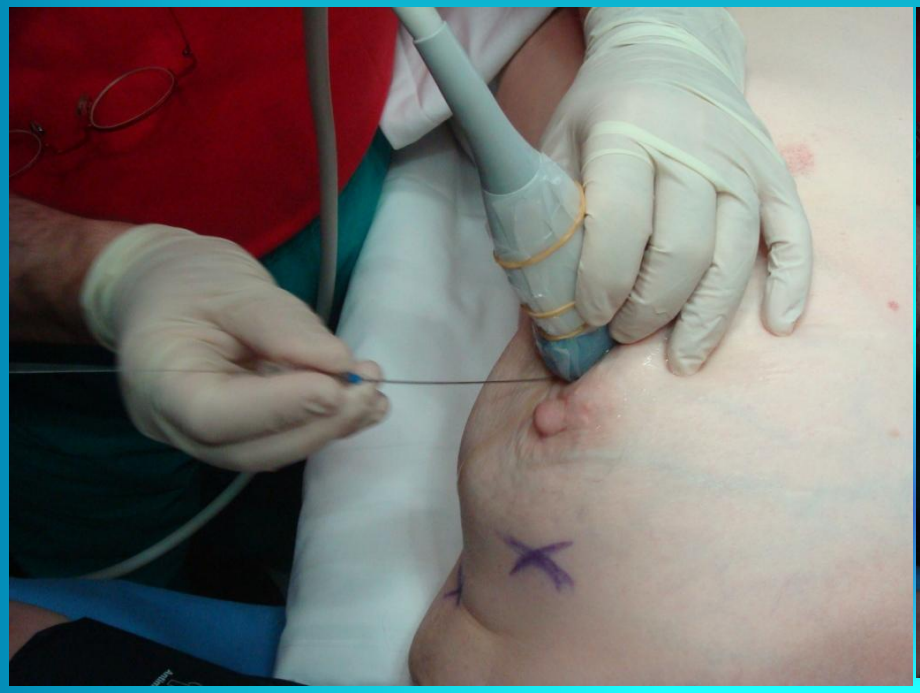
U S LOCALIZATION

- PREOPERATIVE LOCALIZATION IS OF GREAT INTEREST IN CONSERVATIVE SURGERY

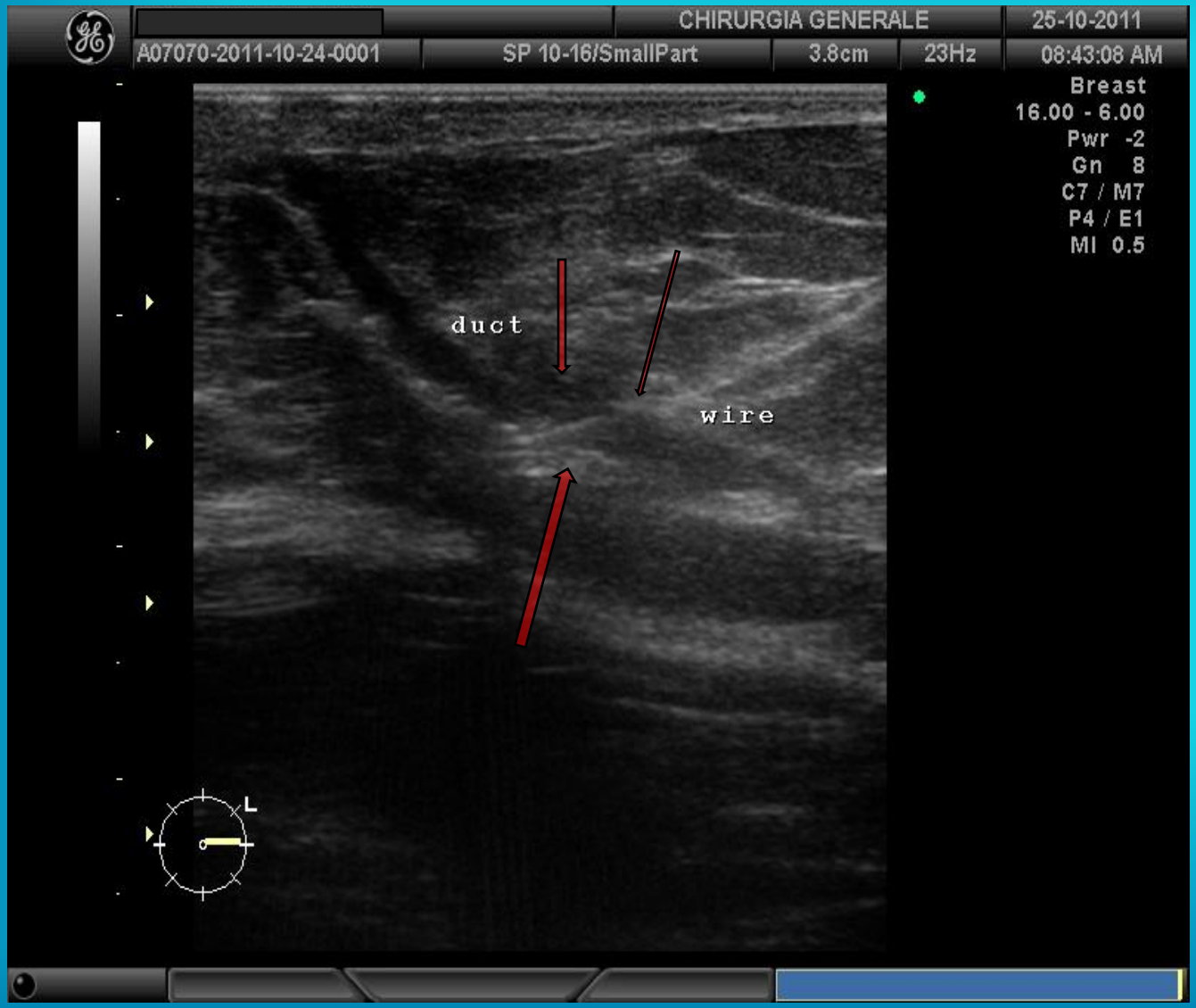
- SUPINE POSITION SHORTENS DISTANCE BETWEEN THE SKIN AND LESION AND ALLOWS ACCURATE JUDGEMENT OF TOPOGRAPHIC LOCATION AND MEASUREMENT OF DISTANCE FROM THE SKIN, FASCIA, NIPPLE.



Radial insertion of wire



The surgeon should be autonomous at the highest degree and master technologies. I had the luck to start very early to use US guided procedures in 1974 after stage to Hans Holm in Gentofte H. with the purpose to improve surgical management of patients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25-10-2011
A07070-2011-10-24-0001
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3.8cm
23Hz
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Breast
16.00 - 6.00
Pwr -2
Gn 8
C7 / M7
P4 / E1
MI 0.5
duct
wire
L

DCIS

One of the advantage of IO localization is that the surgeon visualize the lesion personally in the surgical position and evaluates the three-dimensional shape of the lesion within the breast. In doing so it is appropriate to use a radial approach according the lobar anatomy.

IO US localization is more comfortable for the patient, is time and cost efficient.


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wire

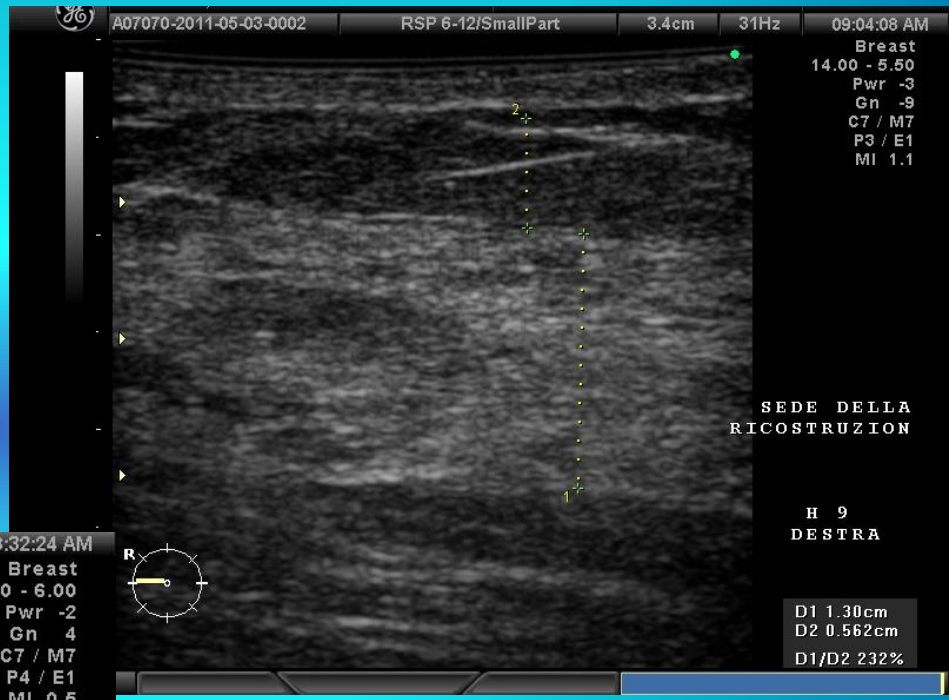
Wire Guided Localization Disadvantages

- *Technical difficult procedure particularly in dense breast ?*
- *Wire can displace ?*
- *Surgical excision of wire localized lesion technically difficult ?*
- *Patients experience of wire insertion as painful ?*
- *Risk of pneumothorax ?*
- *In many published series positive margin rates after WGL are high varying from 14 to 47% ?*

WIRE vs ROLL

difficult procedure particularly in dense breast ?

Surgical excision of wire localized lesion technically difficult ?

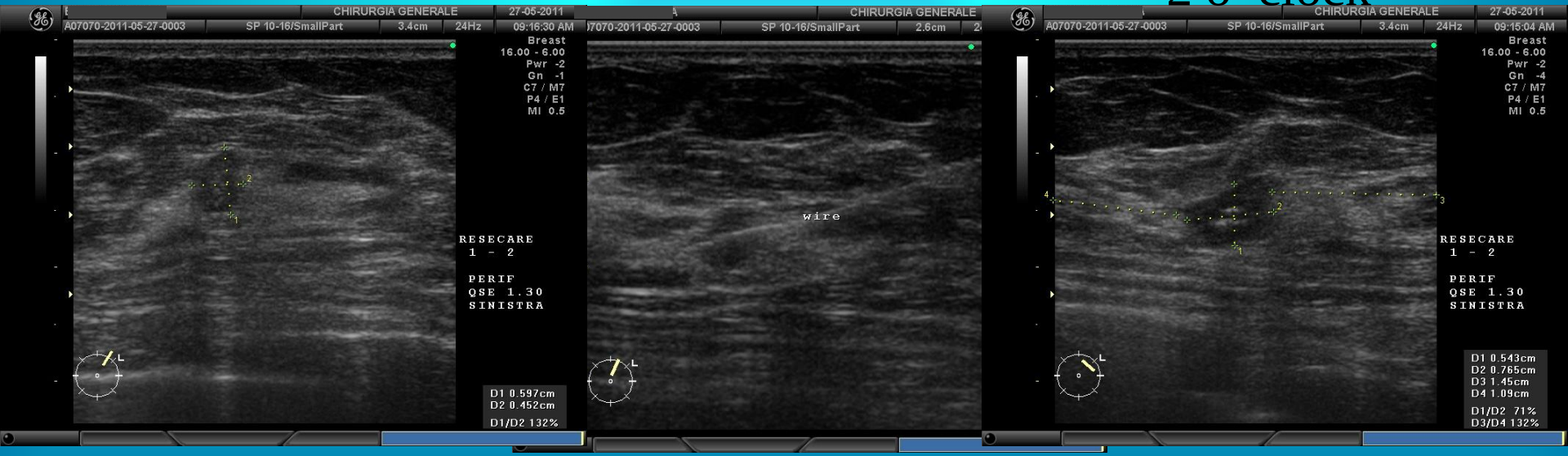


Patients experience of wire insertion as painful ?

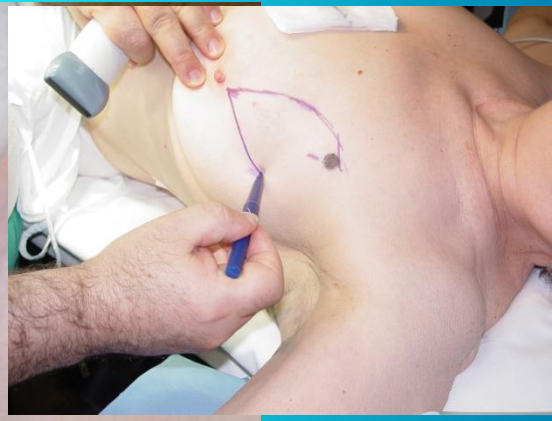
U S LOCALIZATION

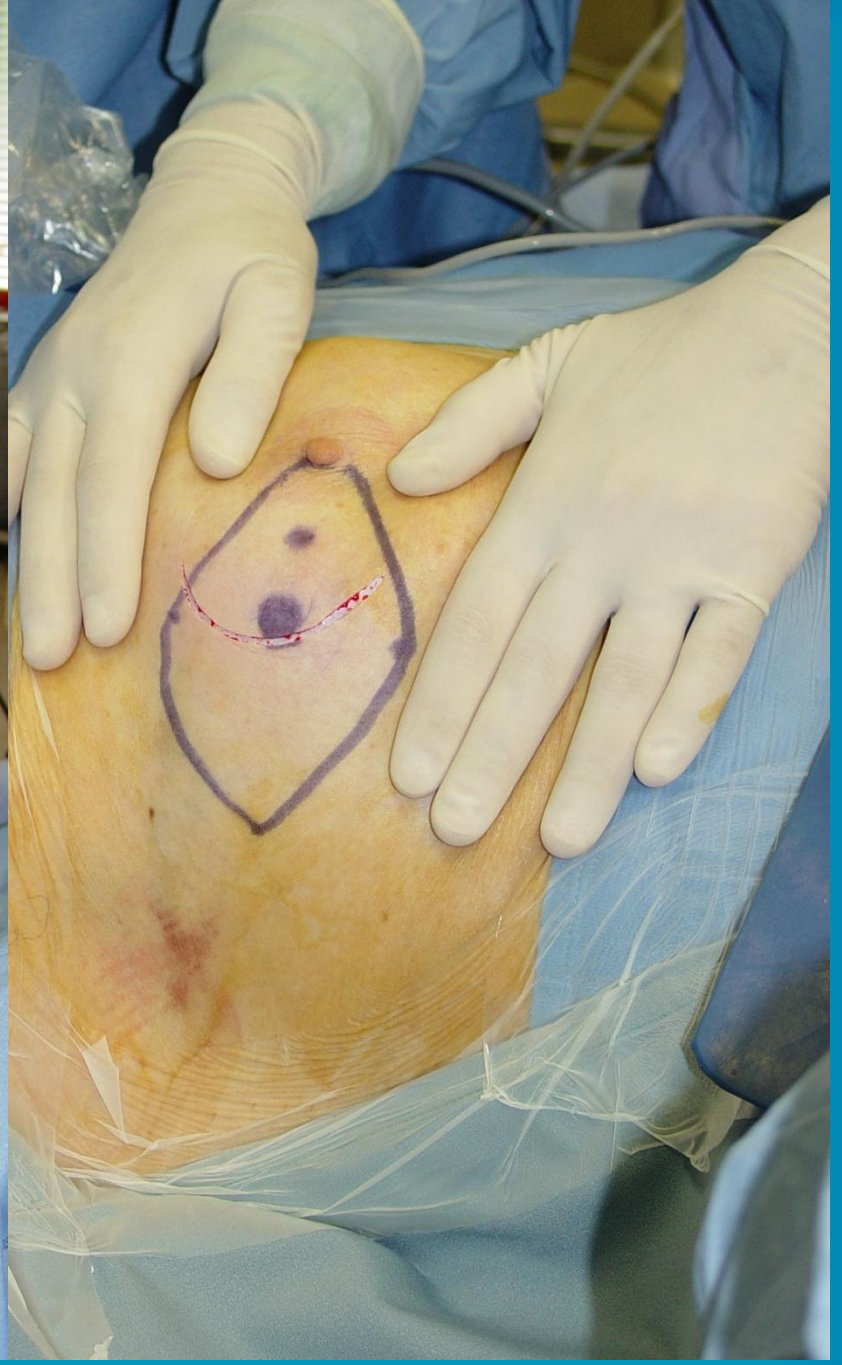
- **NO COMPLICATIONS OCCURRED IN OUR EXPERIENCE.**
- **NO MIGRATION**

Antiradial Scan to select the lobe to resect from 1 to 2 o’ clock



Surgical planning is based on the echographic assessment of lesion and adjacent tissue in radial scans with multifrequency transducer operating at 8-18MHz and with 3D-4D scans with transducer operating at 7-14 MHz. We draw on the skin the extension of the lobe and plan the most advantageous incision always according the Langer lines and the resection of breast tissue according the lobar anatomy

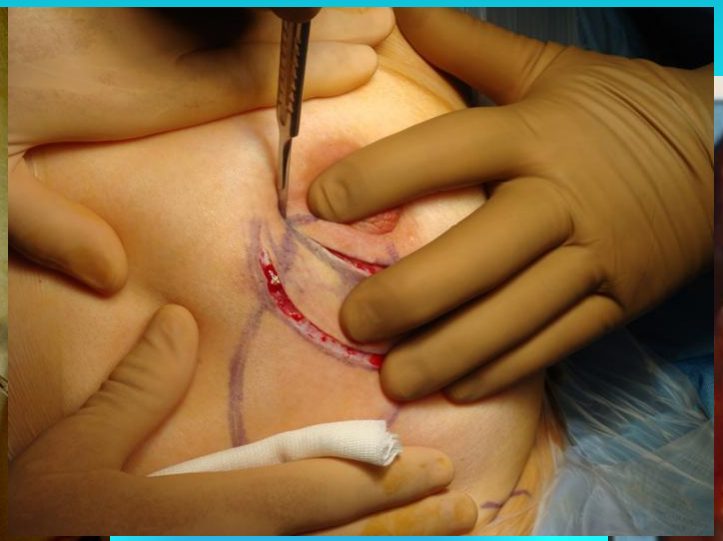


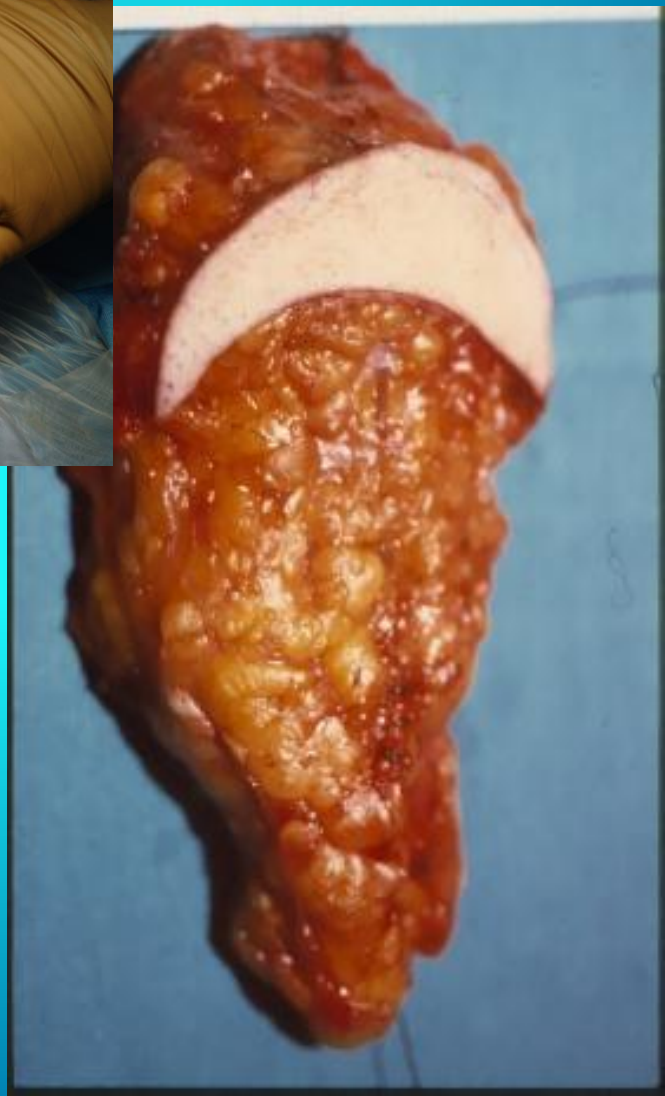


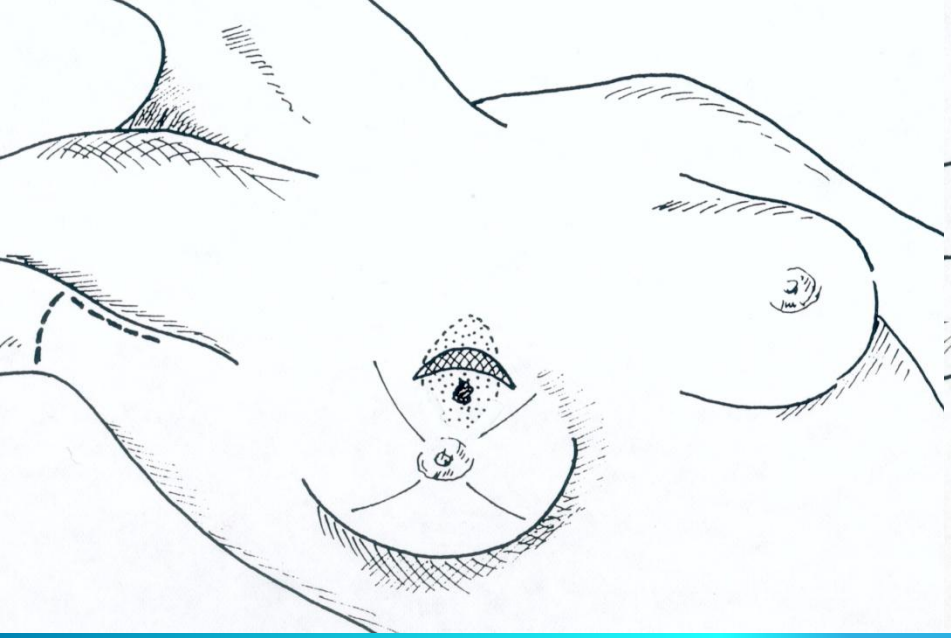
Limits of resecting lobes are depicted on the skin

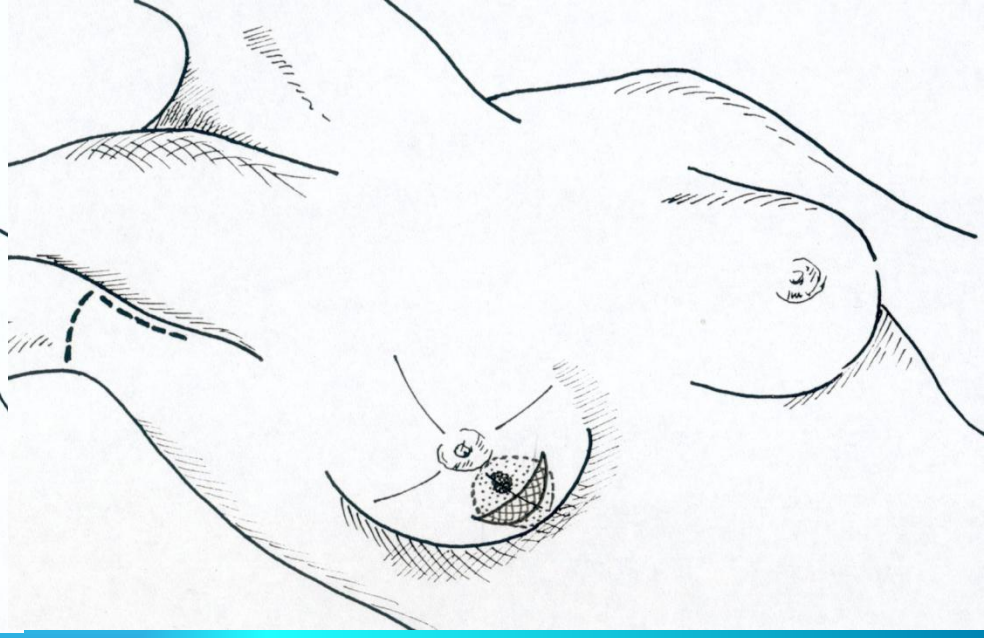
Skin incision is made by curvilinear incision according the Langer's lines parallel to the periareolar line

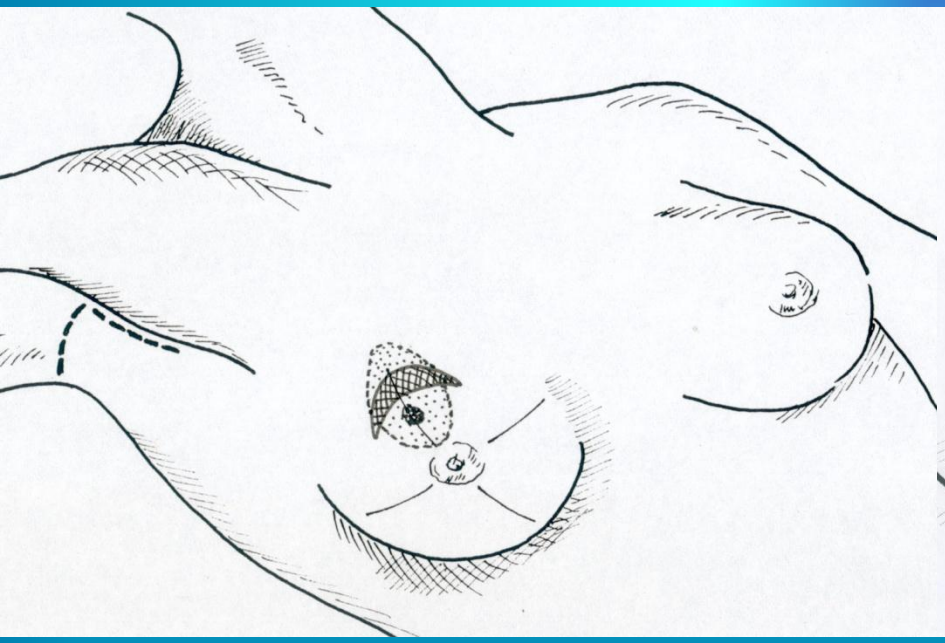
If the tumor is near to the skin or the fascia superficial layer is altered we perform a double curvilinear incision and remove the skin in front of the tumor.

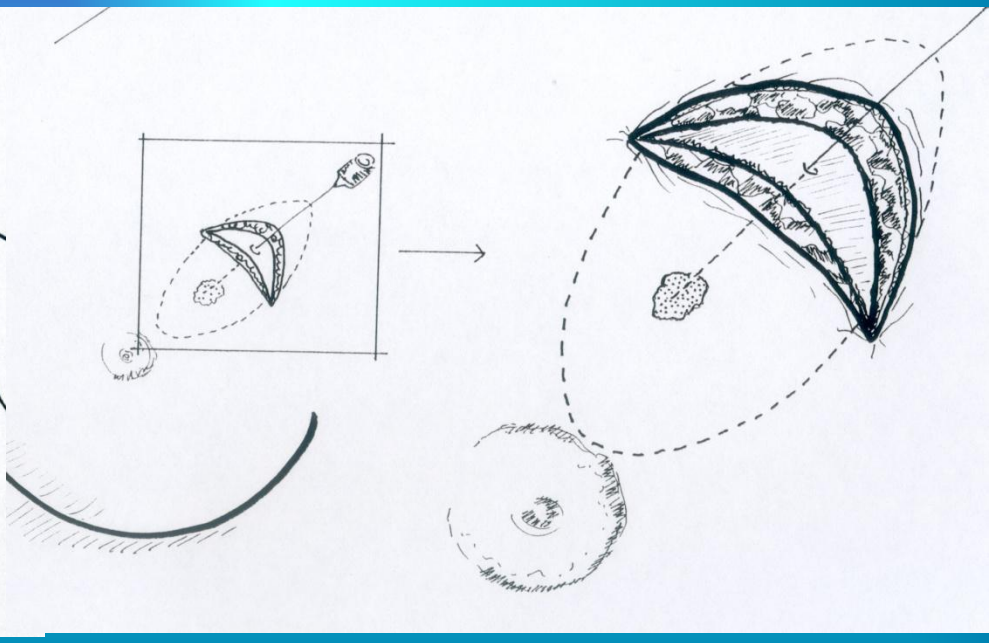




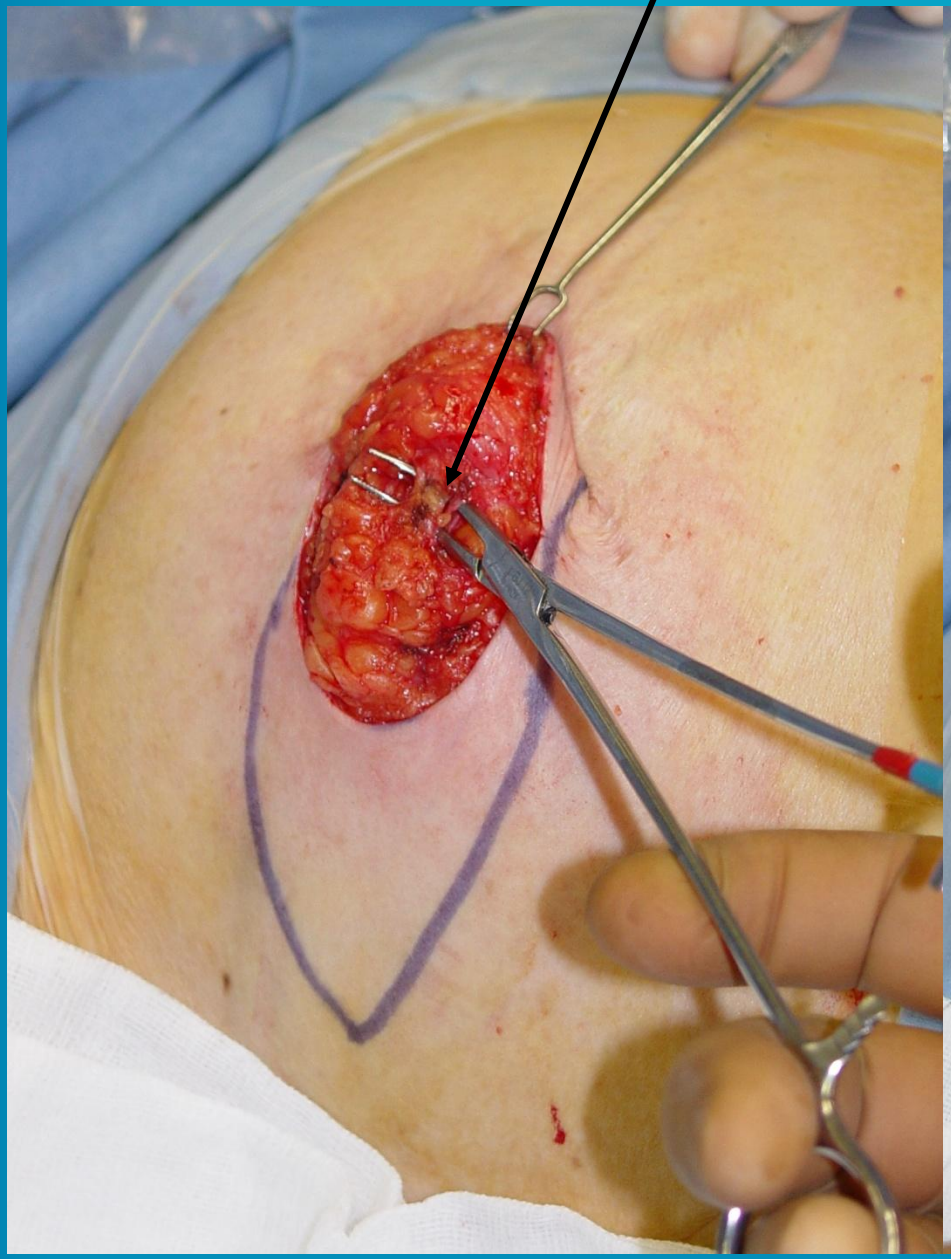


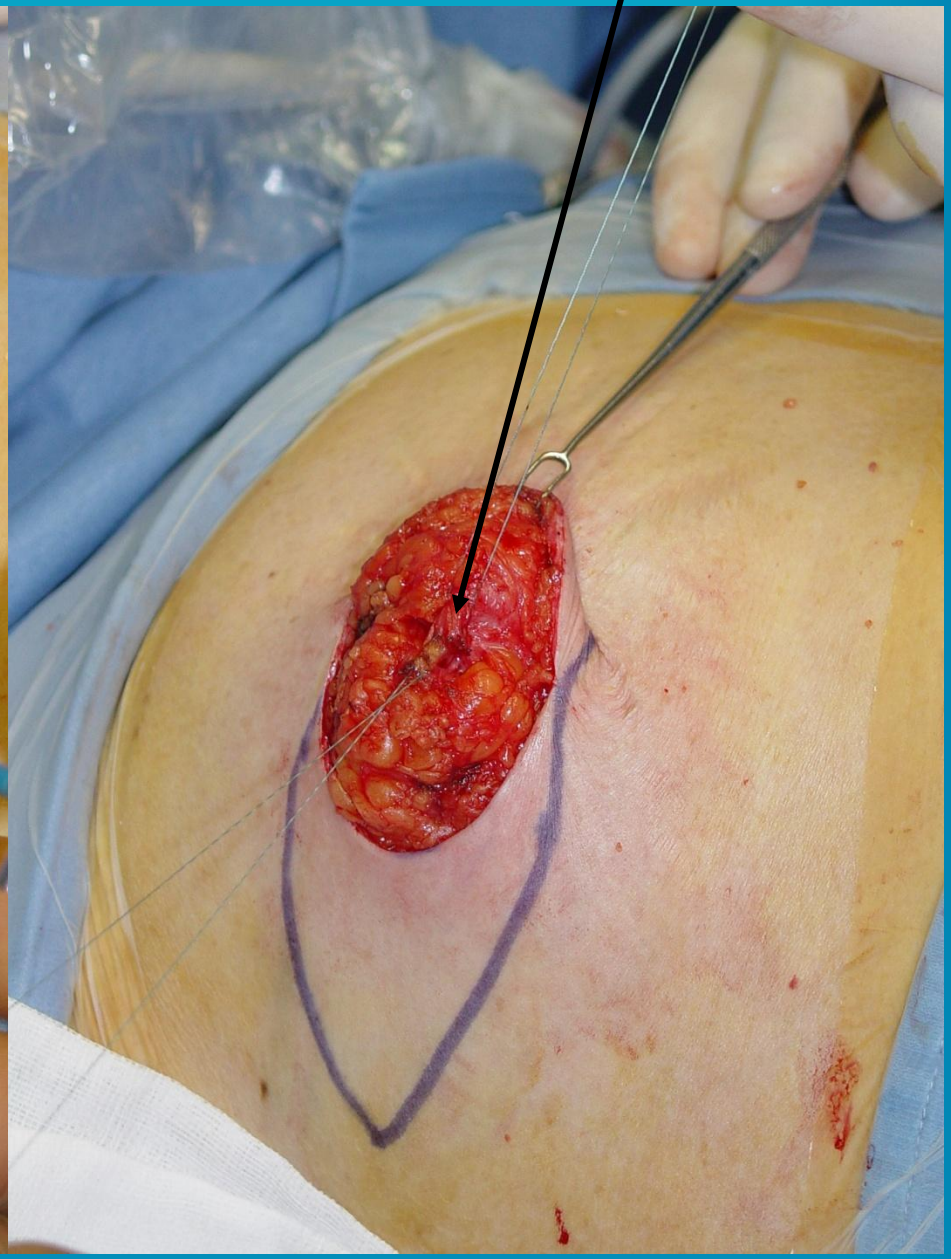




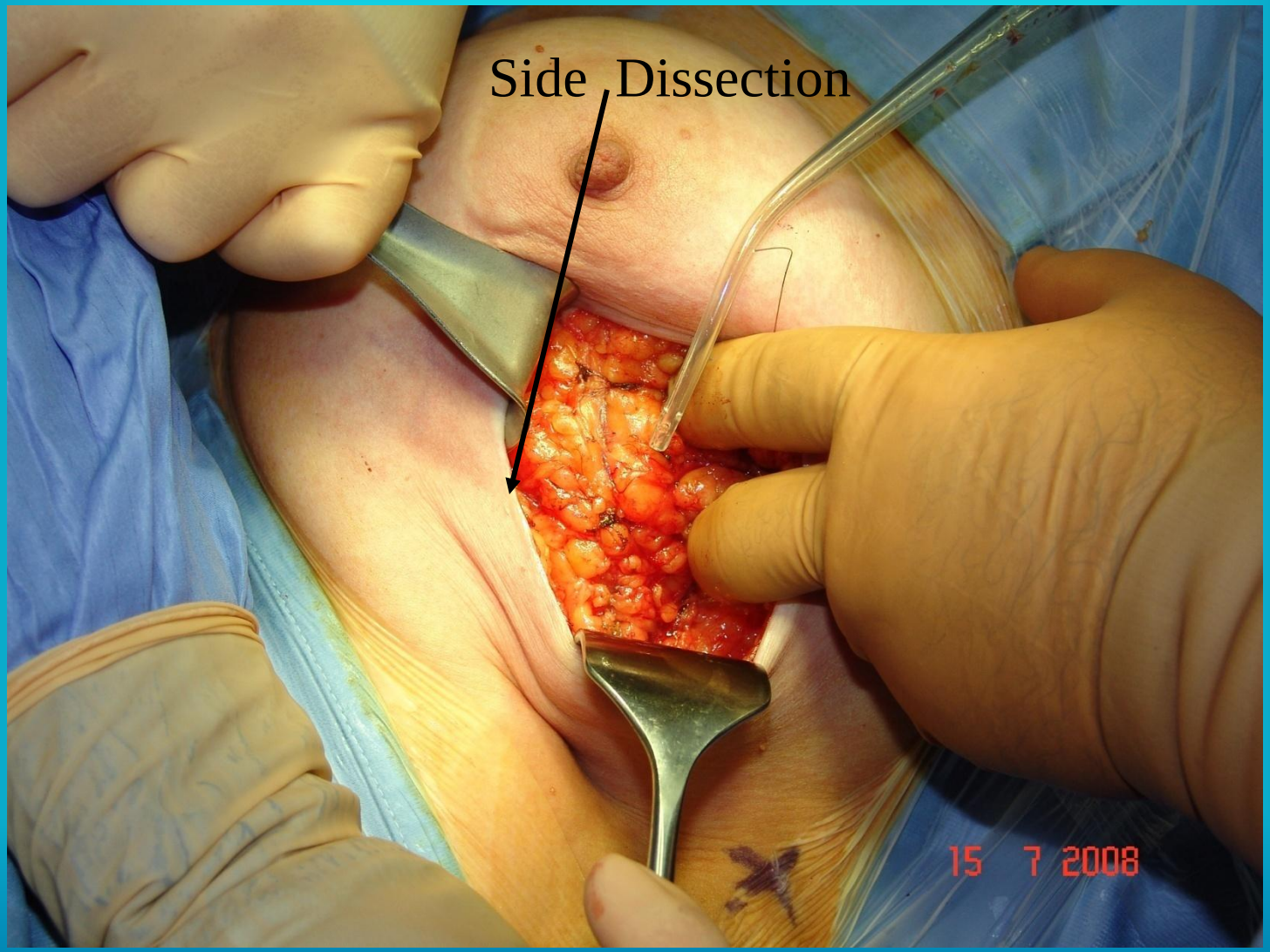


Closure of the terminal duct just at the back of the nipple

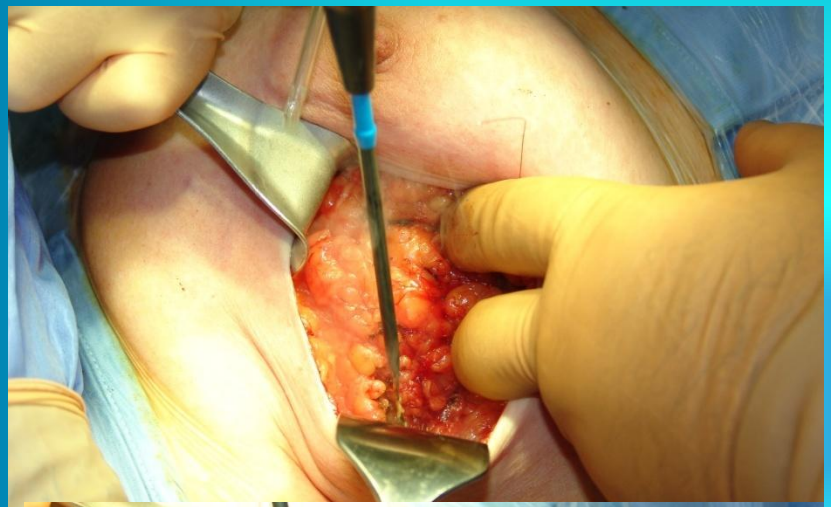


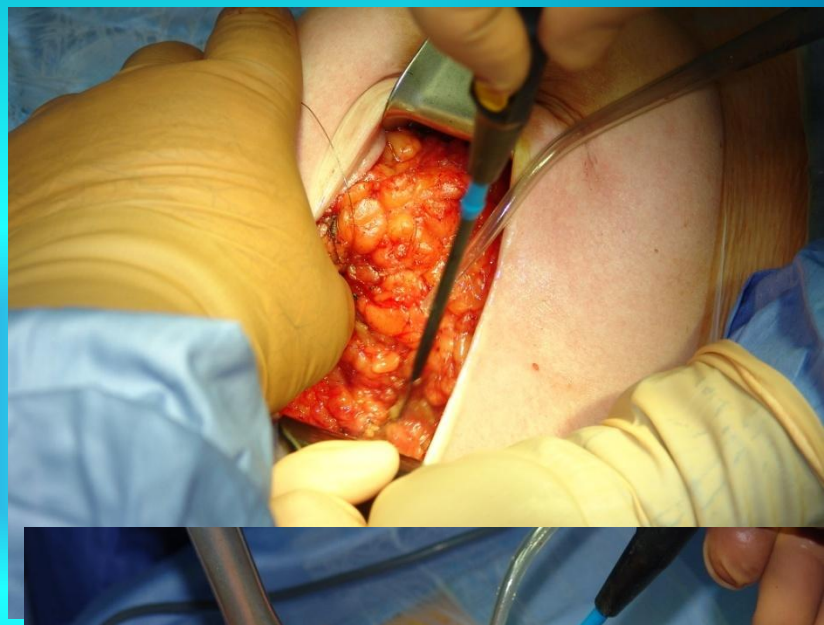


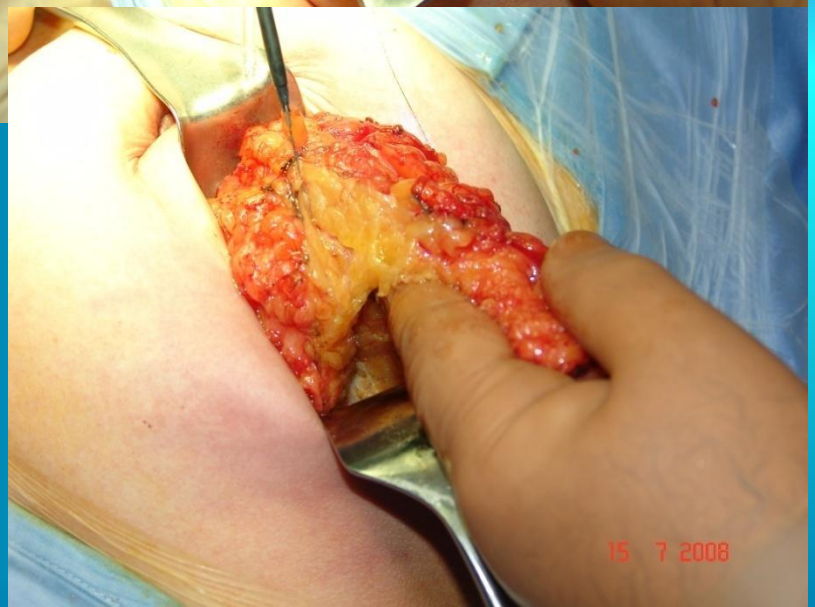
Side dissection is wider than the resected sector so that the reconstruction of the breast parenchyma is facilitated. Deep dissection is made behind the deep layer of the superficial fascia. If the tumor is very near to the major pectoralis muscle's fascia this is removed.

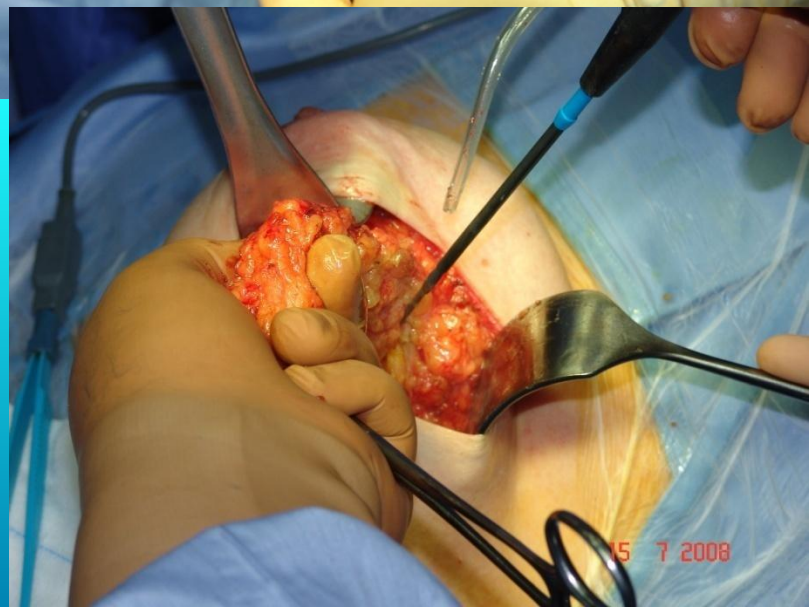


The resection of breast tissue may involve one or more lobes according to the dimensions of tumor and is performed from the periphery to the rear-nipple region where the major ducts are closed by reabsorbable suture N° 0





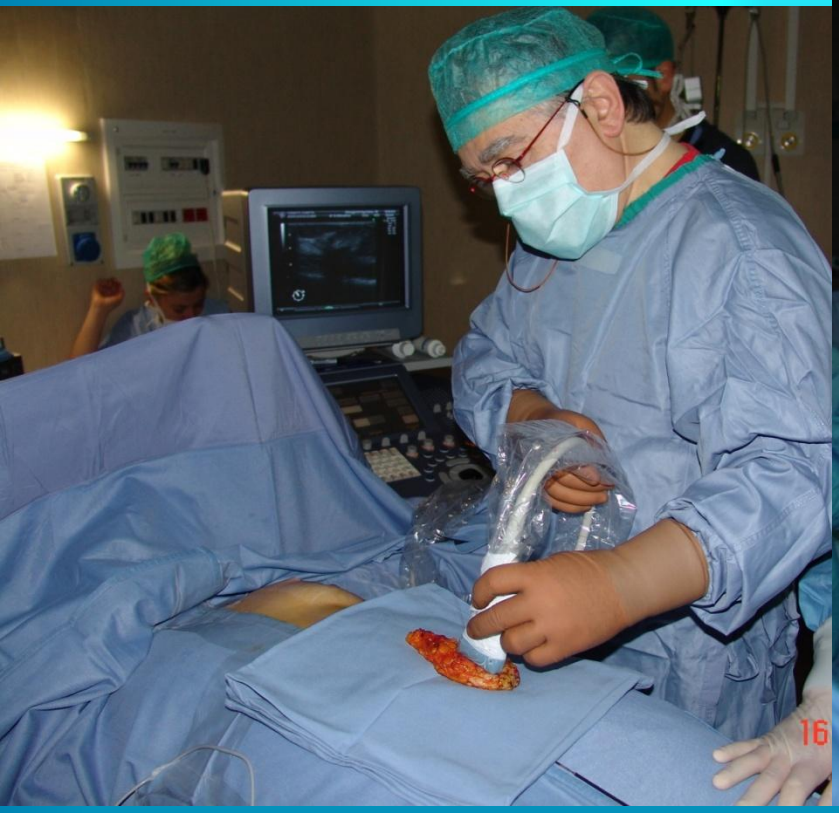


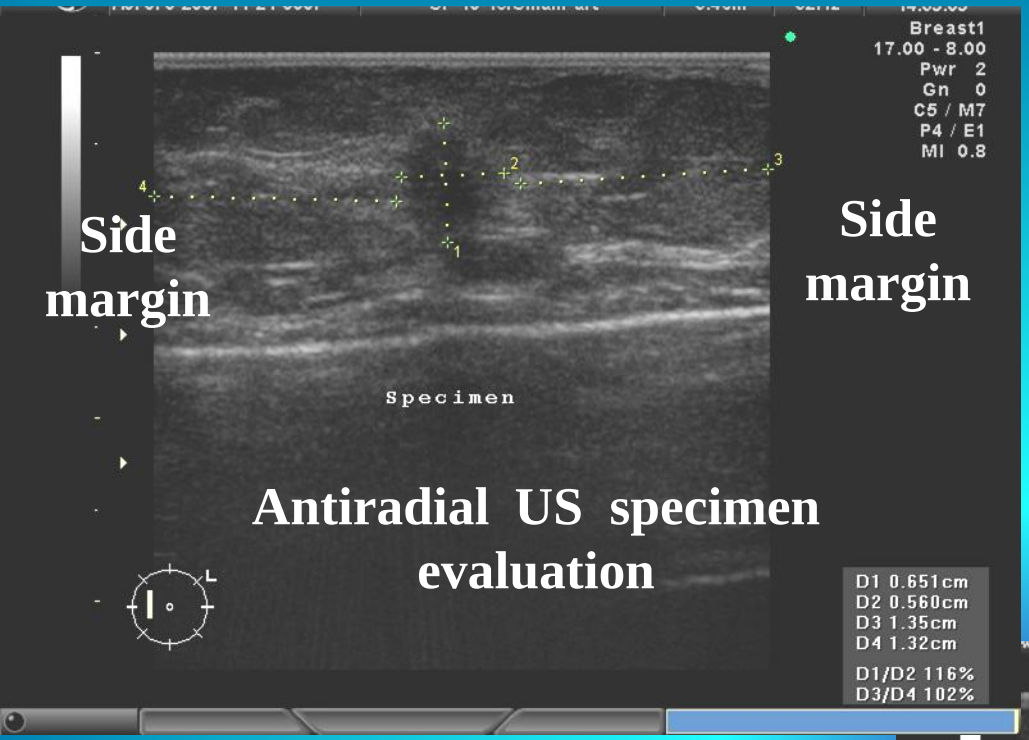


Intraoperative Ultrasound Guided Resection

Intra-operative US provides real-time anatomical and pathological information which enhance intra-operative decision making. There is a clear difference between the roles of intra-operative real-time imaging navigation and pre-operative diagnostic images. After surgery, the excised specimen is examined using US to assess margin status. In cases of positive or close margins, a re-excision is performed.

An US image of the resected specimen immediately allows the surgeon to visualize the presence of lesion, the adequate lateral margins that may benefit, eventually, from immediate reexcision.

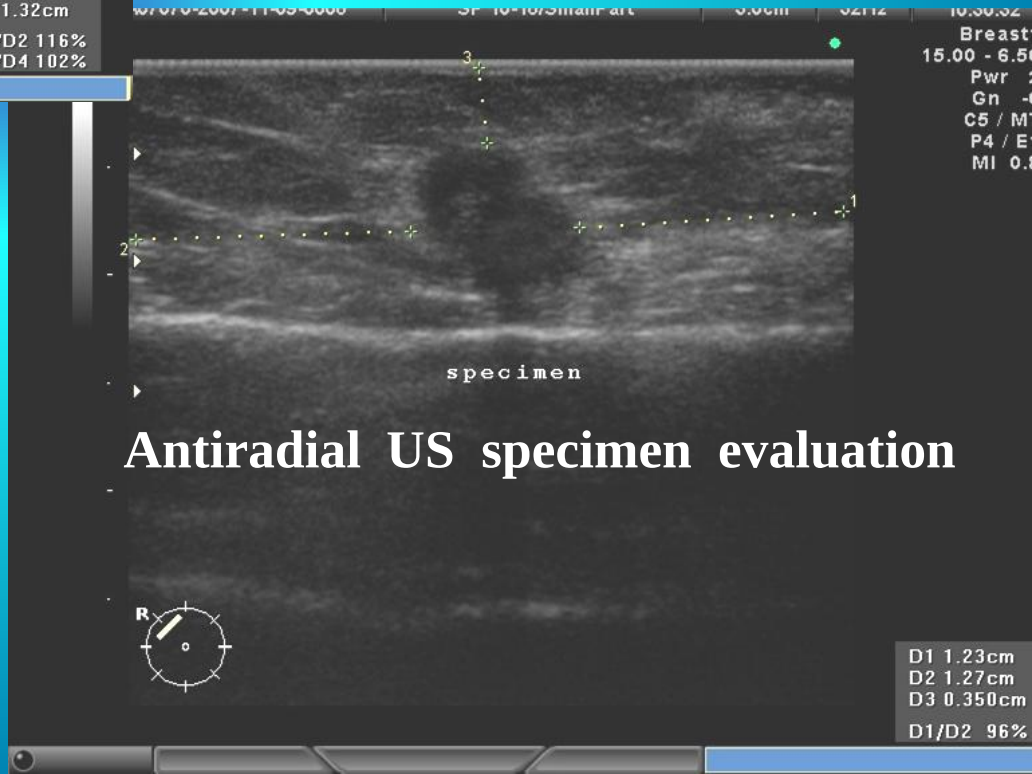




Side margin

Side margin

Antiradial US specimen evaluation



Antiradial US specimen evaluation

Surgical bed of resected sector is US evaluated by 8-18 MHz transducer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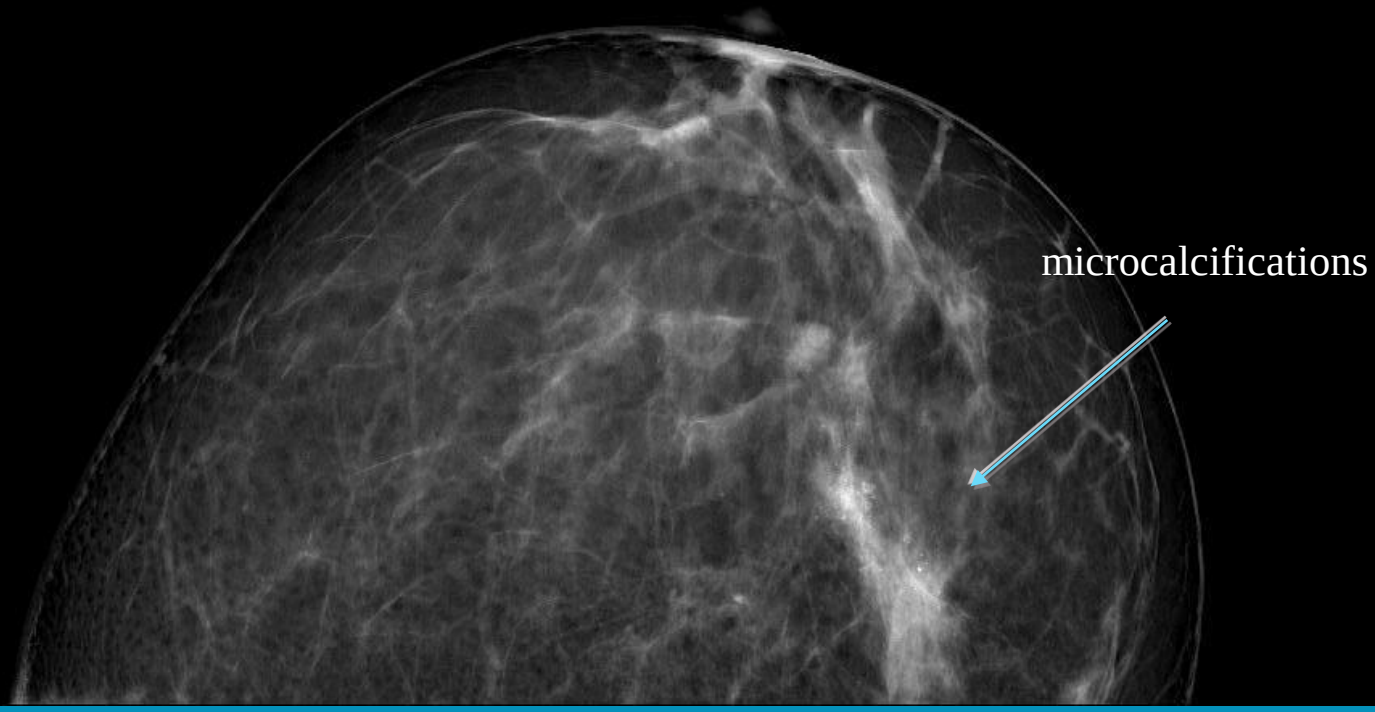
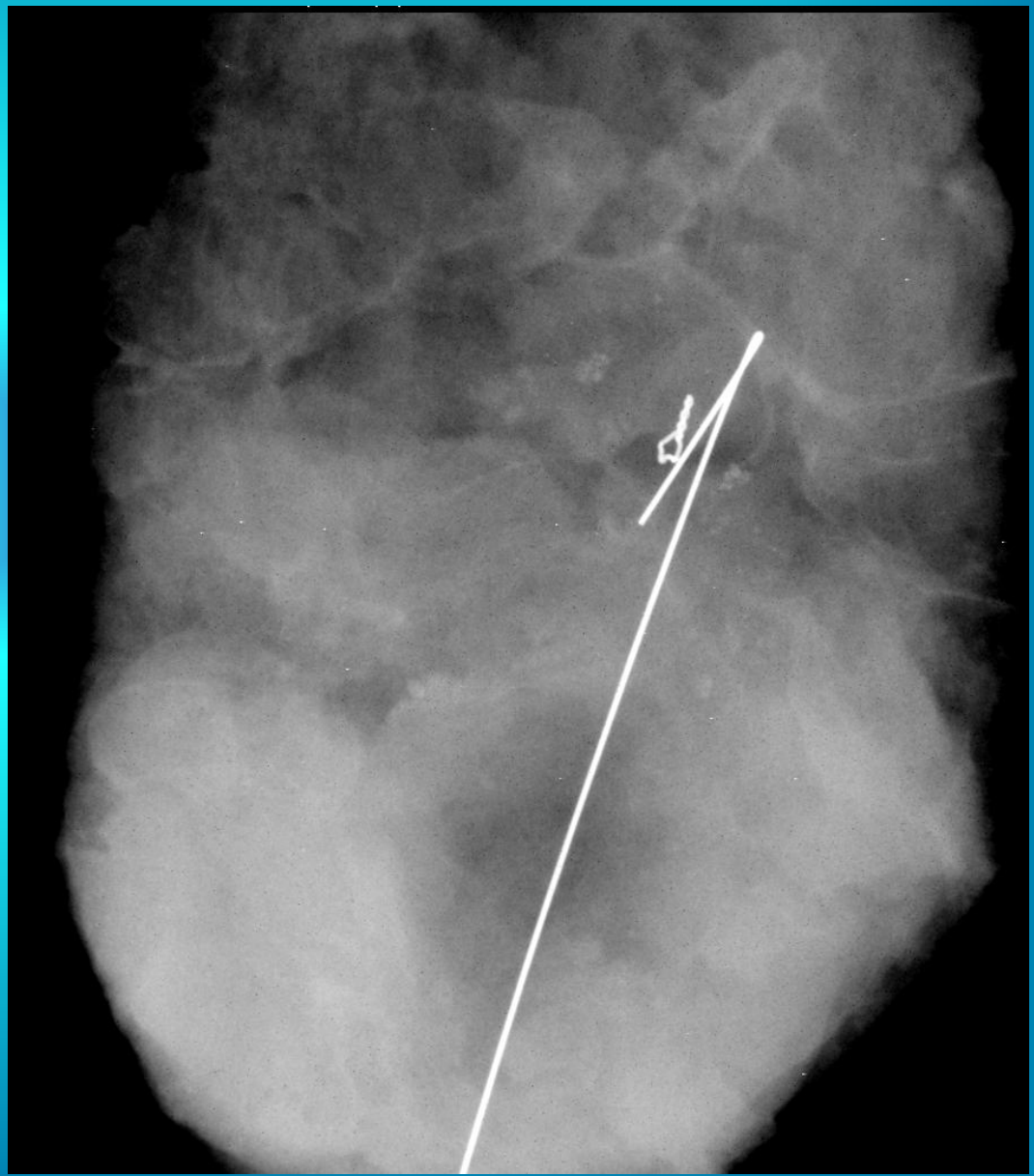
In cases where microcalcifications are the most important sign, digital intraoperative specimen radiography becomes of extreme value



Wire and Digital Rx

I O digital xray examination of wire is performed on every specimen containing microcalcifications in order to ensure correct targeting and side margins removed



Intraoperative Digital Specimen Radiography

IntraOperative Digital Specimen Radiography (IODSR) self-contained unit, placed within a few meters from the operating room, can expose, develop and provide a digital image with high resolution and definition in a few seconds, shortening the operating time and saving at minimum of 20-30 minutes.

Faxitron MX20/DC2

At present there is not a non – destructive intraoperative technique able to rapidly assess the microscopic status of resection margins with an great number of multicenter study validation.

Many techniques have been used:

- Frozen section
- Touch prep cytology
- Specimen Radiography
- Intraoperative Ultrasound
- Radiofrequency spectroscopy
- Optical Coherence Tomography
- Standardized surgical cavity shaving ?
- One-step nucleic acid amplification (OSNA) for sentinel node

Precise orientation of specimen is of vital value but, firstly, is mandatory an adequate resection The Association of Breast Surgery 2010-2011 audit reports a reexcision rate of 11% for invasive and 27% for DCIS .

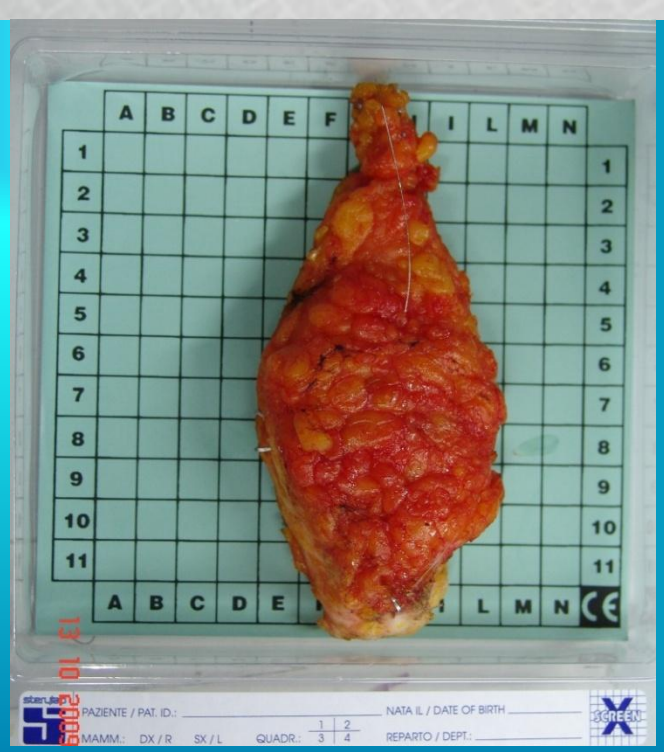
Margins status is a key factor in assessing the adequacy of resection. Negative margins can be obtained only if the surgeon has resected a sufficient parenchima (only around the tumor without any respect of the ductal anatomy?)

Specimen margins are tagged with a number of clips according pathologist agreement and clock-wise as follows:

- 1 clip retro-areola
- 2 clips lateral
- 3 clips external
- 4 clips medial

After the specimen is placed in a square box with 1cm squares.

A wire is inserted along the major axis of the specimen in the proximity of clip left after VAB or in the residual microcalcifications.



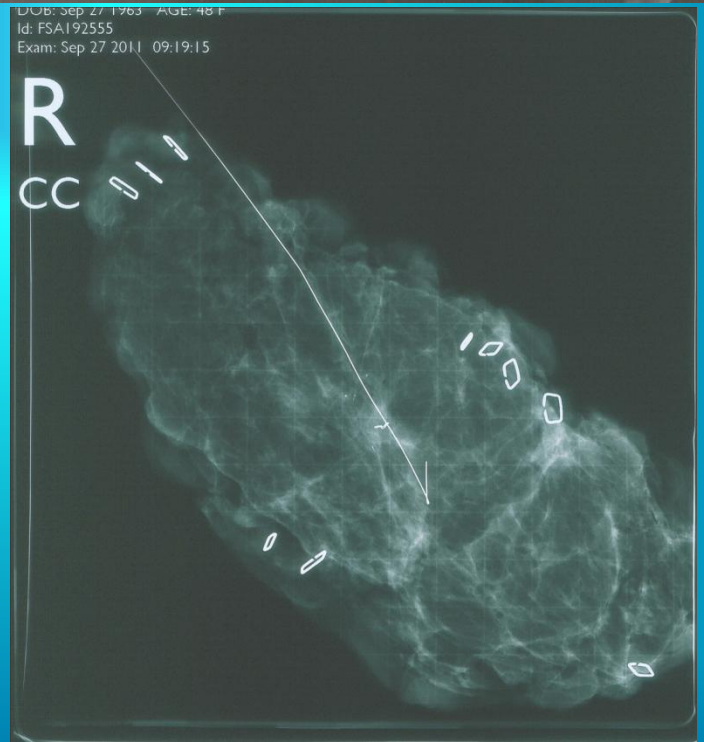
Digital Specimen Radiography System,
BioVision, Bioptics Faxitron Medical, easy to move in the operating room

The cost of system implies increased cost for the departement but with increased number of early diagnosis and increased frequency of image-guided breast conserving surgery at the end we will have a large savings and, importantly, a better evaluation of the specimen containing microcalcifications

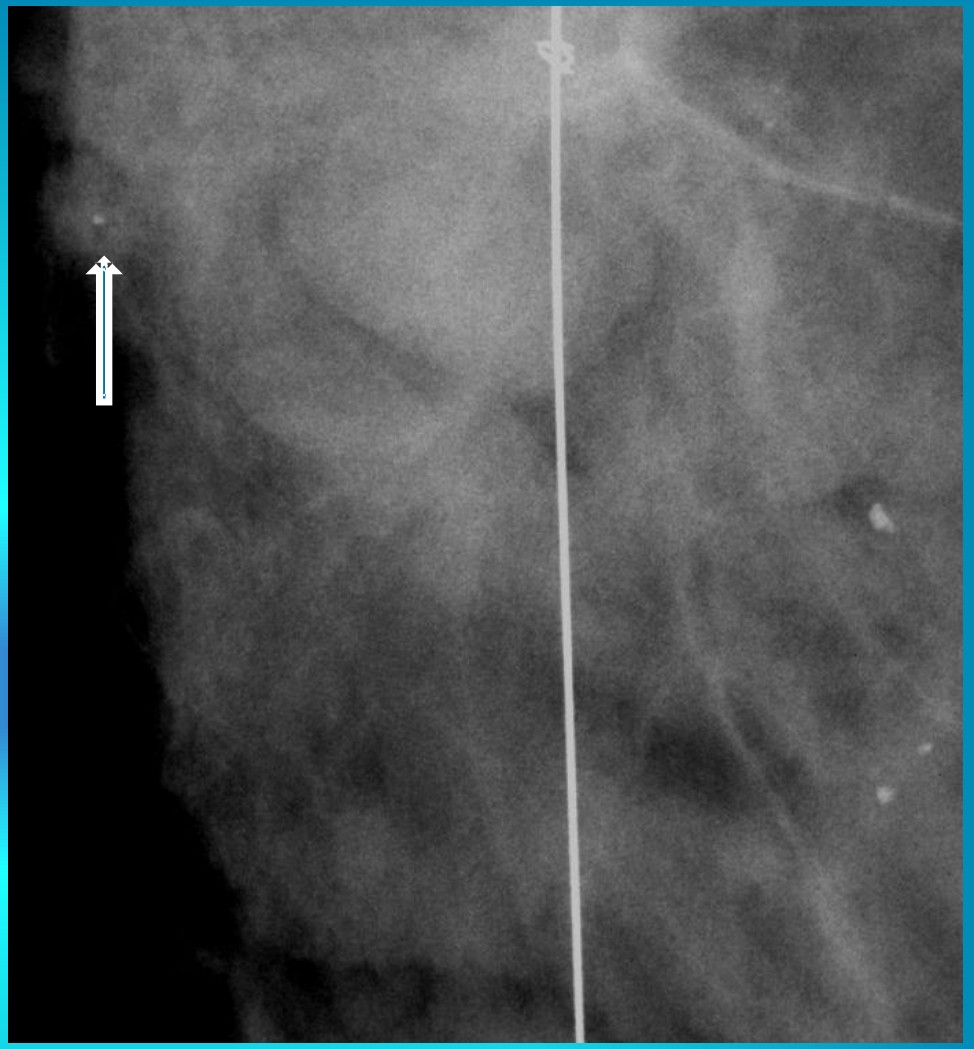
Exposition Time and Kv Selection


faxitron x-ray
026
26
CAUTION X-RAYS PRODUCED WHEN ENERGIZED
WARNING: SAFETY INTERLOCK
Different levels of specimen locating for an higher magnification

Specimen is imaged without compression to avoid distortion or compromise of gross margin assessment relative to the centrally located lesion. Imaging is performed antero-posteriorly with a 90˚ rotation in cases of very superficial or deep microcalcifications. Layfield, 2011, reported sensitivity of 58.1%, specificity of 80.8%, positive predictive value of 56.25%, negative predictive value of 81.9%

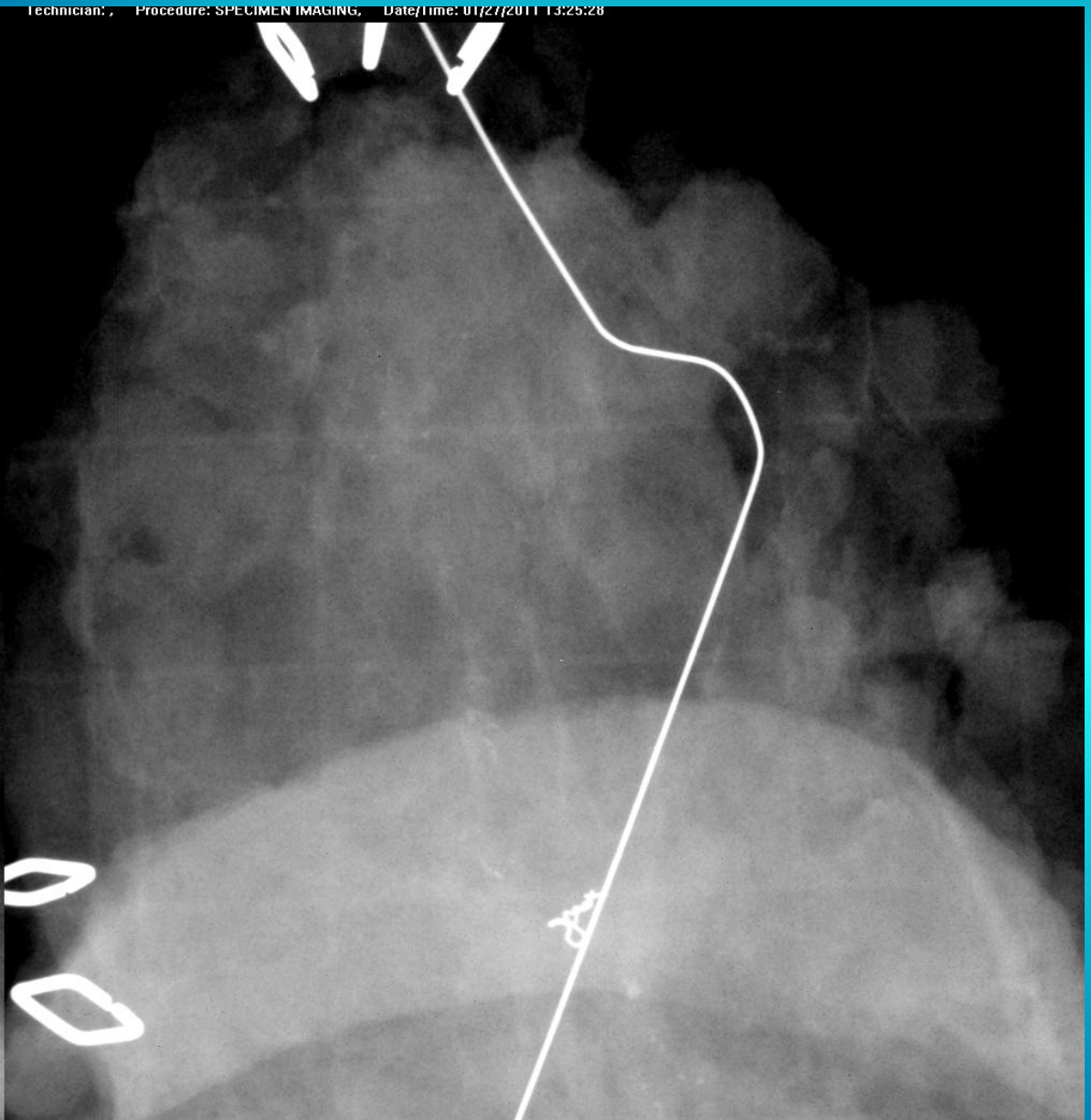


Margins re-excision without residual microcalcifications

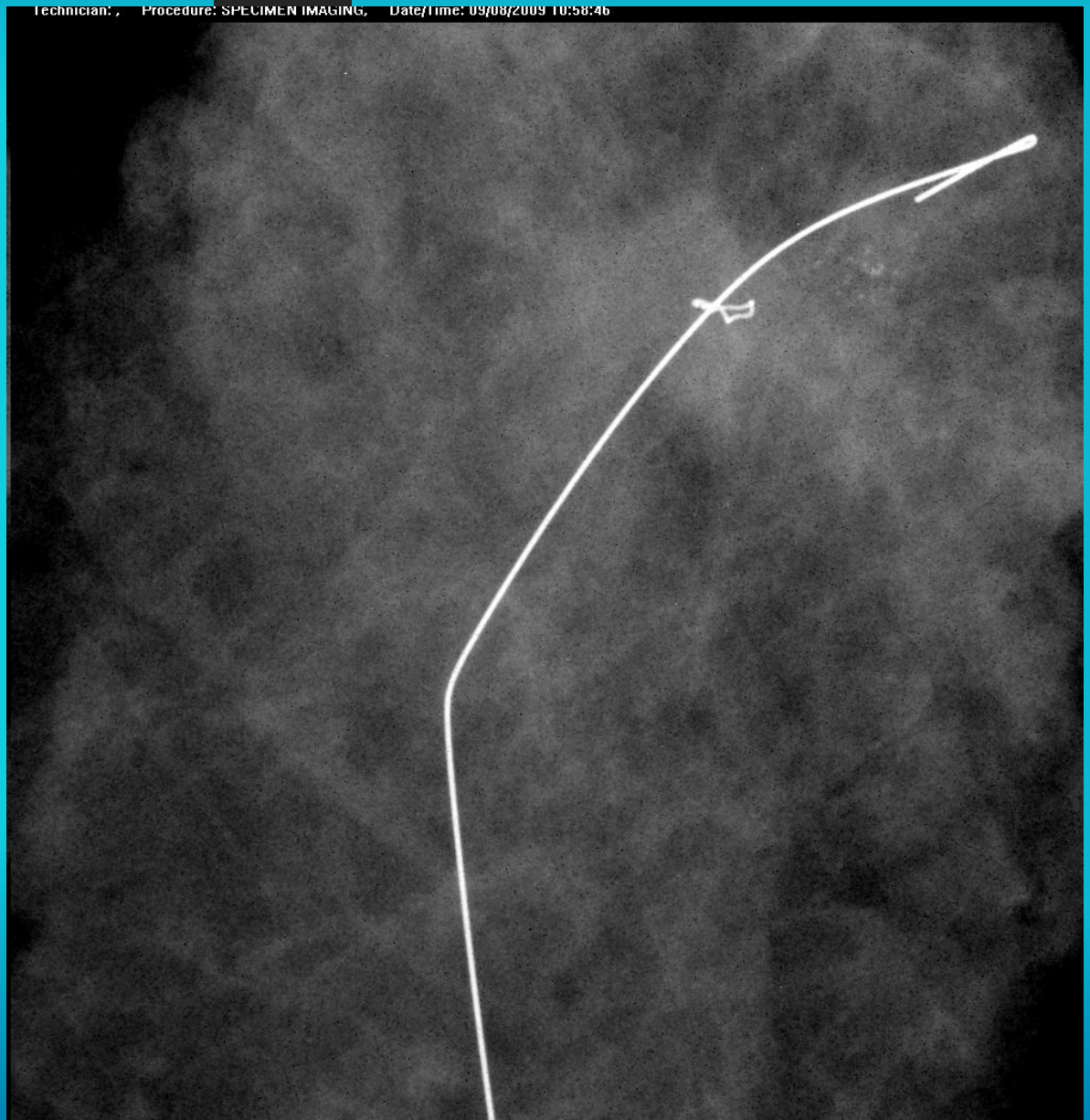


Specimen with few microcalcifications on the margins

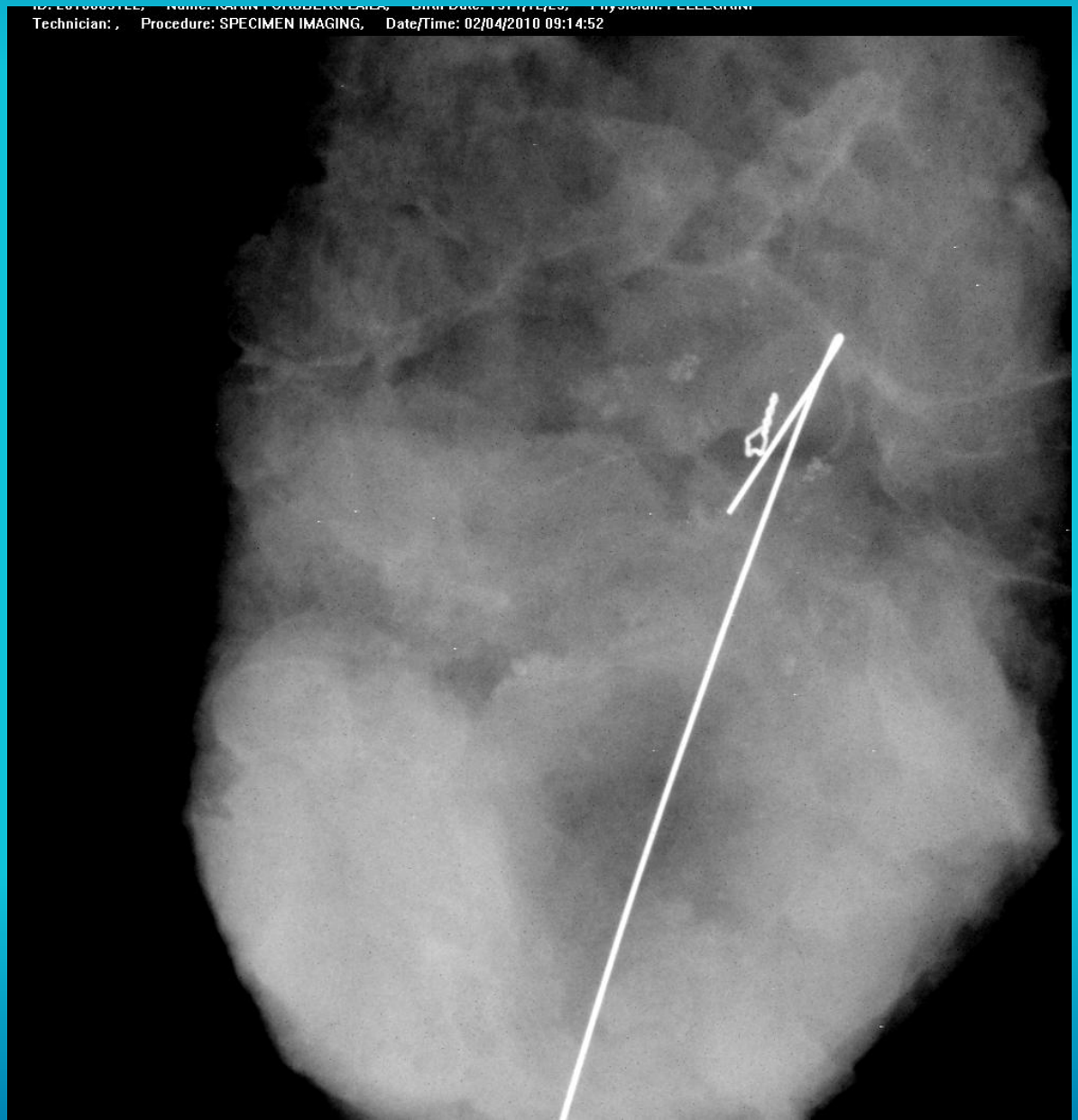
Digital Specimen of Sector with skin, clip and few residual microcalcifications



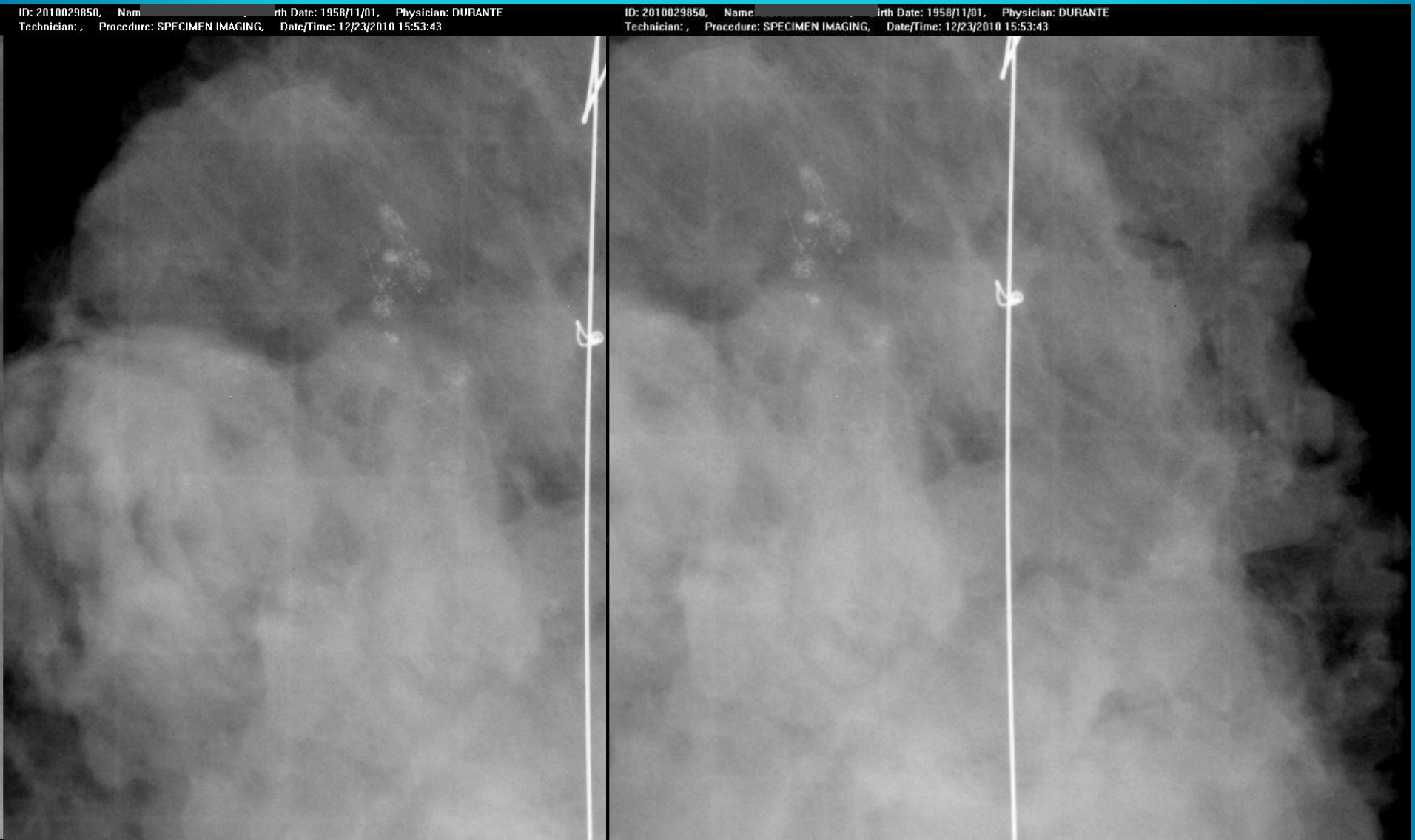
Digital Specimen with clip and residual microcalcifications along the duct major axis



Residual microcalcifications near the wire and clip in the middle of specimen

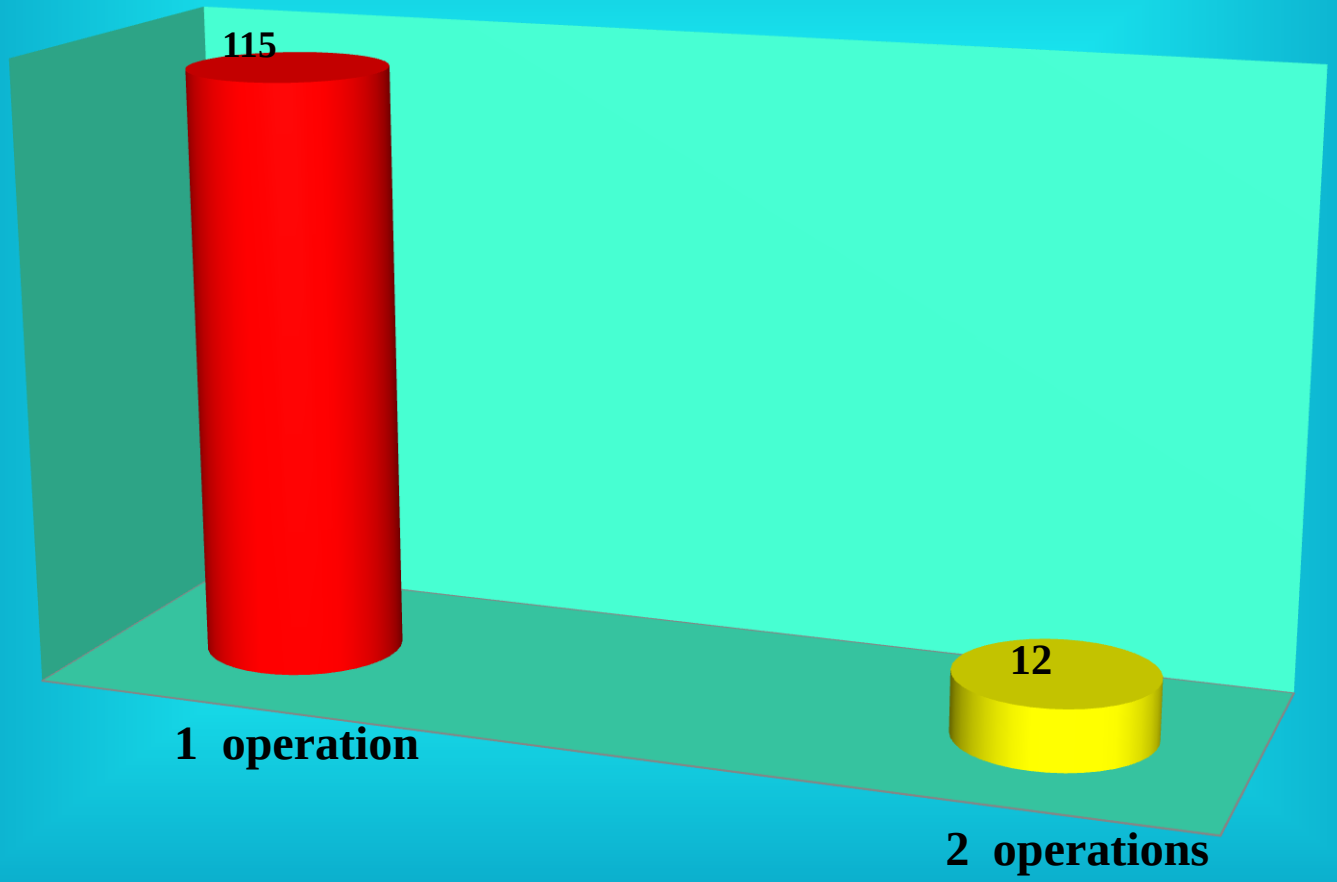


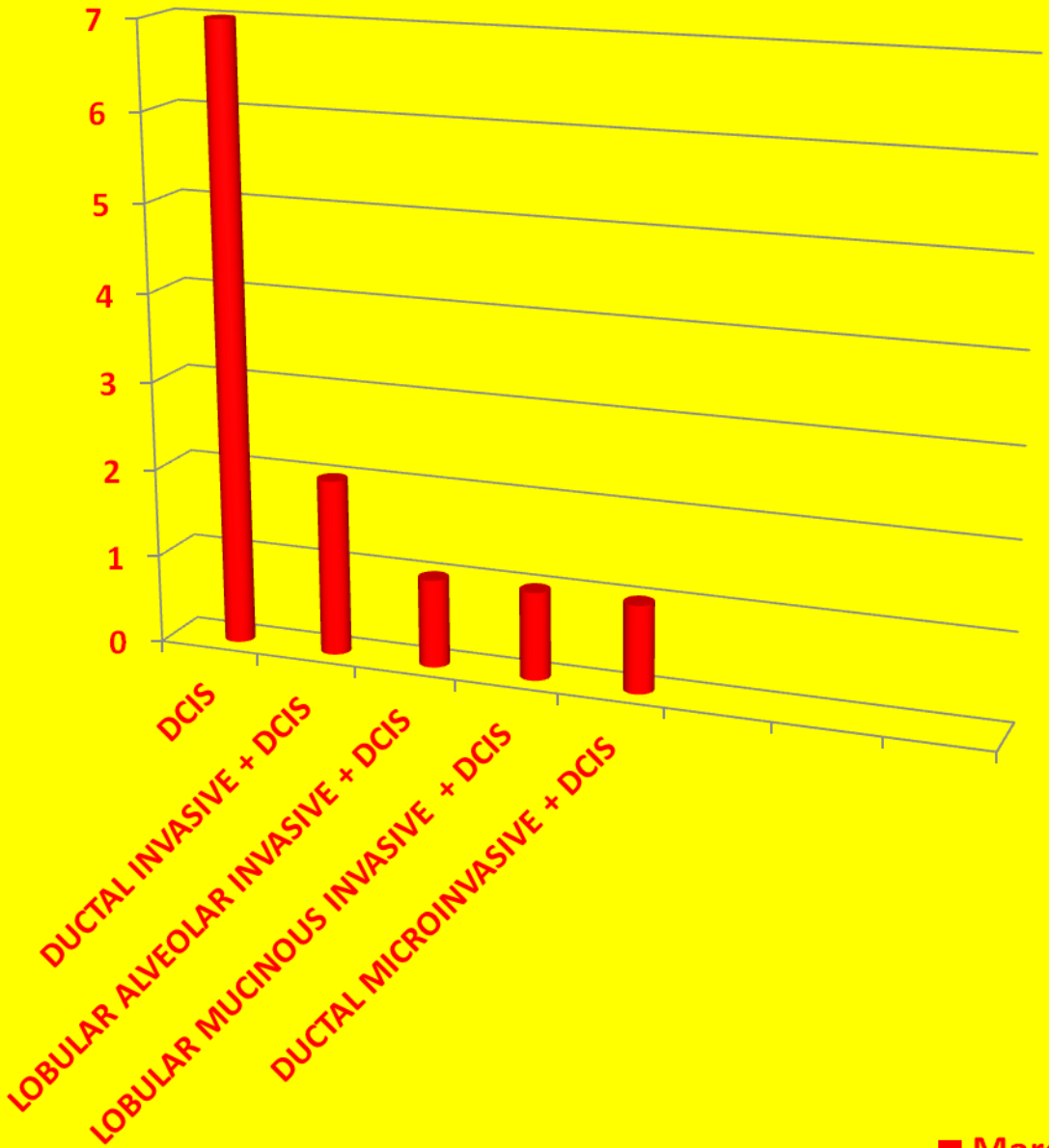
Residual microcalcifications and clip crossed by the wire in the middle of sector



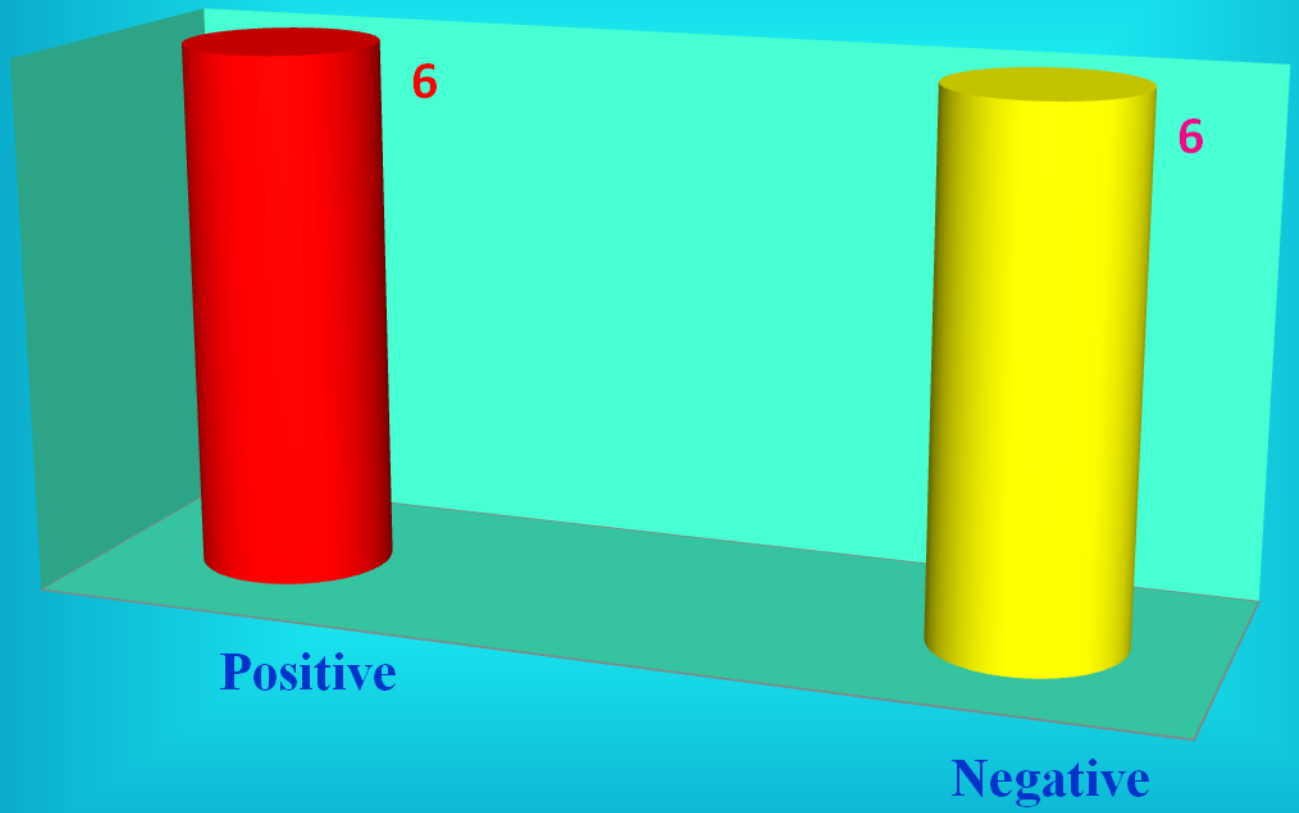
Personal Experience

Breast Conserving Surgery in Patients with microcalcifications

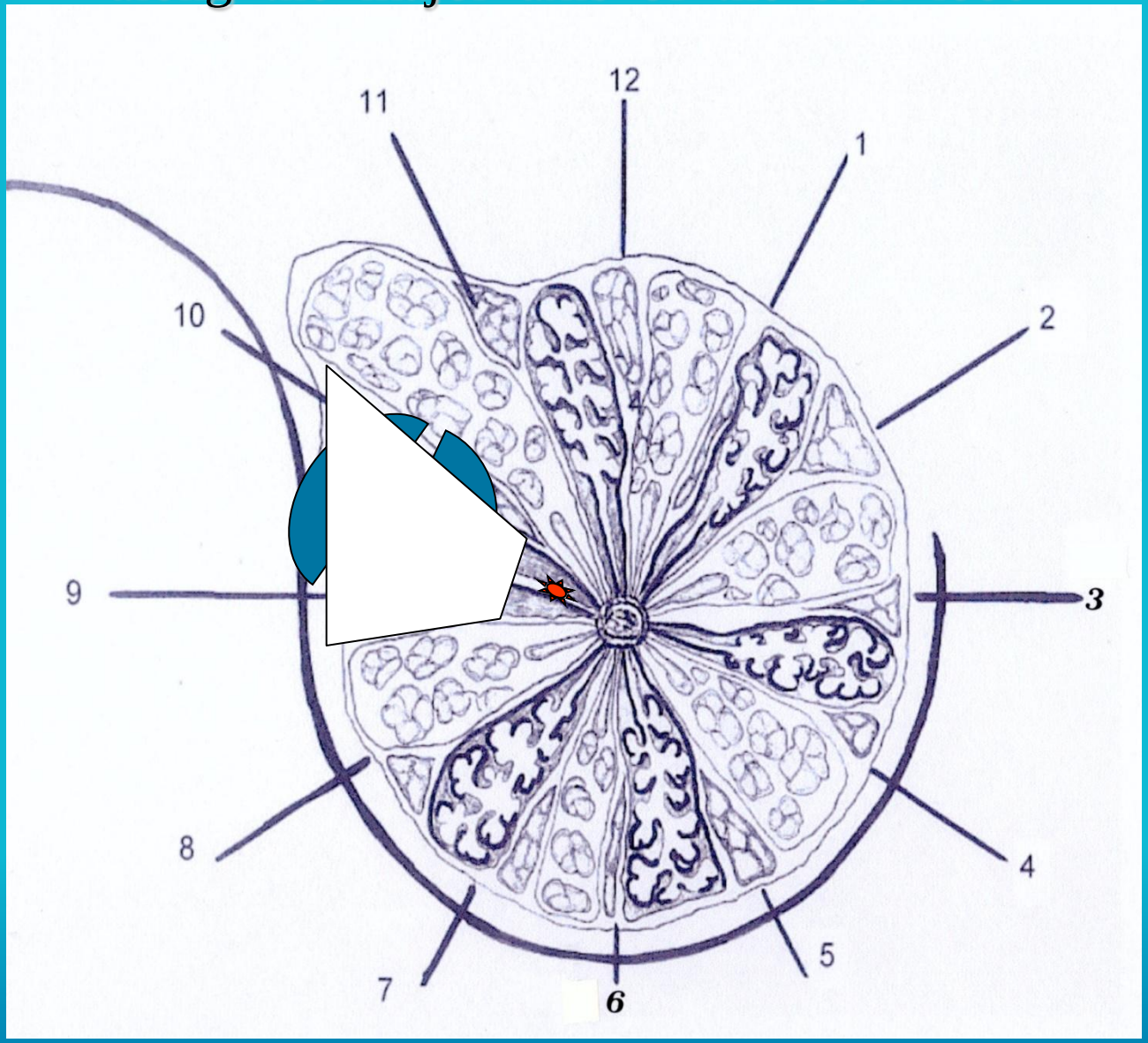



7
6
5
4
3
2
1
0
DCIS
DUCTAL INVASIVE + DCIS
LOBULAR ALVEOLAR INVASIVE + DCIS
LOBULAR MUCINOUS INVASIVE + DCIS
DUCTAL MICROINVASIVE + DCIS
Margin re-excision: positive

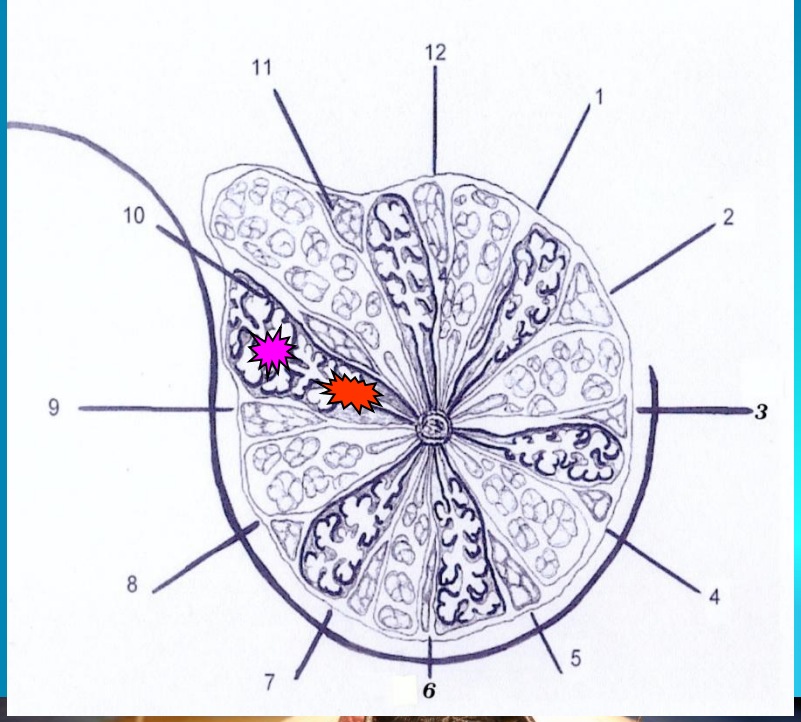
Final Histology in Mastectomy

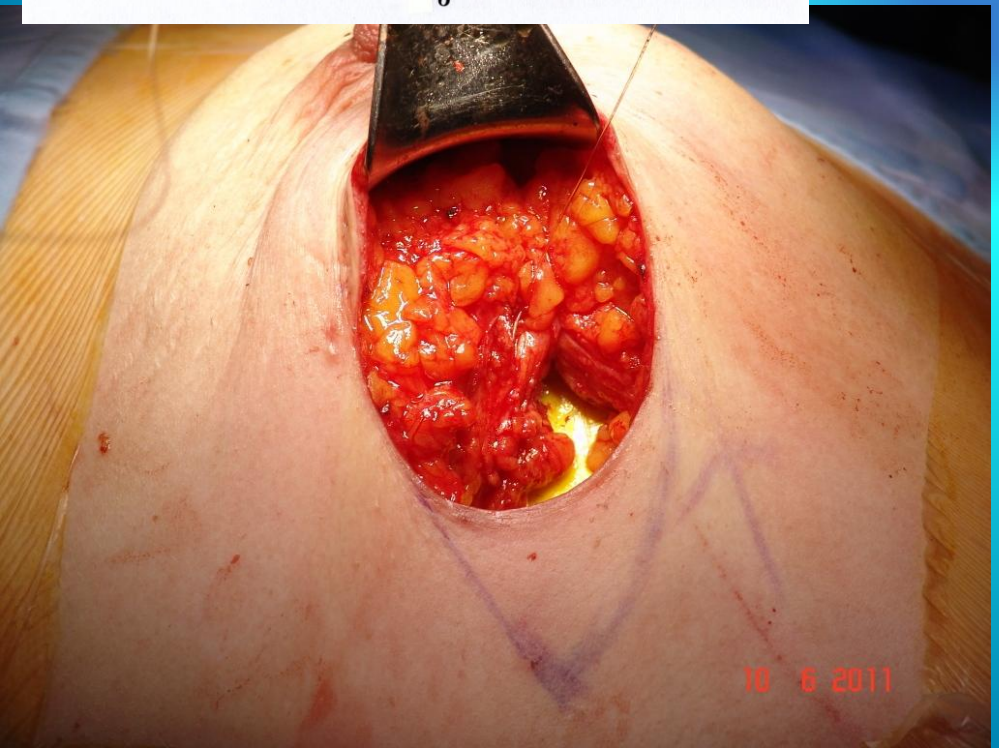


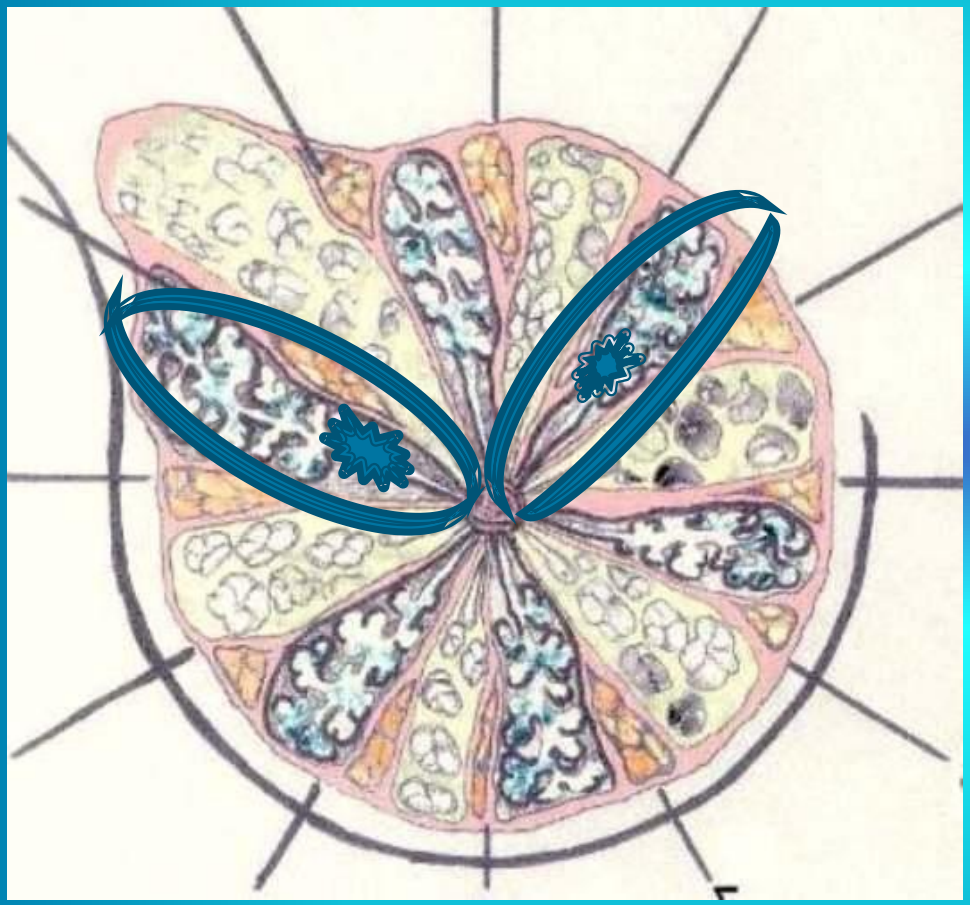
The use of intraoperative US and the principles of the lobar anatomy may avoid to leave in place small foci of cancer along the major axis of the sick lobe



IORT

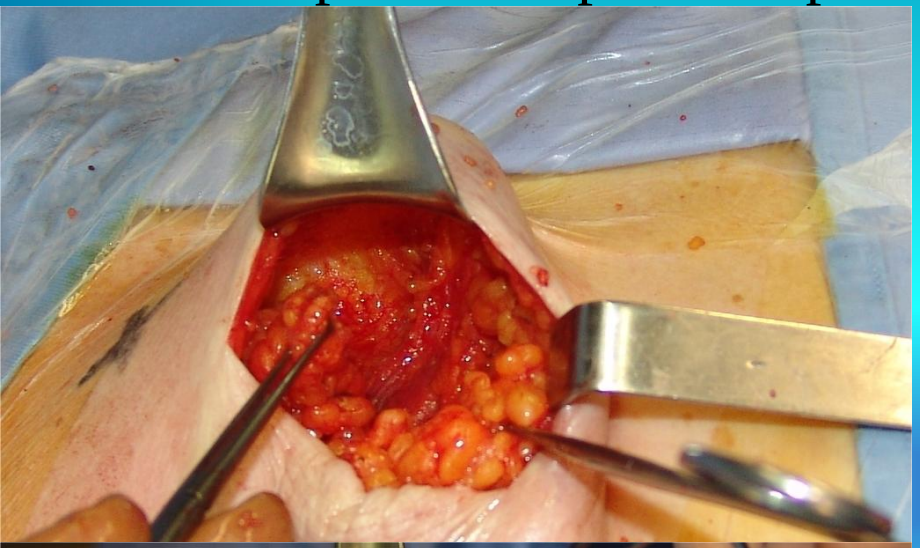


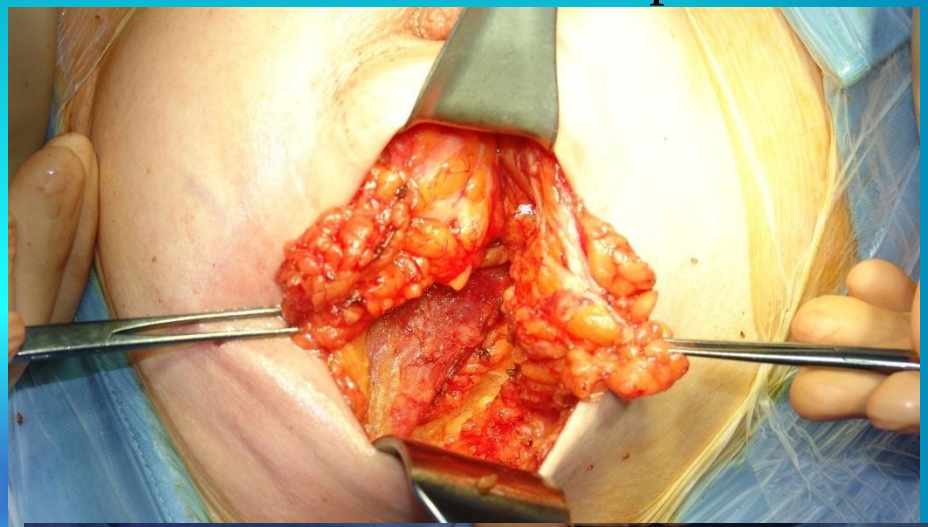


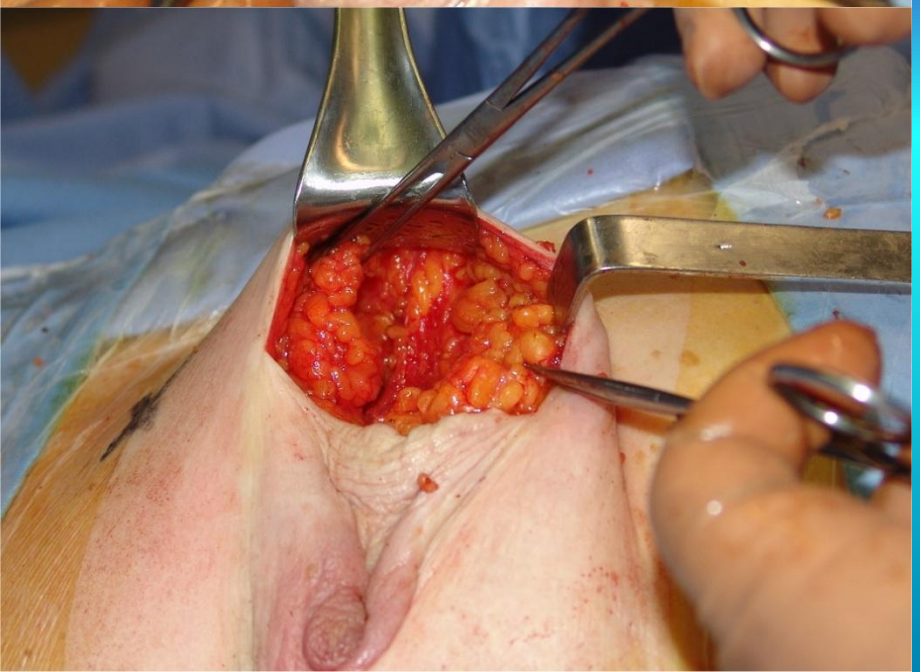


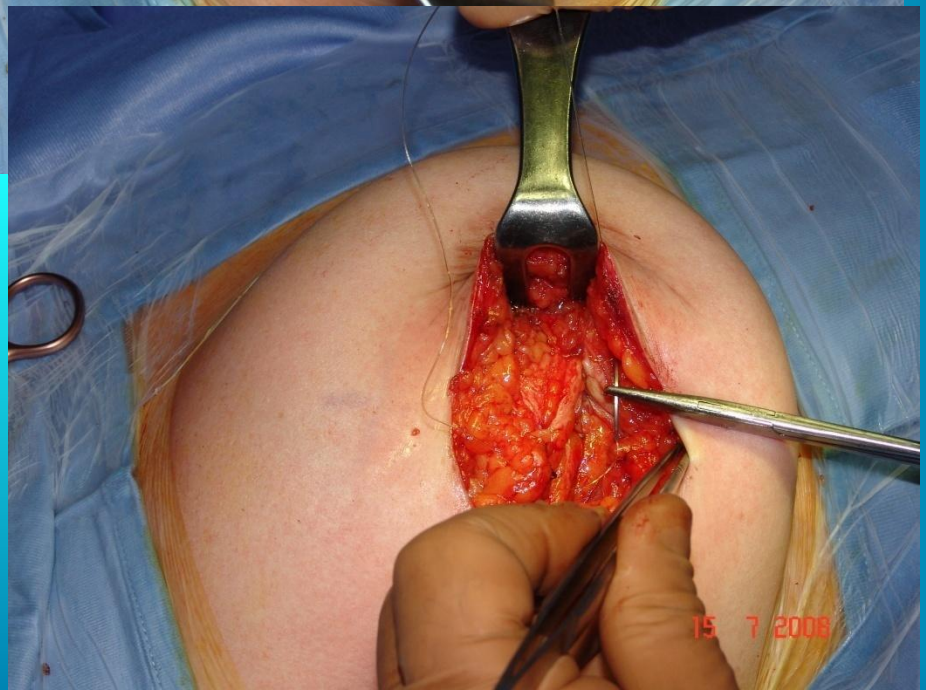
We believe that planning the resection according the lobar anatomy even if we perform excision of more tissue along the major axis of the duct containing the lesion we do not loose the possibility of an adequate volume replacement with broad dissection of breast parenchyma and with its advancement, rotation and trasposition.

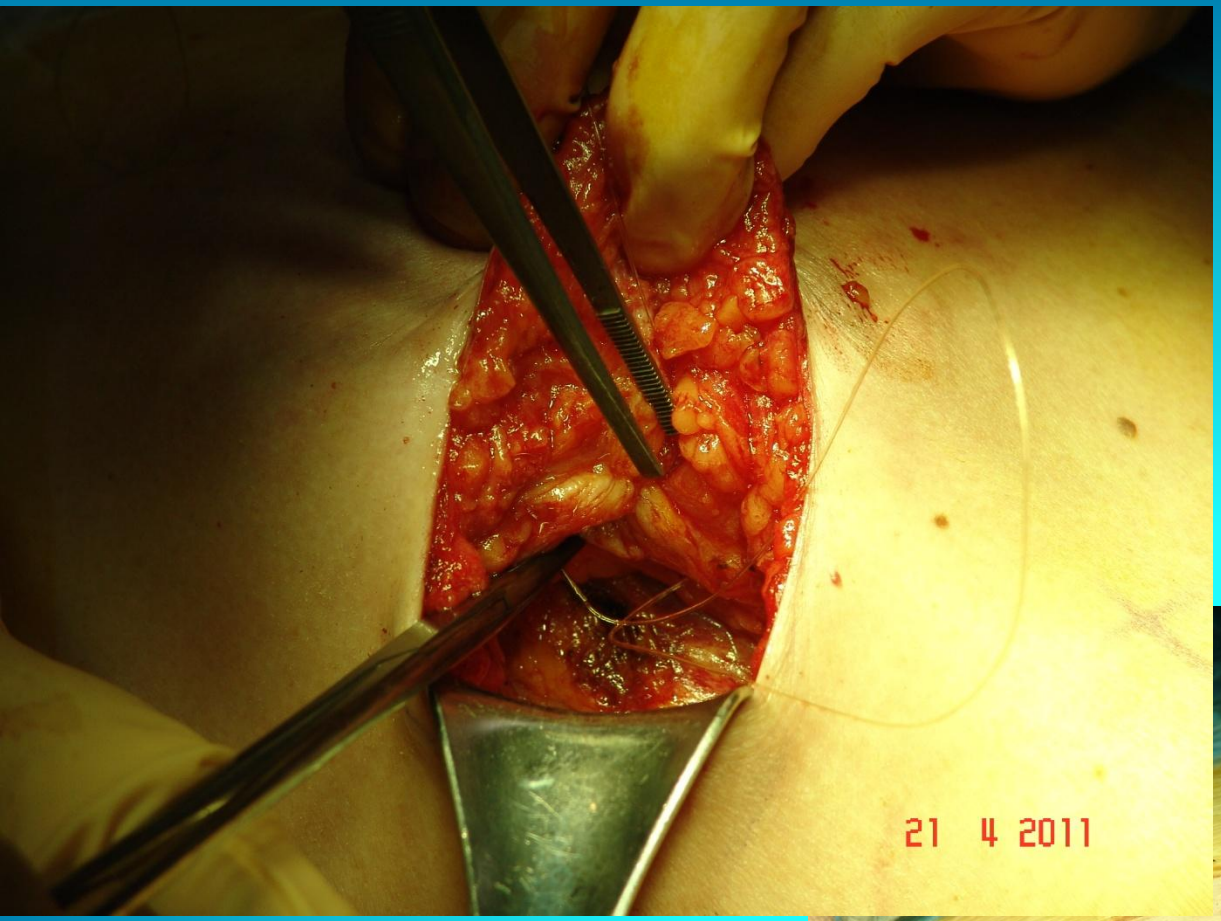
Mobilization of both margins and reconstruction of breast tissue by reabsorbable N° 0-1 suture from the rear-nipple region to the periphery with a deeper and superficial plane in continuous fashion is performed.

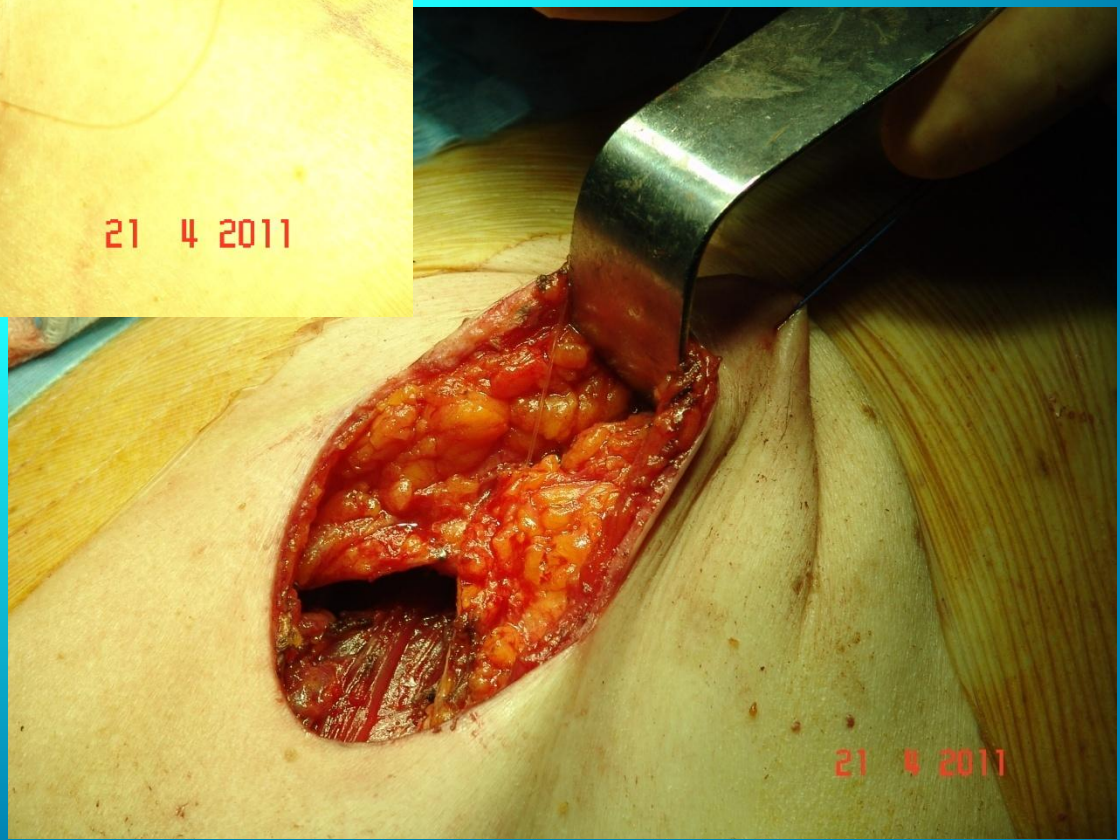




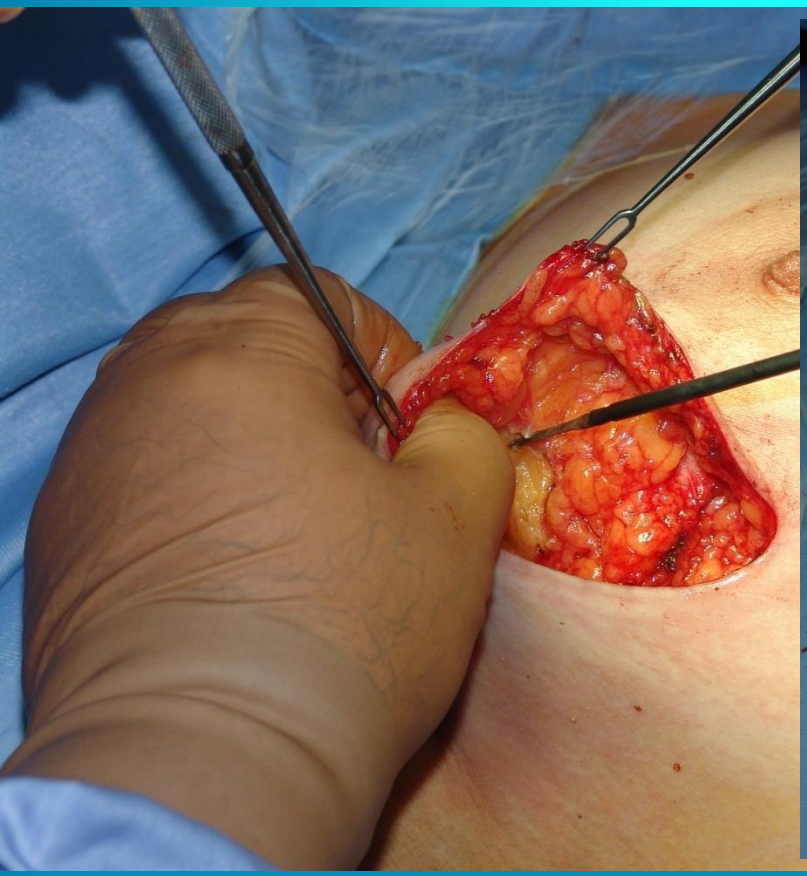




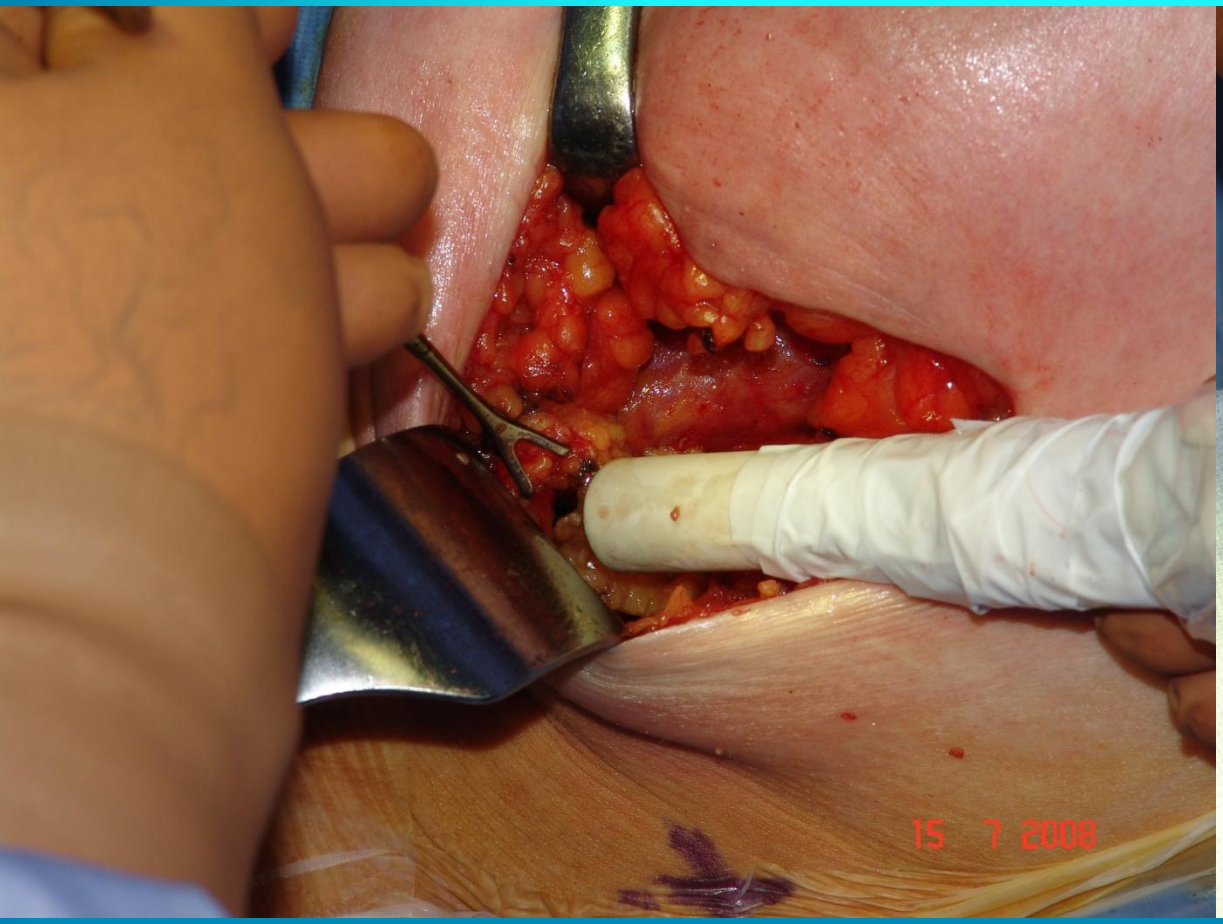

21 4 2011

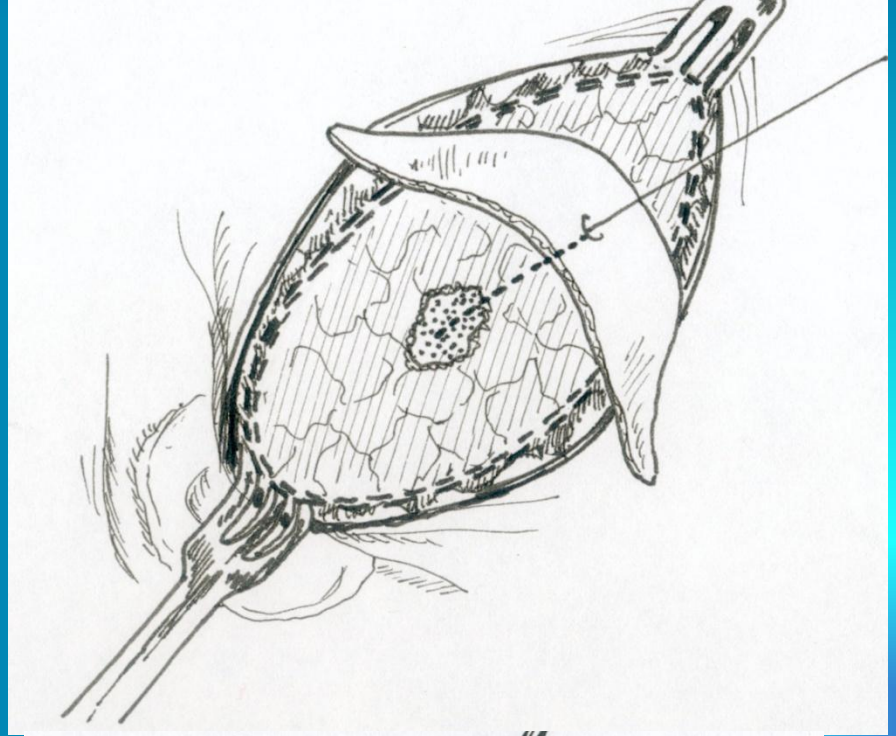

21 4 2011

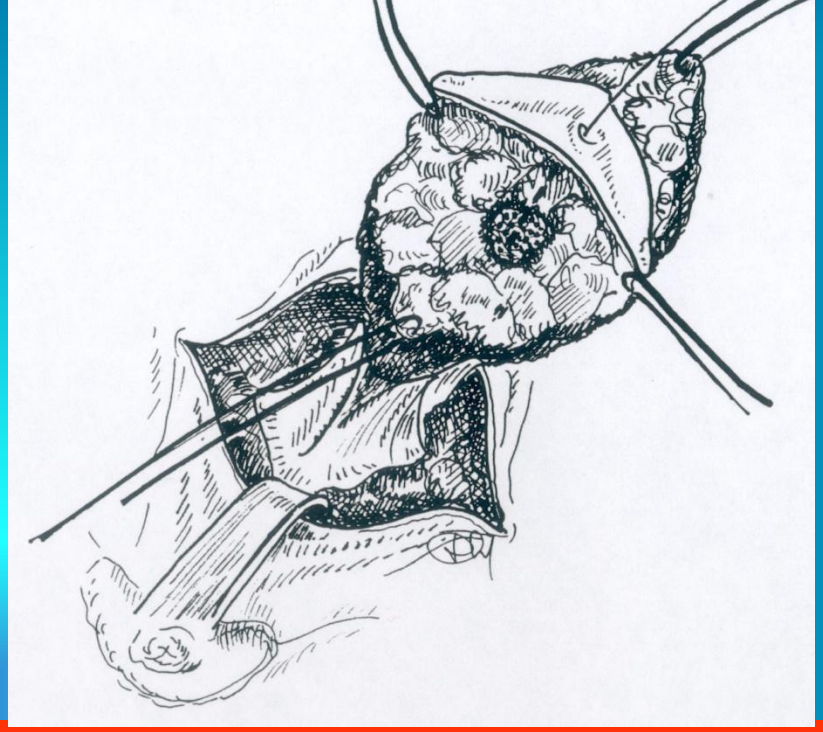
Final Subcutaneous Dissection
is made in order to avoid skin retraction and consequently a bad cosmetic result

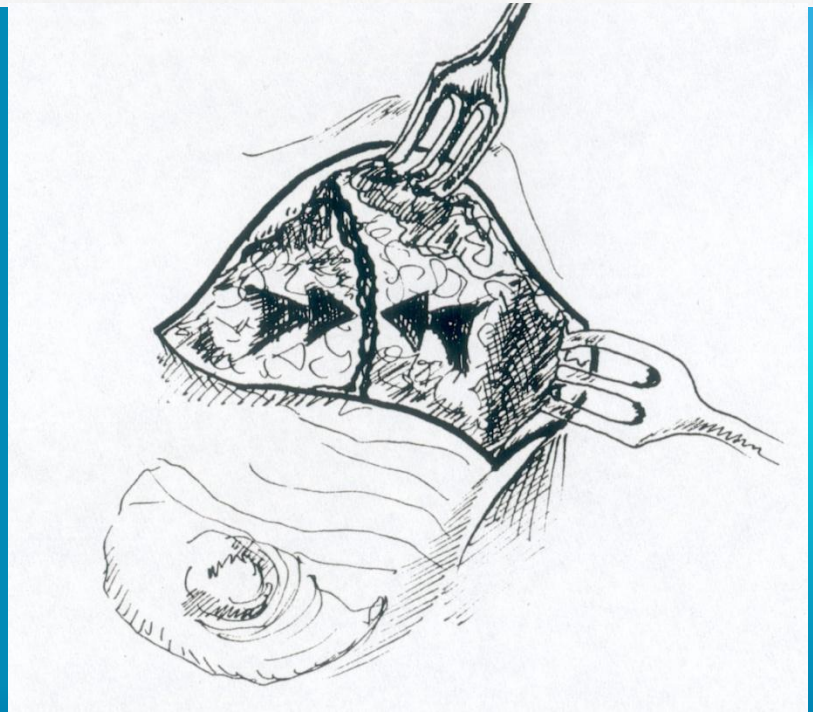


Axillary Sentinel Node removal is obtained in most of cases by the same incision of sectoriectomy



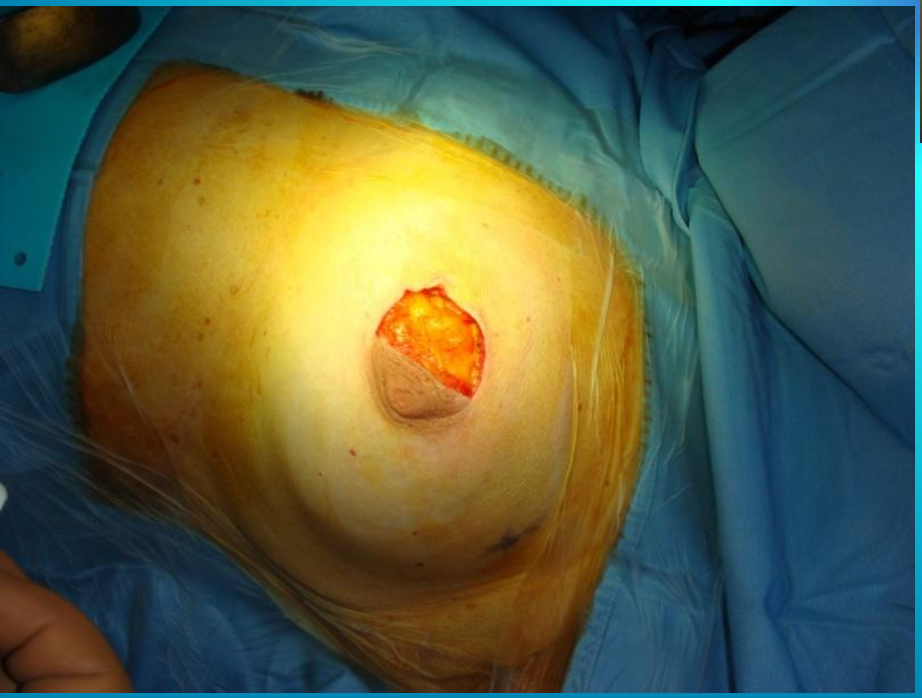






Intradermic suture by reabsorbable suture 3-4/0 is performed.

Utilizing these concept we performed from 1988 to 2006 1094 sectoriectomy for breast cancer according the lobar anatomy using as much as possible the periareolar incision.



U S LOCALIZATION LAST 12 ys

915 LOCALIZATIONS

MALIGNANT LESIONS

STAGE	N°	%
Tis	117	12.8
Tismi	30	3.3
T1a	75	8.2
T1b	321	35.0
T1c	210	22.9
	753	82

162 Localizations Benign Lesions

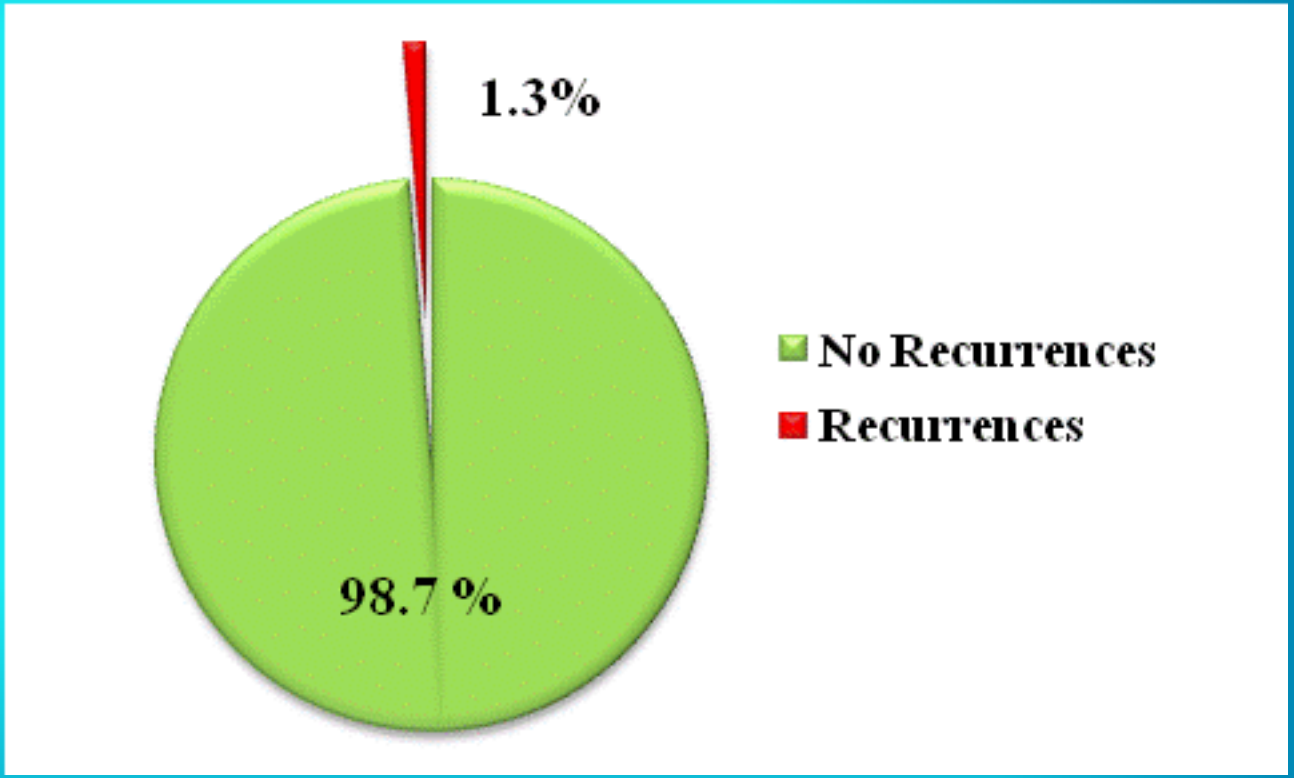
	N°	%
DAH	*12*	*1.3*
LAH	*3*	*0.3*
Papilloma	*42*	*4.6*
Scleroelastosis	*6*	*0.6*
Fibroadenoma	*12*	*1.3*
Complex Prolif.	*36*	*3.9*
Ductal Adenoma	*9*	*0.9*
Sclerosing Adenosis	*24*	*2.6*
Phyllodes	*3*	*0.3*
Scler. Aden.-Multip. Papill	*6*	*0.6*
Adenomyoepithelioma	*6*	*0.6*
Stromal Pseudoangiom. H	*3*	*0.3*
	162	*18*

RECURRENCES

Patient	Time to recurrence / months	Histology	Same Quadrant	Follow- up (years)	Outcome
TZ	26	DCIS		4	missed
CC	44	DCIS	X	11	alive
GC	44	Ductal invasive		7	missed
GB	74	Lobular invasive		10	alive
MP	82	Papillary		8	alive
AL	68	Ductal invasive	X	7	alive
GP	80	Ductal invasive	X	8	alive
CMA	24	Lobular invasive		4	dead
BF	48	Ductal invasive		18	alive
RV	65	Mucoid invasive		20	alive
RV	104	Ductal invasive		20	alive
MM	96	Tubulo-Lobular		18	alive
PAM	144	Lobular invasive		21	alive
BS	120	Ductal invasive		20	alive

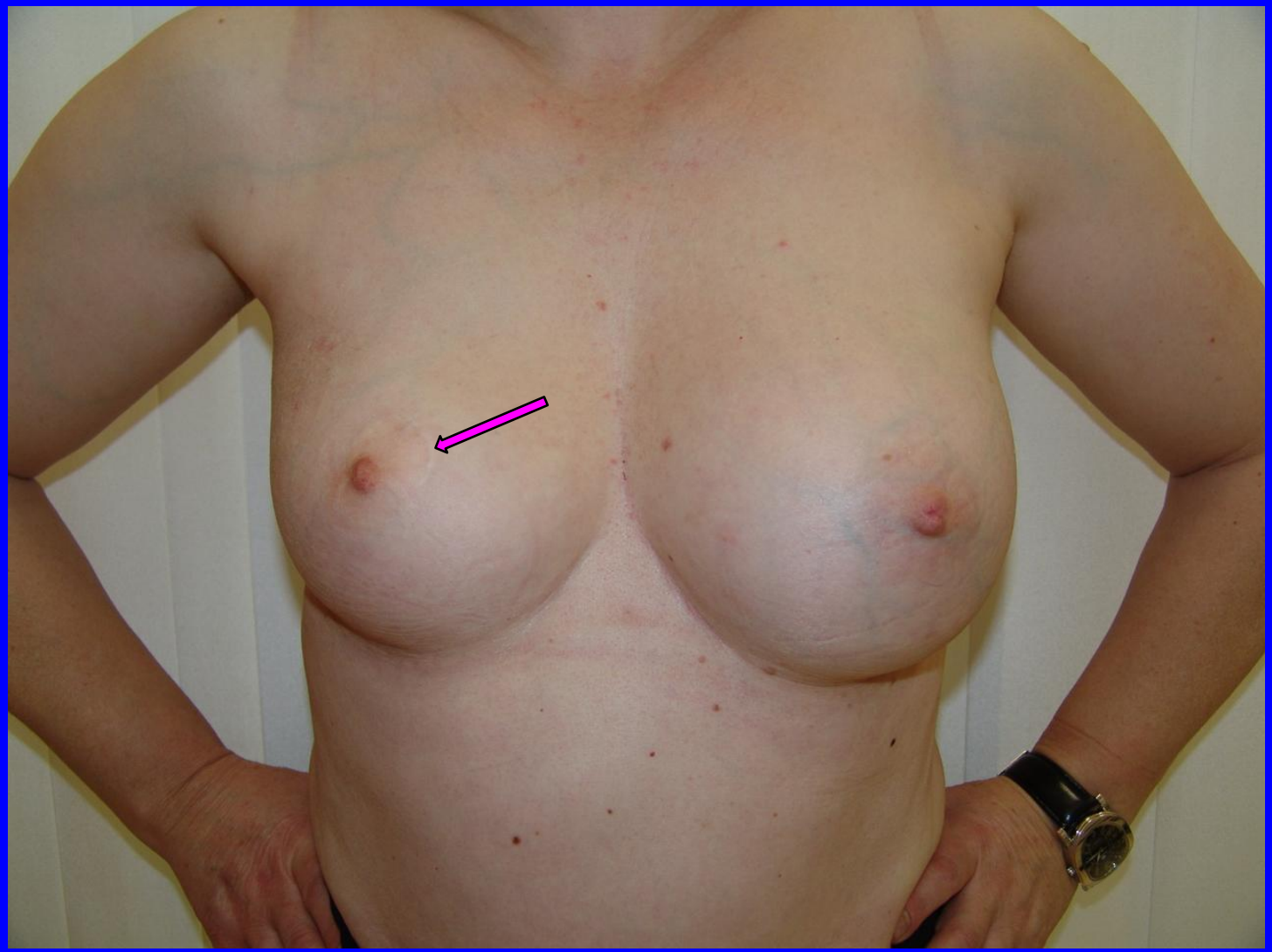
Overall recurrences

Recurrence well accepted in the literature is 1% per year



- **Ductal Invasive U I Q in august 1996**
- **DCIS U O Q in january 2006**

The patient growed 20 kg after 1° surgery so that the radiated right breast increased less than the left



Distant Cosmetic Results


8 4 2009

Distant Cosmetic Results

Distant Cosmetic Results

ADVANTAGES OF US GUIDED SURGERY

- Indipendent planning of surgery according the lobar anatomy
- IO Localization
- Absence of needle dislocation
- Precise planning of incision
- Better anatomic orientation
- Less resection of breast tissue
- Less reintervention for axillary dissection (6%)
- Fewer recurrences (1.3% absolute in 23 ys f-u)
- Less hospitalization (24 hours)
- Patient return sooner to a normal lifestyle
- Cosmesis is improved
- Better ratio cost/benefit

At moment technology should aids in:

- **early diagnosis**
- **shortening operating times**
- **decreasing the size of patient's incision**
- **reducing the procedure's invasiveness and saving health tissues**

All of these can lead to better patient outcomes and faster recoveries

Despite the widespread availability of US equipment in breast centers worldwide its use as surgical tool in the operating room still remains reserved to few surgeons specially trained in this technique and its utility greatly depends on the skill of the operator. The lack of well trained and experienced breast surgeons in US technique has limited, until now, the routine utilization and also didn't allowed a multicentric clinical trial on US guided surgery.