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Queenstown/New Zealand

MR-guided intervention

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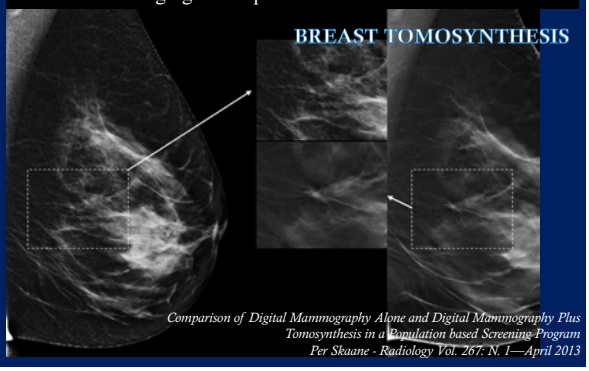
UNIVERSITÀ DI ROMA

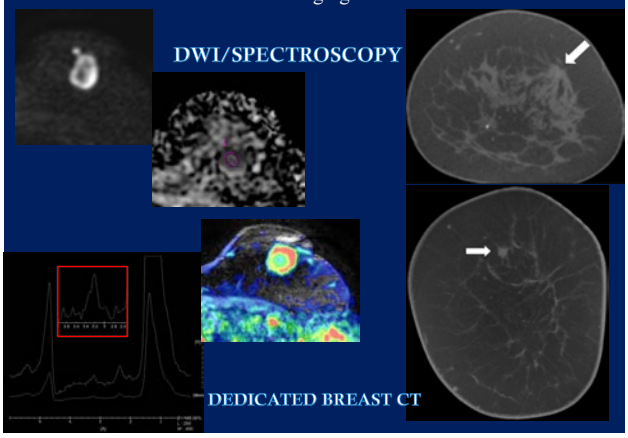
BACKGROUND

Early diagnosis of breast cancer thanks to technical advances of conventional imaging techniques...



Comparison of Digital Mammography Alone and Digital Mammography Plus Tomosynthesis in a Population based Screening Program
Per Skaane - Radiology Vol. 267: N. 1—April 2013

…and the introduction of new imaging methods.



Magnetic Resonance Imaging

Despite in majority of cases MX and US are able to provide the correct diagnosis…

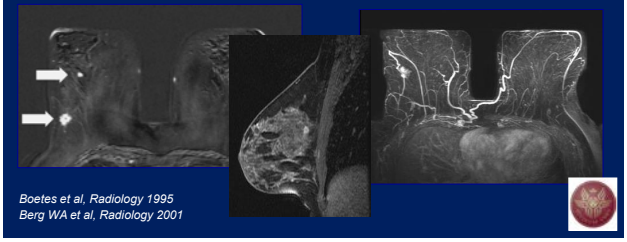
…sometime a lesion can remain hidden until a more accurate examination is performed

Very small lesion
Dense Mx
Inconclusive US scan /second look

Magnetic Resonance Imaging

Breast MR imaging is a highly sensitive technique (94%-100%) for detection of breast cancer.

It can commonly find lesions that are occult on mammograms and US scans



Boetes et al, Radiology 1995
Berg WA et al, Radiology 2001

Radiology

Linda R. LaTrenta, MD
Jennifer H. Menell, MD
Elizabeth A. Morris, MD
Andrea F. Abramson, MD
D. David Dershaw, MD
Laura Liberman, MD

Breast Lesions Detected with MR Imaging: Utility and Histopathologic Importance of Identification with US[1]

Retrospective study on 64 pts and 93 suspicious lesions at MRI (0.9 mm)

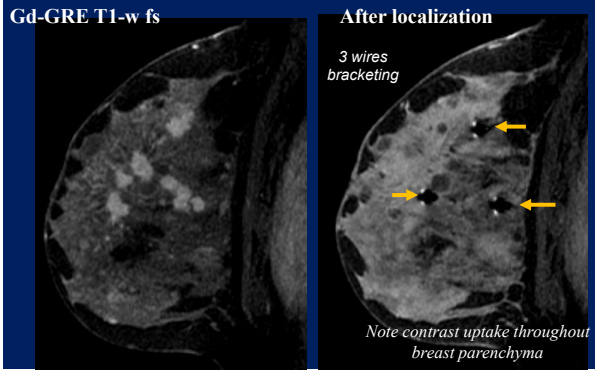
TABLE 1
Presence of US Correlate versus Lesion Type and Histologic Category in (21) of 93 Lesions

Lesion Characteristics	No. with US Correlate	*P* Value	Median Size (cm)
Type			
Mass	19/76 (25)	.34	0.8
Nonmass	2/17 (12)		2.9
Histologic type			
Benign	12/74 (16)	.01	0.9
Malignant	9/19 (47)	.35	1.0
DCIS	2/7 (29)		0.9
Invasive	7/12 (58)		1.3

Note.—Numbers in parentheses are percentages.

MR-guided Biopsy

Wire localization of occult multifocal carcinoma



ACR PRACTICE PARAMETER FOR THE PERFORMANCE OF MAGNETICRESONANCE IMAGING-GUIDED BREAST INTERVENTIONAL PROCEDURES

INDICATIONS FOR MRI-GUIDED BREAST BIOPSY

1. Lesions not seen on MX or US or only seen with certainty on breast MRI
   a. highly suggestive of malignancy (BI-RADS 5)
   b. suspicious abnormalities (BI-RADS 4)
   c. probably benign (BI-RADS 3) only when there are valid clinical indications or when short term interval imaging follow-up would be difficult or unreasonable.

ACR PRACTICE PARAMETER FOR THE PERFORMANCE OF MAGNETICRESONANCE IMAGING-GUIDED BREAST INTERVENTIONAL PROCEDURES

INDICATIONS FOR MRI-GUIDED BREAST BIOPSY

2. Repeat biopsy

Repeat MRI-guided percutaneous sampling is an alternative to surgical biopsy in cases when the initial biopsy results are non-diagnostic or are discordant with the imaging findings.

ACR PRACTICE PARAMETER FOR THE PERFORMANCE OF MAGNETICRESONANCE IMAGING-GUIDED BREAST INTERVENTIONAL PROCEDURES

INDICATIONS FOR MRI-GUIDED BREAST BIOPSY

3. MRI-guided pre-surgical needle localization

a. To guide excision of malignant lesions seen only on MRI or with discordant or non-diagnostic findings on MRI-guided core biopsy.

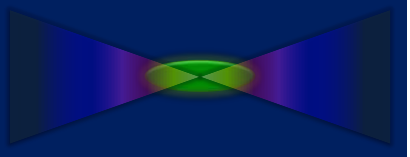
b. For lesions that are not technically amenable to MRI-guided core biopsy due to their location in the breast or the size of the breast.

c. To allow complete excision of an MRI-demonstrated malignancy or high risk lesion when its extent is larger than outlined on mammography or ultrasound, or by previous clip placement.

MR-guided Intervention

From diagnosis…

…To treatment



NON-INVASIVE ABLATION

Several publications focusing on new non-invasive approaches for breast cancer treatment

DIFFERENT WAYS TO ABLATE TISSUE

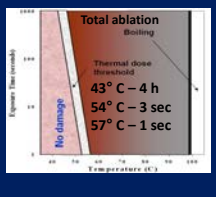
- ✓ **Interstitial Laser Therapy (ILT)**
- ✓ **RadioFrequency Ablation (RFA)**
- ✓ **High Focused Ultrasound (HIFU)**
- ✓ **Cryotherapy**

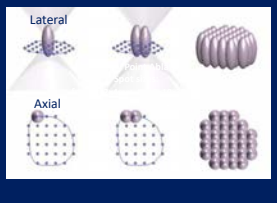
cause tissue necrosis by increasing the temperature

causes tissue necrosis by a rapid temperature decrease

HIGH-INTENSITY FOCUSED ULTRASOUND

A high-energy focused ultrasound beam rapidly generate a substantial increase in local tissue temperatures (>60°) by converting acoustic energy into heat. Consequences are protein denaturation and coagulation necrosis of target tissue with no damage to surrounding structures.

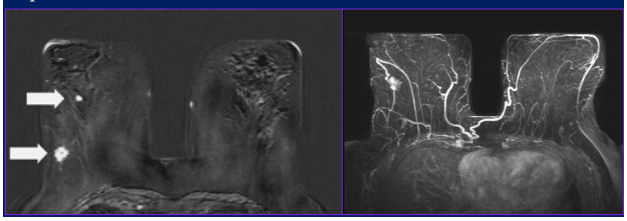




MAGNETIC RESONANCE

Technique of choice for breast cancer imaging

- ***Higher accuracy compared to mammography and US***
- ***Better evaluation of tumor shape and dimensions***
- ***Depiction of synchronus lesions***
- ***Details on neo-angiogenesis***
- ***Best imaging technique for the evaluation response of non-invasive procedures***



MRgFUS

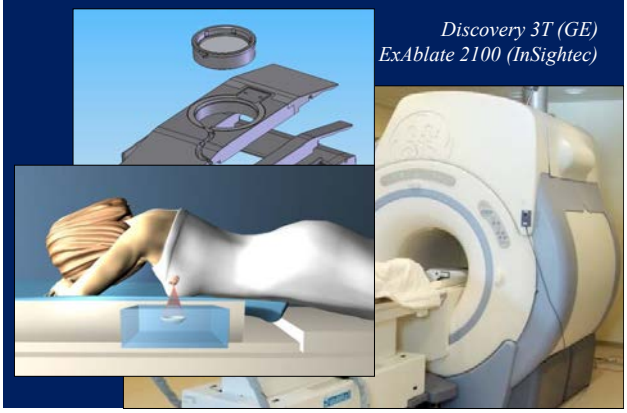
- MRI-guided focused ultrasound (MRgFUS) is a noninvasive thermal ablation method that uses magnetic resonance imaging (MRI) for target definition, treatment planning, and control of energy deposition.
- Integrating FUS and MRI as a therapy delivery system allows to localize, target, and monitor in real time, and thus to ablate targeted tissue without damaging normal structures .

MR guided Focused Ultrasound

Technical aspects and patient positioning

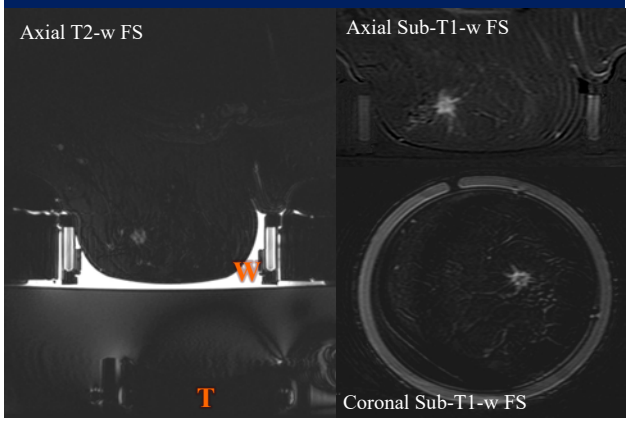
MR-GUIDANCE ADVANTAGES

Patient positioning



Discovery 3T (GE)
ExAblate 2100 (InSightec)

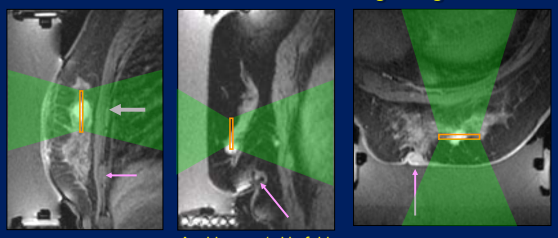
PATIENT POSITIONING



MRgFUS for *Breast* Cancer

3D anatomic views for planning treatment region

Make sure the treatment window is big enough

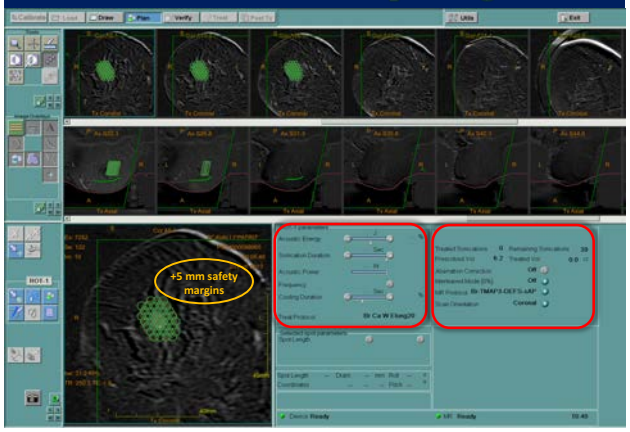


Avoid far field bone

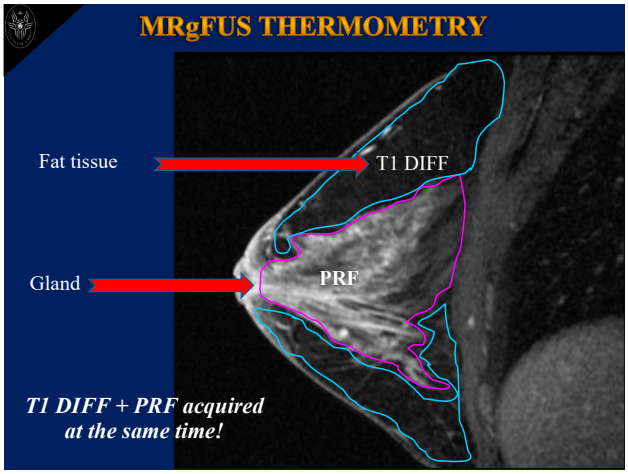
Avoid scars / skin folds and surgical clips

Avoid nipple

Automatic treatment planning



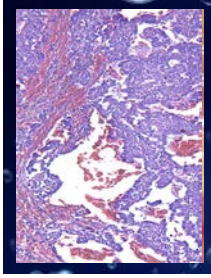
MRgFUS THERMOMETRY



T1 DIFF + PRF acquired at the same time!

CAVITATION

Development of vapor cavity in a tissue that is the consequence of high energy levels. forces acting upon the liquid.



When subjected to high pressure, the bubble can implode and generate an intense and unpredictable shockwave.

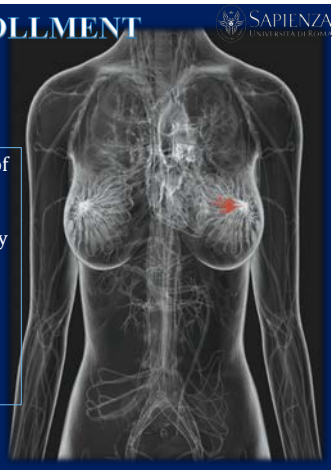
Then it should be avoided in breast cancer MRgFUS treatments

→ **Acoustic Power < 100 W**

MR guided Focused Ultrasound

Personal Experience

Pt ENROLLMENT

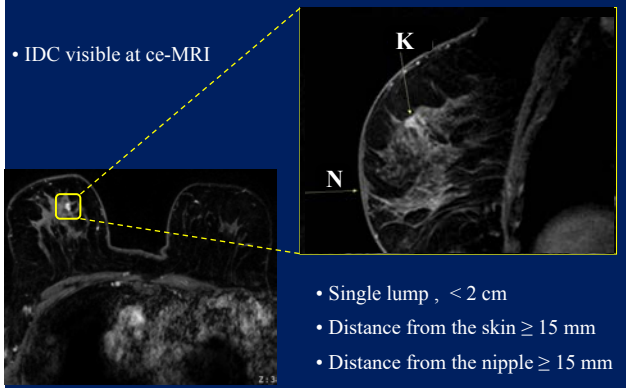


12 patients

- Biopsy-proven single focus of Invasive Ductal Carcinoma.
- No personal or family history suggesting BRCA1/2 gene mutation.
- No evidence of suspicious axillary lymph nodes at imaging.

MRGFUS TECHNIQUE
- *INCLUSION CRITERIA*-

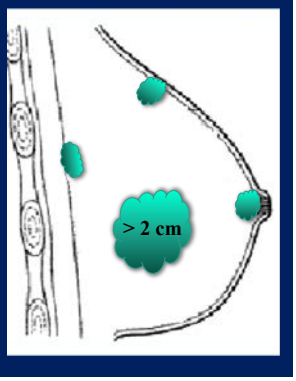
- IDC visible at ce-MRI



- Single lump , < 2 cm
- Distance from the skin ≥ 15 mm
- Distance from the nipple ≥ 15 mm

MRGFUS TECHNIQUE
- *EXCLUSION CRITERIA*-

- **Invasive lobular carcinoma, in situ ductal carcinoma (microcalcifications)**
- **Non-accessible lesions**
- **Breast implants**
- **Ca intolerance**
- **MR non-compatible devices**
- **Claustrophobia and position**



STUDY PROTOCOL

Fat-sat Ax T2-weighted TSE
Fat-sat T1 3D GRE at least on 2 planes
↓
Gd injection
↓
Fat-sat T1 3D GRE on the same planes
→ subtracted images

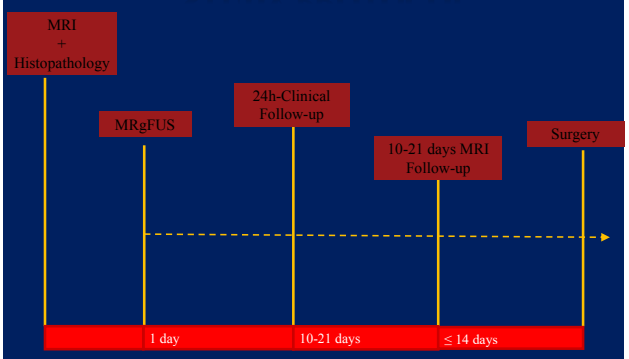
DEPICTION OF LESION DIMENSIONS AND BORDERS

FUS Treatment

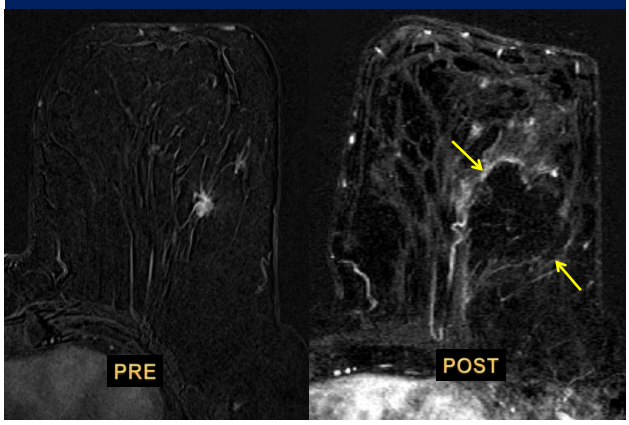
EVALUATION OF TREATMENT EFFICACY

Fat-sat Ax T2-weighted TSE
Fat-sat T1 3D GRE at least on 2 planes
↓
Gd injection
↓
Fat-sat T1 3D GRE on the same planes
→ subtracted images

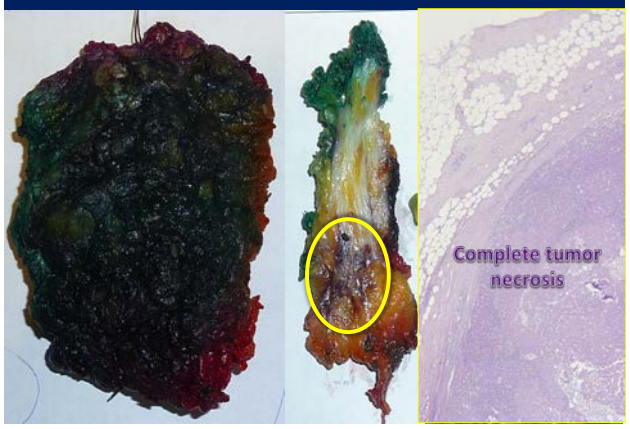
STUDY PROTOCOL



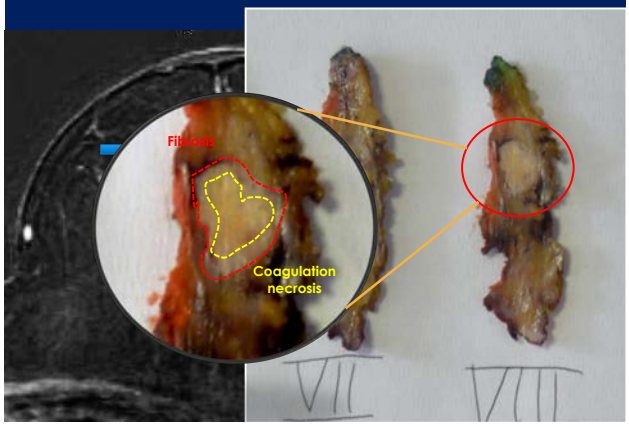
F, 53 yo, left breast IDC



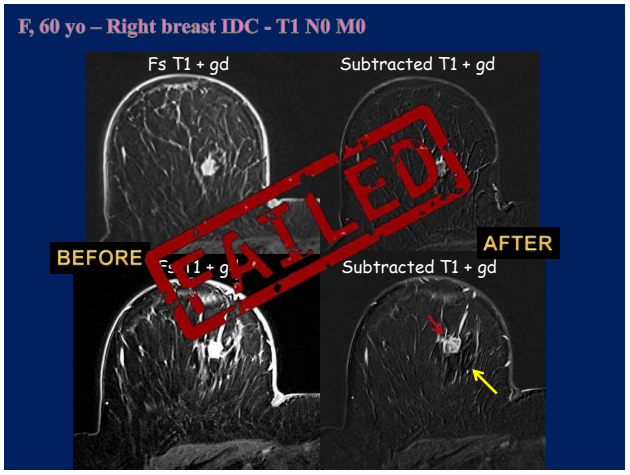
F, 48 yo, left breast IDC



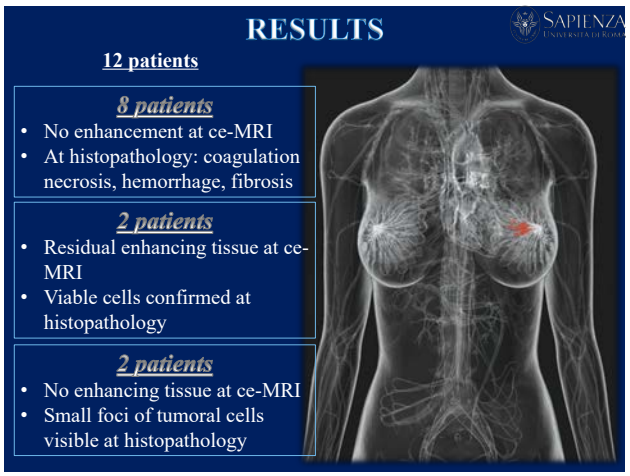
F, 52 yo, left breast IDC



F, 60 yo – Right breast IDC - T1 N0 M0



RESULTS



12 patients

8 patients

- No enhancement at ce-MRI
- At histopathology: coagulation necrosis, hemorrhage, fibrosis

2 patients

- Residual enhancing tissue at ce-MRI
- Viable cells confirmed at histopathology

2 patients

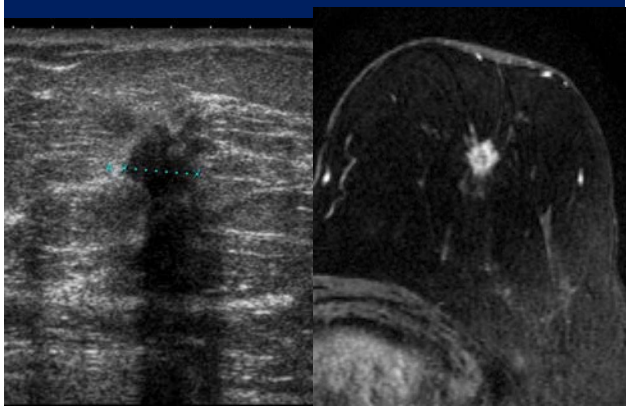
- No enhancing tissue at ce-MRI
- Small foci of tumoral cells visible at histopathology

PATIENT MANAGEMENT

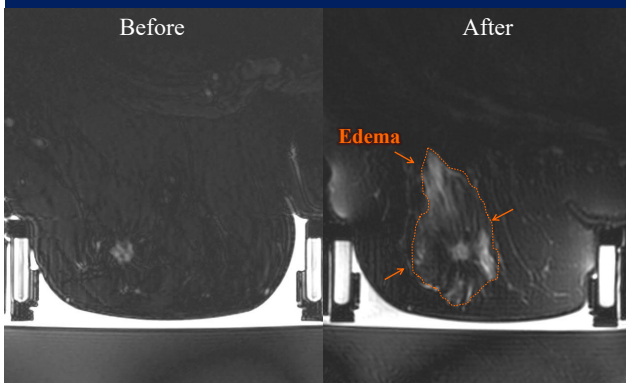
Patient may feel:

- ✓ Skin heat
- ✓ Heat during sonication
- ✓ Rib discomfort/pain
- ✓ Discomfort due to prone position

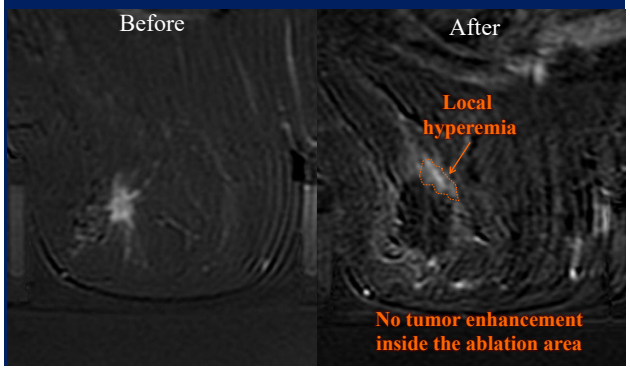
F, 56 yo - 9 mm IDC on the left breast



MRI EVALUATION AFTER TREATMENT
Axial T2-w FS



MRI EVALUATION AFTER TREATMENT
Post-GD FS T1 GRE



RESULTS FROM THE LITERATURE

J Vasc Interv Radiol. 2003 Oct;14(10):1275-82.

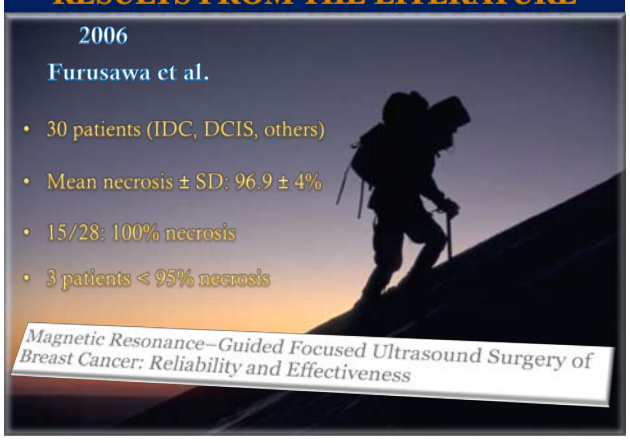
Feasibility of magnetic resonance imaging-guided focused ultrasound surgery as an adjunct to tamoxifen therapy in high-risk surgical patients with breast carcinoma.

Gianfelice D[1], Khiat A, Boulanger Y, Amara M, Belblidia A.

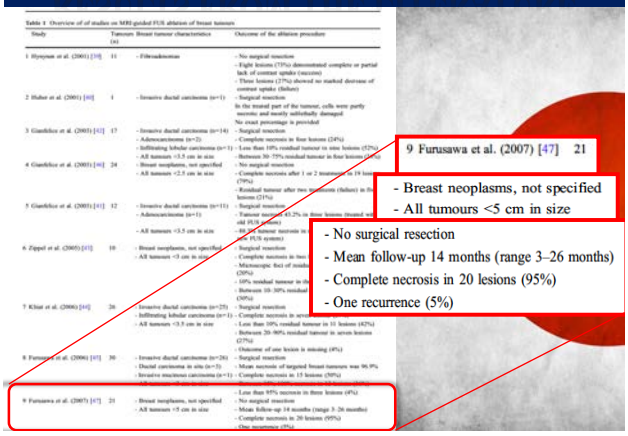
- 24 patients
- NO SURGERY (high risk or refused)
- Possibility of 2° treatment
- FU with imaging and biopsy

- Absence of MR enhancement
- 1 minor complication
- 19/24 negative biopsy
- 3/5 residual tumor

RESULTS FROM THE LITERATURE



RESULTS FROM THE LITERATURE

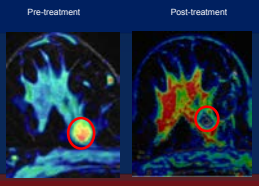


9 Furusawa et al. (2007) [47] 21

- Breast neoplasms, not specified
- All tumours <5 cm in size
- No surgical resection
- Mean follow-up 14 months (range 3–26 months)
- Complete necrosis in 20 lesions (95%)
- One recurrence (5%)

RESULTS *Breast*

- Non-invasive alternative to surgical "lumpectomy"
- Ambulatory, single session procedure
- Over 300 patients treated in Phase I/II trials, up to 48 months follow-up
- Patients treated with MRgFUS, followed by adjuvant therapy
- No recurrences; no severe adverse events



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SOME CONSIDERATIONS…

ORIGINAL ARTICLE

Breast Focused Ultrasound Surgery With Magnetic Resonance Guidance

Eva C. Gombos, MD, Daniel F. Kacher, MS,* Hidemi Furusawa, MD,† and Kiyoshi Namba, MD†*

1) Need for pre-treatment biopsy with immunochemestry

enhanced MRI must replace histopathology. As no additional tissue is obtained, the histological diagnosis and tumor markers (estrogen and progesterone receptor status and HER2-Neu status) must be determined from the pretreatment core biopsy. Additional tissue can be taken at core biopsy for

Magnetic resonance thermal monitoring may be challenging in a breast that is of predominantly fatty composition.[33] Proton resonance frequency shift techniques work in aqueous tissue, but not in fatty tissue. Moreover, subtraction-

2) Difficult thermometry in fatty breasts.

3) Possibility of incomplete ablation.

There is a possibility of residual viable cancer cells with MRgFUS; however, residual tumor is a frequent finding with surgical removal and reexcision: in 50% or more of lumpectomies, the margins are inadequate, involved, or close. Histopathologic studies also demonstrated that histologically negative or close biopsy margins do not guarantee complete excision.[39,40]

SOME CONSIDERATIONS…

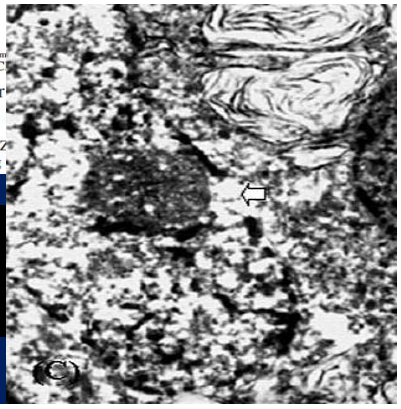
Excerpta Medica

The Am
Cl

Heat fixation of cancer ultrasound

Feng Wu, M.D., Ph.D.[a,*], Z
Zhong-Lin Xu, M.D.[b], Qiang

The use of electronic microscopy and NADH-diaphorase demonstrated no viability in those cells.



A RECENT REVIEW OF LITERATURE…

European Radiology
pp 1–12

Technical success, technique efficacy and complications of minimally-invasive imaging-guided percutaneous ablation procedures of breast cancer: A systematic review and meta-analysis

Authors

Giovanni Mauri, Luca Maria Sconfienza, Lorenzo Carlo Pescatori, Maria Paola Fedeli, Marco Ali, Giovanni Di Leo, Francesco Sardanelli

Forty-five studies were analysed, including 1,156 patients and 1,168 lesions.

Radiofrequency, microwaves, laser, cryoablation and high-intensity focused ultrasound were used.

Mauri, G., Sconfienza, L.M., Pescatori, L.C. et al. Eur Radiol (2017).

A RECENT REVIEW OF LITERATURE…

Results:

- **Pooled technical success was 96%** (95%CI 94–97%) [laser=98% (95–99%); HIFU=96% (90–98%); radiofrequency=96% (93–97%); cryoablation=95% (90–98%); microwave=93% (81–98%)].
- **Pooled technique efficacy was 75%** (67–81%) [radiofrequency=82% (74–88); cryoablation=75% (51–90); laser=59% (35–79); HIFU=49% (26–74)].
- **Major complications pooled rate was 6%** (4–8).
- **Minor complications pooled rate was 8%** (5–13%).

Mauri, G., Sconfienza, L.M., Pescatori, L.C. et al. Eur Radiol (2017).

A RECENT REVIEW OF LITERATURE…

Conclusions:

Imaging-guided percutaneous ablation techniques of breast cancer have a high rate of technical success, while technique efficacy remains suboptimal.

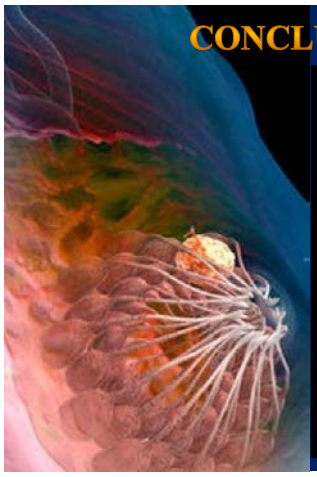
Key Points:

• Imaging-guided ablation techniques for breast cancer are 96% technically successful.

• Overall technique efficacy rate is 75% but largely inhomogeneous among studies.

• Overall major and minor complication rates are low (6–8%).

Mauri, G., Sconfienza, L.M., Pescatori, L.C. et al. Eur Radiol (2017).



CONCLUSIONS

- ✓ **Valid alternative to conservative surgery**
- ✓ **Non-invasive, incisioneless, safe**
- ✓ **Conscious sedation, no hospitalization nor general anesthesia**
- ✓ **No ionizing radiations**
- ✓ **Well tolerated, rapid return to normal daily activities for the patient**
- ✓ **Improvement in quality of life**