Flexible RF Surface Coils for Enhanced Breast Imaging

Melanie Florez[1], Sydney Hankel[1], Alina Jelinski[1], Aleesha Rhodes[1]
Dr. SungMin Sohn, PhD[1]
School of Biological and Health Systems Engineering, Arizona State University

Background

1 in 8 women in the United States have a chance of developing breast cancer [1]. Acquiring imaging is the first step in a patients journey and 9.7% of women undergoing breast MRI encounter false positives due to artifacts / misinterpretations which can be attributed to low Signal-to-Noise Ratio (SNR). Additionally, 64% of women experience pain or discomfort during scans [2].

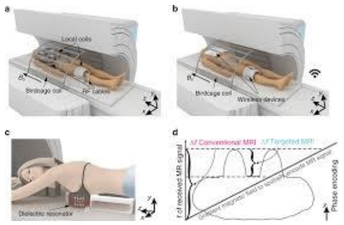

Figure 1: Traditional MRI rigid breast coil, patient in prone position. [3]

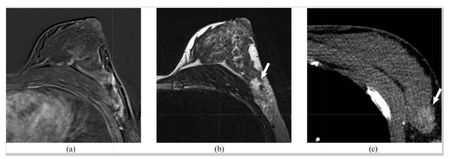

Figure 2: Clinically palpable breast cancer [4]
(a) does not show any mass
(b) T2 weighted image shows palpable mass, but has irregular margins
(c) CT scan shows mass clearly

Our mission is to provide quality imaging and comfort for every patient.

Product Specifications

Customer Needs	Specifications	Metrics
Patient Comfort	Reduce pain/discomfort during scan	Switch to from prone to supine positioning
Image Quality	Superior SNR	≥1 fold SNR gain
Coil Flexibility	Flexible to conform to patients body	Elasticity, Young's Modulus
Calibration/ Tuning	Auto decoupling to ensure coils resonate at desired frequency	↓ signal loss, ↑ SNR, 127.7 MHz for 3.0 T scanner
Safety	Thermal Management	SAR: ≤ 1 C° increase in temperature
Durability	Lifespan of product	Tensile Strength
Ease of Positioning	Easy for technician to adjust on patient	Yes

Product Concept and Design

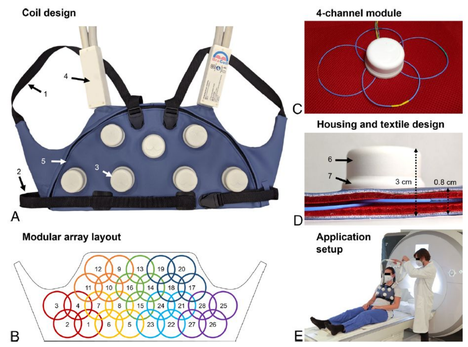

Figure 3: Example of "BraCoil", adjustable for all patients integrated with 28 elements organized in seven 4-channel modules [5].

Our device aims to improve upon the existing BraCoil prototype by focusing on enhanced patient comfort through the use of lighter, stretchable materials. In addition, we will utilize copper wire for improved adaptability, flexibility and imaging performance.

Virtual Prototyping / Models

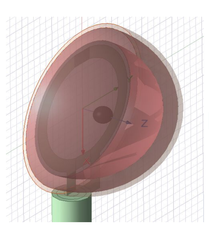

Figure 4: Breast Phantom model in Ansys-HFSS

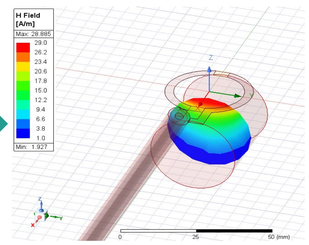

Figure 5: Example Magnetic field simulation

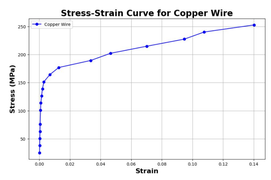

Figure 6: Stress-Strain curve for copper wire

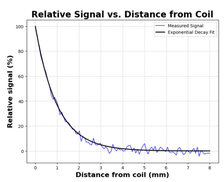

Figure 7: Inverse square law showing distance effect on relative signal

Manufacturing

The flexible copper coil loops with be 5 cm in diameter and embedded within 3 layers: a padding layer for comfort, semi-rigid silicone for coil stability and a flexible, durable fabric for patient adaptability.

Technical Models & Product

Resonant Frequency: $$f = \frac{1}{2\pi\sqrt{LC}}$$

Quality Factor: $$Q = \frac{\omega L}{R}$$

Where Q = (Maximum Energy Stored)/(Average Energy Dissipated per Cycle)

Stress-Strain Relationship: $$\sigma = E\varepsilon$$

Inverse Square Law: $$I \propto \frac{1}{r^2}$$

Design Status / Future Steps

Our team is currently working on developing a single coil loop with flexible copper wire to compare its imaging performance against rigid single coil loop. Simultaneously we are running simulations to analyze differences in imaging quality and how to optimize signal-to-noise ratio. Future steps include a 4 channel system testing with ASU's 9.4 T MRI scanner for SNR.

Acknowledgments

Special thanks to our faculty mentor Dr. SuhnMin Sohn, the Arizona State University's Biomedical Engineering Department, Capstone advisors, and industry mentors for their support and guidance in developing a more comfortable imaging experience for breast cancer diagnostics.

QR Codes / References

Project TImeline-Gantt Chart | **House of Quality** | **Business Model** | **References**