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Computational Modeling of Patient-Specific Healing & Deformation After Breast-Conserving Surgery Using MRI

MRI-informed mechanobiology model predicts post-lumpectomy healing/deformation to personalize care and reduce reoperations.

Breast cancer is one of the most diagnosed cancers in women, with 1 in 8 women receiving a diagnosis for breast cancer within their lifetime. As technology has advanced, survival rates have improved dramatically, thus leading to a growing emphasis on long-term treatment outcomes and enhancing quality of life for breast cancer patients. Currently for early-stage breast cancer, breast-conserving surgery (BCS) is the standard of care. However, BCS can lead to highly variable tissue remodeling and result in visible breast deformation or asymmetry, as the tissue repair process is very complex and patient characteristics greatly impact post-operative healing. Cosmetic outcomes have also been shown to play a large role in patient psychological well-being and overall quality of life. Researchers at Purdue University have created a more advanced mechanobiological computational model that builds on their previously developed computational model of breast cavity healing by incorporating clinical MRI data to better predict post-operative healing and deformation. This model feeds into machine learning surrogate models to evaluate the accuracy of post-BCS outcomes based on patient characteristics. This technology can lead to more personalized treatment plans, reduced risk of post-surgical complications, and minimized need for additional procedures. Additionally, this technology could be applied to other surgeries requiring the wound healing process.

Technology Validation:

-Machine learning models were trained on 20 iterations of randomized 150 training samples and then evaluated with 13 test samples. Breast surface deformation results had mean absolute error of 3.48%, and cavity contraction had root mean square error of 0.046.

-Complementary qualitative review of modeling outcomes by 5 reviewers showed agreeable results (81.23% agreement)

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Advantages

-Model can serve to guide personalized treatment as it considers a patient's MRI information prior to surgery

-Currently considers factors like age, diabetes, smoking, radiation therapy, collagen regenerative tissue filler, cavity margin during model building, which is more advanced than other models out there currently

-Can also account for heterogeneous tissue, angiogenesis, and the inflammatory response

Applications

-Can potentially be extended to other surgeries requiring wound healing response

Publications

Harbin Z, Sohutskay D, Vanderlaan E, Fontaine M, Mendenhall C, Fisher C, Voytik-Harbin S, Tepole AB. Computational mechanobiology model evaluating healing of postoperative cavities following breast-conserving surgery. Computers in biology and medicine. 2023 Oct 1;165:107342.

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Intellectual Property:

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