

# An Example of Computational Surgery: Multi-Scale Modeling of Breast Conservative Therapy

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Computational surgery is the application of mathematic and algorithm enabling technology in imaging, robotic and simulation, from first biological and physical principles in order to improve surgery on patients.

We will present such a computational framework for breast cancer.

According to the world health organization breast cancer is the top cancer in women both in the developed and the developing world: It is estimated that 519 000 women died in 2004 due to breast cancer. Increase life expectancy, increase urbanization and adoption of western lifestyles seems to play a role in the observed growth of breast cancer cases in the developing world. Improving breast cancer outcome and survival depends critically on early detection. The treatment of early breast stage carcinoma will usually involve mastectomy (complete breast removal) or alternatively lumpectomy (only tumor removal), more commonly referenced as Breast Conserving Surgery (BCS). Lumpectomy followed by radiotherapy is labeled as Breast Conserving Therapy (BCT). The goal of BCT is to achieve local control of the cancer as well as to preserve a breast that satisfies the woman's cosmetic concerns.

The complex interplay between mechanical forces due to gravity, breast tissue constitutive law distribution, and internal stress generated by the healing process play a dominant role in determining the success or failure of lumpectomy in preserving the breast shape.

We have developed a multi-scale model that couple several descriptions including imaging analysis reconstruction, soft tissue dynamic in the short time scale and healing processes in the long time scale.

One consider three distinct period of time that follows lumpectomy. First there is the immediate mechanical response of breast deformation under various gravity conditions due to tissue resection. Second the wound may exercises an internal pressure due to the accumulation of liquid for a period of time when inflammation occurs. Third a longer period of time where wound closure will progress and be companion by the generation of some internal mechanical stress during tissue formation and remodeling. This process may lead to a reduction of volume of the breast. It is the overall multi-step path followed by wound recovery all along that may result in cosmetic problems that impact the quality of life of patients.