Bridging the gap in Breast Cancer surgical planning and aesthetic outcome prediction: The European PICTURE Trial

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Breast cancer is the most common cancer in women. According to recent worldwide data, this disease accounted for 23% (1.38 million) of the total new cancer cases [1]. The incidence is rising in most countries [2].

Since breast cancer is an increasingly treatable disease and 10-year survival now exceeds 80%, many women will live a long time with the aesthetic consequences of their treatment. Majority of women with early breast cancer are offered breast conserving surgery as an alternative to the classic mastectomy. This conservative approach, combined with radiotherapy, has made local control of the disease possible, with survival rates similar to those obtained with mastectomy, but with better aesthetic result [3,4].

The increase in breast conserving surgery imposes greater expectations from patients on the quality of their aesthetic surgical outcome. Oncoplastic surgery has developed to address this issue.

Whilst the oncological outcome of breast conservation procedures can easily be assessed objectively, the aesthetic outcome does not yet have an agreed evaluation standard. The assessment of the aesthetic result, as a means to evaluate one of the aspects of treatment quality, has become essential to any institution performing breast cancer treatment [5].

Clinical context and tools for surgical planning

The aesthetic results and patients' Quality of Life (QoL) have become fundamental objectives in breast conserving surgery. There are a number of factors affecting the aesthetic outcome after breast conserving surgery. These can broadly be divided into patient, tumour, and treatment-related factors.

Current standard of care in surgical planning of breast surgery is the preoperative localisation of the tumour either based on palpation, ultrasound or on x-ray mammography. Before the operation, the surgical plan is drawn manually onto the skin of the patient, during the operation the surgeon is guided by these drawings.

There is a lack of universally accepted tools for surgical planning in helping patients to choose between available operative techniques. Moreover it is not easy to demonstrate to patients the aesthetic image of the treatment result. The patient's own perceptions about the results of her surgery may not concur with the perception of a third party [4]. Published results show that about 30% of patients are dissatisfied with their aesthetic outcome [6]. It is of paramount importance that patients should have realistic expectations from the outcome of surgery and for that they should have access to a tool that could demonstrate how the aesthetic outcome would be in their own situation using different techniques.

There is a need for development of better tools for surgical planning in breast conserving surgery, and tailored to the individual patient. The combination of 3D photography and routinely acquired radiological images (i.e. mammography, ultrasound and MRI, when available), together with biomechanical modelling and MR elastography, will go a long way to addressing these requirements. Such tools can be used for surgical planning, and to objectively predict and subsequently evaluate the individual patients' aesthetic outcome after treatment which can empower patients in the decision making process.

The PICTURE Project

The PICTURE project funded by the European Union FP7 programme aims to bridge the current gap and address the unmet needs in this area. This is a collaborative project between 5 Partners

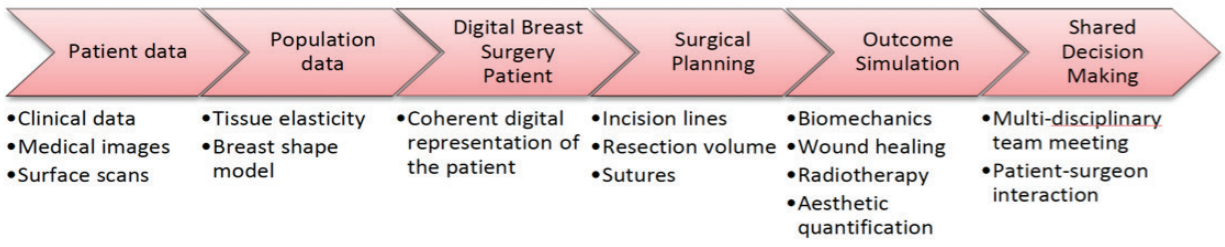

Figure 1: Processing chain of the PICTURE demonstrator.

in 7 Institutions within Europe.

The main aim of the project is to build a demonstrator system for planning and optimising breast conserving surgery.

The primary objective of the PICTURE project is thus the clinical demonstration and validation by building a software for planning and optimising breast-conserving surgery. The demonstrator will be used for three clinical tasks:

1. To predict suitability of patients for breast conserving surgery and the likely aesthetic outcome of the procedure,
2. To communicate the information on the type of breast surgery available and empower patients to take an active role in the shared decision making process,
3. To objectively evaluate the patient's aesthetic result after treatment in comparison with the predicted outcome.

This is achieved by integrating patient-specific imaging data, photographs, tissue parameters, and patient-specific treatment plans with anatomical models, statistical shape models, biomechanical models, models of treatment response, and models of aesthetic outcome for use in patient care, basic research, and shared decision making.

How is this achieved?

It is achieved by a creation of a coherent representation of the patient's health status related to breast surgery, the Digital Breast Surgery Patient. In the breast cancer care pathway, a patient undergoes many different types of examinations before a diagnosis is established and before a treatment decision is taken. These examinations range from manually palpating the breast to modern medical imaging. Each of these examinations produces relevant data on the health status of the patient. In addition, other data of the patient must be included, e.g. non-image data like age, body mass index, staging etc. How to process these data and to combine it in a coherent way with physiological models is an unsolved question and is tackled within the PICTURE project. The Digital Breast Surgery Patient will be the point of integration for

- all the patient specific data (imaging as well as non-imaging),
- patient specific data, but derived from (imaging) data,
- population based statistical data,
- biophysical tissue models.

(Figure 1)

In the scope of PICTURE, we aim to make the outcome of breast-conserving surgery more predictive. In the pre-operative workflow, surgical planning is an essential step. Here, the surgeon uses the available information to define the details of the planned operation, e.g. tumour position, resection margins, surgical technique, etc.

PICTURE will therefore develop tools for the interaction with the Digital Breast Surgery Patient during surgical planning, which allow visualisation of the procedure as well as the predicted outcome.

Special emphasis will be given to a visualisation of the planning result not only for the eyes of the surgeon, but also for use during the surgeon/patient interaction in a shared-decision-making setting (Figure 2).

Development of criteria to assess the result of a breast-conserving surgery from the perspective of cosmesis is another important aim of the project. PICTURE will investigate these criteria with the help of a consensus evaluation on patient data. Once objective criteria are known, the corresponding features are derived from the information in the Digital Breast Surgery Patient.

PICTURE will hence develop a module to (semi-) automatically determine these features from patient images or surface scans. In the surgical planning process, this module will be used on the result of a biophysical simulation to quantify the aesthetic outcome of a given surgical plan.

After almost three years of dedicated work by collaborating centres; we are pleased announce the launch of our demonstrator at the Royal Free London Hospitals NHS Foundation Trust.

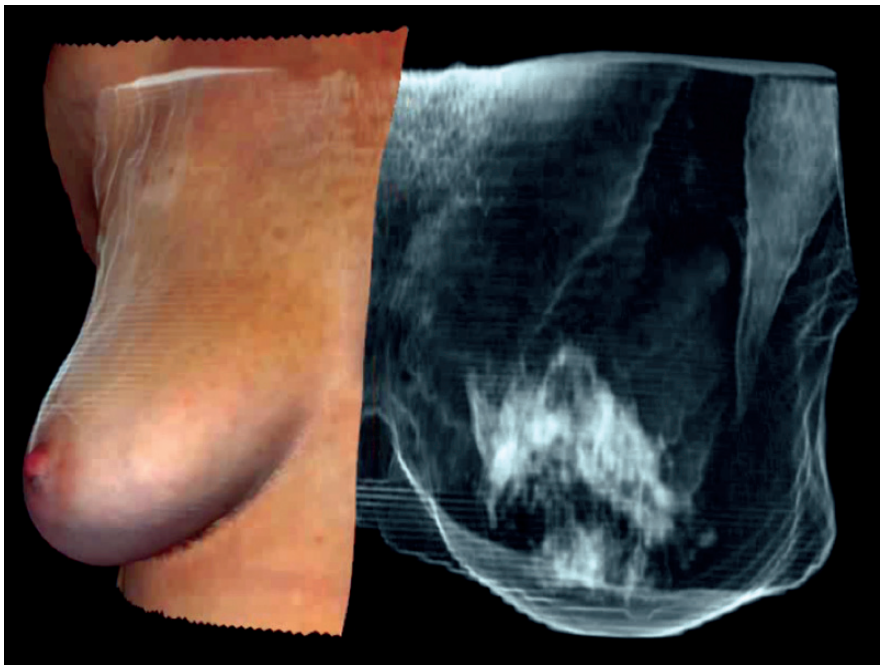

Figure 2: Fusion of upright 3D photography and prone MRI enables a realistic surface rendering of the surgical simulation to be presented to the patient, using a patient specific biomechanical model of the breast anatomy.

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