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Original article

The value of 3D images in the aesthetic evaluation of breast cancer conservative treatment. Results from a prospective multicentric clinical trial

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ABSTRACT

Purpose: BCCT.core (**B**reast **C**ancer **C**onservative **T**reatment. **co**smetic **re**sults) is a software created for the objective evaluation of aesthetic result of breast cancer conservative treatment using a single patient frontal photography. The lack of volume information has been one criticism, as the use of 3D information might improve accuracy in aesthetic evaluation. In this study, we have evaluated the added value of 3D information to two methods of aesthetic evaluation: a panel of experts; and an augmented version of the computational model - BCCT.core3d.

Material and methods: Within the scope of EU Seventh Framework Programme Project PICTURE, 2D and 3D images from 106 patients from three clinical centres were evaluated by a panel of 17 experts and the BCCT.core. Agreement between all methods was calculated using the kappa (K) and weighted kappa (wK) statistics.

Results: Subjective agreement between 2D and 3D individual evaluation was fair to moderate. The agreement between the expert classification and the BCCT.core software with both 2D and 3D features was also fair to moderate.

Conclusions: The inclusion of 3D images did not add significant information to the aesthetic evaluation either by the panel or the software. Evaluation of aesthetic outcome can be performed using of the BCCT.core software, with a single frontal image.

1. Introduction

Breast cancer conservative treatment (BCCT), including breast conserving surgery and breast radiotherapy, is the gold standard treatment for early breast cancer. It is expected to gain even more popularity as recent publications of large retrospective database series show that BCCT has not only identical results in terms of disease free and overall survival (OS), but may possibly result in a better outcome compared to mastectomy [1,2]. The indications for BCCT have also expanded, associated with an increase in the types of surgical and radiotherapy techniques available, although many have not been rigorously evaluated. There is, however, also a challenge to this success story. Although BCCT is very easily evaluated in oncological terms (re-excision rate, number of recurrences, disease-free survival and OS), the aesthetic outcome, one of the main reasons for its existence, is very difficult to evaluate and a standard evaluation method is still missing [3]. The absence of a widely accepted standardized tool for the aesthetic evaluation of BCCT limits the applicability of any comparative analysis of cosmetic outcome, resulting in a gap in the quality control of this important parameter. Methods for evaluating the cosmetic result are traditionally considered to be either subjective or objective.

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Results of subjective evaluation show only a modest inter-observer agreement [4]. Objective methods increase the reproducibility of the assessment, but it has been argued that they do not take into account the global appearance of aesthetic results, as they include only a limited number of measures [5].

The BCCT.core software was developed to provide an objective and automatic evaluation of aesthetic results based on parameters extracted from 2D photographs, such as breast asymmetry, skin colour and scar [6]. The aim was to develop a simple to use, reproducible and widely available methodology, enabling an effective comparison of outcomes between centres and allowing a cost-effective method for quality control of this fundamental outcome of BCCT. The BCCT.core software has gained popularity due to its user-friendly interface and its use has increased steadily in the last five years [7].

One of the often-mentioned limitations of BCCT.core is related to the lack of volume information (3D) as the current version of the BCCT.core software uses a frontal-only photographic view of the patient. No evaluation is done on the side or oblique views [8]. Such images were deliberately not included due to the difficulty in standardizing these additional positions during image acquisition.

Since the launch of BCCT.core, there have been dramatic improvements in the capabilities of RGB-D (red-green-blue plus depth) cameras, which provide both RGB and depth information in each image pixel (as in Microsoft Kinect) [9]. Combining depth and colour information is challenging, but opens new possibilities in different fields, including medical applications [10]. Several research groups have made considerable progress in dealing with 3D depth scans and camera images; the technology has advanced to a point where advantage can be taken of these improvements [11].

In the current work, we investigated if by adding 3D information, the aesthetic outcome was evaluated more accurately subjectively by human experts and objectively by computational models.

2. Material and methods

This study was performed within the scope of the EU-Seventh Framework Programme FP7-ICT-2011-9-600948 Acronym PICTURE Project (http://vph-picture.eu/). Written informed consent was obtained from 106 women who had undergone BCCT (classic conserving surgery and radiotherapy) for early breast cancer with a follow-up of more than one year from three clinical centres (Royal Free Hospital, UK; Champalimaud Cancer Center, Portugal; Leiden University Medical Center, The Netherlands) – ClinicalTrials.gov – NCT02310984 – Picture Breast XS. Each woman was assigned a study-specific unique identifier to maintain confidentiality.

A digital camera (Canon EOS 1100D, red-green-blue components) was used for the acquisition of 2D images (Fig. 1). All anonymised 2D images were sent for evaluation to the PICTURE panel of expert evaluators selected based on their previous experience in this type of evaluation [12] (Table 1). Individual panel experts were not told the names of other experts in the panel until the conclusion of the study. The evaluators classified each image according to the Harris Scale into excellent, good, fair and poor [13]. Results were combined centrally and it was determined that a consensus had been reached for each case when at least 9 experts (over 50%) gave identical scores.

Microsoft Kinect (red-green-blue components, plus depth sensor data) images were acquired continuously (and simultaneously unless interference was encountered) while the patient made a full 180° rotation between lateral views, performed as smoothly as the patient was capable of performing (Fig. 2). Subsequently, a 3D model was generated and the models of all patients were evaluated by the PICTURE expert panel without reference to the previously evaluated 2D images (Fig. 3).

A new aesthetic evaluation model (BCCT.core3d) was developed, integrating volumetric information extracted from depth data with the information already used in the BCCT.core. The BCCT.core and the BCCT.core3d score were determined for all patients, followed by a comparison between the 2 scores.

A paired *t*-test was performed to determine if the agreement strength was statistically different between the 2D and 3D evaluation [14]. The observations have been paired and the mean differences compared. To determine agreement between the classification systems, we calculated the kappa (K) and weighted kappa (wK) statistics, the latter allowing some deviation from perfect agreement (0 – no agreement; 0.01–0.20 slight agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 substantial agreement, 0.81–0.99 almost perfect agreement; 1 – perfect agreement) [15].

3. Results

3.1. Panel 2D versus 3D evaluation

In evaluating the 2D images, the panel reached a consensus in 99 patients. The result was scored as excellent in 40 patients, good

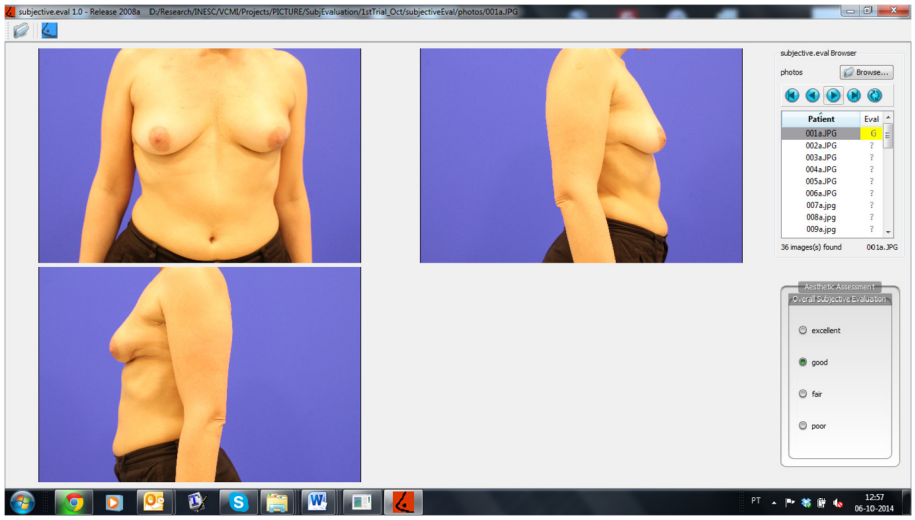

Fig. 1. 2D images (face and lateral views) for subjective evaluation – Software for experts with 2D case display of all views and classification online.