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# The breast cancer conservative treatment. Cosmetic results – BCCT.core – Software for objective assessment of esthetic outcome in breast cancer conservative treatment: A narrative review

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## ABSTRACT

**Background and objective:** Cosmetic outcome of breast cancer conservative treatment (BCCT) remains without a standard evaluation method. Subjective methods, in spite of their low reproducibility, continue to be the most frequently used. Objective methods, although more reproducible, seem unable to translate all the subtleties involved in cosmetic outcome. The breast cancer conservative treatment cosmetic results (BCCT.core) software was developed in 2007 to try to overcome these pitfalls. The software is a semi-automatic objective tool that evaluates asymmetry, color differences and scar visibility using patient's digital pictures. The purpose of this work is to review the use of the BCCT.core software since its availability in 2007 and to put forward future developments.

**Methods:** All the online requests for BCCT.core use were registered from June 2007 to December 2014. For each request the department, city and country as well as user intention (clinical use/research or both) were questioned. A literature search was performed in Medline, Google Scholar and ISI Web of Knowledge for all publications using and citing "BCCT.core".

**Results:** During this period 102 centers have requested the software essentially for clinical use. The BCCT.core software was used in 19 full published papers and in 29 conference abstracts.

**Conclusions:** The BCCT.core is a user friendly semi-automatic method for the objective evaluation of BCCT. The number of online requests and publications have been steadily increasing turning this computer program into the most frequently used tool for the objective cosmetic evaluation of BCCT.

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## 1. Introduction

Breast cancer conservative treatment (BCCT) has become the preferred treatment for early breast cancer with identical overall survival to mastectomy but with a predicted better cosmetic outcome [1,2]. However, 30% of the patients submitted to BCCT have fair to poor cosmetic outcomes [3]. To be able to improve these results, there is the need to fully understand the elements that have an impact in cosmetic outcome. The uprise in recent years of new surgical and radiation techniques turned matters even more difficult, since it is necessary to adequately inform patients of probable cosmetic outcomes that will certainly turn out to be more diverse and difficult to classify [4,5].

However, in spite of its recognized importance, cosmetic outcome of BCCT remains without a standard evaluation tool [6,7]. Innumerable attempts have been made to optimize/standardize cosmetic evaluation of BCCT, but a standard tool has never been recognized by the medical/scientific community. This is most probably due to the fact that cosmetic outcome is a highly subjective concept involving innumerable aspects and subtleties difficult to quantify with simple resources [8].

Subjective evaluation by medical experts of patients, photographs or patient self-assessment are the most frequent methods used to report cosmetic outcome in BCCT [9]. However, subjective evaluation when performed by a panel of observers, which is the most frequent approach, has very low reproducibility values and it is both a difficult and time consuming procedure [10]. Self-assessment on the contrary is easy but usually translates Quality of Life (QOL) issues more effectively than a reproducible value of cosmetic outcome [11,12].

Objective measurements performed manually, in patients or photographs, tried to overcome the low reproducibility values associated with subjective methods but, unfortunately, lacked practicality and were merely based in asymmetry [13,14]. More recently two software programs were developed for the esthetic evaluation of results in BCCT: the BCCT.core [15] and the Breast Analyzing Tool (BAT) [16]. Both make use of a face-only photographic view of the patient and were developed to overcome the lack of reproducibility observed with subjective visual evaluation. The BAT considers only asymmetry measurements while the BCCT.core analyzes several parameters related to asymmetry, color differences and scar appearance [17]. Only the BCCT.core software is actually available for request and use. After manually positioning the reference points on the patient face view image (semi-automatic), the program calculates automatically 14 asymmetry, 8 color and 8 scar features showed in the display (Fig. 1). Finally, machine learning techniques were used to find the best subset of measures and the best relation between them, classifying each case in one of four classes (excellent, good, fair or poor) [18]. The software can be used either to extract individual or multiple measurements or to make use of the created algorithm to calculate the final classification of cosmetic outcome.

In spite of the easiness of the objective evaluation and due to the absence of a recognized gold standard evaluation

method, the majority of authors still use, as advised by the EORTC manual from 2004 [7], a combination of both subjective and objective evaluations with the intention of having a more robust appreciation and, as a consequence, higher reproducibility values [19,20]. Unfortunately, this approach is time consuming rendering the routine evaluation of cosmetic outcome in clinical practice difficult, especially in larger series.

In this work we intend to give the readers an overview of the current use of the BCCT.core software as well as the related published work trying to make proof of its utility as an easy and reproducible method to evaluate the most important quantifiable aspects of cosmetic outcome in BCCT.

## 2. Materials and methods

The BCCT.core software is available online for free download after the signature of a license agreement through the website of the Breast Research Group at INESC Porto (<http://medicalresearch.inescporto.pt/breastresearch>) since June 2007.

All individuals/groups/services/departments requesting the software have been asked for identity information (position, center, city) and reason for requesting the software (clinical, research or both).

A detailed search has been conducted in Medline, Google Scholar and ISI Web of Knowledge using “BCCT.core” as the search term and including references from June 2007 to October 2014.

## 3. Results

From June 2007 to October 2014, 102 centers from all five continents have requested and signed the license agreement for the BCCT.core software use. Europe has been the frontrunner continent in the BCCT.core request (Table 1).

Breast Surgery has been the request leader by specialty, but all other specialties involved in the treatment of breast cancer are also represented (Table 2). The data about the intended use of BCCT.core was often left empty.

Nineteen full papers have been published with the specific use of the BCCT.core as a method for cosmetic evaluation of outcome. Twelve of those 19 papers are from independent groups that developed and published their work without our cooperation [21–32]. Four papers are the reference papers from our group [15,17,33,34] and the remaining 3 are the result of a cooperation between our own and other groups using the software and having team members as co-authors [12,35,36]. These papers correspond to 184 Web of Science citations. Twenty nine abstracts were published in indexed journals also using the BCCT.core as method of cosmetic evaluation (Table 3).

## 4. Discussion

Cosmetic outcome is undoubtedly a very important but difficult topic. How can a sole method translate the complexity of all factors involved in the global cosmetic result? There will probably never be a tool that encompasses all that complexity.

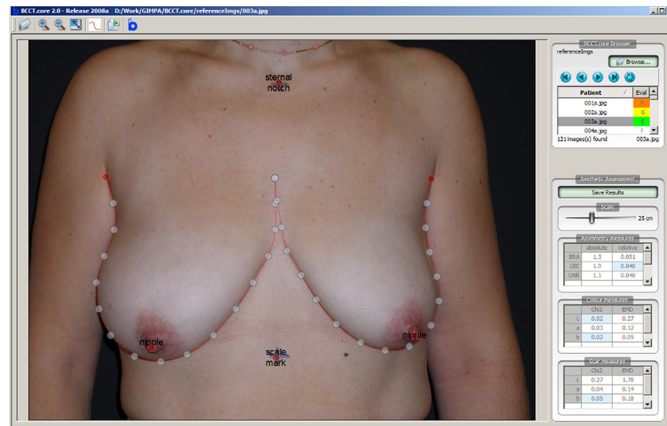


Fig. 1 – The BCCT.core screen layout.

Table 1 – Request by Continent/Country.		
Continent	Country	N
Africa (N = 2)	Egypt	2
America (N = 15)	Argentina	1
	Brazil	5
	Canada	2
	Mexico	1
	USA	6
Asia (N = 19)	China	1
	India	5
	Israel	2
	Japan	6
	Korea	4
	Thailand	1
Europe (N = 61)	Belgium	4
	Czech Republic	1
	Denmark	3
	France	3
	Germany	7
	Hungary	1
	Iceland	1
	Ireland	2
	Italy	2
	Norway	1
	Poland	4
	Portugal	4
	Spain	6
	Switzerland	3
	The Netherlands	9
UK	10	
Oceania (N = 5)	Australia	5
Total		102

Table 2 – Request by Department/Service.	
Department/Service	N
Breast surgery	25
General surgery	18
Gynecology	4
Medical oncology	5
Medical physics	2
Plastic surgery	17
Radiation oncology	18
Surgical oncology	9
Others	4
Total	102

Yet we still need a method that, even without being the most perfect, still is highly reproducible, easy to apply, not expensive and, additionally, is able to translate the most important factors responsible for the final esthetic result [6].

Subjective methods have been leading the way in this journey in spite of their low reproducibility values and the additional difficulty and cost associated with the need of having more than one observer, ideally a mixed panel [37].

Self-assessment was and still is considered by many the most important form of evaluation. If a patient is satisfied with the result why should we undertake changings in our practice? The answer is easy: unfortunately this self-assessment has very low reproducibility values and is much more dependent of the psycho-social adjustment than of the real cosmetic outcome [12,19].

Manual objective measurements were supposed to answer all the previous issues but were never established as an isolated evaluation tool because clinicians thought that basing cosmetic evaluation only on asymmetry measurements was a simplification of the process not capable of translating the huge complexity of cosmetic evaluation [5,9,38].

To make matters more difficult there was a push toward the use of all three methods together (subjective, objective and self-assessment) to be able to have a more complete evaluation [7]. Very likely true but very difficult to apply in studies with large series of patients and even more difficult in standard clinical practice.

With the development of new radiotherapy techniques and new oncoplastic surgical techniques, cosmetic evaluation is progressively becoming one of the most important aspects of outcome. We need to understand, in the short and long run, how the cosmetic result will be. This cosmetic result will be certainly one of the major factors that will help in the decision of the best technique to choose in each case both by caregivers and caretakers.

This was the idea behind the development of the BCCT.core software. We needed an inexpensive tool that could include all

**Table 3 – Publications as full papers and abstracts in conferences: Using the BCCT.core and citing the software in the publication<sup>a</sup>. Typical venues include the European Journal of Cancer Supplements (9 publications), The Breast (6), European Journal of Surgical Oncology (6), and International Journal of Radiation Oncology\*Biography\*Physics (4).**

		Full papers	Web of Science Citations (by Feb 2015)	Conferences
Using the BCCT.core software	Our Group	4	126	8
	Cooperation	3	3	5
	Independent	12	55	16
Total		19	184	29

<sup>a</sup> The complete list, periodically updated, can be found at <http://medicalresearch.inescporto.pt/breastresearch/BCCTcore/bibtexbrowser.php?bib=BCCTcoreUsers.bib>.

the most important features that we recognize as important in the evaluation of cosmetic outcome [15]. The simplification of the process was mandatory. No photographic studios, with costly material, no 3D scans. Plain and simple digital face view photographs in a normal environment. The capacity of automatically measuring the most important differences between breasts (asymmetry, color differences and scar visibility). With the use of a previous dataset of cases evaluated by a panel of experts [37], an algorithm was created to allow the allocation of each case into one of the four classes of the Harris scale (excellent, good, fair and poor). The first publication describing the tool was published in 2007 and immediately after that, the software was made available online for download after a license agreement [33].

The main criticism to the software was and still is related to the fact that it does not include oblique or lateral views. However lateral views did not prove to add strong additional value as we published in a subsequent paper comparing face-view only to four views with software and observers evaluation [34]. We agree that volume information is important and can add another dimension to the evaluation as published by Eder et al. in 2012 but 3D evaluation continues to be very difficult to generalize due to acquisition conditions and cost [21].

Self assessment, in spite of being the least reproducible method, continues to be one of the most popular forms of cosmetic evaluation. Self evaluation was compared in one publication co-authored by our group with the BCCT.core software [12]. The inter-rater reliability for the semi-automated BCCT.core was very good with agreement rates up to 84%. The agreement rates of the BCCT.core and the Breast Cancer Treatment Outcome Scale – Esthetic Status was only moderate. The patients, as expected, judged their esthetic outcome more positively than the software.

Probably the more significant published work using the software and showing comparable performance to the more popular subjective evaluation and to the standard simple objective measurement is the one by Hau et al. in 2012 using all available methods for cosmetic outcome: subjective panel evaluation; objective BRA measurement; BCCT.core evaluation; self-assessment. The methods were used in a subset of 385 patients from the St George and Wollongong randomized breast boost trial. Except for patient self-assessment all other three forms of evaluation showed similar performances giving the BCCT.core software the advantage derived from the simplicity of use [24].

One additional advantage of the software is the capacity of using single or multiple feature evaluation without the use of the built algorithm that allocates cases into one of four classes

(excellent, good, fair or poor). Clinicians can simply extract the measures they need. That was the case of the works published by Immink et al. in 2012 and Lyngholm et al. in 2013 [29,35].

In 2012, Immink et al. used some of the BCCT.core software features to evaluate the long-term cosmetic changes after breast-conserving treatment of patients included in the EORTC ‘boost versus no boost’ trial. The study evaluated a subset of 348 patients using seven asymmetry measurements that were posteriorly correlated with patient, tumor and treatment factors [35]. Similarly Lyngholm et al. in 2013 used only BRA measured by the BCCT.core software in 214 patients from the study of long-term follow-up of late morbidity, cosmetic outcome and body image after breast conserving therapy from the Danish Breast Cancer Cooperative Group (DBCG), demonstrating that breast asymmetry was the only significant factor correlated to clinician evaluation of cosmesis in multivariate analysis [29].

The design and usability of BCCT.core have been already reported by us elsewhere [39]. Additionally, several independent groups also highlight those features of BCCT.core [24,25,36]. The very good usability of BCCT.core, the flexibility to extract detailed measures that can be individually used in exhaustive statistical analysis, and the effective evaluation of the overall cosmetic outcome, are encouraging, we believe, the permanent shift to objective methods: some groups have already reported results with BCCT.core in more than one study.

Many of the recent requests of the software have been applied to other techniques besides BCCT, especially new oncoplastic approaches like replacement volume techniques with latissimus dorsi and also displacement volume techniques essentially using local flaps [26,27,30,32]. Although results are promising, we must be cautious because published series are relatively small. It is logical to expect identical performance in these settings but we must wait for further results especially when researchers use the algorithm constructed for BCCT and not the extracted individual features.

## 5. Conclusion

During the last 8 years the BCCT.core software has made proof of its value through requests and publications. It does not pretend to encompass all aspects of cosmetic outcome of BCCT but, to this moment, represents the only low cost and reproducible solution, easy to apply that allows users to have a fast and reasonable result in the objective evaluation of patients’ cosmetic outcomes.

All the algorithms used on the BCCT.core software have been developed in a specific database of images. Our current work aims to validate the algorithms in an international image database that will make a more consistent proof of software ability to correctly evaluate cosmetic outcome of BCCT.

In an interrelated line of research, the algorithms at the core of BCCT.core are currently being integrated in the demonstrator of the PICTURE project. PICTURE (Patient Information Combined for the Assessment of Specific Surgical Outcomes in Breast Cancer) is funded by the European Community's Seventh Framework Programme and aims to support the patient-specific planning, evaluation, prediction, and quantification of the outcome of breast-conserving surgery.

### Conflicts of interest

Maria João Cardoso and Jaime Santos Cardoso are the main researchers involved in the development of the BCCT.core software.

The BCCT.core is available for download free of charge. No commercial interests exist.

Helder Oliveira and Pedro Gouveia declare no conflicts of interest.

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