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ORIGINAL ARTICLE

The Assessment of the Magnitude of Frontal Plane Postural Changes in Breast Cancer Patients After Breast-Conserving Therapy or Mastectomy – Follow-up Results 1 Year After the Surgical Procedure

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Abstract Breast cancer is the most common malignancy in Polish women. Management of breast cancer includes surgical treatment as well as adjuvant chemotherapy, radiotherapy, hormonal therapy, and combination regimens. One of the adverse consequences of oncological management of breast cancer may involve changes in frontal plane body posture. The objective of the study was to assess the frontal plane body posture changes in women treated for breast cancer. A prospective study including 101 of female breast cancer patients subjected to surgical treatment in the period from October 2011 to October 2012 (mastectomy was performed in 51 cases while breast conserving therapy was administered in the remaining 50 cases). The body posture in the frontal plane was assessed using the computer-assisted postural assessment system with Moiré fringe analysis. No statistically significant differences were observed in pre-operational postural parameters of interest. Exam II revealed highly significant differences in SLA values; results suggesting more pronounced dysfunction were observed in the MAS group. Exam III revealed highly significant differences in PIA, SH, SD and SLA values; results suggesting more pronounced dysfunction were observed in the MAS group. Undesirable postural changes occur both in women who were treated with radical mastectomy and in those who underwent breast-conserving surgery; breast-conserving surgery is associated with decreased severity in postural abnormalities;

Keywords Breast conserving therapy · Mastectomy · Computed-assisted postural assessment · Body posture · Frontal plane

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Introduction

Breast cancer is the most common malignancy in Polish women. Primary management of breast cancer includes surgical treatment including mastectomy of breast conserving therapy. A number of adverse effects, including lymphoedema, limited shoulder mobility, spinal pains, scar adhesion at surgical site, and muscle cramps are observed following surgical management of breast cancer. These factors may lead to the adoption of pain-avoiding positions and postural changes. Breast cancer treatment includes surgical methods as well as adjuvant therapies such as chemotherapy, radiotherapy, or hormonal therapy. An adverse consequence of surgical and adjuvant treatments may consist in changes leading to restrictions in everyday activities and the range of motion within the upper limb [1, 2]. These result in disturbed torso balance and changes in frontal plane body posture.

The objective of the study was to compare the frontal plane postural disorders 1 year after surgical treatment of breast cancer in female patients treated by means of mastectomy (MAS) or breast conserving therapy (BCT). This was

achieved by means of computer-assisted postural assessment with Moiré fringe analysis.

Methods

The study was conducted pursuant to the approval of the local bioethics committee (The Bioethics Committee of the Medical College of the Nicolaus Copernicus University, decision no. KB 226/2011) from October 2011 to October 2013. The study group consisted of 101 female patients treated for breast cancer at the Clinical Department of Breast Cancers and Breast Reconstruction Surgery of Bydgoszcz Oncology Center: 51 patients underwent mastectomy (MAS) while the remaining 50 were subjected to breast conserving treatment with sentinel node dissection (BCT). Body weights and heights of patients were measured before the study. The obtained values were used in calculation of body mass index (BMI) values of each patient.

The body posture was evaluated by means of a computer-assisted postural assessment system (CAPS) with Moiré fringe analysis.

Patient inclusion criteria were as follows:

- provision of an informed consent to participate in a research study;
- patient age between 25 and 70 years.

Patient exclusion criteria were as follows:

- diseases of the nervous or musculoskeletal system;
- history of bodily injuries resulting in permanent alteration of normal body posture (or injuries that occurred during the treatment);
- bone metastases;
- the necessity to radicalize the treatment while in the study (i.e., to perform mastectomy in a patient following previous breast conservation therapy);
- breast reconstruction surgery while in the study;
- intake of medications that affect bodily balance.

Photogrammetric examinations were performed on three occasions:

- Exam I – on the day before the surgical procedure,
- Exam II – 2 months after the surgical procedure; no adjuvant treatment had been initiated by that time,
- Exam III – 1 year after the surgical procedure.

The characteristics of the clinical material, individual postural parameters were presented using the basic descriptive statistics (mean, standard deviation, median). PQStat statistical software package ver. 1.4.2.324 was used for the analysis of results. Age, body weight, height and BMI values were compared between the MAS and BCT using Mann-Whitney's *U*-test. In qualitative scales, MAS and BCT groups were compared using the chi-square test. The obtained postural parameters were compared between the MAS and BCT using Mann-Whitney's *U*-test. Friedman's test and Dunn's post-hoc test were used for in-group comparisons between individual exams (I, II, III). The choice of non-parametric methods of data analysis were preceded by verification of normal distribution using the Shapiro-Wilk's test and of the uniformity of variance using the Levene's test. Test statistic probability of $p<0.05$ was considered significant while test statistic probability of $p<0.01$ was considered highly significant.

Results

No statistically significant differences were observed in the age, body weight, height and BMI values of patients in both groups. Table 1 presents a detailed analysis of distribution of the above parameters.

The study group was characterized in terms of adjuvant treatment received. All study patients were subjected to post-operative treatment. The most common type of adjuvant treatment in both the MAS and the BCT group included combination of CHTH and RTH. The least common types of adjuvant therapy were radiotherapy (RTH) in the MAS group and hormonal therapy (HTH) in the BCT group (Table 2).

The following frontal plane body posture parameters were analyzed in detail:

- TIA – trunk imbalance angle determined in posturometric measurements by determination of the deviation of the line connecting the spinous processes of C7–S1 from the vertical axis in the frontal plane (to the right/to the left). TIA values obtained in posturometric measurements are either positive or negative. Absolute TIA values were used for the purposes of statistical analysis.
- PRA – pelvic rotation angle determined in posturometric measurements by comparison of the positions of the protrusions of right posterior superior iliac spine (MR) and left posterior superior iliac spine (ML). If ML protrusion is located above MR, the result is positive while when ML protrusion is located below MR, the result is negative. Absolute values of the PRA were used in the statistical analyses.
- PIA – pelvic inclination angle that describes the inclination of the line connecting the [anterior superior iliac spine and the] posterior superior iliac spine.

Table 1 Somatic characteristics of study patient groups

		Descriptive statistics							Mann-Whitney's *U*-test
		Mean	Standard deviation	Minimum	Lowermost quartile	Median	Uppermost quartile	Maximum	
Age	MAS	54.02	7.91	35.00	50.00	54.00	59.00	69.00	0.4054
	BCT	55.18	9.23	33.00	49.00	55.00	62.00	70.00	
Weight	MAS	72.57	14.84	47.00	61.00	72.00	80.00	120.00	0.5387
	BCT	70.82	12.18	53.00	63.00	70.00	76.00	104.00	
Height	MAS	1.63	0.06	1.50	1.58	1.64	1.68	1.77	0.4468
	BCT	1.62	0.05	1.53	1.58	1.64	1.64	1.74	
BMI	MAS	27.26	5.47	17.26	23.03	26.57	31.62	41.52	0.8785
	BCT	26.92	4.98	19.49	23.42	26.67	28.84	40.63	

- SLA – shoulder line angle that describes the inclination of the line that connects the points determining the position of the right shoulder SR and the left shoulder SL.
- SH – a parameter corresponding to the difference in the heights of inferior scapular angles.
- SD – a parameter describing the distance of the shoulder blades from the spine with the assumption that the spine is a straight line.

Table 3 presents the results that characterized the distribution of the assessed parameters.

The results of our own research revealed no statistically significant differences in the studied frontal plane posture parameters before the surgery. Exam II revealed highly significant differences in PIA and SH and a significant difference in SLA values; results suggesting more pronounced dysfunction were observed in the MAS group. Exam III revealed highly significant differences in PIA, SH, SD and SLA values; results suggesting more pronounced dysfunction were observed in the MAS group.

SLA, SH and SD were the parameters that provided information on the asymmetry of shoulder and shoulder blade positions; the values of these parameters were expressed in millimeters. Highly significant increase in SLA values was observed in the MAS group at exams II and III; a difference in shoulder, albeit less pronounced, was also observed in the BCT group. Distances of the inferior scapular angles from the spine as assessed by the SD parameter were also subject to highly significant increases in both study groups. Changes were also observed in the values of SH parameter that described the difference in the heights of both inferior scapular angles; the increase in this parameter was highly significant in both study groups. Interesting findings were made when comparing the parameters indicating the asymmetry of shoulder and shoulder blade positions between MAS and BCT groups. No significant differences were observed between both groups at Exam I; a significant difference in SLA (poorer results in the MAS group) was observed at Exam II while highly significant differences in SLA, SD, and SH were observed at Exam III (with higher discrepancies being observed in the MAS group).

Table 2 The characteristics of the study groups in terms of adjuvant treatment

Adjuvant treatment	Group		Overall
	MAS	BCT	
CHTH, RTH	27	28	55
% of the study group	52.94 %	56.00 %	
CHTH	14	0	14
% of the study group	27.45 %	0.00 %	
RTH	3	21	24
% of the study group	5.88 %	42.00 %	
HTH	7	1	8
% of the study group	13.73 %	2.00 %	
Overall	51	50	101

MAS group treated by mastectomy, *BCT* group treated by breast conserving therapy, *CHTH* chemotherapy, *RTH* radiotherapy, *HTH* hormone therapy

Discussion

The objective of the study was to determine the frontal plane postural changes in female patients treated for breast cancer by means of mastectomy and breast conserving treatment with sentinel node dissection. The study was conducted using the computer-assisted postural assessment system with Moiré fringe analysis. No postural changes were observed in the study group before the surgery. Two months after the surgery, postural changes were observed in both groups. The analysis of postural deformations in both groups revealed common

Table 3 Analysis of TIA, PRA, PIA, SH, SD, and SLA values measured as part of successive exams within MAS and BCT groups and inter-group relationships

Sagittal plane postural parameters	MAS group				BCT group				Mann-Whitney's *U*-test
	Arithmetic mean				Arithmetic mean				
	I	II	III	F test	I	II	III	F test	
TIA	1.04	1.16	1.29	$p=0.003$	1.07	1.06	1.20	$p=0.037$	I 0.6737 II 0.5500 III 0.8095
PRA	3.13	4.46	5.01	$p<0.01$	3.25	3.50	4.05	$p<0.01$	I 0.6515 II 0.0677 III 0.0757
PIA	0.02	2.01	2.45	$p<0.01$	0.57	0.99	1.21	$p<0.01$	I 0.4468 II 0.0013 III 0.0001
SH	2.68	5.35	7.06	$p<0.01$	2.80	3.21	3.62	$p<0.01$	I 0.3902 II 0.0007 III 0.0000
SD	5.30	6.53	7.91	$p<0.01$	4.93	5.49	6.11	$p<0.01$	I 0.6662 II 0.1470 III 0.0257
SLA	5.51	8.25	10.09	$p<0.01$	5.26	6.03	6.46	$p<0.01$	I 0.6176 II 0.0207 III 0.0002

MAS group treated by mastectomy, *BTC* group treated by breast conserving therapy, *TIA* trunk imbalance angle, *PRA* pelvic rotation angle, *PIA* pelvic inclination angle, *SH* difference in heights of inferior scapular angle, *SD* distance between the scapulae and the spine, *SLA* shoulder line angle

trends in the postures of patients having undergone surgical treatment of breast cancer involving mastectomy or breast conserving treatment. Changes were observed in both groups; although their magnitude was higher in the MAS group. One of the causes of these changes might include dysfunctions within the shoulder region, the shoulder at the operated side being lifted and contralateral shoulder being lowered. These changes are observed both in patients having undergone mastectomy and in patients having undergone the BCT [3]. Changes in shoulder heights were observed in the study. As demonstrated by the study conducted by Yang et al., the most common problem experienced by patients included ulnar joint dysfunctions 3 months after the surgery, thoracic muscle dysfunctions 6 months after the surgery and lymphoedema 12 months after the surgery. The problem of changes in postural parameters within the ulnar joint and chest pertained not only to patients treated by means of mastectomy but also those having undergone BCT as evidenced by increased values of SH, SD and SLA. Disturbances in SLA, SH, and SD values should be related to the surgical intervention that was the cause behind the dysfunctions within the upper body. Normal functioning of upper body is essential for proper conduct of everyday physical tasks [4]. As shown by Crosible, mastectomy results in an asymmetry in the positions of shoulders and shoulder blades, leading to disturbances in spinal kinematics [5, 6]. This has been confirmed in the MAS group in this study. We also demonstrated that the same problem pertained to females treated by BCT including sentinel node dissection procedure. Upper limb dysfunction is a serious aftermath of the surgical treatment of breast cancer. As shown by the studies, the biomechanical function of the joint may disturbed be for as long as 1 year after the procedure [7]. Restricted ulnar joint mobility may occur as early as several weeks after the surgical procedure leading to many adverse effects. The procedure involves a change in the position of the scapula which is drawn toward the front and twisted [8]. Potential causes of the functional changes within the ulnar joint may also include musculofascial disorders associated with irradiation of the pectoral muscle region leading to limited mobility and range of motion of the ulnar joint [9]. Breast conserving treatment is associated with a less extensive surgical intervention. The procedure does not damage the muscle structure while damaging the fascia to a much lower degree than mastectomy; better cosmetic effects may also be achieved [10–12]. As shown in this study, postural changes occurred in study patients despite their having undergone breast conserving therapy. Back pain experienced by female patients after the surgical procedure and intensifying over time is also responsible for postural deformations within the frontal plane. Back pains may lead to adoption of unnatural body positions and lead to changes in pelvic alignment. Changes within the PIA and PRA values were observed in the study

group. Literature reports and describes pain disorders in women after mastectomy while providing no similar data on women after breast conserving procedures [13]. Cancer and cancer treatment are associated with anxiety and stress which may additionally impact the increased muscle tone within the torso [13]. Surgical procedure may lead to transient or permanent damage to the nerves in the surgical area [14].

Can one therefore reduce the magnitude of postural changes? As shown by literature reports, simultaneous breast reconstruction is a warranted procedure that leads to reduced postural changes [15]. The effects of reconstruction can be seen as late as 2 years after the procedure and following the completion of adjuvant treatment. Information on the use of external breast prostheses on postural deformations was provided by the studies of Bąk et al. who demonstrated that the use of such prostheses, also during the night, reduced the magnitude of postural changes in women after mastectomy while not being able to completely eliminate these changes [16].

As shown by this study, changes (i.e., increase) in SLA values were observed in both the MAS and the BCT groups. Changes and deformations within the motor organ in female patients after surgical treatment of breast cancer may also be due to surgical scars. Rigid scars, if not timely mobilized, frequently adheres to chest walls leading to mobility restrictions within the ulnar and spinal joints thus causing postural deformation and changes within the trunk [17]. Patients undergoing surgical treatment, regardless of the treatment type, limit their physical activity which leads to an increase in body weight which also influences postural dysfunctions [18].

Postural defects in both MAS and BCT groups may also be related to adjuvant treatment, particularly radiotherapy. Radiotherapy may lead to skin and subcutaneous tissue disorders within the irradiated area and, by damaging the walls of tiny blood vessels, reduces the flexibility and mobility of the skin and subcutaneous tissue. Another cause of postural deformations may be the tissue fibrosis secondary to adjuvant radiotherapy. In this study, adjuvant radiotherapy was recommended in 30 patients in the MAS group; 49 patients in the BCT group were also subjected to radiation treatment. Radiotherapy is recommended in patients with breast cancer infiltrates following local tumor resection; its efficacy was confirmed in numerous clinical studies [19–22]. Radiotherapy may disturb the mobility of the L-S spinal segment leading to changes in the muscle tone in this region [14].

The use of radiation therapy is associated with adverse effects including swelling of the affected breast or radiation dermatitis. Swelling may persist for 6–12 months after irradiation; adverse effects of radiotherapy may be stronger in patients additionally subjected to chemotherapy. Moreover, by restricting the mobility in the treated region, radiotherapy leads to skeletal disturbances within the spine [23]. This might explain the results obtained in both MAS and BCT groups.

Having analyzed the results of this study one may conclude that both patients subjected to mastectomy and those undergoing BCT with sentinel node dissection require rehabilitation treatment. Largest deviations in the measured postural parameters were observed 2 months after the surgery. No rehabilitation treatment had been initiated by that time, patients after mastectomy had not used breast prostheses and limited their everyday activity.

Conclusions

As shown by the results of this study, it is important to initiate rehabilitation as early as in the preoperative period regardless of the type of the surgical procedure. Rehabilitation should include activities supporting both physical and emotional health; patients must be convinced on the purposefulness of rehabilitation before it is initiated. The necessity of postoperative rehabilitation regardless of type of the surgical procedure was also demonstrated.

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