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Evaluation of Body Posture After Unilateral Mastectomy in Breast Cancer Patients: A Retrospective Single-Center Study

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Abstract

Objective: This study aimed to quantify the pre- and postoperative changes in spinal alignment in patients treated with unilateral mastectomy for breast cancer using the Cobb angle, and to evaluate the long-term postural effects of surgery.
Materials and Methods: This retrospective, single-center study included 29 patients who underwent unilateral simple mastectomy or modified radical mastectomy for histopathologically confirmed breast cancer between January 2, 2020, and September 30, 2024, with a minimum postoperative follow-up of 12 months. Cobb angles were measured from coronal vertebral sections on positron emission tomography-computed tomography scans obtained before and after surgery. Vertebral curvature direction and slope side (ipsilateral, contralateral, or neutral relative to the mastectomy side) were determined. The magnitude of postural change was calculated as the absolute difference between postoperative and preoperative Cobb angles.
Results: The mean age was 53.55 ± 13.32 years, and the mean BMI was 29.33 ± 5.84 kg/m². The mean preoperative Cobb angle was 7.16 ± 7.05°, increasing to 9.03 ± 6.23° postoperatively ($z = 3.353$, $p = 0.001$). Contralateral postural tilt developed in 62.1% of patients. Ten patients (34.5%) exceeded the ≥10° scoliosis threshold postoperatively, compared with seven (24.1%) preoperatively. BMI differed significantly according to slope side ($p = 0.016$).
Conclusion: Measurable postural changes in spinal alignment develop following unilateral mastectomy, predominantly in the contralateral direction. These findings suggest that postural assessment should be integrated into long-term postoperative follow-up, and early rehabilitation strategies should be considered when indicated.

Keywords: Mastectomy; Breast cancer; Cobb angle; Posture; Spinal alignment; Scoliosis

Meme Kanserli Hastalarda Unilateral Mastektomi Sonrası Vücut Postürünün Değerlendirilmesi: Retrospektif Tek Merkezli Çalışma

Özet

Amaç: Bu çalışmada, meme kanseri nedeniyle unilateral mastektomi uygulanan hastalarda ameliyat öncesi ve sonrası spinal dizilim değişikliklerinin Cobb açısı kullanılarak kantitatif olarak değerlendirilmesi ve cerrahinin uzun dönem postüral etkilerinin ortaya konması amaçlanmıştır.
Gereç ve Yöntem: Bu retrospektif, tek merkezli çalışmaya 2 Ocak 2020 ile 30 Eylül 2024 tarihleri arasında histopatolojik olarak doğrulanmış meme kanseri tanısıyla unilateral basit mastektomi veya modifiye radikal mastektomi uygulanan ve ameliyattan en az 12 ay sonra takibi olan 29 hasta dahil edildi. Ameliyat öncesi ve sonrası pozitron emisyon tomografisi-bilgisayarlı tomografi görüntülerinden Cobb açıları ölçüldü. Vertebral eğim yönü ve eğim tarafı (ipsilateral, kontralateral, nötral) mastektomi tarafına göre belirlendi. Postural değişiklik büyüklüğü, ameliyat sonrası ile ameliyat öncesi Cobb açıları arasındaki mutlak fark olarak hesaplandı.
Bulgular: Çalışma grubunun yaş ortalaması 53,55 ± 13,32 yıl, ortalama vücut kitle indeksi (VKİ) 29,33 ± 5,84 kg/m² idi. Ortalama preoperatif Cobb açısı 7,16 ± 7,05° ve postoperatif değer 9,03 ± 6,23° olarak saptandı. Preoperatif ve postoperatif Cobb açıları arasındaki fark istatistiksel olarak anlamlıydı ($p = 0,001$). Hastaların %62,1'inde kontralateral yönde postüral eğilme geliştiği belirlendi. Preoperatif dönemde 7 hastada (%24,1), postoperatif dönemde 10 hastada (%34,5) Cobb açısı ≥10° idi. VKİ, eğim tarafına göre karşılaştırıldığında anlamlı farklılık gözlendi ($p = 0,016$).
Sonuç: Unilateral mastektomi sonrası spinal dizilimde ölçülebilir postüral değişiklikler gelişmektedir ve bu değişiklikler sıklıkla kontralateral yöndedir. Bu bulgular, unilateral mastektomi sonrası uzun dönem takipte postüral değerlendirmenin ve gerektiğinde erken rehabilitasyon stratejilerinin planlanmasının önemini vurgulamaktadır.

Anahtar kelimeler: Mastektomi; Meme kanseri; Cobb açısı; Postür; Spinal dizilim; Skolyoz

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INTRODUCTION

Breast cancer remains the most prevalent malignancy among women worldwide, and surgical intervention continues to represent a cornerstone of curative treatment [1]. Advances in multimodal therapy have substantially improved survival rates, thereby increasing the importance of understanding long-term functional and biomechanical sequelae of surgical treatment [2,3]. The surgical approach may range from breast-conserving procedures to various forms of mastectomy, depending on tumor characteristics, disease stage, and patient preference [1].

Unilateral mastectomy results in asymmetric breast tissue loss, altering the center of gravity of the trunk. Patients may develop compensatory postural adaptations to restore balance, frequently manifesting as shoulder asymmetry, lateral thoracic tilt, and impaired trunk alignment [2]. Several studies have demonstrated that these postural changes may become persistent over time, adversely affecting spinal biomechanics and leading to musculoskeletal pain, limited range of motion, and decreased functional capacity [3,4]. From a biomechanical standpoint, unilateral mass loss from the anterior chest wall is expected to produce a compensatory lateral tilt toward the contralateral side as the body attempts to re-establish equilibrium [4,5]. In the long term, these compensatory adaptations may progress to structural spinal deformities, including scoliosis [6,7].

The Cobb angle is the standard radiographic parameter for quantifying spinal curvature and serves as a fundamental diagnostic criterion for scoliosis, with an angle of 10° or greater considered the diagnostic threshold [8]. Although the Cobb angle is widely used in clinical practice, studies employing objective radiological measurements to evaluate spinal alignment changes following breast surgery remain limited. Specifically, there is a paucity of data comparing pre- and postoperative Cobb angles in the same patients to quantitatively document the magnitude of postural change attributable to mastectomy [5].

This study aimed to investigate perioperative changes in the Cobb angle among breast cancer patients undergoing unilateral mastectomy, to evaluate the direction and magnitude of postural alterations, and to examine the association between patient-related factors and the development of spinal malalignment. We hypothesized that unilateral mastectomy would lead to a measurable increase in the Cobb angle, predominantly in the contralateral direction, consistent with compensatory biomechanical adaptation to asymmetric tissue loss.

MATERIALS AND METHODS

Study Design and Ethical Approval

This study was designed as a retrospective, single-center observational cohort study. Ethical approval was obtained from the Clinical Research Ethics Committee of Ordu University Faculty of Medicine (decision number 135, dated October 11, 2024). Due to the retrospective design, informed consent was waived by the ethics committee.

Patient Selection and Study Size

All patients diagnosed with breast cancer at the General Surgery and Breast Clinic of Ordu University Training and Research Hospital between January 2, 2020, and September 30, 2024, were retrospectively reviewed. A total of 127 patients who underwent mastectomy during this period were initially identified from the hospital information management system. The inclusion criteria were: (a) histopathologically confirmed breast cancer, (b) unilateral simple mastectomy or modified radical mastectomy, (c) availability of both preoperative and postoperative positron emission tomography-computed tomography (PET-CT) images, and (d) a minimum elapsed time of 12 months since surgery. The exclusion criteria were: (a) incomplete medical records (n = 18), (b) known pre-existing orthopedic or musculoskeletal diseases affecting spinal alignment (n = 9), (c) history of prior spinal surgery (n = 3), (d) bilateral mastectomy (n = 14), (e) breast implant reconstruction after mastectomy (n = 11), (f) unavailability of paired preoperative and postoperative PET-CT images (n = 38), and (g) less than 12 months of postoperative follow-up (n = 5). After applying these criteria, 29 patients met all eligibility requirements and constituted the final study cohort (Figure 1).

As this was a retrospective study utilizing all eligible patients during the study period, a formal a priori sample size calculation was not performed. Given the small sample size (n = 29) and even smaller subgroups in stratified analyses (ipsilateral n = 8, contralateral n = 18, neutral n = 3), the statistical power for detecting moderate effect sizes is limited. A post-hoc power analysis for the primary outcome (paired Cobb angle comparison) using a two-sided Wilcoxon signed-rank test with an observed effect size of 0.62 (Cohen's d) and $\alpha = 0.05$ yielded a power of approximately 0.82 for the overall paired comparison. However, the power for subgroup analyses is lower, and secondary findings should therefore be interpreted with caution.

Data Collection

Demographic and clinical data were extracted from the hospital information management system. The variables evaluated included age, side of mastectomy, type of operation (simple mastectomy vs. modified radical mastectomy), body mass index (BMI), mastectomy specimen weight, neoadjuvant and adjuvant treatment status, clinical and pathological staging (American Joint Committee on Cancer, 8th edition), and immunohistochemical subtypes based on estrogen receptor (ER), progesterone receptor (PR), HER2, and Ki-67 status. BMI was classified according to the World Health Organization criteria: normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), obese (30.0–39.9 kg/m²), and morbidly obese (≥40.0 kg/m²) [9]. No missing data were identified for any of the analyzed variables: all 29 patients had complete records for all demographic, clinical, and radiological variables.

Data on postoperative physical rehabilitation, physical activity levels, or the use of external breast prostheses were not available in the retrospective medical records and therefore could not be included in the analysis. These unmeasured factors represent potential confounders and are acknowledged as limitations of this study.

Postural and Radiological Evaluation

Spinal curvature was quantified using the Cobb angle, defined as the angle formed by the intersection of a line drawn parallel to the superior endplate of the most tilted vertebra at the cephalad end of the curvature and a line drawn parallel to the inferior endplate of the most tilted vertebra at the caudad end of the curvature. Measurements were performed on coronal reconstructions of PET-CT images obtained before mastectomy and at least 12 months postoperatively. The segment demonstrating the most pronounced curvature was selected for measurement.

All Cobb angle measurements were performed by an orthopedic surgery specialist using the RadiAnt DICOM Viewer software (version 2023.1, Medixant, Poznań, Poland). To assess intra-observer reliability, a random subset of 15 patients was re-measured after a two-week interval. The intraclass correlation coefficient (ICC) for intra-observer reliability was 0.94 (95% CI: 0.85–0.98), indicating excellent reproducibility.

It is acknowledged that PET-CT is not the standard imaging modality for spinal alignment assessment. The gold standard for Cobb angle measurement is a standing posteroanterior full-spine radiograph [8]. In the present study, PET-CT was utilized because these scans were routinely obtained as part of oncological staging and follow-up, thereby avoiding additional radiation exposure to the patients. PET-CT images are acquired in the supine position, which differs fundamentally from the standing position used in standard scoliosis radiography. Supine positioning may underestimate the true degree of spinal curvature, as gravitational loading on the spine is reduced. Therefore, the Cobb angle values reported in this study may represent conservative estimates of the actual postural changes that occur in the upright position. Despite this limitation, the paired comparison design (pre- vs. postoperative measurements in the same patient using the same imaging modality and positioning) ensures internal consistency and allows for valid assessment of within-patient change over time.

A Cobb angle of ≥10° was considered the diagnostic threshold for scoliosis [8]. The direction of vertebral curvature was classified as right, left, or neutral based on the postoperative Cobb angle measurement. The curvature side was then categorized as ipsilateral, contralateral, or neutral relative to the mastectomy side. Specifically, "neutral slope side" was defined as a postoperative Cobb angle of <2° in any direction, indicating no clinically meaningful lateral curvature on the postoperative assessment. This threshold was applied exclusively to the postoperative measurement to classify patients according to the direction of their postural status following mastectomy. The slope angle difference was calculated as the absolute difference between the postoperative and preoperative Cobb angles to quantify the magnitude of postural change.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was evaluated using the Shapiro–Wilk test. As the data were not normally distributed, non-parametric tests were employed. Descriptive statistics are presented as mean ± standard deviation (SD) and median (minimum–maximum) for continuous variables, and as frequency (percentage) for categorical variables. The difference between preoperative and postoperative Cobb angles was evaluated using the Wilcoxon signed-rank test. The paired comparison of the proportion of patients with Cobb angle ≥10° in the preoperative and postoperative periods was performed using McNemar's test. For intergroup comparisons based on slope side, the Kruskal–Wallis test was applied for continuous variables, including body mass index, follow-up duration, mastectomy specimen weight, and slope angle difference. When the overall Kruskal–Wallis test result was significant, Bonferroni-corrected post-hoc pairwise comparisons were performed. Categorical variables were analyzed using Fisher's exact test due to small expected cell counts. Correlations between slope angle difference and continuous variables (age, BMI, follow-up duration, and mastectomy specimen weight) were examined using Spearman's rank correlation analysis. The statistical significance level was set at $p < 0.05$.

RESULTS

Participant Flow

A total of 127 patients who underwent mastectomy during the study period were initially identified. After applying the inclusion and exclusion criteria, 29 patients met all eligibility requirements and constituted the final study cohort. The participant flow is detailed in Figure 1.

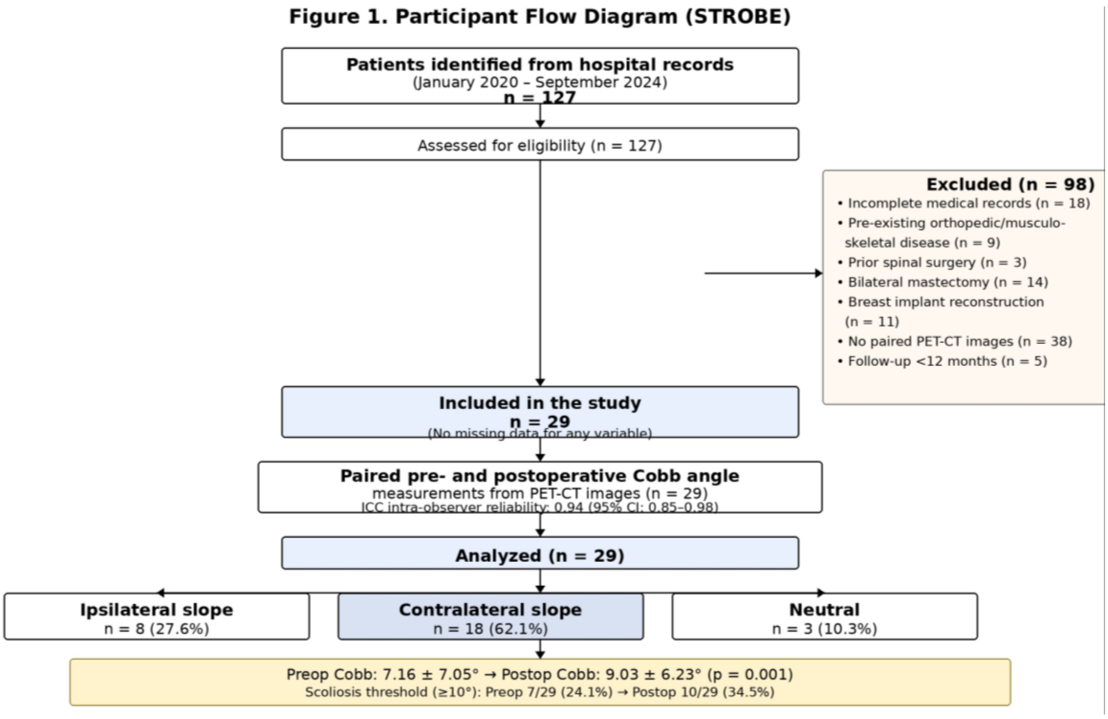

Figure 1. Participant flow diagram showing patient selection process.
A total of 127 patients were initially identified, of whom 98 were excluded based on predefined criteria. The final study cohort comprised 29 patients with complete paired pre- and postoperative Cobb angle measurements.

Demographic and Clinical Characteristics

The study cohort consisted of 29 female patients treated with unilateral mastectomy. The mean age was 53.55 ± 13.32 years (median 56.0; range 26–77), with a mean BMI of 29.33 ± 5.84 kg/m² (median 30.3; range 21.0–45.0). Based on WHO BMI categories, 24.1% (n = 7) were classified as normal weight, 24.1% (n = 7) as overweight, 41.5% (n = 12) as obese, and 10.3% (n = 3) as morbidly obese. Detailed demographic and clinical characteristics are presented in Table 1.

Right-sided mastectomy was performed in 37.9% of patients (n = 11), while 62.1% (n = 18) underwent left-sided procedures. Simple mastectomy was performed in 37.9% (n = 11) and modified radical mastectomy in 62.1% (n = 18) of patients. The most frequent tumor type was invasive ductal carcinoma, observed in 75.9% (n = 22) of patients. The predominant immunohistochemical subtype was Luminal B (62.1%, n = 18). Regarding clinical stage, 48.3% (n = 14) of patients were classified as stage IIA. Neoadjuvant therapy was administered in 69.0% (n = 20) and adjuvant therapy in 82.8% (n = 24) of patients. The mean mastectomy specimen weight was 891.14 ± 511.09 g (median 785.0; range 180–2000). Tumor types, staging distributions, and immunohistochemical subtypes are presented in Table 1.

Postural and Radiological Findings

The direction of vertebral angulation on the postoperative assessment was classified as rightward in 51.8% (n = 15), leftward in 37.9% (n = 11), and neutral in 10.3% (n = 3) of patients. When classified relative to the mastectomy side, the slope direction was ipsilateral in 27.6% (n = 8), contralateral in 62.1% (n = 18), and neutral (postoperative Cobb angle <2°) in 10.3% (n = 3) of patients. Postural and radiological measurements are shown in Table 2.

The mean preoperative Cobb angle was 7.16 ± 7.05° (median 6.0°; range 0.0–29.3°), increasing to a mean postoperative value of 9.03 ± 6.23° (median 7.47°; range 0.0–28.97°). The difference was statistically significant (Z=3.353, p = 0.001). The median absolute change in Cobb angle was 2.08° (mean 2.64 ± 2.42°; range 0.0–8.85°). Individually, the Cobb angle increased in 21 patients (72.4%), decreased in 5 patients (17.2%), and remained unchanged in 3 patients (10.3%).

Regarding the scoliosis threshold, seven patients (24.1%) had a preoperative Cobb angle ≥10°, whereas ten patients (34.5%) exceeded this threshold postoperatively. The paired categorical comparison between the preoperative and postoperative periods was evaluated using McNemar's test and was not statistically significant (p = 0.453).

Table 1. Demographic and clinical characteristics of patients

Variable		Value†
Age (years)	Mean ± SD	53.55 ± 13.32
	Median (Min–Max)	56.0 (26–77)
BMI (kg/m²)	Mean ± SD	29.33 ± 5.84
	Median (Min–Max)	30.3 (21.0–45.0)
BMI Classification*	Normal weight (18.5–24.9)	7 (24.1)
	Overweight (25.0–29.9)	7 (24.1)
	Obese (30.0–39.9)	12 (41.5)
	Morbidly obese (≥40.0)	3 (10.3)
Type of Operation	Simple mastectomy	11 (37.9)
	MRM	18 (62.1)
Side of Operation	Right	11 (37.9)
	Left	18 (62.1)
Tumor Type	DCIS	2 (6.9)
	Invasive ductal	22 (75.9)
	Mucinous	2 (6.9)
	Papillary	1 (3.4)
	Tubular	1 (3.4)
	Lobular	1 (3.4)
Immunohisto chemical Subtype	Luminal A	8 (27.6)
	Luminal B	18 (62.1)
	HER2-positive	1 (3.4)
	Triple negative	2 (6.9)
Clinical Stage	Stage 0	2 (6.9)
	Stage I	5 (17.2)
	Stage IIA	14 (48.3)
	Stage IIB	8 (27.6)
Pathological Stage	Stage I	3 (10.3)
	Stage IIA	12 (41.5)
	Stage IIB	7 (24.1)
	Stage IIIA	6 (20.7)
	Stage IIIC	1 (3.4)
Neoadjuvant Therapy	Yes	20 (69.0)
	No	9 (31.0)
Adjuvant Therapy	Yes	24 (82.8)
	No	5 (17.2)
Mastectomy Specimen Weight (g)	Mean ± SD	891.14 ± 511.09
	Median (Min–Max)	785.0 (180–2000)

†Continuous variables are presented as Mean±SD and Median (Min–Max); categorical variables are presented as n (%). *WHO BMI classification criteria [9]. BMI:Body Mass Index; MRM:Modified Radical Mastectomy; DCIS:Ductal Carcinoma In Situ; HER2:Human Epidermal Growth Factor Receptor 2.

Table 2. Postural and radiological measurements

Variable		Value†
Preoperative Direction of Vertebral Angulation‡	Right	14 (48.3)
	Left	7 (24.1)
	Neutral	8 (27.6)
Postoperative Direction of Vertebral Angulation‡	Right	15 (51.8)
	Left	11 (37.9)
	Neutral	3 (10.3)
Slope Side (relative to mastectomy)‡	Ipsilateral	8 (27.6)
	Contralateral	18 (62.1)
	Neutral (<2°)	3 (10.3)
Preoperative Cobb Angle (°)	Mean ± SD	7.16 ± 7.05
	Median (Min–Max)	6.0 (0.0–29.3)
Postoperative Cobb Angle (°)	Mean ± SD	9.03 ± 6.23
	Median (Min–Max)	7.47 (0.0–28.97)
Absolute change in Cobb angle (°)	Mean ± SD	2.64 ± 2.42
	Median (Min–Max)	2.08 (0.0–8.85)
Patients with Cobb ≥10° (preop)		7 (24.1)
Patients with Cobb ≥10° (postop)		10 (34.5)
McNemar test (preop vs. postop Patients with Cobb ≥10°)	p	0.453
Follow-up Duration (months)	Mean ± SD	17.66 ± 5.39
	Median (Min–Max)	16.0 (12–33)

†Continuous variables: Mean ± SD and Median (Min–Max); categorical variables: n (%). ‡Determined based on the postoperative Cobb angle measurement.

Table 3. Comparison of demographic and clinical variables according to slope side

Variable	Ipsilateral (n = 8)	Contralateral (n = 18)	Neutral (n = 3)	p
BMI (kg/m²), median (min-max)	32.8 (26.0–45.0)	28.4 (21.1–33.7)	27.9 (21.0–28.5)	0.016*
Follow-up Duration (months), median (min-max)	13.5 (12–33)	17.5 (12–27)	17.0 (13–25)	0.602*
Mastectomy Specimen Weight (g), median (min-max)	832.5 (546–1848)	758.0 (290–2000)	230.0 (180–1186)	0.353*
Slope angle difference (°), median (min–max)	1.69 (0.23–6.23)	3.22 (0.60–8.85)	0.0 (0.0–0.0)	0.009*
Operation Type (Simple Mastectomy), n (%)	4 (36.4)	6 (54.5)	1 (9.1)	0.844**
Operation Type (Modified Radical Mastectomy), n(%)	4 (22.2)	12 (66.7)	2 (11.1)	
Neoadjuvant therapy (Yes), n (%)	7 (35.0)	12 (60.0)	1 (5.0)	0.185**
Neoadjuvant therapy (No), n (%)	1 (11.1)	6 (66.7)	2 (22.2)	
Adjuvant therapy (Yes), n (%)	6 (25.0)	15 (62.5)	3 (12.5)	0.786**
Adjuvant therapy (No), n (%)	2 (40.0)	3 (60.0)	0 (0.0)	

*Kruskal–Wallis test; **Fisher's exact test.

Subgroup Analyses

BMI differed significantly among the three slope-side groups (Kruskal–Wallis test, p = 0.016), with the highest values observed in the ipsilateral group (32.8 [26.0-45.0]) compared with the contralateral (28.4 [21.1-33.7]) and neutral (27.9 [21.0-28.5]) groups. Follow-up duration and mastectomy specimen weight did not differ significantly between groups (Table 3). Slope angle difference also differed significantly across the slope-side groups in the overall Kruskal–Wallis analysis (p = 0.009). Bonferroni-corrected pairwise comparisons are presented in Table 4. Categorical variables were compared across slope-side groups using Fisher's exact test. No statistically significant differences were observed for operation type (p = 0.844), neoadjuvant therapy status (p = 0.185), or adjuvant therapy status (p = 0.786) (Table 3).

Table 4. Pairwise Comparisons of BMI and Slope Angle Difference According to Slope Side

Comparison	BMI (p*)	Slope angle difference (p*)
Neutral vs. Contralateral	1.000	0.008
Neutral vs. Ipsilateral	0.060	0.152
Contralateral vs. Ipsilateral	0.034	0.582

*Bonferroni-adjusted p-values. Pairwise comparisons were performed after the overall Kruskal–Wallis test.

Spearman correlation analysis revealed no statistically significant associations between slope angle difference and age (rho = 0.12, p = 0.534), BMI (rho = 0.08, p = 0.681), follow-up duration (rho = -0.05, p = 0.795), or mastectomy specimen weight (rho = 0.15, p = 0.438) (Table 5).

Table 5. Spearman Correlation Analysis Between Slope Angle Difference and Clinical Variables

Variable	rho	p
Age (years)	0.12	0.534
BMI (kg/m²)	0.08	0.681
Follow-up duration (months)	−0.05	0.795
Mastectomy specimen weight (g)	0.15	0.438

rho: Spearman's rank correlation coefficient. No statistically significant correlations were observed (p > 0.05 for all).

DISCUSSION

This retrospective single-center cohort study demonstrated statistically significant changes in spinal alignment following unilateral mastectomy in breast cancer patients. The principal findings were: (a) a significant increase in the postoperative Cobb angle (from 7.16° to 9.03°, p = 0.001), (b) a predominance of contralateral postural tilt (62.1%), and (c) a significant difference in BMI according to postoperative slope-side classification (p = 0.016). Additionally, the number of patients exceeding the diagnostic ≥10° threshold increased from seven preoperatively to ten postoperatively.

While the mean increase in Cobb angle (approximately 1.87°) reached statistical significance, the clinical relevance of this magnitude of change warrants careful consideration. The generally accepted minimum clinically important difference (MCID) for Cobb angle change is ≥5°, and the reported measurement error for Cobb angle assessment typically ranges from 3° to 5° [8,10]. Therefore, while the observed change is statistically significant at the group level, its clinical significance for most individual patients remains modest.

However, two observations suggest potential clinical importance. First, 34.5% of patients exceeded the ≥10° scoliosis threshold postoperatively (compared with 24.1% preoperatively), indicating that a meaningful proportion of patients developed or worsened scoliosis-range curvature. Second, these measurements were obtained in the supine position during PET-CT, which likely underestimates the true curvature present during weight-bearing activities.

The predominance of contralateral postural tilt observed in the present study is consistent with previous reports [2,3] and can be explained by compensatory biomechanical mechanisms that develop in response to asymmetric loading following mastectomy. The present study extends these findings by providing paired pre- and postoperative Cobb angle data, enabling quantitative documentation of the magnitude of change within individual patients.

Serel et al. reported contralateral tilt and spinal deformity following unilateral mastectomy and suggested that this modification may be related to compensatory balance mechanisms [4]. Similar postoperative spinal alignment changes have also been reported in radiographic studies [5,6]. The descriptive observation in our study that patients with pre-existing Cobb angles ≥10° showed a larger mean postoperative change (+2.91° vs. +1.58°) is consistent with Gutkin et al.'s findings [7]; however, this difference was not formally tested given the small and unbalanced subgroup sizes and should be interpreted as hypothesis-generating.

The significant difference in BMI according to slope direction is a notable finding. The higher BMI observed in the ipsilateral tilt group suggests that body habitus may influence compensatory postural responses after mastectomy. Previous studies have reported associations between BMI, spinal alignment, and postural control [11–13]. However, given the small subgroup sizes (ipsilateral n = 8, contralateral n = 18, neutral n = 3), this finding should be interpreted with caution and regarded as hypothesis-generating.

Recent literature has increasingly examined postural changes after mastectomy not only in terms of static alignment but also with regard to balance, mobility, and quality of life [14–17]. Exercise-based rehabilitation programs applied in the post-mastectomy period have been reported to have corrective effects on posture, spinal mobility, and quality of life [18,19]. When considered alongside our findings, these data support the integration of postural assessment and targeted rehabilitation into routine long-term follow-up protocols for patients undergoing unilateral mastectomy.

Several limitations of this study should be acknowledged. First, the retrospective design may introduce selection bias, as the cohort was restricted to patients who had PET-CT scans both pre- and postoperatively. Second, the small sample size (n = 29) limits statistical power, particularly for subgroup analyses. The neutral group (n = 3) was too small for robust statistical comparison. Although post-hoc power analysis confirmed adequate power for the primary paired comparison, secondary analyses should still be interpreted with caution. Third, PET-CT is not the standard modality for Cobb angle measurement, and supine imaging may underestimate spinal curvature compared with standing posteroanterior radiographs. Inter-observer reliability was not assessed, although intra-observer reliability was excellent (ICC = 0.94).

Several potential confounders were not controlled for, including pre-existing scoliosis or degenerative spinal changes, adjuvant radiotherapy, postoperative rehabilitation status, physical activity levels, use of external breast prostheses, and natural age-related spinal degeneration during follow-up. The single-center design may also limit generalizability. Finally, functional outcomes, patient-reported quality of life measures, and musculoskeletal pain assessments were not included. Despite these limitations, the paired pre- and postoperative measurement design, in which each patient serves as her control, represents a notable strength, as it minimizes the influence of interindividual variability on the primary outcome.

CONCLUSION

Measurable alterations in spinal alignment were identified following unilateral mastectomy in breast cancer patients during postoperative follow-up. The statistically significant increase in the postoperative Cobb angle and the predominantly contralateral development of postural tilt suggest that postural adaptations following unilateral breast tissue loss extend beyond temporary compensatory changes. The observed difference in BMI according to slope-side classification suggests that individual patient characteristics may influence postural adaptation patterns. Although the clinical significance of the mean Cobb angle change remains modest and should be interpreted within the context of known measurement error, the observation that over one-third of patients exceeded the scoliosis diagnostic threshold postoperatively points to the potential clinical relevance of these findings. Incorporating postural assessments into long-term follow-up protocols and planning early rehabilitation interventions when indicated may be beneficial. Prospective studies with larger sample sizes, standing radiographic measurements, and inclusion of functional outcome measures are needed to further elucidate the clinical significance and temporal progression of postural changes following mastectomy.

Ethics Committee Approval

Ethical approval for this study was obtained from the Clinical Research Ethics Committee of Ordu University Faculty of Medicine (decision number: 135, dated: October 11, 2024). Due to the retrospective design, informed consent was waived by the ethics committee.

Author Contributions

Conception - Yasemin Dönmez Yurtsever, Çağrı Akalın, Abdullah Alper Şahin, Mümin Demir; Design - Yasemin Dönmez Yurtsever, Çağrı Akalın, Abdullah Alper Şahin, Mümin Demir; Supervision - Yasemin Dönmez Yurtsever, Çağrı Akalın, Abdullah Alper Şahin, Mümin Demir; Data Collection and/or Processing - Yasemin Dönmez Yurtsever, Çağrı Akalın, Abdullah Alper Şahin, Mümin Demir; Analysis and/or Interpretation - Yasemin Dönmez Yurtsever, Çağrı Akalın, Abdullah Alper Şahin, Mümin Demir; Literature Search - Yasemin Dönmez Yurtsever, Çağrı Akalın, Abdullah Alper Şahin, Mümin Demir; Writing - Yasemin Dönmez Yurtsever, Çağrı Akalın, Abdullah Alper Şahin, Mümin Demir; Critical Review - Yasemin Dönmez Yurtsever, Çağrı Akalın, Abdullah Alper Şahin, Mümin Demir.

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Conflict of Interest

The authors declare no conflicts of interest.

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