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ORIGINAL ARTICLE BREAST

Effects of Reduction Mammaplasty Operations on the Spinal Column: Clinical and Radiological Response

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Abstract
Background Women with macromastia suffer from bodily disproportions like increased spinal curvature owing to the mass effect caused by severely large breasts. In such cases, the erector spinae muscles generate an overcompensatory pressure to maintain a normal posture, resulting in neck, back, and lumbar pain. This study aimed to objectively show the improvement of physical symptoms after reduction mammaplasty and evaluate psychological and physical changes of patients.
Methods Pre- and postoperative cervical, thoracic, and lumbar bidirectional (anteroposterior and lateral) radiographs were obtained from 40 patients who underwent reduction mammaplasty. Cervical lordosis, thoracic kyphosis, lumbar lordosis, and lumbosacral angles were evaluated. Body mass index, breast tissue volume, and excised tissue amount were recorded for each patient. Visual Analog Scores (VAS) were used to qualify the severity of neck, back, and lumbar pain, the Nottingham Health Profile (NHP) to evaluate quality of life (QoL), and the Beck Depression Inventory (BDI) to evaluate depression severity.
Results Cervical lordosis, thoracic kyphosis, lumbar lordosis, and lumbosacral angle improved, and patients' neck, back, and lumbar pain decreased. The positive correlation between the excised glandular tissue amount and the decrease in neck, back, and lumbar pain was reflected in the results of VAS, NHP, and BDI tests. After reduction mammaplasty, depression symptoms caused by macromastia decreased. Parameters of QoL, including physical activity, socialization, fatigue, sleeping, and emotional reactions, significantly improved.
Conclusion Patients with macromastia should be considered for reduction mammaplasty before the onset of postmenopausal osteoporosis to improve QoL.
Level of Evidence III This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Reduction mammaplasty · Lumbar pain · Body posture · Visual analog score (VAS) · Nottingham Health Profile (NHP) · Beck Depression Inventory (BDI)

Introduction

Breasts provide women with a sense of femininity and increase self-esteem from the prepubertal period [1]. However, oversized breasts beyond the norm are considered a deformity by some. Thus, methods to decrease the size of breast dimensions to obtain normal breast size have been practiced for years [2].

A heavy load on the anterior thoracic wall increases the spinal incline. Cervical lordosis and thoracic kyphosis increase because the breasts exert a mass affect; thus, additional tension is generated during cervical extension and the center of gravity of the body changes. This shift causes permanent contraction of the posterior spinal muscles that is associated with pain and compression of the

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intervertebral disks [3–8]. If the cervical lordosis and thoracic kyphosis are severe or sustained for long periods, osteophytes develop on the posterior surface of the vertebrae, increasing the risk of cervical pain and spondylosis [5]. This study aimed to confirm the effects of reduction mammaplasty on patient symptoms by objective tests.

Clinical Materials

A total of 59 female patients who were admitted to the Plastic and Reconstructive Surgery Clinic for reduction mammaplasty between 2008 and 2012 were included in the study. We received approval from the Local Ethical Board, and patients gave informed consent prior to enrollment in the study. Before the operative decision making, all patients were evaluated by a physical therapist to exclude pain caused by any neurological or musculoskeletal disorder. Patients having at least one of the following criteria were excluded from the study: congenital kyphosis or history of spinal surgery, postmenopausal status, history of medication use (especially NSAID or antidepressants), aged <18 years, missing pre- or postoperative radiographs or missing tests, or history of breast surgery.

Therefore, 19 patients were excluded from the study. Before the operation, patient age, weight, height, and breast cup size (A, B, C, D) were determined, and spine radiographs were taken. The Body Mass Index (BMI) of each patient was calculated using the following formula: weight/height^2 (kg/m^2). Patients were then classified according to the BMI ($\geq$18.5 BMI <24.9 = normal weight, $\geq$25.0 BMI <29.9 = overweight, $\geq$30.0 BMI <39.9 = obese). The breast cup size of every patient was calculated as the difference between the overbust and under-band measurements as follows: <6.5 cm (A cup), 6.5–13 cm (B cup), 13–19 cm (C cup), 19.5–26 cm (D cup), and >26 cm (DD cup).

Radiologic evaluation comprised preoperative anteroposterior and lateral radiographs of the cervical, thoracic, and lumbosacral regions obtained with the patients in a relaxed upright standing position without shoes. Neck, back, and lumbar pain severity was measured using the Visual Analog Score (VAS), quality of life (QoL) by the Nottingham Health Profile (NHP), and depression severity by the Beck Depression Inventory (BDI). The BDI test, composed of 21 questions for evaluating quantitative depression density, was used on the patients. The differences between the preoperative and postoperative BDI scores were statistically significant (Fig. 1; Tables 4, 6, $p < 0.001$). The NHP test, composed of 38 questions under six categories (stamina level, pain, emotional reactions, sleep, socialization, and physical abilities), was applied to the patients both pre- and postoperatively.

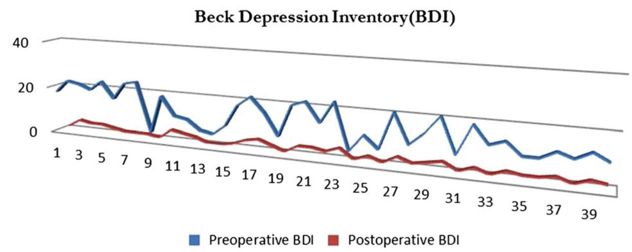

Fig. 1 Preoperative and postoperative Beck Depression Inventory

All patients underwent reduction mammaplasty with the inferior pedicle mammaplasty technique under general anesthesia. Postoperatively, the weight of the resected tissue was recorded for each patient. At 6 months postoperatively, new spine radiographs were obtained. Cervical lordosis, thoracic kyphosis, and lumbar lordosis were calculated based on the radiographs using the Cobb method. For lumbosacral angle measurement, the angle between the line of the superior aspect of L1 and the line of the superior aspect of the sacrum in the superior plane was calculated [9] (Figs. 2c, 3 D1–2). Questionnaires of VAS, BDI, and NHP tests were repeated. A single physical therapist performed all measurements.

Statistical Analysis

The Statistical Package for Social Sciences version 13.0 for Windows was used to analyze the differences between pre- and postoperative cervical lordosis, thoracic kyphosis, lumbar lordosis, lumbosacral angle values, and VAS, NHP,

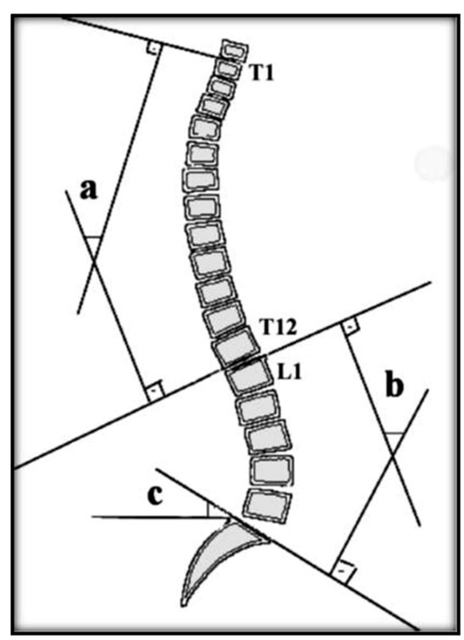

Fig. 2 Schematic view of the Cobb method

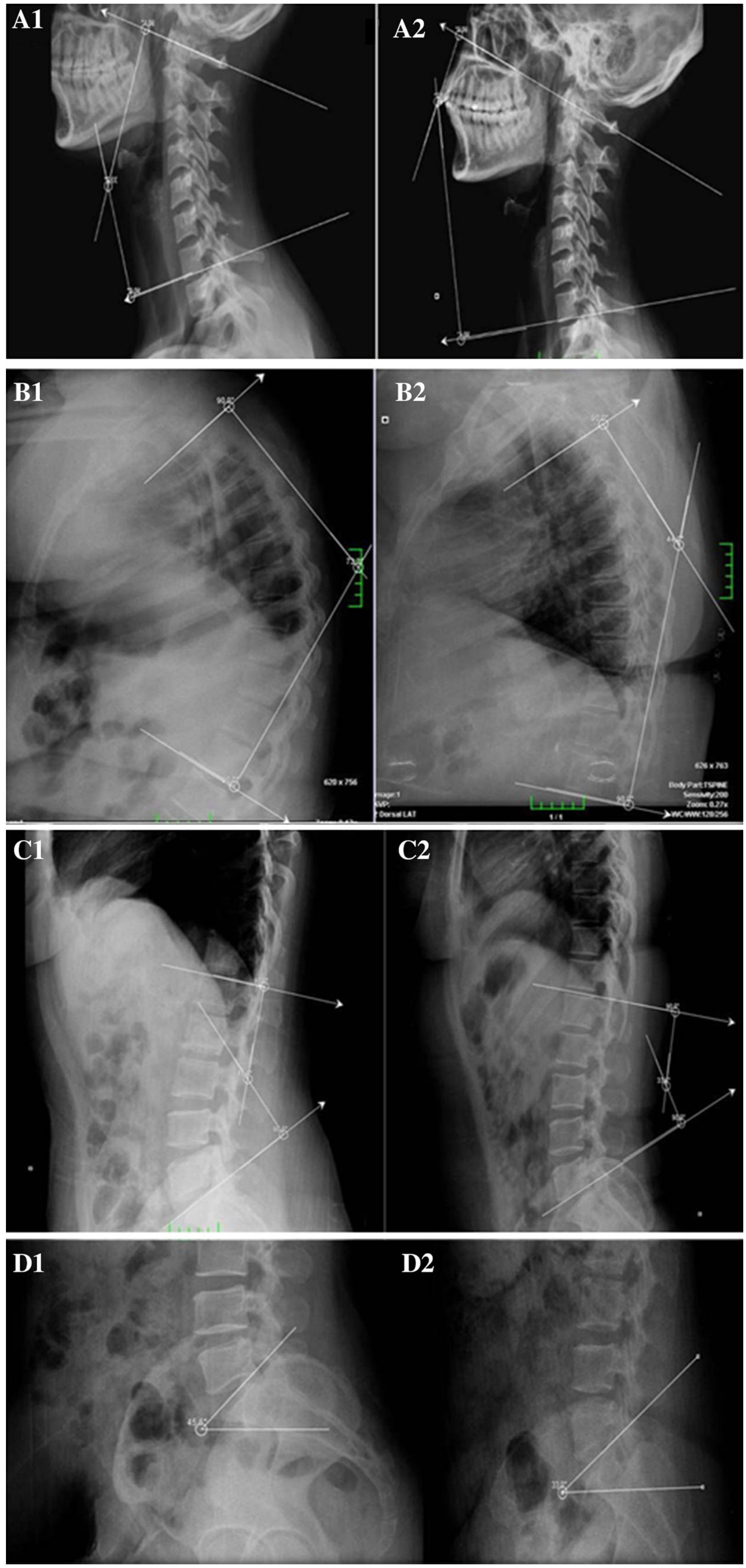

Fig. 3 The vertebral column angle measurements. **a1–2** Calculation of cervical lordosis. The line is drawn from the midpoint of the anterior and posterior tubercle of the atlas and from the caudal aspect of the C7 corpus, combined with the two different corresponding lines. The angle between these lines is then calculated. **b1–2** Calculation of thoracic kyphosis. The angle between the plane of the superior aspect of T1 and the plane of the caudal aspect of T12 was measured. **c1–2** Calculation of the lumbar lordosis. Lumbar lordosis is calculated on radiographs by the Cobb method. The angle between the line drawn perpendicular to the plane of the superior aspect of the L1 and the plane of the superior aspect of the sacrum is measured. **d1–2** Measurement of the lumbosacral angle. The angle between the line of the superior aspect of L1 and the line of the superior aspect of the sacrum in the superior plane is calculated

and BDI results. The Kruskal–Wallis test was used to compare the differences between the pre- and postoperative values of the study groups. Numerical data obtained pre- and postoperatively for relationships between repeated measurements provided by parametric assumptions were determined by paired *t* test. Wilcoxon signed-rank test was used to provide assumptions for parametric variables of the non-parametric tests. Relationships between continuous variables were assessed using Pearson's correlation coefficient. The relations between categorical variables were assessed by χ^2 test. A value of $p \leq 0.05$ was considered statistically significant.

Results

We evaluated 40 women with various breast sizes. Patient age ranged from 26 to 48 (median 39.07 ± 5.8) years. According to the classification of BMI, two patients had normal weight (5 %), 14 patients were overweight (35 %), and 24 were obese (60 %). The preoperative breast cup measurements were as follows: 18 patients had DD cup (Group I); 12 patients had D cup (Group II); and 10 patients had C cup (Group III). None of the patients had A or B cup size. The distribution of age was homogenous between the groups, and there was no significant difference (Table 1, $p = 0.281$). There was a significant difference among the groups for BMI ($p = 0.005$) and breast tissue removed (right and left breasts) (Table 1, $p = 0.000$). The resected tissue volume was significantly higher in Group I ($p < 0.05$).

There were no significant differences among the groups regarding pre- and postoperative cervical lordosis, thoracic kyphosis, lumbar lordosis, and lumbosacral angles (Table 1). The overall analysis of patients (ungrouped) showed that there was a significant ($p < 0.001$) difference in pre- and postoperative cervical lordosis values (Fig. 4; Table 2). The overall evaluation of thoracic kyphosis values showed that there was a significant difference ($p < 0.001$) between the pre- and postoperative values at 6 months (Fig. 5; Table 2). The overall evaluation of lumbar lordosis angles showed that the difference between pre- and postoperative values at 6 months was not significant (Fig. 6; Table 2, $p > 0.05$).

When comparing pre- and postoperative cervical lordosis and thoracic kyphosis angles of patients grouped according to cup size, there was a significant postoperative decrease of these angles (Table 3, $p < 0.001$), whereas the decrease of lumbar lordosis angles did not reach statistical significance (Table 3, $p > 0.05$). When patients were analyzed as ungrouped and grouped, the differences between pre- and postoperative measurements of lumbosacral angles at 6 months were not significant across study groups (Fig. 7; Tables 2, 3, $p > 0.05$).

The differences between the pre- and postoperative VAS values for neck, back, and lumbar pain (most disturbing pain) were statistically significant (Fig. 8; Tables 4, 5, 6$p < 0.001$).

Table 1 The comparison of the changes in terms of preoperative and postoperative measurement values of vertebral column angles among the groups

	Group 1 $n = 18$ median, IQR	Group 2 $n = 12$ median, IQR	Group 3 $n = 10$ median, IQR	p value*
Age	41.5 (35.7–45.0)	40.5 (35.2–42.7)	39.0 (29.0–42.2)	0.281
BMI	33.6 (30.6–39.4)	28.0 (25.3–33.0)	29.3 (26.0–31.9)	0.005
RTPB (right)	1475 (1000–1900.0)	752 (685–822.5)	452.5 (386.2–590)	0.000
RTPB (left)	1500 (1000–1862.5)	742 (685–800)	480 (362.5–581.25)	0.000
Number of deliveries	2 (1–2)	2 (1–2)	1.5 (1–2)	0.863
CL preoperative	44.95 (42.95–47.42)	42.95 (38.27–44.50)	44.10 (37.70–46.05)	0.133
CL postoperative	31.90 (27.90–35.42)	35.85 (30.17–38.37)	34.95 (30.50–40.22)	0.150
TK preoperative	56.90 (51.87–63.47)	64.55 (57.50–67.07)	64.00 (59.05–66.05)	0.115
TK postoperative	42.95 (36.20–44.85)	45.25 (41.60–48.25)	43.70 (40.05–45.80)	0.160
LL preoperative	34.30 (23.92–43.20)	41.75 (27.95–47.32)	39.50 (25.92–42.82)	0.455
LL postoperative	32.05 (29.07–44.05)	38.95 (30.52–40.65)	36.20 (29.12–39.45)	0.719
LA preoperative	33.95 (28.22–47.60)	46.35 (35.77–50.35)	35.00 (30.75–47.80)	0.416
LA postoperative	38.50 (35.30–42.42)	41.45 (35.17–43.27)	35.90 (29.67–45.77)	0.509

IQR interquartile range (25–75 %), *RTPB* resected tissue per breast, *CL* cervical lordosis, *TK* thoracal kyphosis, *LL* Lumbar lordosi, *LA* Lumbosacral angle

* Kruskal–Wallis Test

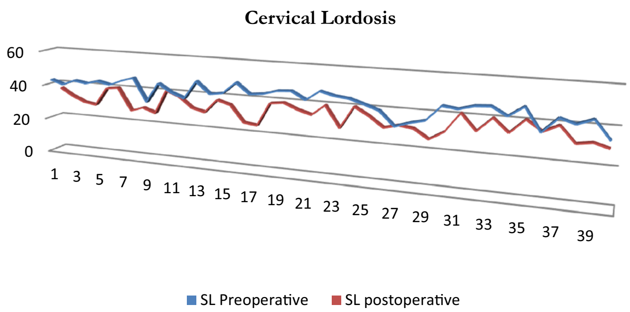

Fig. 4 Preoperative and postoperative cervical lordosis

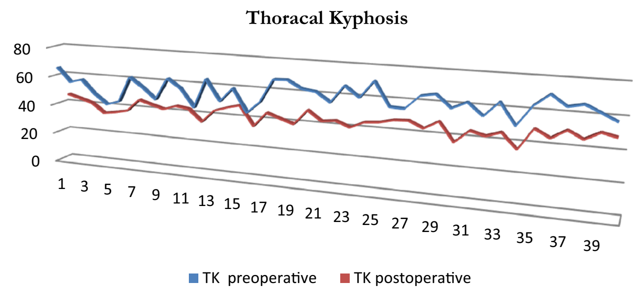

Fig. 5 Preoperative and postoperative thoracal kyphosis

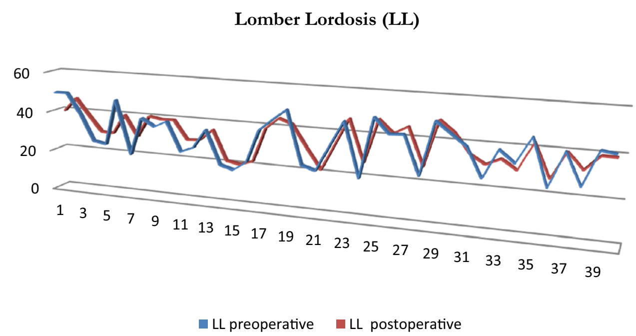

Fig. 6 Preoperative and postoperative lumber lordosis

There was a significant difference ($p < 0.001$) in the NHP test scores for pain, physical activity, socialization, fatigue, sleep, and emotional reaction pre- and postoperatively (Table 4). There was a positive correlation between the removed glandular tissue amount and reduction of neck, back, and lumbar pain as well as the results of VAS, NHP, and BDI tests. Overall, the complication rate was low. Delayed wound healing was observed in two patients, fat necrosis was observed in one, and postoperative infection developed in one patient.

Discussion

Macromastia is a source of aesthetic and psychological disorders. There is a general consensus that macromastia causes important functional problems [10], including shoulder, lumbar, and neck pain [7, 11], intertrigo [12], shoulder/bra strap grooving [11], and decreased physical performance [13]. Additionally, brachial plexus compression resulting in paresthesia of the hand and breathing disorders have been reported [3, 4, 7, 14–16].

Added to physical symptoms, macromastia has cosmetic and psychological components. Psychosocial effects may include difficulty in exercising [17], potentially worsening or contributing to poor self-image and in the worst cases, body dysmorphic disorder [18]. From a sociologic standpoint, patients may complain of difficulties obtaining appropriately sized clothes and disability or discomfort when engaging in daily, sports, or sexual activities [5, 11]. Despite this, reduction mammaplasty is generally considered a cosmetic procedure [19–21]. The only relatively objective parameter used to measure symptom relief has been the weight of the removed glandular tissue, but the correlation between functional improvement and weight of the removed tissue has not been proven objectively [22].

Fındıkçıoğlu et al. [23] conducted a study to evaluate thoracic kyphosis and lumbar lordosis axis angles after reduction mammaplasty. They advocated that the vertebral column has a sensitive balance that may be affected by small changes. They found a decrease in terms of thoracic kyphosis and lumbar lordosis angles after reduction mammaplasty but not any relationship between the sacral angle and breast size. However, the relationship between

Table 2 Patients who underwent breast reduction in terms of changes in the vertebral column angle

	Pre-operative mean value	Post-operative 6th month mean value	p value*
Cervical lordosis	43.2 ± 4.0 (33–49.6)	33.3 ± 4.9 (25.6–40.9)	<0.001
Thoracal kyphosis	59.9 ± 7.6 (43.1–72.6)	42.9 ± 4.4 (34.3–49.9)	<0.001
Lumbar lordosis	35.7 ± 10.2 (18.8–49.6)	35.1 ± 7.8 (19.6–48.9)	>0.005**
Lumbosacral angle	39 ± 10 (23.9–55.1)	38.8 ± 5.7 (28.3 ± 48.6)	>0.005**

* Paired Samples Student t Test

** Not significant

Table 3 The comparison of the changes in terms of preoperative and postoperative measurement values of vertebral column angles among the groups

	Group 1 $n = 18$ median, *IQR*	*p* value*	Group 2 $n = 12$ median, *IQR*	*p* value*	Group 3 $n = 10$ median, *IQR*	*p* value*
CL preoperative	44.55 (42.95–47.42)	0.000	41.70 (38.27–44.50)	0.002	42.60 (37.70–46.05)	0.005
CL postoperative	31.60 (27.90–35.42)		34.40 (30.17–38.37)		35.03 (30.05–40.22)	
TK preoperative	57.58 (51.87–63.47)	0.000	61.79 (57.50–67.07)	0.002	62.07 (59.05–66.05)	0.005
TK postoperative	41.57 (36.20–44.85)		44.92 (41.60–48.25)		42.98 (40.05–45.80)	
LL preoperative	33.77 (23.92–43.20)	0.913	38.59 (27.95–47.32)	0.209	35.58 (25.92–42.82)	0.721
LL postoperative	34.28 (29.07–44.05)		36.53 (30.52–40.65)		34.80 (29.12–39.45)	
LA preoperative	37.22 (28.22–47.60)	0.349	42.85 (35.77–50.35)	0.308	37.63 (30.75–47.80)	0.959
LA postoperative	38.92 (35.30–42.42)		40.10 (35.17–43.27)		36.83 (29.67–45.77)	

IQR interquartile range (25–75 %), *CL* Cervical lordosis, *TK* Thoracal kyphosis, *LL* Lumbar lordosi, *LA* Lumbosacral angle

* Wilcoxon Signed-Rank Test

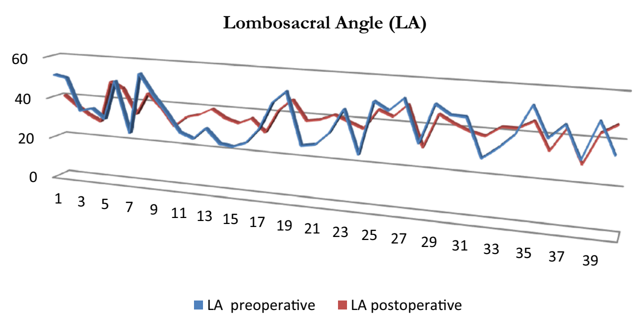

Fig. 7 Preoperative and postoperative lumbosacral angle

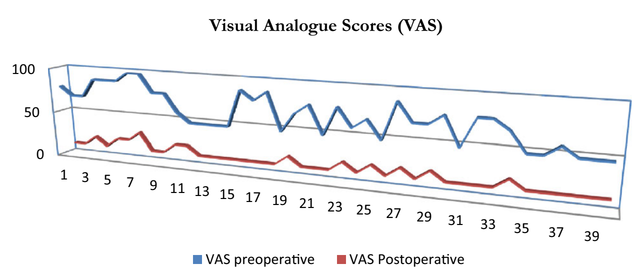

Fig. 8 Preoperative and postoperative Visual Analog Scores

the resected tissue amount and cervical lordosis, thoracic kyphosis, lumbar lordosis, and lumbosacral angles was not specified. Although the change in the cervical lordosis is the primary change caused by the center of gravity shift, it was not evaluated in their study. The vertebral column has an integral response to the changes of the body's center of gravity. Furthermore, pain, decreased stamina, emotional response disorders, sleep and socialization disorders, physical disabilities, and intensity of depressive symptoms were not investigated in that study.

Karabekmez et al. [24] reported a preoperative increase of cervical lordosis and thoracic kyphosis angles in all patients and a significant decrease of the aforementioned angles in the postoperative period. In their study, lumbar lordosis decreased in seven patients and increased in eight patients, and the preoperative total breast volume was correlated with the BMI and thoracic kyphosis angle. However, their study was limited by the lack of evaluation of quality of life changes in the postoperative period to support their findings [25]. In our study, while the BMI was significantly different among the groups (Table 1), we did not find any correlation between the postoperative vertebral column changes and BMI (Tables 1, 2, 3). In contrast, there was a significant difference among the groups for the amount of tissue removed, and all groups experienced a significant improvement in terms of cervical lordosis and thoracic kyphosis and a decrease in neck, back, and lumbar pain (Tables 1, 2, 3). A correlation was detected between the vertebral angle improvements and the amounts of removed tissue. This correlation was seen particularly in patients with DD (group 1) as well as those with D (group 2) and C (group 3) cup sizes. Interestingly, we found statistically significant differences between the groups according to BMI, but no correlation was found with the vertebral column angles (Table 1).

Onder et al. [26] evaluated the thoracic kyphosis and lumbar lordosis angles after reduction mammaplasty. From the preoperative and postoperative thoracic kyphosis and lumbar lordosis angle values, the main affected vertebral region was the upper vertebral column. As in our study, they found that the lumbar and sacral angles had changed slightly. They suggested that these changes could be attributed to preoperative breast size. In contrast, although there was a significant difference among groups regarding breast size, all of the patients had significant improvements of thoracic kyphosis and cervical lordosis angles. The non-significant results of the previous reports may be attributed

Table 4 The results of the patients who underwent breast reduction in terms of changes in VAS, BDI, and NHP test values

	Pre-operative mean value	Post-operative 6th month mean value	*p* value*
VAS	69.5 ± 16.5	13.3 ± 5.3	<0.001
BDI	15.3 ± 6.3	1.7 ± 1.3	<0.001
NHP-pain	28.4 ± 14.4 (12.5–50)	1.9 ± 5.3 (0–12,5)	<0.001
NHP-physical activity	25.6 ± 13.3 (0–50)	0.9 ± 3.3 (0–12,5)	<0.001
NHP-socialization	12.9 ± 14.9 (0–40)	0 ± 0 (0–0)	<0.001
NHP-fatigue	55.4 ± 24.3 (0–100)	0.8 ± 5.2 (0–33)	<0.001
NHP-sleep	40.5 ± 18.9 (20–80)	1.5 ± 5.3 (0–20)	<0.001
NHP-emotional reaction	20.6 ± 12 (0–44)	0 ± 0 (0–0)	<0.001

* Wilcoxon Signed-Rank Test

Table 5 The results of the VAS test values

Pre-operative			Post-operative		
n	%	Severity of the pain	*n*	%	Severity of the pain
13	32.5	50	28	70	10[a]
3	7.5	60	11	27.5	20
7	17.5	70	1	2.5	30
9	22.5	80			
6	15	90			
2	5	100[b]			

[a] No pain

[b] Expressed as intolerable severity of the pain

Table 6 The results of the BDI test values

Pre-operative			Post-operative		
n	%	Points	*n*	%	Points
7	17.5	0–9[a]	40	100	0–9[a]
15	37.5	10–16[b]			
18	45	17–29[c]			
0	0	30–60[d]			

[a] Showed minimal level depressive symptoms

[b] Showed mild level depressive symptoms

[c] Showed intermediate level depressive symptoms

[d] Showed severe level depressive symptoms

to the lack of knowledge of the critical effect of breast tissue weight on the anterior chest wall tissue that may affect the vertebral column. Additionally, there is a difference in the biomechanical response of each patient. In our study, the resected breast tissue per breast ranged between a minimum of 362.5 g and a maximum of 1900 g. Based on our clinical experience, a breast tissue weight of 600 g on the thoracic wall may affect the vertebral angles, but this needs to be validated by further investigations.

A biomechanical study showed the improvement of symptoms in terms of pain frequency and irradiation after reduction mammaplasty to reduce the low-back compressive forces [24]. In another study, an improvement in body posture was achieved because of the reestablishment of the body's center of gravity after reduction mammaplasty [25]. In the literature, some studies reported on the physical effects of oversized breasts, but these reports only evaluated the physical symptoms subjectively [7, 14].

In this study, there was no statistically significant difference between the groups in terms of pre- and postoperative values of cervical lordosis, thoracic kyphosis, lumbar lordosis, and lumbosacral angles, while these preoperative and postoperative values were evaluated separately (Table 1, $p > 0.05$). In contrast, when the groups were evaluated separately, there was a statistically significant difference between pre- and postoperative values (Table 3, $p < 0.05$). Regardless of the group, while the pre- and postoperative vertebral column angles were evaluated, there was a significant difference between pre- and postoperative values of cervical lordosis and thoracic kyphosis (Table 2).

We evaluated the pre- and postoperative radiographs of patients with macromastia and found a significant ($p < 0.001$, Tables 2, 3) decrease of the cervical lordosis angle (mean 9.9 ± 0.9) and thoracic kyphosis angle (mean of 17.0 ± 6.1) after reduction mammaplasty. Despite the decrease of the lumbar lordosis angle (mean of 3.7 ± 9.1) and the lumbosacral angle (mean of 0.3 ± 8.2), these decreases were not significant ($p > 0.05$, Tables 2, 3).

In a study composed of 50 patients, it was demonstrated by the BDI score that breast size affected the risk of spinal disk herniation, and it was correlated with psychological problems [26]. Our BDI results supported their results. We performed VAS, BDI, and NHP tests to evaluate the effects of reduction mammaplasty on the social life and psychological aspects of the patients. While the mean preoperative VAS pain severity score of patients was 69.5 ± 16.5, it decreased to a mean score of 13.3 ± 5.3 points postoperatively. While the severity of depressive symptoms according to BDI was mild to moderate (15.3 ± 6.3) preoperatively, the results decreased to minimal severity of depression postoperatively (1.7 ± 1.3). There seems to be a positive correlation between the severity of pain and depressive symptoms and cervical lordosis, thoracic kyphosis, lumbar lordosis, and lumbosacral angles. By performing a comparison of pre- and postoperative pain, physical activity, socialization, fatigue, sleep, and emotional parameters of the NHP scores to evaluate the quality of life of patients with macromastia, we showed an improvement of complaints directly associated with macromastia.

After the operation, an improvement was achieved in body posture disturbances, mainly those caused by heavy and ptotic breasts. The improvements of vertebral column angles are seen clearly in patients with DD cup size (Tables 1, 3). Because of the improvement of postural disturbances, the body's center of gravity readjusts, and thus the pressure on the posterior aspect of intervertebral disks decreases. Thus, back, neck, and lumbar pains are resolved. We evaluated postoperative radiographs at 6 months postoperatively. Based on the present results, we believe that this follow-up period is sufficient to assess postoperative outcomes of reduction mammaplasty.

While designing the study, we excluded postmenopausal women and those suspected of having lumbar pain caused by other disorders to highlight the real effects of reduction mammaplasty. We performed this study to determine objectively the effects of reduction mammaplasty and to show the improvements of the physical, psychological, and social problems caused by macromastia. The results of this study reflect the benefits of reduction mammaplasty for such patients. A significant postoperative improvement in vertebral column angle was found and the VAS, NHP, and BDI improved.

This study had some limitations that are worthy of mention. Data are lacking regarding the normal incline and angle of our study population and the variation between age and sex groups. Thus, we used the reference values for the general population.

Conclusion

After reduction mammaplasty, improvement of cervical lordosis and thoracic kyphosis was achieved, and thus patients' back, neck, and lumbar pain decreased. Patients in whom the mass effect resolved by removing large and ptotic breasts presented improvements in depression severity and quality of life as well. The positive correlation between the amounts of removed glandular tissue and the decrease in neck, back, and lumbar pain was reflected in the results of VAS, NHP, and BDI tests.

Patients who suffered from macromastia should be considered for reduction mammaplasty before the onset of postmenopausal osteoporosis to improve their quality of life.

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Conflict of interest All named authors hereby declare that they have no conflicts of interest to disclose.

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