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# Investigation of the impact of radiotherapy on the shoulder joint by ultrasonography in breast cancer patients

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## ABSTRACT

**Objectives:** This study aimed to investigate the impact of radiotherapy (RT) on the supraspinatus, long head of the biceps and subscapularis tendons, and shoulder subcutenous fat tissue.

**Methods:** Patients diagnosed with breast cancer who received RT to the anterior chest wall and axillary-supraclavicular region after breast-conserving surgery or mastectomy in our hospital. Overall, 56 (36 RT, 20 control group) patients were enrolled in this study. Pre-RT, post-RT 6-week, 3-month, and 6-month ultrasonographic and clinical assessments were performed.

**Results:** The mean interval between surgery and RT was 5.6 (range: 2-8) months. Ten (27.7%) patients developed ultrasonographic abnormalities during the post-RT period. However, only 2 of these patients had shoulder pain and restricted range of motion in the shoulder. The thickness of the supraspinatus, biceps and subscapularis tendons were similar between the dominant and non-dominant sides of the control and RT group patients (5.7 mm vs. 5.1 mm, 2.87 mm vs. 2.89 mm, and 4.13 mm vs. 3.97 mm; respectively, $p > 0.05$). Thirteen patients were given RT on the ipsilateral side, and 23 received RT on the contralateral side. The pre-RT supraspinatus tendon thickness was significantly higher in the ipsilateral group than in the contralateral group ($p = 0.026$). However, there was no significant difference in the post-RT period ($p = 0.408$).

**Conclusions:** In breast cancer patients undergoing adjuvant RT, RT may cause temporary edema in shoulder tendons. In addition, shoulder pain and restricted range of motion of the shoulder joint can be present in these patients.

**Keywords:** Breast cancer, radiotheraphy, shoulder, tendon, ultrasonography

In patients with lymph node metastasis or primary tumors larger than 5 cm, adjuvant RT significantly decreased the risk of local recurrence. It was also reported that adjuvant RT led to a 9% increase in survival [1-3]. These findings were also confirmed by systematic reviews [4]. Therefore, RT is accepted as a fundamental component of the therapeutic management in patients with Stage 1 or 2 breast cancer who underwent breast-conserving surgery (BCS) [5]. It was also noted that RT decreased the risk of distant metastasis [6]. Notably, the primary purpose of post-mastectomy RT is to eliminate the residual tumor cells in

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the anterior chest wall, skin, residual breast tissue, and local lymphatics [7, 8]. Therefore, giving RT to the whole breast area has become a standard approach in patients who underwent BCS [9].

In breast cancer patients, RT is given to the anterior chest wall and peripheral lymphatic area (i.e., axillary-supraclavicular region). The total radiation dose is 50 Gy which is given in 25 fractions. For most patients, the total dose is divided into daily doses five times a week for six weeks.

Despite its benefits, RT applied to breast cancer patients has side effects correlated with the dose and treatment duration. These side effects can be listed as lymphedema, skin, breast, pulmonary, cardiac complications, cerebrovascular accidents, and the development of cancer in the contralateral breast or other organs. In addition, complications related to the shoulder, such as reduced range of motion and pain, can also occur due to the vicinity of this joint to the radiated field. Therefore, in this study, we aimed to investigate the impact of RT on the anatomical components of the shoulder, including subcutaneous tissue, subacromial bursa, supraspinatus tendon (RCTs), long head of the biceps tendon (LHBT) and subscapularis tendon. We used shoulder ultrasonography (USG) since it is a cost effective, noninvasive, and portable method for imaging shoulder pathologies [10].

## METHODS

This prospective study was approved by Trakya University Medical Faculty Ethical review committee (Number: 02.2009-03/34- TUTFEK/35) and informed consent was obtained from each patients.

All patients diagnosed with breast cancer who received RT to the anterior chest wall and axillary-supraclavicular region after BCS or mastectomy in our hospital radiation oncology department. The control group was selected from the age-matched female asymptomatic volunteers who presented to the hospital for a check-up without chronic systemic disease, RT history, regular medication use, trauma, or congenital musculoskeletal anomaly.

Radiologic assessment of the acromioclavicular joint (ACJ) was done on the chest X-rays of the patients. Exclusion criteria included ACJ degeneration, patients with a history of shoulder or arm trauma, acromioclavicular joint hypertrophy, comorbidities predisposing to tendinopathies such as rheumatoid arthritis, collagen tissue disorders, and renal dysfunction.

A total radiation dose of 50 Gy was given to the patients in the RT group in 25 fractions. The total amount was divided into daily doses five times a week for six weeks. These patients were examined four times in the radiation oncology outpatient clinic, and the relevant data were collected for subsequent analysis.

All the sonographic assessments were done by a radiology resident under the supervision of a senior radiologist with four and ten years of experience, respectively. Both shoulders were examined. In addition, the dominant arm and the RT side were determined. Ultrasonographic assessment of the shoulder joint was done four times:

I. Pre-RT examination of both shoulders and determining the dominant arm (i.e., pre-RT)

II. Post-RT examination performed immediately after a 6-week RT (i.e., 6th-week assessment)

III. Follow-up examination performed three months after the first day of RT (i.e., 3rd-month assessment)

IV. Follow-up examination performed six months after the first day of RT (i.e., 6th-month assessment)

The pre-RT assessment included both shoulders, while only the radiated side was analyzed during subsequent visits. The RT group patients underwent a shoulder USG on the days of these examinations. Subsequently, they were physically examined by an orthopedic surgeon regarding the range-of-motion (ROM) of the shoulder joint and the presence or absence of shoulder pain. The radiologist and orthopedic surgeon were blinded to each other`s reports. All patients' shoulders were imaged by the Mylab 60 (Esaote, Genova, Italy) ultrasonography device with a 10 MHz linear probe and a color Doppler with high-resolution software developed explicitly for musculoskeletal ultrasound imaging. The patient sat on a swivel stool for proper positioning.

Since the tendon thickness and pathologies can be affected by the dominancy of the arm, the RT patients were classified into two subgroups called "ipsilateral" (i.e., the radiated field and the dominant arm are on the same side) or "contralateral" (i.e., the radiated area and the dominant arm are on opposite sides).

During shoulder ultrasounds, the LHBT, subscapularis tendon, and supraspinatus tendon were assessed regarding integrity, contours, thickness, and echoic features. Also, the presence or absence of potential shoulder tendon pathologies, including tears, tendinosis, tenosynovitis, subacromial bursitis (SAB), and calcific tendinitis, were investigated during these assessments.

All tendon thicknesses were measured longitudinally at locations where the tendon shows uniform thickness (Fig. 1). The results found during the pre-RT examination and three post-RT examinations were compared.

### Statistical Analysis

The statistical analyses were performed using the software STATISTICA AXA 7.1 (Serial No. AXA 507C775506FAN3, StatSoft Inc, Tulsa, US). The normal distribution of the variables was tested by the Kolmogorov-Smirnov test. The normally-distributed parameters were compared by the independent groups t-test, while the non-normally distributed data were compared using the Mann-Whitney U test. The repeated measures analysis of variance (ANOVA) test and Wilcoxon two-sample test were performed to compare the time-varying covariates. The descriptive variables were given as medians, minimums, maximums, and means ± standard deviations (SDs). The *p* value was considered significant when it was lower than 0.05.

## RESULTS

Overall, 56 patients were enrolled in this study. Among these patients, 36 were in the case (i.e., RT) group, while 20 were in the control group. The mean age of the RT and control groups were 50.8 (range: 33-73) years and 51 (range: 37-69) years. The mean interval between surgery and RT was 5.6 (range: 2-8) months. The demographic characteristics of the patients in the RT group are displayed in Table 1.

Among the 36 patients in the RT group, 23 (64%) did not have any ultrasonographic or clinical pathological findings. The main findings in the remaining 13 cases were peritendinous effusion of the biceps tendon (PTEBT), increased peritendinous blood flow at the biceps tendon, and intrasubstance tear in the supraspinatus tendon, peritendinous effusion of the supraspinatus tendon (i.e., subdeltoid effusion) and peritendinous effusion of the subscapularis tendon (Fig. 2).

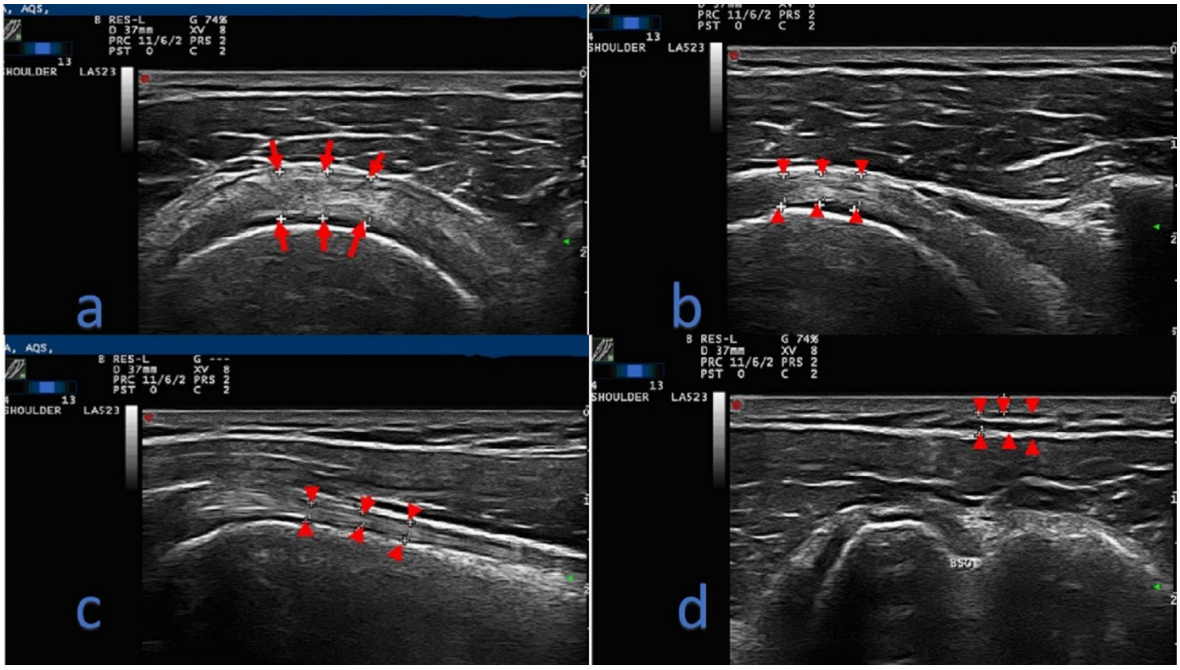


**Fig. 1. Ultrasonographic measurements. (a) Supraspinatus tendon, (b) Subscapularis tendon, (c) long head of the biceps tendon, and (d) Subcutaneous fat tissue.**

**Table 1.** Demographic data of the patients

| | Initials | Age (years) | Dominant arm | Surgical side | Surgery | Surgery-radiotherapy interval (months) |
|---|---|---|---|---|---|---|
| **1** | BO | 45 | Right | Right | Mastectomy | **6** |
| **2** | SY | 44 | Right | Right | Mastectomy | **7** |
| **3** | GT | 48 | Right | Right | Mastectomy | **7** |
| **4** | SK | 51 | Right | Right | Mastectomy | **5** |
| **5** | ST | 53 | Right | Right | Mastectomy | **7** |
| **6** | SB | 55 | Right | Right | Mastectomy | **8** |
| **7** | DA | 35 | Left | Right | Mastectomy | **7** |
| **8** | TS | 67 | Right | Right | Mastectomy | **4** |
| **9** | ST | 33 | Right | Right | Mastectomy | **5** |
| **10** | SG | 55 | Right | Right | BCS | **8** |
| **11** | FÇ | 59 | Right | Right | BCS | **5** |
| **12** | AY | 65 | Right | Left | Mastectomy | **6** |
| **13** | SB | 43 | Right | Left | Mastectomy | **3** |
| **14** | AY | 60 | Right | Left | Mastectomy | **8** |
| **15** | SK | 54 | Right | Left | Mastectomy | **5** |
| **16** | FK | 44 | Right | Left | Mastectomy | **5** |
| **17** | TS | 38 | Right | Left | Mastectomy | **4** |
| **18** | RE | 54 | Right | Left | Mastectomy | **3** |
| **19** | RT | 73 | Right | Left | Mastectomy | **7** |
| **20** | FN | 60 | Right | Left | Mastectomy | **2** |
| **21** | HK | 57 | Right | Left | Mastectomy | **7** |
| **22** | ZK | 38 | Right | Left | Mastectomy | **5** |
| **23** | HG | 45 | Right | Left | Mastectomy | **5** |
| **24** | HG | 35 | Right | Left | Mastectomy | **5** |
| **25** | MÖ | 62 | Right | Left | Mastectomy | **7** |
| **26** | SY | 53 | Right | Left | Mastectomy | **5** |
| **27** | HE | 57 | Right | Left | Mastectomy | **7** |
| **28** | ND | 33 | Right | Left | Mastectomy | **5** |
| **29** | EŞ | 50 | Left | Left | Mastectomy | **8** |
| **30** | RB | 43 | Left | Left | Mastectomy | **4** |
| **31** | AY | 53 | Left | Left | Mastectomy | **7** |
| **32** | PI | 54 | Right | Left | BCS | **6** |
| **33** | LD | 67 | Right | Left | BCS | **7** |
| **34** | ŞE | 49 | Right | Left | BCS | **3** |
| **35** | AG | 53 | Right | Left | BCS | **6** |
| **36** | **CU** | **47** | **Right** | **Left** | **BCS** | **7** |

There were 3 (8.3%) patients with abnormal ultrasonographic findings during the pre-RT assessment. These patients had peritendinous effusion of the biceps tendon, and 2 of these patients had associated pain. In 1 of these 2 cases, the effusion and shoulder pain persisted. In the other case, peritendinous effusion of

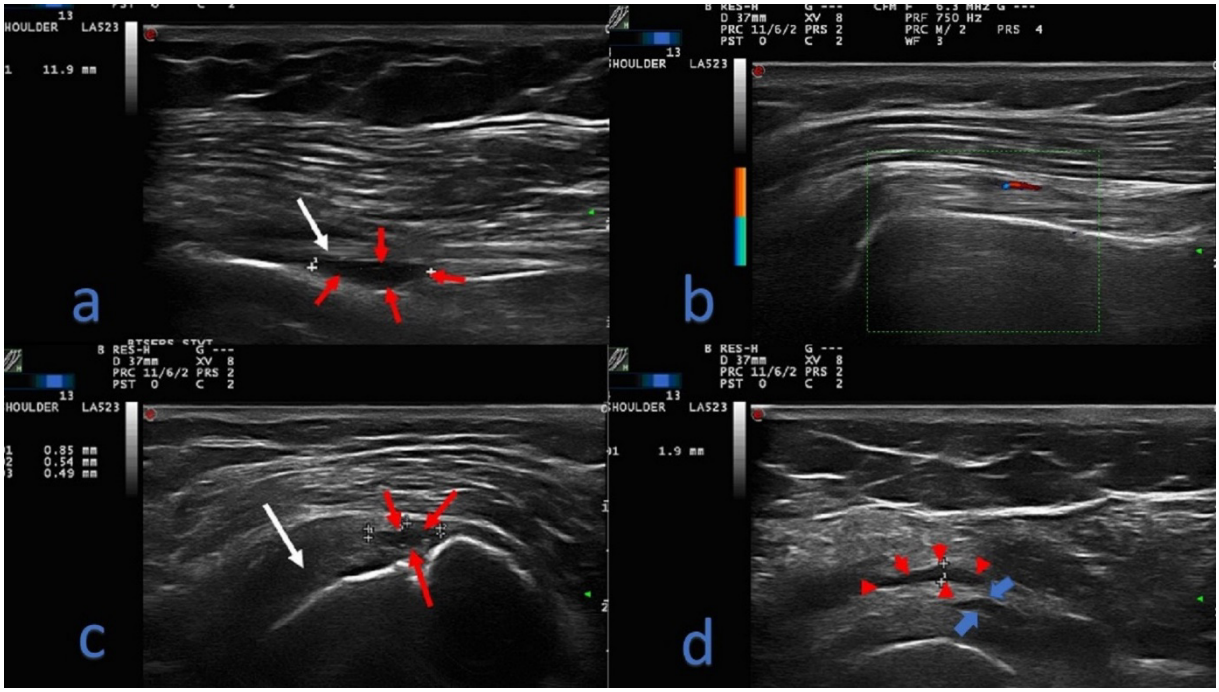


**Fig. 2. Findings detected by ultrasonography. (a) effusion within the biceps long head tendon sheath, (b) Tenosynovitis of the long head of the biceps tendon, (c) Partial tear of supraspinatus tendon, and (d) Subdeltoid efusion (red arrows) and partial tear of supraspinatus tendon (blue arrows).**

supraspinatus and subscapularis tendons was detected during the 6th-week and 3-month follow-up. However, this patient had peritendinous effusion of the supraspinatus tendon and pain at the post-RT 6-month visit. The third patient with pre-RT PTEBT did not have pain; this patient showed no changes during follow-up encounters.

On the other hand, 10 (27.7%) patients developed ultrasonographic abnormalities during the post-RT period (Table 2). Among these, 6 (16.6%) had PTEBT at the 6th week of the assessment without any clinical findings. Three of these 6 patients did not have any abnormal USG findings during 3-month and 6-month follow-ups. In one of the 6 cases, the peritendinous effusion persisted until it completely resorbed at the 6-month follow-up. However, this patient complained about pain and was diagnosed with restricted ROM in the shoulder joint. Another patient detected to have PTEBT at the 6-week assessment complained about pain and was determined to have restricted ROM during the 6-month visit. Finally, in one of the six patients detected to have PTEBT during the 6-week visit, peritendinous effusion of the supraspinatus tendon and intrasubstance tear were added to the picture. However, this patient did not have pain or any physical examination findings.

In 1 (2.8%) of the ten patients with post-RT abnormal findings, shoulder pain preceded the abnormal USG findings. This patient complained about pain during the 6-week assessment, but the USG was completely normal then. However, this patient was detected with PTEBT and increased peritendinous blood flow at the biceps tendon at the 6-month visit. Similarly, another patient with no pre-RT complaints or abnormal USG findings developed PTEBT and peritendinous effusion of the supraspinatus tendon three months after RT. The former finding persisted until the 6-month assessment, but this patient did not have any complaints. Finally, one (2.8%) patient developed PTEBT, while another (2.8%) had peritendinous effusion of the supraspinatus tendon at the post-RT 6-month assessment. However, these two patients had no pain or physical examination findings.

All control group patients had normal ultrasonographic findings. The thickness of the supraspinatus, biceps, subscapularis tendons and subcutaneous fat was similar between the dominant and non-dominant sides of the control group patients, and the cases (5.7

**Table 2.** Cases with clinical and/or radiological abnormalities

| | Pre-RT | | 6.week | | | | 3.month | | | | 6.month | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PBTE | PAIN | PRCTE | PBTE | PSTE | PAIN | PRCTE | PBTE | PSTE | PAIN | PRCTE | RCPT | PBTE | IPBBF | RM | PAIN |
| GT | - | - | - | - | - | - | + | - | - | - | - | - | - | - | - | - |
| SB | - | - | - | + | - | - | + | - | - | - | + | + | + | - | - | - |
| FÇ | - | - | - | - | - | - | - | - | - | - | - | - | + | - | - | - |
| AY | - | - | - | + | - | - | - | - | - | - | - | - | - | - | +* | + |
| AY | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - |
| RE | - | - | - | - | - | + | - | - | - | - | - | - | + | + | - | - |
| HK | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - |
| ZK | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - |
| HG | - | - | - | - | - | - | + | + | - | - | - | - | + | - | - | - |
| ND | - | - | - | + | - | - | - | + | - | + | - | - | - | - | +** | + |
| SK | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - | + |
| TS | + | + | - | + | - | + | - | + | - | + | - | - | + | - | - | + |
| AG | + | - | - | + | - | - | - | + | - | - | - | - | + | - | - | - |

PBTE = Peri-biceps tendon effusion, PRCTE = Peri-supraspinatus tendon effusion, PSTE = Peri-subscapularis tendon effusion, RCPT = Rotator cuff partial tear, IPBBF = Increased peri-biceps tendon blood flow, RM = Restricted motion, +* = Internal rotation+extension, +**= External rotation+abduction

mm vs. 5.1 mm, 2.87 mm vs. 2.89 mm, 4.13 mm vs. 3.97 mm, and 3.97 mm vs. 3.89 mm; respectively, $p > 0.05$).

Among 36 patients in the RT group classification into two subgroups as "ipsilateral" (i.e., the radiated field and the dominant arm are on the same side) and "contralateral" (i.e., the radiated area and the dominant arm are on opposite sides) revealed that 13 patients were given RT to the ipsilateral side and 23 received RT to the contralateral side. These groups were also compared regarding tendon and subcutaneous fat thicknesses (Table 3). This analysis showed that the pre-RT supraspinatus tendon thickness was significantly higher in the ipsilateral group than in the contralateral group ($p = 0.026$). However, the same comparison did not reveal a significant difference in the post-RT period ($p = 0.408$). As such, there was no difference between the two groups regarding the thicknesses of the biceps tendons analyzed during post-RT 3-month and 6-month assessments ($p = 0.468$). It was also the case for the thickness of the subscapularis tendon ($p = 0.385$).

The thickness of the subcutaneous fat significantly decreased in the ipsilateral group; the mean decrease was 0.6 mm ($p = 0.001$). However, this figure started to increase three months after RT and went up to its pre-RT levels before the post-RT 6-month visit.

The results of the comparative analysis of the 13 RT group patients with abnormal clinical or ultrasonographic findings with the 23 RT group who did not have any abnormal findings concerning the thickness of the subcutaneous fat are displayed in Table 4. This analysis did not reveal a significant difference.

## DISCUSSION

Magnetic resonance imaging is the gold standard method for delineating the shoulder anatomy and diagnosing shoulder pathologies since it is a high-resolution multiplanar imaging tool. However, it has disadvantages as being expensive, time-consuming, and less likely to be immediately available than other cross-sectional imaging methods. On the other hand, USG can delineate the anatomy and show the pathologies of the shoulder with considerable sensitivity and specificity. Furthermore, it is portable, readily available, cheaper, and faster than MRI. Its combination

**Table 3. Comparison of the tendon and subcutaneous fat thicknesses of the patients who underwent RT**

| Variable | Ipsilateral (n = 13)<br>Mean ± SD<br>Median (Min-Max) | Contralateral (n = 23)<br>Mean ± SD<br>Median (Min-Max) | *p value* |
|---|---|---|---|
| **Pre-RT** | | | |
| **RCTT** | 6.15 ± 0.98<br>6.3 (4.8-8.4) | 5.39 ± 0.87<br>5.4 (3.9-8.1) | **0.026***ǂ |
| **BTT** | 2.93 ± 0.29<br>3.1 (2.5-3.3) | 2.89 ± 0.32<br>2.9 (2.1-3.7) | 0.537* |
| **STT** | 4.10 ± 0.81<br>3.9 (3.5-6.7) | 4.24 ± 0.78<br>4.1 (3.2-6.2) | 0.558* |
| **SCF** | 5.13 ± 1.49<br>4.9 (1.9-7.5) | 4.45 ± 1.53<br>4.4 (1.4-7.8) | 0.204** |
| **6. week** | | | |
| **RCTT** | 6.30 ± 0.91<br>6.1 (5.1-7.9) | 6.04 ± 0.74<br>5.9 (4.5-7.5) | 0.371** |
| **BTT** | 3.29 ± 0.42<br>3.2 (2.9-4.2) | 3.07 ± 0.44<br>3.1 (2.3-4.3) | 0.296* |
| **STT** | 4.15 ± 0.63<br>4.1 (3.3-5.6) | 4.37 ± 0.72<br>4.3 (3.3-6.3) | 0.366** |
| **SCF** | 4.51 ± 1.65<br>4.7 (1.8-7.5) | 4.39 ± 1.71<br>4.1 (2.0-8.4) | 0.116** |
| **3. month** | | | |
| **RCTT** | 6.25 ± 0.97<br>5.8 (5.1-8.2) | 6.33 ± 0.77<br>6.2 (5.0-8.0) | 0.478* |
| **BTT** | 3.34 ± 0.36<br>3.4 (2.6-3.8) | 3.32 ± 0.49<br>3.4 (2.3-4.1) | 0.893** |
| **STT** | 4.40 ± 0.72<br>4.1 (3.5-6.4) | 4.50 ± 0.74<br>4.3 (3.2-5.9) | 0.519* |
| **SCF** | 4.83 ± 1.39<br>5.1 (2.0-6.5) | 4.34 ± 1.63<br>4.2 (1.5-7.4) | 0.367** |
| **6. month** | | | |
| **RCTT** | 5.97 ± 0.94<br>6.1 (4.4-7.7) | 6.31 ± 0.80<br>6.5 (5.1-7.8) | 0.259** |
| **BTT** | 3.32 ± 0.43<br>3.2 (2.5-3.9) | 3.37 ± 0.61<br>3.4 (2.3-4.2) | 0.792** |
| **STT** | 4.35 ± 0.47<br>4.3 (3.5-5.3) | 4.58 ± 0.80<br>4.3 (3.6-6.4) | 0.729* |
| **SCF** | 5.39 ± 1.51<br>5.9 (2.0-7.2) | 4.98 ± 2.15<br>4.9 (1.8-9.9) | 0.548** |

RCTT = Supraspinatus tendon thickness, BTT = Biceps tendon thickness, STT = Subscapular tendon thickness, SCF = Subcutaneous fat thickness, RT = Radiation treatment, SD = Standard deviation

*: Mann Whitney U test **: Independent groups t test ǂ: $p < 0,05$ indicating statistical significance

**Table 4. Comparison of the subcutaneous fat thickness between patients with and without clinical and/or ultrasonographic abnormalities**

| | Abnormality present (n = 13)<br>Mean ± SD<br>Median (Min-Max) | No abnormality (n = 23)<br>Mean ± SD<br>Median (Min-Max) | *p value* |
|---|---|---|---|
| **Pre-RT** | 4.75 ± 0.85<br>4.4 (3.9-6.2) | 4.64 ± 1.77<br>4.9 (1.4-7.8) | 0.739* |
| **6. week** | 4.46 ± 1.06<br>4.4 (3.1-6.0) | 4.46 ± 1.9<br>4.5 (1.8-8.4) | 0.724* |
| **3. month** | 4.85 ± 1.05<br>4.7 (2.9-6.5) | 4.40 ± 1.74<br>4.1 (1.5-7.4) | 0.389* |
| **6. month** | 5.52 ± 1.11<br>5.4 (3.9-7.2) | 5.05 ± 2.24<br>4.9 (1.8-9.9) | 0.410* |

*Mann Whitney U test, RT = Radiation treatment, SD = Standard deviation

with color Doppler increases its efficacy in diagnosing the inflammatory pathologies of the muscles, tendons, and synovium. The introduction of the novel high-frequency (20 MHz) ultrasonic devices facilitated the evaluation of even the fibers of the tendons. In addition, the novel multifrequency probes rendered the synchronized imaging of the superficial and deep structures. Therefore, in recent decades, USG has become popular in imaging the musculoskeletal system [11].

The primary aim of RT is to kill the tumor cells while protecting the healthy tissue from inadvertent damage [12]. The RT-related adverse effects in patients with breast cancer are neck, shoulder, or arm pain, lymphedema in the arm, axillary paresthesia, restricted motion in the arm and shoulder, and brachial plexopathy [13, 14]. These adverse effects were reduced by the recent advances in RT techniques and modifications in the dose-fraction schemes.

Among the listed side effects, restricted shoulder motion is a common effect reducing the quality of life [15, 16]. The primary reasons for the motion restriction are pectoral muscle fibrosis, neuronal damage, lymphedema, and damage to the vascular structures. Our study did not analyze the contributions of these factors in patients with restricted ROM in the shoulder joint; however, ROM assessment was the essential assessment performed by the orthopedic surgeon. Among 36 patients in the RT group, 2 (5.6%) had restricted ROM in the shoulder joint during the post-RT 6-month visit.

There is a risk of tendon pathology in patients receiving 20 Gy or more radiation [17]. It was reported that the pathogenetic mechanisms leading to RT-related soft tissue damage involved endothelial thickening resulting from microvascular injury, degeneration, necrosis, and inflammatory reactions leading to progressive fibrosis [18]. Also, free oxygen radicals formed after an ischemia period can contribute to this process following reperfusion by causing ischemia-reperfusion injury. Recurrent hyperemia caused by radiation is also implicated in this process. Our patients in the RT group were given a total radiation dose of 50 Gy. Therefore, there was a considerable risk for shoulder tendon pathologies. In line with this assumption, all of our RT patients were detected to have minimal edema in the shoulder tendons at the 6-week assessment. The only ultrasonographic finding in 23 of 36 RT group patients was edema. However, the edema was prominent in the biceps tendon since this tendon is closer to the radiated field than the other tendons. In only 10 cases, the edema was accompanied by peritendinous effusion.

It was postulated that tenosynovitis, demonstrated by the presence of peritendinous effusion, was due to the thermal effects of the radiation and subsequent inflammation. However, in our study, PTEBT was more common than peritendinous effusion of the

supraspinatus and subscapularis tendons. This finding is in line with the fact that the long head of the biceps tendon is closer to the anterior chest wall and axillary-supraclavicular radiation fields.

It is known that one of the most common causes of tendinopathy is trauma. Nevertheless, since all of our RT group patients underwent breast surgery (BCS or mastectomy) before starting RT, it is reasonable to assume that they protected the ipsilateral shoulder and the arm from trauma. Thus, it can be suggested that all tendinopathies were due to radiation damage rather than trauma. In addition, only one of our patients had supraspinatus tendon's tear. However, more data are required to suggest that RT facilitates tendon tears in minor traumas. Our patients did not have other potential facilitators, such as a history of trauma, acromioclavicular joint hypertrophy, and comorbidities predisposing to tendinopathy.

In one of our cases, increased peritendinous blood flow at the biceps tendon and PTEBT were detected during the 6-month visit. However, this patient did not complain about shoulder pain. This finding is consistent with the reports, which noted that synovial hyperemia was not correlated with pain [19].

In all of our cases, we detected an increase in the tendon thicknesses after a 6th-week RT. However, this increase was statistically insignificant. In addition, the increased tendon thicknesses started to reduce afterward. This finding can be explained by sublethal damage repair [20, 21]. It was noted that the subcutaneous fat was susceptible to radiation, which caused a significant but temporary decrease in both the number and the size of the lipid cells [22]. Our results align with these reports since we observed a decrease and a subsequent increase in subcutaneous fat thickness during the 6th-week and 6th-month assessments.

Blomqvist *et al*. compared the patients who underwent mastectomy and RT with those who did not receive RT after mastectomy regarding shoulder motions [23]. The comparison made after a mean post-RT period of 15 months revealed that RT led to restricted mobility in the shoulder and a weakening in the strength of the shoulder muscles. The lowest impact was detected in external rotation. In our study, two patients had a restricted range of motion in the shoulder joint. One of these cases had restrictions on internal rotation and extension, while the other had restricted external rotation and abduction. These two patients were detected to have biceps tenosynovitis during the 6th-week assessment. It was postulated that radiation might cause inflammation in the synovium, and subsequent healing by a severe fibrogenic process might lead to fibrosing tenosynovitis. However, our results are insufficient to support this hypothesis, nor are they comparable to those of Blomqvist *et al*. since our six-month follow-up period was six months [23].

In our cohort, all but two cases with tenosynovitis improved before the post-RT 3-month visit. The remaining two patients healed before the 6-month assessment. Interestingly, none of the cases with tenosynovitis had pain, and the only case who complained about shoulder pain during the 6-week visit did not have any abnormal ultrasonographic findings.

It was reported that mastectomy alone could cause motion restriction in the shoulder joint, shoulder pain, and arm pain, and physiotherapy could reduce the risk of these complications [24, 25]. In our cohort, 29 of the 36 RT group patients underwent a mastectomy, and all of these patients stated that they were compliant with the post-mastectomy physiotherapy program.

### Limitations

Our study has some limitations. First, the follow-up period is relatively short. Second, the sample size is relatively small. Third, the analysis does not include data regarding initial admission, including surgical parameters and complications.

## CONCLUSION

In breast cancer patients undergoing adjuvant RT following BCS or mastectomy, RT causes temporary edema in shoulder tendons in the irradiated field. However, the edema is relatively more prominent in the long head of the biceps tendon. Shoulder pain and restricted range of motion can be present in these patients. Nevertheless, these complaints do not correlate with the ultrasonographic findings.

*Authors' Contribution*

Study Conception: BA; Study Design: SK, BA; Supervision: BA; Funding: N/A; Materials: N/A; Data Collection and/or Processing: SK; Statistical Analysis

and/or Data Interpretation: SK, BA; Literature Review: SK, BA; Manuscript Preparation: SK and Critical Review: SK, BA.

*Conflict of interest*

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