

Case Study

## The treatment efficacy of complete decongestive therapy for breast cancer-related lymphedema from the perspective of skin mechanical properties: a case study

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**Abstract.** [Purpose] To quantitatively assess skin mechanical properties in a case of breast cancer-related lymphedema (BCRL) and examine their clinical utility. [Participant and Methods] A 69-year-old female was diagnosed with BCRL of the left upper extremity. In this case, the patient was admitted to our institute for two weeks of intensive lymphedema drainage. Complex decongestive therapy (CDT), the standard treatment for lymphedema, was administered during hospitalization. Pre-intervention and at one- and two-weeks post-intervention, circumferential diameter, motor function, and quality of life of the affected extremity were measured, along with skin mechanical properties using a skin elasticity meter. [Results] Skin mechanical properties on the affected side before intervention were inferior to those of the unaffected side. During inpatient CDT, in addition to reductions in limb circumference and improvements in motor function and quality of life, all three parameters of skin mechanical properties also improved. [Conclusion] These findings suggest that measuring skin mechanical properties using a skin elasticity meter provides a useful quantitative assessment for longitudinal evaluation in BCRL.

**Key words:** Breast cancer-related lymphedema, Skin mechanical properties, Skin elasticity meter

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## INTRODUCTION

Secondary lymphedema most commonly occurs as an aftereffect of cancer treatment<sup>1)</sup>. Breast cancer-related lymphedema (BCRL), the most common form of secondary lymphedema, occurs when the lymphatic system is impaired by breast cancer treatment, preventing adequate drainage through the lymphatic vessels and causing the accumulation of protein-rich lymph fluid in the interstitial space<sup>2)</sup>. Symptoms of BCRL include abnormal swelling, tightness, heaviness, pain, and functional impairment of the affected upper limb or trunk, all of which contribute to reduced quality of life<sup>3–5)</sup>.

Complex decongestive therapy (CDT) is the current standard of care for lymphedema<sup>6)</sup>. Components of CDT include skin care, manual lymphatic drainage, compression therapy, and lymphedema rehabilitation exercises, all of which enhance the transport capacity of the lymphatic vessel system<sup>7)</sup>. Assessment tools used to determine the effectiveness of CDT in lymphedema, particularly BCRL, include edema volume, limb circumference, range of motion, pain, and quality of life.

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However, few studies have focused on the skin's mechanical properties in BCRL<sup>8</sup>. Skin mechanical properties is a collective term that includes stiffness, thickness, retraction, extension, pliability, elasticity, and viscosity<sup>9</sup>. Skin changes in patients with lymphedema have been included in the International Society of Lymphology (ISL) consensus staging system, which reflects disease progression based on changes in mechanical properties<sup>10</sup>. However, in clinical lymphedema therapy, skin mechanical properties are often assessed subjectively through palpation by the evaluator. This is primarily due to the lack of an established method for objectively evaluating these properties in patients with lymphedema<sup>1</sup>.

The skin elasticity meter (Cutometer; Courage and Khazaka Electronic GmbH, Cologne, Germany) is a noninvasive tool developed to provide objective, quantitative measurements of skin mechanical properties<sup>10</sup>. The device operates based on the suction method, in which the skin's resistance to negative pressure (firmness) and its ability to return to its original position (elasticity) are measured in real time and displayed as curves (penetration depth in mm over time). These curves allow for the calculation of various parameters related to skin mechanical properties, including elasticity and viscoelasticity of the skin surface. Although several previous studies have used the skin elasticity meter to assess skin mechanical properties in patients with lymphedema, standardized measurement protocols have not yet been established<sup>8</sup>.

Therefore, in this case report, we aimed to examine the efficacy of treatment using skin mechanical properties as an indicator in a patient with BCRL. If it can be demonstrated that skin mechanical properties can be objectively measured in patients with BCRL, this may contribute to the identification of new indicators of treatment efficacy and the elucidation of factors influencing therapeutic outcomes in the future.

## CASE

The case was fully explained orally and in writing, and informed consent was obtained for this report. A 69-year-old Japanese female (height: 156.0 cm; body weight: 74.0 kg; BMI: 30.4 kg/m<sup>2</sup>; right-handed) was admitted to our institute for breast cancer surgery. She had no prior medical history and was able to perform her activities of daily living independently. She had received neoadjuvant chemotherapy, including taxane. The left upper extremity presented with significant edema upon admission, which was presumed to result from compression of the veins and lymphatic vessels by the tumor in the axillary region. Breast cancer surgery consisted of total mastectomy and axillary lymph node dissection. During the perioperative period, rehabilitation focused on shoulder function associated with breast cancer surgery. There was no significant change in the edema status approximately one month postoperatively, leading to hospitalization for intensive lymphedema drainage. In the diagnostic process, other conditions presenting with edema were excluded.

At our institution, intensive drainage hospitalization for lymphedema typically lasts two weeks. During this period, daily assessments of edema morphology are conducted, and comprehensive evaluations of edema morphology, motor function, and quality of life are performed upon admission and discharge. Edema assessment and treatment are carried out by a licensed rehabilitation therapist or a certified lymphedema nurse therapist.

The ISL classification of the left upper extremity on admission was between late stage 2 and stage 3 disease. The differences in circumference between the left and right upper extremities were 8 cm at the upper arm, 10 cm at the forearm, and 5 cm at the hand. Skin mechanical property values measured using the skin elasticity meter were as follows: upper arm—R0+offset: 1.482 mm; R2: 72.0%; R7: 47.0%; forearm—R0+offset: 1.485 mm; R2: 59.9%; R7: 37.8%. The skin elasticity meter was set to apply a vacuum of 450 mbar on the skin surface for 3 s, followed by 3 s at atmospheric pressure (Mode 1 setting). A probe with a diameter of 2 mm was used in this case. The measurements were conducted three times at each site, and the average values were calculated. In addition, the room temperature and humidity in the measurement room were maintained at 23 ± 2°C and 50–60%, respectively. Measurement values were based on previous studies and included the following parameters: R0+offset (distensibility), R2 (gross elasticity), and R7 (biological elasticity)<sup>8, 9</sup>. Higher values for any of these parameters indicate better skin performance. The two standardized measurement sites were defined as follows: (i) upper arm—10 cm proximal to the elbow crease along a line parallel to the arm axis, measured from the midpoint between the medial and lateral epicondyles; (ii) forearm—5 cm distal to the elbow crease along a line parallel to the arm axis, also measured from the midpoint between the medial and lateral epicondyles<sup>8</sup>. In addition, grip strength in the left hand was 12.1 kg, and the Box and Block Test (BBT) score was 47. The Lymphedema Quality of Life Questionnaire for the Arm (LYMQOL-Arm), a disease-specific scale for assessing quality of life in lymphedema patients, yielded the following scores: function, 2.6; appearance, 3.6; symptoms, 3.5; emotions, 2.8; and overall, 4. The LYMQOL-Arm consists of domain-specific items, with lower scores (range: 1–4) indicating better outcomes in function, appearance, symptoms, and emotions, and higher scores (range: 0–10) indicating better overall quality of life.

Lymphedema treatment consisted of CDT—including skin care, lymphatic drainage, compression therapy, and lymphedema rehabilitation exercises under compression—as well as patient education, which covered edema self-management, exercise therapy for weight loss, and nutritional counseling by a certified nutritionist. Compression therapy was performed using MOBIDERM bandages (Fig. 1). CDT and physical function training were conducted for 60 minutes each in the morning and afternoon and were continued throughout the day with multilayer lymphedema bandaging. In addition, the patient was fitted with a selection of elastic compression garments for both daytime and nighttime use prior to hospital discharge (Fig. 2).

The results of the interim assessment after one week of intervention and the final assessment after two weeks are summarized in Table 1. As shown in Table 1, improvements were observed in all three parameters of skin mechanical properties, circumference, motor functions, and QOL after CDT treatment (Fig. 3).

DISCUSSION

We identified two important clinical insights. This case of BCRL is valuable because it demonstrates that the skin mechanical properties of the affected extremity can be quantitatively and longitudinally assessed during treatment.

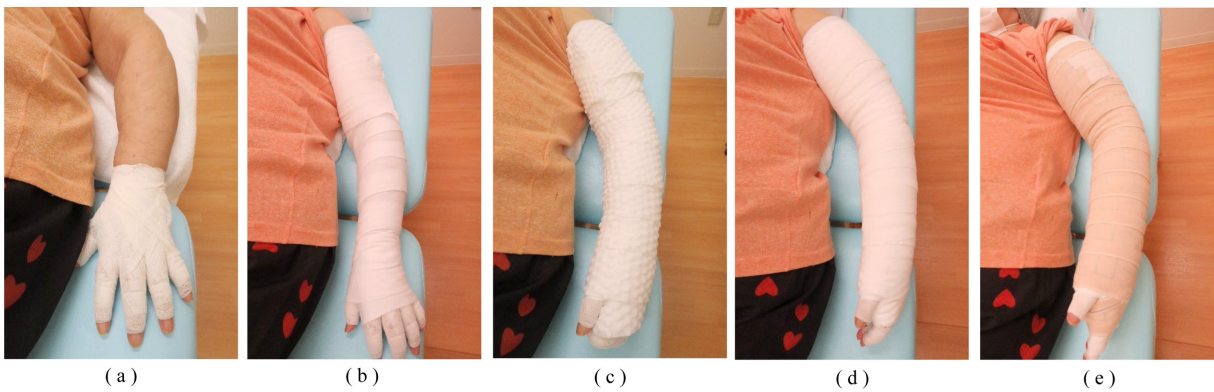


Fig. 1. Mobiderm bandages.  
(a) finger bandages, (b) cotton bandage, (c) mobiderm, (d) biflexideal, (e) biflex.

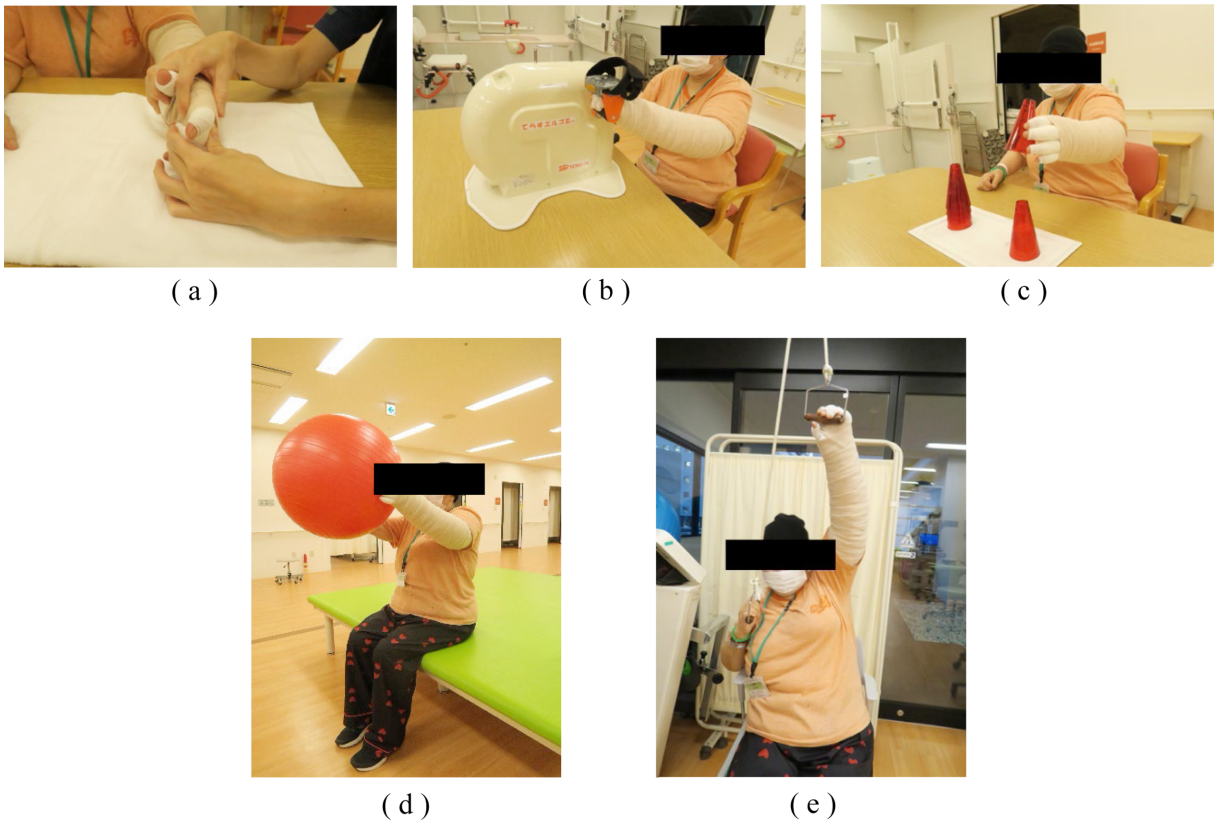
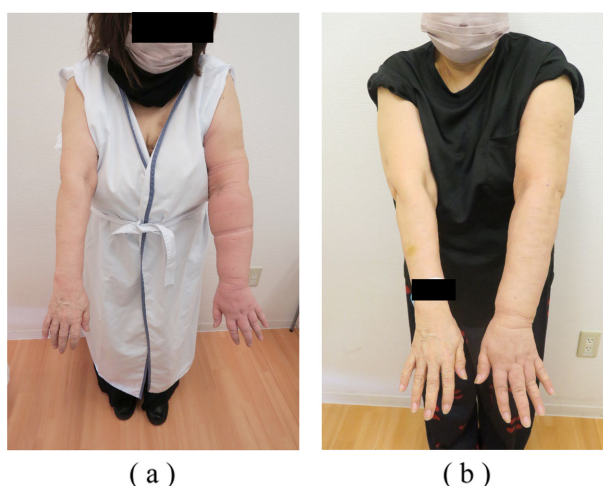


Fig. 2. Exercise therapy under compression therapy (one section).  
(a) Range of motion training, (b) Upper extremity ergo meter, (c) Object handling practice, (d) Gross motor training, (e) Pulley movement.

**Table 1.** Changes in body composition, physical function, skin mechanical properties, and quality of life

|                            | Pre-intervention | After one week | After two weeks |
|----------------------------|------------------|----------------|-----------------|
| Body weight (kg)           | 74               | 73.5           | 71.6            |
| BMI (kg/m <sup>2</sup> )   | 30.4             | 30.2           | 29.4            |
| Grip strength (kg)         | 12.1             | 12.7           | 15.1            |
| BBT                        | 47               | 51             | 54              |
| Skin mechanical properties |                  |                |                 |
| R0+offset (mm)             | 1.482/1.485      | 1.577/1.585    | 1.611/1.621     |
| Upper arm/Lower arm        |                  |                |                 |
| R2 (%)                     | 72.0/59.9        | 73.8/62.3      | 79.2/68.8       |
| Upper arm/Lower arm        |                  |                |                 |
| R7 (%)                     | 47.0/37.8        | 51.5/41.8      | 63.4/44.4       |
| Upper arm/Lower arm        |                  |                |                 |
| LYMQOL                     |                  |                |                 |
| Function                   | 2.6              | 2.3            | 2.3             |
| Appearance                 | 3.6              | 3.6            | 3.2             |
| Symptoms                   | 3.5              | 3.7            | 3.3             |
| Emotions                   | 2.8              | 2              | 2.3             |
| Over all                   | 4                | 5              | 6               |

BMI: body mass index; BBT: box and block test; LYMQOL: lymphoedema quality of life questionnaire.



**Fig. 3.** Morphological changes in the left breast cancer-related lymphedema (BCRL) before and after treatment, such as reduction in circumference.  
(a) before, (b) after.

First, the skin mechanical properties in BCRL were quantitatively measured. Although the skin elasticity meter is considered a reliable device, its clinical application in lymphedema patients has not been widely adopted. Previous studies have reported on the clinical use of the skin elasticity meter employed in this study, primarily in the cosmetic industry<sup>11, 12</sup> and in dermatologic conditions<sup>13, 14</sup>. In those studies, quantitative assessments of skin mechanical properties were used for supplementary diagnostics and product development. Although this case remains exploratory in demonstrating the skin mechanical properties of BCRL quantitatively, such measurements may prove useful in determining treatment strategies and evaluating therapeutic efficacy in clinical practice. The parameters used in this study—offset+R0, R2, and R7—reflect distensibility and elasticity, which are commonly impaired in lymphedema. The ability to quantitatively demonstrate these properties is considered a novel contribution.

Second, the skin mechanical properties of BCRL were shown to change longitudinally over the course of treatment. To our knowledge, no previous reports have captured such longitudinal assessments during BCRL treatment<sup>8</sup>. Previous studies have mostly been cross-sectional studies, and measurements were conducted at a single point for various types of edema associated



with cancer treatment. In this case, CDT not only improved lymphedema morphology and quality of life but also enhanced the skin mechanical properties of the edematous limb. Although longitudinal studies using a skin elasticity meter have been conducted in patient populations other than those with lymphedema—such as individuals with burns<sup>15)</sup> and scars<sup>16)</sup>—such applications in BCRL are limited. These studies suggest that measurements obtained with a skin elasticity meter provide a valid method of quantifying changes in skin mechanical properties over time. In the present case, skin mechanical properties were measured at multiple time points, and longitudinal changes were successfully quantified and demonstrated. This approach may hold promise for application in BCRL, similar to its use in previous studies. However, both the present case and prior studies that assessed longitudinal changes in skin mechanical properties were limited by small sample sizes. Therefore, further clinical validation is required for the standardized application of this method.

The assessment of skin mechanical properties in patients with lymphedema is important for understanding the patient's condition and severity. However, in clinical practice for lymphoedema to date, assessment and treatment of skin conditions have been based on the experience of therapists. Although the method described in this case report cannot yet be generalized, it demonstrates that the skin mechanical properties of patients with lymphedema can be measured quantitatively, and its clinical application is expected in the future.

In conclusion, this case report demonstrated quantitative measurements and longitudinal changes in the skin mechanical properties of a patient with BCRL using a skin elasticity meter. Quantitative evaluation of skin conditions commonly observed in lymphedema may be useful for accurately understanding the pathophysiology of edema. Furthermore, it may be useful for elucidating the causes of edema, evaluating the effectiveness of treatment for patients, and developing new treatment strategies.

### *Conflict of interest*

The authors declare no conflicts of interest.

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