



Breast Cancer

Estimation of Hand Function Impairment in Breast Cancer Survivors with Lymphedema

Sandeep B. Shinde¹ Pooja P. Jain² Diksha S. Jagwani² Sanjay K. Patil³ Anand Gudur⁵
Ravindra V. Shinde⁵

¹ Associate Professor, Head of Department of Musculoskeletal Sciences, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Deemed to be University, Karad, Maharashtra, India

² Department of Musculoskeletal Sciences, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Deemed to be University, Karad, Maharashtra, India

³ Department of Obstetrics and Gynecology, Krishna Vishwa Vidyapeeth, Krishna Institute of Medical Sciences Deemed to be University, Karad, Maharashtra, India

⁴ Department of Oncology, Krishna Vishwa Vidyapeeth, Krishna Institute of Medical Sciences Deemed to be University, Karad, Maharashtra, India

Address for correspondence Sandeep B. Shinde, BPTH, MPTh, Associate Professor, Head of Department of Musculoskeletal Sciences, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Karad, Maharashtra 415539, India
(e-mail: dr.sandeepshinde24@gmail.com).

⁵ Department of Microbiology, Krishna Vishwa Vidyapeeth, Krishna Institute of Medical Sciences Deemed to be University, Karad, Maharashtra, India

South Asian J Cancer 2025;14(1):23–29.

Abstract



Sandeep B. Shinde

Breast cancer (BC) is one of the most frequent cancers in women, and breast cancer-related lymphedema (BCRL) is a common side effect of BC treatment. When the lymphatic drainage system is damaged, lymphedema develops, which further exacerbates swelling and leads to pain, an increase in limb circumference, a reduction in joint range of motion, and a decrease in the use of the affected hand for functional tasks. Handgrip strength is essential for performing upper limb functional daily activities. Less is known about the long-term effects of lymphedema on hand function. The objective of the study was estimation of hand function impairment in BC survivors with lymphedema. This study was carried out by randomly selecting 100 out of 1,200 women with lymphedema, aged between 40 and 80 years, and who underwent sentinel lymph node biopsy along with radiotherapy, were included in this study. The handgrip strength was tested using an electronic handheld dynamometer. The functional wrist and hand scales were used to evaluate hand function. The Michigan Hand Outcome Questionnaire (MHQ) was used to evaluate the hand's overall function. A statistical analysis was done using SPSS statistical software (version 23.0). Handgrip strength of the affected hand by BCRL when compared with the unaffected hand was reduced. Functional hand and wrist scale have shown very poor results of the affected hand when compared with the unaffected hand. Majority of participants in the MHQ were unsatisfied with the overall functioning of the hand ($p < 0.0001$). This study concluded that there was significant hand function impairment in BC survivors with lymphedema. BCRL had a negative impact on daily activities of the individual and also affected the mental, emotional, and social aspects. BCRL also had an impact on overall self-reported physical function and quality of life.

Keywords

- breast cancer
- lymphedema
- hand function
- quality of life
- grip strength

DOI <https://doi.org/10.1055/s-0044-1779301> ISSN 2278-330X

How to cite this article: Shinde SB, Jain PP, Jagwani DS, et al. Estimation of Hand Function Impairment in Breast Cancer Survivors with Lymphedema. South Asian J Cancer 2025;14(1):23–29.

© 2024. MedIntel Services Pvt Ltd. All rights reserved.

This is an open access article published by Thieme under the terms of the Creative Commons Attribution-NonDerivative-NonCommercial-License, permitting copying and reproduction so long as the original work is given appropriate credit. Contents may not be used for commercial purposes, or adapted, remixed, transformed or built upon. (<https://creativecommons.org/licenses/by-nc-nd/4.0/>)

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

Introduction

Cancer is a collection of diseases caused by the uncontrolled growth and division of abnormal cells, which, if uncontrolled further, may lead to death. It may be both hereditary and epigenetic.¹ Many more individuals die from cancer than from AIDS, TB, and malaria combined.² There were 18 million new instances of cancer diagnosed in 2018, with lung, breast, and prostate cancers accounting for the majority of these cases (2.09 million, 2.09 million, and 1.28 million, respectively).³ The most frequent type of cancer among women is breast cancer (BC), which has the highest mortality rate worldwide.² Despite screening mammography and a decline in mortality, the incidence of BC in women has been rising over the past 10 years.⁴

BC patients are managed with a variety of surgical techniques, including breast conserving surgery, modified radical mastectomy (RC), and RC.⁵ Even in patients with axillary lymph node (LN) positivity, sentinel lymph node dissection (SLND) has replaced axillary lymph node dissection (ALND) as the standard axillary staging method for early BC.⁶ In order to locate sentinel LNs and decide whether to remove them based on the findings of frozen sections, 1 mL of 0.8% indigo carmine dye is intradermally injected in four directions around the areola before surgery.⁷ Radiation therapy improves patient survival rates and decreases the likelihood of local BC recurrence.⁸ Upper extremity lymphedema is the most frequent of the many problems that can arise from radiotherapy.^{9–11} SLND BC patients have a lower incidence of breast cancer-related lymphedema (BCRL; 0–7%) compared to ALND patients.¹² Furthermore, radiotherapy administered following surgery increases the risk of BCRL more than cases in which just surgery is carried out; radiotherapy administered at an axillary site greatly raises the risk of BCRL.^{10,11,13}

The lymphatic system has channels that carry fluid and plasma proteins from interstitial tissue to the blood circulation. When the lymphatic drainage system is compromised, the flow of lymphatic fluid is disrupted, fluids build up in the tissue, and lymphedema develops.¹⁴ Lymphedema is defined as a connective tissue condition that results from damage to the normal lymphatic drainage and develops in the subcutaneous tissues.¹⁵ According to the International Society of Lymphology, staging lymphedema is divided into four stages: stage 0 (latent lymphedema) refers to lymph flow impairment following injury without any apparent signs of edema or swelling; stage 1 (spontaneously reversible lymphedema), which is characterized by noticeable swelling or edema that subsides with elevation or compressive therapy, stage 2 lymphedema is a progressive form of edema that does not completely respond to conventional therapies, stage 3 (lymphostatic elephantiasis) is the last stage, and is characterized by severe, long-term swelling, fibrosis, and lipid deposition, which produces thickened, firm tissues in the form of hyperkeratosis. Hence, this lymphedema may further cause swelling.¹⁶ Patient's quality of life is negatively impacted by lymphedema in numerous ways.^{17,18} Compression bandaging, donning a sleeve or glove, manual lymphatic drainage, and pneumatic pumping are all effective treatments for this condition, which may be reversible. If the edema is allowed to worsen

without receiving treatment, the volume will expand, the arm will begin to weigh more, and the result will cause pain and discomfort.^{14,19,20}

Increased limb circumference, reduced range of motion in affected joints, stiffness, sensory loss in the hand, and decreased use of the affected limb for functional tasks are the main signs and symptoms of lymphedema.²¹ Radiotherapy may also affect muscle metabolism, which leads in muscle wasting and a decline in muscle strength and fitness.²² For carrying out upper limb functional everyday activities, handgrip strength is crucial. In order to execute an effective and thorough clinical assessment and intervention to address any impairments or functional limits in women with BCRL, it is crucial to objectively assess handgrip strength and hand function.^{17,23–25}

There has been little study done to assess hand function in BC patients after surgery and radiotherapy, both objectively and subjectively. As a result, the goal of this study is to estimate the hand function impairment in women with BCRL using objective and subjective outcome measures. This will provide more clarity and precision concerning the extent to which these women perform functional activities of daily life than subjective evaluation alone, which will greatly improve clinical practice.

Materials and Methods

This was a cross-sectional study and was carried out in the tertiary care hospital's BC survivorship support group for about 6 months. Ethical clearance was obtained from the Ethical Committee of Krishna Vishwa Vidyapeeth, Karad (Protocol number: 049/2022–2023) The purpose of the study was explained to each individual and written consent was obtained. Women between the ages of 40 and 80 who had undergone sentinel lymph node dissection (SLND) or radiotherapy and had been diagnosed with lymphedema and its associated symptoms were chosen for the study. Postoperative radiation was given to all the patients. Patients were positioned on a table in a supine or contralateral-side-down oblique position for the procedure, with the ipsilateral hand behind the head. The average time from surgery or radiotherapy to evaluation was around 6 months. The manuscript was written in accordance with Consolidated Standards of Reporting Trials (CONSORT) principles. Any woman with a history of traumatic musculoskeletal injuries, neurological deficits, or patients who underwent surgery for BC but did not have lymphedema were excluded from the study. A total of 100 women were chosen at random from a group of 1,200 using a simple random selection technique, and the randomization was carried out using the computerized SPSS software based on inclusion and exclusion criteria. In this study, grip strength of the hand as well as functional strength of the hand and wrist were assessed.

Data Collection Tools

Handheld Dynamometer

To test an objective evaluation of handgrip strength, an electronic hand dynamometer was employed. The participants

were told to hold the hand dynamometer with their shoulder relaxed, their forearm supported in a neutral position, and their elbow and wrist flexed 90 degrees. The greatest outcome for each hand on the hand dynamometer was recorded after subjects were encouraged to push it three times as hard as they could.

Functional Wrist and Hand Scale

A functional wrist and hand scale was used to provide a subjective evaluation of the hand strength of individuals with BCRL. This scale was scored using a 4-point system: unable to perform the task: 0, complete task partially: 1, complete task but is slow and clumsy: 2, and perform tasks normally: 3.

Michigan Hand Outcome Questionnaire

It is an accurate and valid tool for assessing hand function. It is a task-specific tool that evaluates hand function through the use of six subquestionnaires. The scale was useful in evaluating a person's general hand function, daily activities, work performance, pain, aesthetics, and level of pleasure with hand function. The most appropriate option had to be chosen by the subject, and the score was then determined. The Michigan Hand Outcome Questionnaire (MHQ) Scoring method was used to normalize the score. The sum of the scores from each of the six scales was divided by six to produce the final MHQ Score. Following that, a score out of 100 is determined. A greater rating means that the hand's overall functioning is better. A lower score indicates poor hand function.

Statistical Analysis

The statistical program SPSS (version 23.0) was used to conduct the analysis. This software was also used to calculate the mean and standard deviation of grip strength, wrist function, and hand function. The data collected were statistically evaluated using descriptive statistics like percentage, mean, and standard deviation. A percentage was computed for each of the following variables: hand dominance, population type, age, body mass index (BMI), and hand affected by BCRL. The *t*-test was employed to compare the outcomes of the affected and unaffected handgrip strength, hand and wrist function, and hand and wrist motion.

Results

The data collected were compiled, statistical analysis was performed using descriptive statistics like mean, standard deviation, percentage, and *t*-test was used to compare the outcomes of handgrip strength and hand function of both the affected and nonaffected hand.

Demographic Variables

In total, 100 women between the ages of 40 and 80 had breast surgery combined with radiation and lymphedema. Majority of the 100 participants were between the ages of

50 and 60, while only 12% of the participants were between the ages of 70 and 80. Only 12% of the participants were left hand-dominant, with the highest value being 38% suffering from left hand-impacted BCRL. The majority of the participants were right hand-dominant, with 62% of them having right hand-affected BCRL. The vast majority of people lived in rural areas. Eighty-nine percent of participants came from rural areas, and the remaining 11% were from urban areas. The results of the study revealed that BC affected an individual's overall health. Approximately 82% of the patients had a normal BMI, 12% were underweight, and just 6% were identified as being overweight while having BC. Data about the patients' demographics are displayed in [Table 1](#).

Handgrip Strength

Our study indicated that women with BCRL (14.851 ± 2.768) have less grip strength in their affected hand compared to their unaffected hand (22.484 ± 4.505). Additionally, it was shown that women with right hand-impacted BCRL and right hand-dominance had better grip strength than women with left hand-impacted BCRL and right hand-dominance. Additionally, the data indicated that grip strength decreased with advancing age, BMI, and lymphedema severity. The precision and prehension grasp, which are required for fine motor functions of the hand, are also impacted by a decrease in handgrip strength. [Table 2](#) shows the comparison of the handgrip strength of the affected and nonaffected hand.

Table 1 Patient demographics

Parameters	Number of participants	Percentage of participants
Age (years)		
40 to 50	29	29%
50 to 60	30	30%
60 to 70	29	29%
70 to 80	12	12%
Dominant hand		
Right	88	88%
Left	12	12%
Type of population		
Urban	11	11%
Rural	89	89%
Body mass index (kg/m²)		
Below 18.5	12	12%
18.5 to 24.9	82	82%
25 to 29.9	6	6%
Hand affected with BCRL		
Right	62	62%
Left	38	38%

Abbreviation: BCRL, breast cancer-related lymphedema.

Table 2 Michigan Hand Outcome Questionnaire

Parameters	Mean ± standard deviation	Standard error of mean	p-Value
Overall hand function	53.65 ± 6.066	0.6066	<0.0001
Activities of daily living	21.51 ± 0.7849	0.07849	<0.0001
Work performance	34.45 ± 8.525	0.8525	<0.0001
Pain scale	27.6 ± 5.662	0.5662	<0.0001
Aesthetic scale	61.3 ± 11.70	1.171	<0.0001
Satisfaction with hand function	44.68 ± 10.081	1.008	<0.0001
Total score	40.35 ± 3.056	0.3056	<0.0001

Table 3 Comparison of handgrip strength of the affected and nonaffected hand

Parameter	Affected hand	Nonaffected hand	Difference
Mean	14.851	22.484	−7.633
Standard deviation	2.768	4.505	4.387
Standard error	0.2886	0.4697	0.4574
Median	15.1	22.1	−7
t value	16.686		
p-value	<0.0001		

Hand and Wrist Function

Compared to the unaffected hand, the affected hand and wrist function performed poorly. This study shows that although there was no significance in the functional mobility of the hands in patients whose dominant or nondominant arm was affected, the functional mobility of the affected hand was considerably lower than that of the unaffected hand in these individuals. Along with the advancing age, BMI, and severity of hand edema, functional hand mobility also reduced. Most frequently mentioned limitations included diminished fine motor skills such as those required to pick up a pen, decreased upper extremity strength, limited range of motion, carrying capacity, and bending. ▶ **Table 3** shows the comparison of the functional hand and wrist scale between the affected and the nonaffected hand.

Hand Function

A patient’s overall score on the MHQ (40.35 ± 3.056) was acquired, and it was compared with the questionnaire’s typical score. The patient’s scores on the MHQ were considerably lower. With rising edema severity, BMI, and advancing age, these ratings also revealed a strong correlation between declining hand function, a reduced ability to execute activities of daily living, and a decline in work performance. It has been observed that radiation increases the chances of BCRL after surgery. The score for the affected hand was much lower than for the unaffected hand, which made it more challenging for women to carry out their everyday activities. Women with lymphedema of the dominant arm had significantly

Table 4 Comparison of the hand and wrist function of the affected and nonaffected hand

Parameter	Affected hand	Nonaffected hand	Difference
Mean	25.121	47.727	−22.606
Standard deviation	1.58	6.808	7.066
Standard error	0.1588	0.6842	0.7102
t value	31.83		
p-value	<0.0001		

superior daily functioning skills than those with lymphedema of the nondominant arm. It was also seen that the extent of hand function impairment and the level of satisfaction varied with different professions. Additionally, this questionnaire’s component revealed that the negative impacts of BCRL on women’s physical, emotional, and interpersonal functioning had an impact on their professional lives. ▶ **Table 4** shows the MHQ.

The results showed that lymphedema had negatively affected the people’s overall hand functioning due to their decreased grip strength, loss of prehension activities, increase in task time, restriction of finger flexion and extension, and restricted wrist motions. Additionally, the study’s findings showed that the lymphedema caused by BC had a significant negative impact on handgrip strength.

Discussion

This study “Estimation of Hand Function Impairment in Breast Cancer Survivors with Lymphedema” was conducted to estimate the hand function and grip strength of the BC survivors with lymphedema. Study was conducted among the BC women with lymphedema between the age of 40 and 80 years who underwent surgery and radiotherapy. A total of 100 women were included in this study. The purpose of the study was to identify the effect of BCRL on hand function. The present study showed that the overall functioning of the hand was significantly affected. The results of the study indicate that handgrip strength is severely affected due to the lymphedema caused secondary to BC. Furthermore,

power grip and precision grip strength were also shown to be significantly reduced.

BC survivors may experience axillary web syndrome, frozen shoulder, numbness, shoulder pain and range of motion restriction, lymphostasis and lymphedema following breast surgery, ALND, radiotherapy, and chemotherapy.¹⁴ Among these, lymphedema is the most common complication in the BC treatment. According to many studies, the majority of cases of lymphedema develop within the first 1 to 2 years following the primary treatment. Norman et al mentioned in their study that mild type of lymphedema is most common in these patients. It was previously reported that 60 to 70% of cases with upper extremity lymphedema affected the hand area. Hand edema adversely affects daily activities and mobility.²⁶ After breast surgery, it has been shown to produce upper strength limb impairment, which can compromise grip strength, hand function, and daily activities.²⁷ Gomes et al mentioned that 6 months after the surgery, there is change in the body composition and handgrip strength of the BC survivors.²¹

In one study it was seen that in women with BCRL, wrist joint and tiny joints are involved in the kinesthetic sense, which lowers the force production during gripping tasks, which could be the reason for grip strength reduction in these participants. In our study, handgrip strength was assessed by handheld dynamometer (Intraclass correlation coefficient [ICC]=0.986), hand strength was assessed by functional hand and wrist scale (ICC=0.92), and the overall hand function and activities of daily living was assessed by MHQ (ICC=0.71–0.84 for the subscales).^{28–30} All were assessed on the affected side (mostly which was operated) and was compared with the nonaffected side. In this study the overall hand function scale score assessed movements of the wrist and fingers, sensation in the hand, grip strength of hand, and thus overall functioning of the hand was seen impaired. Shinde et al mentioned that lymphedema in the hand and wrist cause a reduction in the range of motion of the wrist and fingers as well as the beginning of wrist extension and finger flexion.³¹

When polled after completing treatment, 13 to 28% of BC survivors experienced limits in everyday activities and the degree of dysfunction and level of satisfaction varied with different professions. This study evaluated the participants with BCRL for activities of daily living tasks, such as taking up heavy and large things, scribbling, simulating feeding, etc., which demanded both a power grip and a precision grip which was decreased and hence, hand function was impaired. This decreased hand function may be caused by a decrease in grip strength, both power and precision, and a decrease in kinesthetic awareness, suggesting that handgrip strength impairment affects how efficiently the hands function.²⁷ In our study, task time was increased and also participants showed reduction in strength and hence, strength plays an important role in performing various hand functions.

In one study, difference percentage between two arms is reported and results showed that handgrip strength and hand function reductions in BCRL women were clinically significant, as evidenced by moderate-to-large effect sizes in

all outcomes, except power handgrip strength in the left hand and this reduced precision and power grip strength will affect how well an activity is performed.³² Activities like tip, key, and tripod pinching using precision grip strength demand finer motor control and are more likely dependent on intact feeling. Decrease in grip strength, loss of kinesthetic awareness in extreme cases, loss of prehension activities, increase in task time, restriction in finger flexion and extension, and restricted wrist motions owing to lymphedema left the people miserable with their overall hand functioning.³³

In this study, the scale assessed the activities that can be performed using one hand and the activities that require the use of both hands simultaneously. The BCRL had an impact on single-handed tasks like twisting a doorknob and picking up a penny, holding a glass of water, and turning a key in a lock. Activities that required the simulative engagement of both hands were likewise affected by BCRL. Functional mobility and daily living activities of the upper extremity are greatly impacted by BCRL. Furthermore, women with BCRL may have weakness, restriction of shoulder range of motion and decreased quality of life, as well as decreased daily functioning abilities, fatigue, and motivation.^{23,27,34–36}

Another study showed that participants with BCRL had an unpleasant sense of self and were preoccupied with their appearance. Women's professional lives were impacted by BCRL's detrimental effects on their physical, emotional, and interpersonal functioning, also they have been proven to experience anxiety and to be more susceptible to unfavorable social and interpersonal interaction alterations.^{37,38} In our study participants showed great dissatisfaction with the work performance of the hand affected by BCRL. Additionally, the participants' fatigue brought on by the intensity of the pain caused them to stop working frequently, which extended the time required to finish the work. Also, these lymphedema-related symptoms negatively affected the participants' physical health as well as faced emotional difficulties which directly have an impact on women's professional lives. Physical challenges include reduced upper extremity strength due to pain and swelling associated with BCRL when they are engaged in activities like lifting and typing at work. The emotional disruptions caused by lymphedema in BC patients have a significant emotional impact and are linked to lower quality of life.³⁹ Lymphedema symptoms cause distress that has behavioral, social, and attribute components. Participants described how continuing lymphedema-related symptoms increased physical discomfort and caused "distress" and "frustration" in their daily lives regularly.⁴⁰

Vassard et al (2010), mentioned that this lymphedema diagnoses have been linked with social avoidance, aberrant body image, sexual dysfunction, anxiety, and depression.³⁹ In our study it was seen that, BCRL had a negative impact on individuals' social lives, which made it challenging for them to participate in social events. Also, these individuals complained about others acting inappropriately toward them at home, at work, and at the office, which increased their anxiety and stress. In severe situations, being dependent on others for daily living tasks damaged the individual's

emotional stability and results in them feeling reliant on others. There are many studies which show the short-term changes in handgrip strength, body composition, and lymphedema due to BC surgery. Our study focuses on extent of hand function impairment in BC survivors with lymphedema and how it has an impact on women's daily activities and quality of life including mental, emotional, and social aspects.

During the period of the study, some limitations in this study were acknowledged. The study's results cannot be generalized to all types of cancer due to the limited group size. It was confined to a single geographic area. The study's duration was also strictly enforced. A larger sample size would yield better findings. The results of the current study highlight the necessity of developing rehabilitation programs with a multidisciplinary approach for patients with hand function impairment in BC survivors as their daily activities and quality of life are impacted, rather than focusing solely on hand rehabilitation.

Conclusion

This study concluded that there was significant hand function impairment in BC survivors with lymphedema. BCRL had a negative impact on daily activities of the individual and also affects in mental, emotional, and social aspects. BCRL also had an impact on overall self-reported physical function and quality of life.

Ethical Approval

This study was approved by Ethical Committee of Krishna Vishwa Vidyapeeth, Karad.

Authors' Contribution

D.S.J. conducted literature review for this manuscript, developed the introduction section of the manuscript, conducted the discussion of the study, findings, collected data, and analyzed the data. S.B.S. provided a description of the background information, collected data and analyzed the data, and participated in the prescription of the manuscript. All the authors read and approved the final manuscript.

Funding

This study was funded by Krishna Vishwa Vidyapeeth, Karad.

Conflict of Interest

None declared.

References

- Garcia-Martinez L, Zhang Y, Nakata Y, Chan HL, Morey L. Epigenetic mechanisms in breast cancer therapy and resistance. *Nat Commun* 2021;12(01):1786
- Center M, Siegel R, Jemal A. Global Cancer Facts & Figures. Atlanta: American Cancer Society; 2011;3:1–52
- Mattiuzzi C, Lippi G. Current cancer epidemiology. *J Epidemiol Glob Health* 2019;9(04):217–222
- Babasaheb SS, Rajesh KK, Yeshwant KS, Patil S. Analysis of spinal dysfunction in breast cancer survivors with lymphedema. *Asian Pac J Cancer Prev* 2021;22(06):1869–1873
- De Groef A, Van Kampen M, Tieto E, et al. Arm lymphoedema and upper limb impairments in sentinel node-negative breast cancer patients: a one year follow-up study. *Breast* 2016;29:102–108
- Kim HK, Ju YW, Lee JW, et al. Association between number of retrieved sentinel lymph nodes and breast cancer-related lymphedema. *J Breast Cancer* 2021;24(01):63–74
- Han A, Moon HG, Kim J, et al. Reliability of sentinel lymph node biopsy after neoadjuvant chemotherapy in breast cancer patients. *J Breast Cancer* 2013;16(04):378–385
- Cuzick J, Stewart H, Rutqvist L, et al. Cause-specific mortality in long-term survivors of breast cancer who participated in trials of radiotherapy. *J Clin Oncol* 1994;12(03):447–453
- Oh SH, Kim JH, Seong ST, et al. Lymphoscintigraphy in patients with breast cancer-related lymphedema after sentinel lymph node dissection and axillary radiation therapy. *Medicine (Baltimore)* 2022;101(49):e31985
- Jeong HJ, Eom MS, Choi SB, Kim DS, Kang KM. Risk factors for developing upper limb lymphedema following breast cancer surgery. *J Korean Acad Rehabil Med* 2008;32(01):95–99
- Lee DG. Delayed lymphedema due to activated axillary lymph node dysfunction in a patient with breast cancer. *Ann Rehabil Med* 2020;44(06):510–511
- Lucci A, McCall LM, Beitsch PD, et al; American College of Surgeons Oncology Group. Surgical complications associated with sentinel lymph node dissection (SLND) plus axillary lymph node dissection compared with SLND alone in the American College of Surgeons Oncology Group Trial Z0011. *J Clin Oncol* 2007;25(24):3657–3663
- Warren LE, Miller CL, Horick N, et al. The impact of radiation therapy on the risk of lymphedema after treatment for breast cancer: a prospective cohort study. *Int J Radiat Oncol Biol Phys* 2014;88(03):565–571
- Johansson K, Branje E. Arm lymphoedema in a cohort of breast cancer survivors 10 years after diagnosis. *Acta Oncol* 2010;49(02):166–173
- Executive Committee. The diagnosis and treatment of peripheral lymphedema: 2016 Consensus Document of the International Society of Lymphology. *Lymphology* 2016;49(04):170–184
- International Society of Lymphology. The diagnosis and treatment of peripheral lymphedema: 2013 Consensus Document of the International Society of Lymphology. *Lymphology* 2013;46(01):1–11
- Park JE, Jang HJ, Seo KS. Quality of life, upper extremity function and the effect of lymphedema treatment in breast cancer related lymphedema patients. *Ann Rehabil Med* 2012;36(02):240–247
- Lee TS, Morris CM, Czerniec SA, Mangion AJ. Does lymphedema severity affect quality of life? Simple question. Challenging answers. *Lymphat Res Biol* 2018;16(01):85–91
- Jaju CS, Shinde S. Prevalence of peripheral neuropathy in chronic musculoskeletal oedematous conditions. *Int J Physiother* 2019;9:282–286
- Casley-Smith JR. Alterations of untreated lymphedema and its grades over time. *Lymphology* 1995;28(04):174–185
- Gomes PR, Freitas Junior IF, da Silva CB, et al. Short-term changes in handgrip strength, body composition, and lymphedema induced by breast cancer surgery. *Rev Bras Ginecol Obstet* 2014;36(06):244–250
- Clarkson PM, Kaufman SA. Should resistance exercise be recommended during breast cancer treatment? *Med Hypotheses* 2010;75(02):192–195
- Rietman JS, Dijkstra PU, Hoekstra HJ, et al. Late morbidity after treatment of breast cancer in relation to daily activities and quality of life: a systematic review. *Eur J Surg Oncol* 2003;29(03):229–238

- 24 Mak MK, Lau ET, Tam VW, Woo CW, Yuen SK. Use of Jebsen Taylor Hand Function Test in evaluating the hand dexterity in people with Parkinson's disease. *J Hand Ther* 2015;28(04):389–394, quiz 395
- 25 Hayes SC, Rye S, Battistutta D, DiSipio T, Newman B. Upper-body morbidity following breast cancer treatment is common, may persist longer-term and adversely influences quality of life. *Health Qual Life Outcomes* 2010;8:92
- 26 Norman SA, Localio AR, Potashnik SL, et al. Lymphedema in breast cancer survivors: incidence, degree, time course, treatment, and symptoms. *J Clin Oncol* 2009;27(03):390–397
- 27 Karadibak D, Yavuzsen T. Evaluation of kinesthetic sense and hand function in women with breast cancer-related lymphedema. *J Phys Ther Sci* 2015;27(06):1671–1675
- 28 Sullivan SJ, Chesley A, Hebert G, McFaull S, Scullion D. The validity and reliability of hand-held dynamometry in assessing isometric external rotator performance. *J Orthop Sports Phys Ther* 1988;10(06):213–217
- 29 Mehta SP, MacDermid JC, Richardson J, MacIntyre NJ, Grewal R. A systematic review of the measurement properties of the patient-rated wrist evaluation. *J Orthop Sports Phys Ther* 2015;45(04):289–298
- 30 Chung BT, Morris SF. Reliability and internal validity of the michigan hand questionnaire. *Ann Plast Surg* 2014;73(04):385–389
- 31 Shinde S, Joshi D, Patil S, Pawar P. Estimation of neural tissue mobility in breast cancer survivors with lymphedema. *Asian Pac J Cancer Prev* 2022;23(10):3355–3360
- 32 Mistry S, Ali T, Qasheesh M, et al. Assessment of hand function in women with lymphadenopathy after radical mastectomy. *PeerJ* 2021;9:e11252
- 33 Elkot NM, Shehata SR, Wahba ES, Waked IS. Impact of hand lymphedema on pain and grip strength of the hand in women with breast cancer. *Int J Health Sci* 2022;6(S4):1373–1382
- 34 Smoot B, Boyd BS, Byl N, Dodd M. Mechanosensitivity in the upper extremity following breast cancer treatment. *J Hand Ther* 2014;27(01):4–11
- 35 Voogd AC, Ververs JMMA, Vingerhoets AJJM, Roumen RMH, Coebergh JWW, Crommelin MA. Lymphoedema and reduced shoulder function as indicators of quality of life after axillary lymph node dissection for invasive breast cancer. *Br J Surg* 2003;90(01):76–81
- 36 Dawes DJ, Meterissian S, Goldberg M, Mayo NE. Impact of lymphoedema on arm function and health-related quality of life in women following breast cancer surgery. *J Rehabil Med* 2008;40(08):651–658
- 37 Sun Y, Shigaki CL, Armer JM. The influence of breast cancer related lymphedema on women's return-to-work. *Womens Health (Lond Engl)* 2020;16:1745506520905720
- 38 Ussher JM, Sandoval M, Perz J, Wong WKT, Butow P. The gendered construction and experience of difficulties and rewards in cancer care. *Qual Health Res* 2013;23(07):900–915
- 39 Vassard D, Olsen MH, Zinckernagel L, Vibe-Petersen J, Dalton SO, Johansen C. Psychological consequences of lymphoedema associated with breast cancer: a prospective cohort study. *Eur J Cancer* 2010;46(18):3211–3218
- 40 Fu MR, Rosedale M. Breast cancer survivors' experiences of lymphedema-related symptoms. *J Pain Symptom Manag* 2009;38(06):849–859
- 41 Erickson VS, Pearson ML, Ganz PA, Adams J, Kahn KL. Arm edema in breast cancer patients. *J Natl Cancer Inst* 2001;93(02):96–111