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Rehabilitation of the Upper Limb After Radical Mastectomy: A Literature Review

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Abstract
Background: Radical mastectomy often results in upper extremity complications, including shoulder impairment, pain, reduced range of motion, lymphedema, and diminished muscle strength, which significantly impact quality of life. Key risk factors include extent of lymph node dissection, older age, and axillary radiation, exacerbating morbidity.
Aim: This review synthesizes current literature on upper extremity complications post-radical mastectomy and evaluates the effectiveness of rehabilitation strategies.

Material and methods: A comprehensive search of PubMed, PEDro, and Scopus identified English-language studies from the last decade on shoulder impairment in adult women post partial or total mastectomy for breast cancer.
Results: Complications are highly prevalent, with rehabilitation interventions demonstrating efficacy in improving shoulder function, reducing pain and lymphedema. Challenges persist due to heterogeneous protocols and limited high-quality trials.
Conclusions: Targeted rehabilitation interventions post-radical mastectomy significantly improve shoulder function, range of motion, muscle strength, and reduce pain and lymphedema incidence, thereby enhancing quality of life and functional independence (Marco et al., 2023; Xu et al., 2024; Zhang et al., 2022). Despite these demonstrated benefits from early exercises and structured programs (Lazaraviciute & Chaturvedi, 2017; Naqvi, 2021), heterogeneous protocols, paucity of high-quality randomized trials, and variability due to risk factors like axillary dissection and radiation underscore the urgent need for standardized guidelines and further large-scale RCTs (Bruce et al., 2021).

Key words: radical mastectomy, upper extremity rehabilitation, lymphedema, shoulder function, breast cancer.

1. Introduction

Breast cancer is the leading cause of cancer-related morbidity and mortality among women worldwide, with significant advancements in early detection, multimodal treatments, and surgical techniques significantly improving prognosis and long-term survival rates (Paolucci et al., 2020). Historically, radical mastectomy—entailing removal of the entire breast, overlying skin, pectoral muscles, and axillary lymph nodes—served as the cornerstone of treatment for advanced disease, offering high oncologic control but at the cost of substantial upper extremity morbidities, including pain, joint dysfunction, reduced range of motion, lymphedema, and diminished muscle strength (Lazaraviciute & Chaturvedi, 2017). Pain has a prevalence ranging from 12% to 51%, and joint dysfunction from 1.5% to 50% (Naqvi, 2021). Lymphedema affects 25-40% of patients, while decreased muscle strength is observed in 23% at 3 months and 19% at 6 months post-surgery (Zhang et al., 2022).

Several factors contribute to the severity and prevalence of upper extremity impairments following radical mastectomy, including patient age, extent of surgical intervention, and adjuvant therapies (Marco et al., 2023). Older age is associated with heightened vulnerability due to reduced physiological resilience, comorbidities, and slower recovery of muscle strength and joint function, as evidenced in post-mastectomy cohorts (Aleem et al., 2023). More extensive surgical techniques, such as Halsted's radical mastectomy involving pectoral muscle and comprehensive axillary lymph node dissection, lead to greater lymphatic disruption, scarring, shoulder immobility, and lymphedema risk compared to less invasive approaches like modified radical mastectomy (Huertas et al., 2021). Another critical factor predominantly contributing to the incidence of lymphedema is the technique of lymph node dissection; sentinel lymph node biopsy has a substantially lower impact than complete axillary lymph node dissection (Huertas et al., 2021). Adjuvant therapies, particularly axillary radiation,

independently elevate lymphedema incidence and overall upper limb morbidity, compounding surgical effects (Bruce et al., 2021). These impairments underscore the critical need for targeted rehabilitation to restore function and quality of life (Marco et al., 2023).

Effective upper extremity rehabilitation is crucial for patient recovery and long-term well-being following radical mastectomy, as it directly addresses prevalent complications, which otherwise compromise functional independence, daily activities, and quality of life (Zhang et al., 2022). By restoring range of motion, grip strength, and shoulder function through targeted interventions like early postoperative exercises, rehabilitation mitigates scarring, edema, and adhesions, while reducing chronic morbidity exacerbated by surgical extent and adjuvant therapies (Lazaraviciute & Chaturvedi, 2017). Ultimately, comprehensive programs enhance psychological resilience, prevent permanent disability, and promote sustained oncologic recovery and holistic well-being (Bruce et al., 2021).

This review aims to summarize current evidence on radical mastectomy surgical techniques, describe common upper extremity complications, evaluate rehabilitation interventions, and identify gaps in the research literature.

2. Materials and methods

A comprehensive literature search was conducted across PubMed, PEDro, and Scopus databases, focusing on English-language studies published within the last decade, specifically addressing shoulder impairment in adult women treated for breast cancer with partial or total mastectomy. Additionally, a Cochrane review published in 2010 was included, owing to its frequent citations in clinical guidelines.

3. Results

3.1. Overview of Surgical Techniques and Their Implications for Rehabilitation

3.1.1. Surgical Techniques

Radical Mastectomy involves the removal of the entire breast, overlying skin, pectoral muscles, and all axillary lymph nodes. While highly effective in cancer removal, this extensive procedure often led to severe functional deficits and disfigurement.

The evolution of surgical techniques led to the **Modified Radical Mastectomy**, which became widely adopted due to its comparable oncological outcomes with significantly reduced morbidity. MRM involves the removal of the entire breast tissue, overlying skin, and axillary lymph nodes, but typically preserves the pectoral muscles (Koca et al., 2020). This preservation is a key difference that lessens the impact on muscle integrity and shoulder function compared to the radical mastectomy.

Simple Mastectomy involves the removal of the entire breast tissue, but generally **does not include the removal of axillary lymph nodes** unless there is suspicion of lymph node involvement. This procedure is typically less invasive than MRM and is often performed for prophylactic reasons or for non-invasive cancers.

The emphasis has further shifted towards **Breast-Conserving Therapy**, which includes lumpectomy followed by radiation, as a safe option for early breast cancer where possible (Freitas-Silva et al., 2010). However, when BCT is not feasible, mastectomy followed by immediate reconstruction is an alternative (Freitas-Silva et al., 2010). The management of the axilla in conjunction with these breast surgeries involves either sentinel lymph node biopsy or complete axillary lymph node dissection (Freitas-Silva et al., 2010).

3.1.2. Impact on Upper Extremity

The extent of axillary surgery is the primary determinant of lymphatic drainage disruption and the risk of lymphedema. Axillary lymph node dissection, which is part of both radical and

modified radical mastectomies, involves the removal of axillary lymph nodes. This procedure significantly increases the risk of lymphedema compared to sentinel lymph node biopsy. Following breast cancer treatment, lymphedema prevalence over the first 3 years was 31% among patients undergoing axillary lymph node dissection, compared to only 4.6% in those receiving sentinel lymph node biopsy instead (Huertas et al., 2021). Simple mastectomy without axillary lymph node removal generally carries a lower risk of lymphedema, as the lymphatic system in the axilla remains largely undisturbed; however, if axillary nodes are removed, the risk increases. The comparison between mastectomy and breast-conserving therapy for lymphedema incidence has yielded mixed results, with some studies suggesting a higher occurrence in mastectomy patients, while others found no significant difference (Freitas-Silva et al., 2010). Radiation therapy targeting the axilla, often accompanying extensive lymph node removal, is also independently correlated with an increased risk of lymphedema (Bruce et al., 2021). Furthermore, surgical techniques that involve significant tissue removal, such as Halsted's radical mastectomy, are associated with a higher incidence of extensive scarring, reduced shoulder mobility, and life-altering decreases in quality of life due to their invasive nature (Lazaraviciute & Chaturvedi, 2017). Conversely, newer surgical approaches like axillary reverse mapping and lymphatic microsurgical preventative healing aim to mitigate lymphedema risk by identifying and preserving functional lymphatic drainage pathways (Donahue et al., 2023). These advanced techniques demonstrate a critical shift in surgical philosophy towards balancing oncological efficacy with the preservation of upper extremity function, thereby directly influencing post-operative rehabilitation protocols.

Table 1. Mastectomy Surgical Types, Descriptions, and Morbidities - an overview

Type of Mastectomy	Extent of Surgery	Axillary Involvement	Lymphedema Risk	Upper Extremity Functional Outcomes
Simple (Total) Mastectomy	Removal of the breast and fascia of the pectoralis major muscle	Sentinel node dissection*	**Low**	Minimal impact on upper limb function; shoulder range of motion generally preserved
Skin-Sparing Mastectomy	Removal of breast tissue with preservation of skin envelope and nipple–areola complex; fascia removed	Sentinel node dissection*	**Low**	Preserved shoulder mobility; favorable cosmetic and psychosocial outcomes; minimal upper extremity morbidity
Modified Radical Mastectomy (Madden Method)	Removal of breast, fascia of pectoralis major, and axillary lymph nodes	Axillary lymph node dissection (levels I–II)	**Moderate to High**	Increased risk of shoulder stiffness, pain, sensory disturbances, and functional limitation due to axillary dissection
Modified Radical Mastectomy (Patey Method)	Removal of breast, fascia of pectoralis major, pectoralis minor muscle, and axillary lymph nodes	Extensive axillary dissection (including Rotter's nodes)	**High**	Reduced shoulder strength and range of motion; higher incidence of lymphedema and chronic pain
Radical Mastectomy (Halsted Method)	Removal of breast, pectoralis major and minor muscles, and axillary lymph nodes	Complete axillary clearance	**Very High**	Severe upper extremity morbidity: marked limitation of shoulder mobility, muscle weakness, extensive scarring, lymphedema, and long-term quality-of-life impairment

* Sentinel lymph node biopsy with a ferromagnetic marker is a less invasive option than axillary lymph node dissection for staging the axilla.

Source: Noszczyk, W. (Ed.). (2005). Surgery: A textbook for students (Vol. 2). Warsaw, Poland: PZWL Medical Publishing. ISBN 978-83-200-3983-2

3.2. Common Post-Mastectomy Complications Affecting the Upper Extremity

Post-mastectomy pain can manifest as acute nociceptive pain, neuropathic pain, or chronic pain syndromes, with reported prevalence rates varying widely from 12% to 51% across different studies (Naqvi, 2021). This chronic pain is often linked to nerve damage from axillary lymph node dissection and radiation therapy, significantly impacting a patient's quality of life (Klein et al., 2023).

Limited shoulder range of motion is a frequently observed morbidity following mastectomy, particularly when accompanied by axillary lymph node dissection, due to tissue damage and scarring that restrict movement and impact daily activities (Hidding et al., 2014). Early rehabilitation is vital in preventing long-term shoulder dysfunction and expediting recovery of shoulder ROM, which is critical for timely initiation of adjuvant therapies, thereby reducing the risk of local recurrence (Kim et al., 2019).

Lymphedema, characterized by chronic swelling due to impaired lymphatic drainage, can significantly impair upper extremity function and is a common sequela of breast cancer treatment, affecting up to 70% of patients with functional limitations (Macdonald et al., 2023). The condition typically presents as progressive, chronic swelling that can lead to skin changes, increased infection risk, and psychological distress (Koca et al., 2020). Its onset can be immediate post-surgery or years later, necessitating diligent long-term monitoring and management strategies (Koca et al., 2020).

Muscle weakness in the upper extremity, particularly in the shoulder girdle, is a prevalent complication following mastectomy, often stemming from surgical trauma, nerve damage, disuse atrophy, and the development of fibrosis associated with radiation therapy (Xu et al., 2024; Zhang et al., 2022).

Other complications include seroma, infection, and sensory changes (Naqvi, 2021). These complications, while less directly impactful on long-term upper extremity function than lymphedema or ROM deficits, can nonetheless impede immediate postoperative recovery and rehabilitation progress.

Key risk factors for post-mastectomy complications affecting the upper extremity include extensive axillary lymph node dissection, higher body mass index, and the administration of adjuvant radiotherapy or chemotherapy (Torgbenu et al., 2020). Furthermore, reconstructive surgery and certain genetic predispositions have also been identified as contributing factors to an increased likelihood of developing these debilitating sequelae (Freitas-Silva et al., 2010). These factors collectively underscore the necessity for comprehensive pre- and post-operative assessments and individualized rehabilitation protocols to mitigate adverse outcomes and enhance patient quality of life (Koca et al., 2020).

3.3. Current Rehabilitation Approaches and Protocols

3.3.1. Early Mobilization

Early mobilization protocols are increasingly advocated to counteract the detrimental effects of prolonged immobilization, which can lead to limited shoulder range of motion and reduced functional capacity (Huertas et al., 2021; Kim et al., 2019). Research indicates that initiating shoulder mobilization within one week post-surgery can significantly enhance short-term recovery of shoulder range of motion without increasing complications such as seroma formation or lymphedema (Kim et al., 2019). This contrasts with older protocols that mandated prolonged immobilization, demonstrating that early, carefully guided movement enhances recovery trajectories and patient outcomes (Bruce et al., 2021; Kim et al., 2019). The following delineates various rehabilitation methods.

Physical therapy interventions:

Range of motion exercises: Therapeutic exercises, including pendulum exercises and active-assisted range of motion, are critical for restoring glenohumeral and scapulothoracic mobility, thereby preventing adhesive capsulitis and impingement syndromes (Kim et al., 2019). Conversely, resisted isometric and isotonic exercises are introduced progressively to rebuild muscle strength and endurance, particularly in the deltoid and rotator cuff muscles, which are often weakened due to surgical intervention and disuse (Lauridsen et al., 2005). These exercises are systematically advanced based on individual patient tolerance and recovery milestones, ensuring a safe and effective progression toward regaining full functional capacity (Xu et al., 2024).

Strength training: Strength training, employing progressive resistance exercises, is pivotal for restoring muscular function and endurance in the upper extremity, addressing the atrophy and weakness often induced by surgical trauma and subsequent immobilization (Meer et al., 2023). These protocols typically involve the gradual introduction of resistance bands, light weights, and bodyweight exercises, which are meticulously tailored to the patient's recovery phase and pain thresholds to optimize muscle hypertrophy and neural adaptation (Sözen & Emir, 2022). The judicious implementation of these exercises is crucial, as premature or overly aggressive regimens can exacerbate seroma formation or increase the risk of lymphedema (Eidenberger, 2022).

Manual therapy: Manual therapy techniques, such as myofascial release and scar massage, are employed to address tissue restrictions, improve lymphatic flow, and alleviate pain caused by adhesions and fibrosis in the post-surgical area, ultimately enhancing tissue extensibility and restoring normal movement patterns (González-Rubino et al., 2025). These techniques are particularly beneficial for mitigating the effects of axillary web syndrome and improving the pliability of irradiated tissues (Lauridsen et al., 2005).

Table 2. Physical Therapy Interventions and Their Effectiveness in Preventing Arm Morbidities After Mastectomy

Physical Therapy Intervention	Targeted Arm Morbidities	Effectiveness in Prevention/Management
Range of Motion Exercises	Glenohumeral and scapulothoracic mobility restrictions, adhesive capsulitis, impingement syndromes, adhesions	Critical for restoring mobility; activates muscles, prevents adhesions, and restores upper limb function
Strength Training	Muscle weakness, disuse atrophy, reduced muscular function and endurance, reduced arm function	Pivotal for restoring muscular function and endurance; improves arm function and muscular strength without increasing arm volume or lymphedema risk
Manual Therapy	Tissue restrictions, lymphatic flow impairment, pain, adhesions, fibrosis, axillary web syndrome	Addresses tissue restrictions, improves lymphatic flow, alleviates pain, enhances tissue extensibility, restores normal movement patterns; particularly beneficial for mitigating axillary web syndrome and improving pliability of irradiated tissues
Complete Decongestive Therapy	Lymphedema (chronic swelling, impaired lymphatic drainage, skin changes, infection risk)	Highly effective multi-faceted approach; significantly reduces limb volume, optimizes lymphatic flow, and prevents complications such as fibrosis and infections; optimizes lymphatic flow and maintains skin integrity

Patient Education and Self-Management	Lymphedema progression, poor adherence to treatment	Empowers individuals with knowledge about early symptom recognition, meticulous skin care, and consistent application of compression garments to minimize disease progression and enhance quality of life; enables patients to sustain benefits achieved through clinical interventions and prevent further exacerbation of swelling
Occupational Therapy	Limitations in daily activities, reduced functional independence, productivity issues	Focuses on functional training and adaptation for daily activities, including instruction on ergonomic principles, adaptive equipment use, and task modification to facilitate independence and maintain productivity
Psychological Support	Anxiety, depression, body image disturbances, fear of recurrence, adherence to rehabilitation protocols, emotional distress hindering physical rehabilitation	Integral for addressing issues that significantly impact adherence to rehabilitation protocols and overall recovery; can significantly improve patients' engagement with physical therapies and contribute to a more holistic recovery

Sources: Eidenberger, 2022; González-Rubino et al., 2025; Huertas et al., 2021; Kim et al., 2019; Koca et al., 2020; Lauridsen et al., 2005; Meer et al., 2023; Sözen & Emir, 2022; Torgbenu et al., 2020

3.3.2. Lymphedema Management

It is important to note that studies consistently report higher rates of shoulder impairment and chronic pain after axillary node clearance than after sentinel lymph node biopsy, underscoring the importance of surgical technique in influencing rehabilitation outcomes (Bruce et al., 2021). The surgical lymph node removal is the strongest predictor of post-mastectomy lymphedema across many studies, with reported incidence rates varying significantly based on the extent of nodal dissection and adjuvant therapies (Naczk et al., 2022). Below are strategies for managing this challenging complication.

3.3.2.1. Complete Decongestive Therapy

Complete Decongestive Therapy is a cornerstone in lymphedema management, encompassing manual lymphatic drainage, compression therapy with bandages or garments, therapeutic exercises, and meticulous skin care (Koca et al., 2020). This multi-faceted approach aims to reduce limb volume, improve tissue texture, and prevent complications by optimizing lymphatic flow and maintaining skin integrity (Eidenberger, 2022). Additionally, educational components regarding self-management strategies, including diligent skin care and adherence to compression protocols, empower patients to actively participate in their long-term lymphedema management (Reyes, 2018).

3.3.2.2. Education and Self-Management

Patient education is crucial for effective long-term management of lymphedema, helping patients gain knowledge about early symptom recognition, importance of skin care, and the consistent application of compression garments to minimize disease progression and enhance quality of life (Huertas et al., 2021). Moreover, self-lymphatic drainage and regular home exercises are critical components, enabling patients to sustain the benefits achieved through clinical interventions and prevent further progression of swelling (Torgbenu et al., 2020).

3.3.2.3. Emerging Approaches

There has been many recent advancements, including the application of low-level laser therapy and extracorporeal shockwave therapy to improve lymphatic function in chronic lymphedema, offering novel avenues for therapeutic intervention (Meer et al., 2023). Moreover, it is shown that it can be also utilized to mitigate fibrosis after the surgery.

3.3.3. Psychological Support

Psychological counseling, support groups, and cognitive-behavioral therapies are integral for addressing issues such as anxiety, depression, body image disturbances, and fear of recurrence, which significantly impact adherence to rehabilitation protocols and overall recovery (Eidenberger, 2022). Addressing these psychological challenges can significantly improve patients' engagement with physical therapies and contribute to a more holistic recovery, as emotional distress can impede adherence to rehabilitation regimens (Koca et al., 2020; Sözen & Emir, 2022).

3.4. Effectiveness of Rehabilitation Interventions

3.4.1. Impact on Range of Motion

Numerous studies demonstrate that early rehabilitation interventions significantly improve shoulder range of motion in post-mastectomy patients. A Cochrane review highlighted in clinical trials shows that early shoulder exercises (postoperative days 1–3) facilitate superior short-term ROM recovery compared to delayed exercises (postoperative day 4+). Significant short-term benefits were acheived for shoulder flexion ROM (WMD: 10.6 degrees; 95% CI: 4.51 to 16.6) and shoulder abduction at one week (MD: 11.65 degrees; 95% CI: 2.93 to 20.38) and six months (MD: 4.31 degrees; 95% CI: 1.38 to 7.25), without increasing risks like seroma or lymphedema (McNeely et al., 2010). Physical exercise protocols, including ROM exercises, stretching, and strengthening, enhance shoulder mobility by activating muscles, preventing adhesions, and restoring upper limb function [e.g. improved shoulder flexion ROM in the short-term (WMD: 12.92 degrees; 95% CI: 0.69 to 25.16)] (McNeely et al., 2010; Meer et al., 2023; Xu et al., 2024). Physiotherapy further improves shoulder function post-surgery, addressing impairments from axillary dissection and radiation (Lauridsen et al., 2005). Early mobilization prevents long-term dysfunction, with cross-sectional data linking reduced immobilization to better ROM outcomes (Huertas et al., 2021).

3.4.1.1. Impact on Lymphedema

Rehabilitation interventions play a crucial role in preventing and managing lymphedema following mastectomy, with Complete Decongestive Therapy emerging as a highly effective multi-faceted approach. CDT, which includes manual lymphatic drainage, compression bandaging or garments, therapeutic exercises, and skin care, significantly reduces limb volume, optimizes lymphatic flow, and prevents complications such as fibrosis and infections (Eidenberger, 2022; Koca et al., 2020; Reyes, 2018). The Cochrane review and clinical trials indicate that early postoperative exercises facilitate shoulder recovery without elevating lymphedema risk, as they promote lymphatic drainage through muscle pumping action and counteract stagnation from immobilization (Huertas et al., 2021; Kim et al., 2019; McNeely et al., 2010). Progressive resistance and strengthening exercises further enhance arm function and muscular strength without increasing arm volume, particularly when combined with other modalities for advanced lymphedema (Koca et al., 2020; Meer et al., 2023; Reyes, 2018). Patient education on self-management, including self-lymphatic drainage and consistent compression use, sustains these benefits long-term and empowers adherence (Huertas et al.,

2021; Reyes, 2018). Patients undergoing axillary lymph node dissection face higher lymphedema incidence compared to sentinel lymph node biopsy, but tailored rehabilitation mitigates this risk effectively (Bruce et al., 2021; Hidding et al., 2014).

3.4.1.2. Improvements in Strength and Functional Outcomes

Rehabilitation interventions, particularly progressive resistance and strengthening exercises, significantly enhance muscle strength and functional independence in post-mastectomy patients. Upper body resistance exercises, such as those using bands, improve arm function and muscular strength without increasing arm volume or lymphedema risk (Meer et al., 2023; Reyes, 2018). Occupational therapy emphasizes functional training, ergonomic adaptations, and adaptive equipment to restore independence in daily activities and productivity (Sözen & Emir, 2022). These approaches also correlate with improved grip strength and reduced disability scores, supporting overall upper extremity recovery (Hidding et al., 2014; Koca et al., 2020).

3.4.1.3. Patient-Reported Outcomes and Quality of Life

Studies utilizing patient-reported outcome measures, such as the Disabilities of the Arm, Shoulder, and Hand questionnaire and WHOQOL-BREF (World Health Organization Quality of Life scale-short form), demonstrate that rehabilitation interventions significantly reduce pain, improve upper extremity function, and enhance overall quality of life in post-mastectomy patients (Koca et al., 2020). Physical therapy protocols have been shown to alleviate shoulder disability and pain while improving quality of life, regardless of baseline characteristics or time elapsed since surgery (Ferrara et al., 2023). Comprehensive rehabilitation approaches, including exercises and supportive therapies, correlate with better patient-reported functional independence, reduced limitations in daily activities, and enhanced well-being (Aleem et al., 2023; Hidding et al., 2014; Marco et al., 2023).

3.5. Gaps in Existing Research and Future Research Directions

3.5.1. Standardization of Protocols

The heterogeneity in approaches often leads to inconsistencies in patient outcomes and complicates the comparison of intervention efficacy across different studies (Torgbenu et al., 2020). A lack of standardized assessment tools and outcome measures further impedes the ability to draw definitive conclusions and formulate evidence-based guidelines for post-mastectomy rehabilitation (Marco et al., 2023).

3.5.2. Long-term Outcomes

There is a critical need for additional long-term follow-up studies. Specifically, extended prospective studies are needed to evaluate the sustained impact of various rehabilitation protocols on chronic pain, lymphedema progression, and shoulder-arm morbidity, especially considering the long latency periods associated with some complications (Freitas-Silva et al., 2010).

3.5.3. Personalized Rehabilitation

Further research should investigate the efficacy of tailored interventions that account for individual genetic predispositions, comorbidities, and psychosocial factors to optimize recovery trajectories and minimize adverse effects. Finally, more homogeneous studies are needed to better understand the optimal treatment protocols and dosages for various rehabilitation interventions, enabling robust meta-analyses to establish definitive evidence-based guidelines (Ferrara et al., 2023).

3.5.4. Role of Technology

The integration of artificial intelligence for personalized rehabilitation planning and wearable devices for real-time functional monitoring offers a transformative potential for patient-centered care, addressing critical gaps in current rehabilitation strategies (Cai et al., 2025). Additionally, tele-rehabilitation platforms could significantly enhance accessibility and adherence to prescribed exercise regimens, especially for patients in remote areas or those with mobility limitations (Mathieu et al., 2022). However, further research is needed to document the effectiveness and long-term adherence rates of such technology-driven interventions, especially in diverse socioeconomic contexts (Mathieu et al., 2022).

3.5.5. Cost-Effectiveness Studies

A key gap in the literature is the economic evaluation of comprehensive post-mastectomy rehabilitation programs. Cost-effectiveness studies are essential to demonstrate savings from reduced complications (e.g., lymphedema, chronic pain, functional impairments), supporting resource allocation and policy advocacy (Bruce et al., 2021; Hidding et al., 2014). Furthermore, understanding the cost-effectiveness of various rehabilitation approaches will inform resource allocation and promote the integration of comprehensive post-mastectomy care into standard clinical pathways.

4. Conclusions

This review highlights the significant impact of radical mastectomy and its evolved forms on upper extremity function, underscoring the critical need for comprehensive rehabilitation. Key findings indicate that post-mastectomy patients frequently experience a range of debilitating upper extremity complications, including chronic pain, reduced range of motion, lymphedema, and muscle weakness (Hidding et al., 2014; Koca et al., 2020; Miccinilli et al., 2021). These issues significantly impair quality of life and functional independence (Aleem et al., 2023). Risk factors such as extensive axillary lymph node dissection, higher BMI, and adjuvant therapies contribute to the severity and incidence of these complications (Koca et al., 2020). The evolution from radical mastectomy to modified radical mastectomy and breast-conserving therapy has aimed to reduce morbidity while maintaining oncological efficacy (Freitas-Silva et al., 2010). However, axillary interventions, particularly axillary lymph node dissection, remain a primary determinant of lymphatic drainage disruption, lymphedema risk, and nerve damage leading to chronic neuropathic pain (Bruce et al., 2021). These insights underscore the importance of integrating a multidisciplinary approach to rehabilitation, emphasizing early intervention and patient-specific care plans to optimize functional recovery and mitigate long-term morbidity after radical mastectomy (Hidding et al., 2014). Moreover, the proactive integration of pre-operative patient education and physiotherapy has been demonstrably linked to superior post-treatment outcomes, advocating for its routine incorporation into care pathways (Ferrara et al., 2023).

A multi-faceted approach to rehabilitation is crucial for post-mastectomy recovery. Early mobilization effectively prevents long-term shoulder dysfunction and improves short-term range of motion recovery (Kim et al., 2019). Therapeutic exercises, including range of motion and progressive strength training, are essential for restoring mobility, strength, and endurance (Meer et al., 2023). Manual therapy techniques, such as myofascial release and scar massage, help address tissue restrictions, improve lymphatic flow, and reduce pain (González-Rubino et al., 2025). Complete Decongestive Therapy is key for lymphedema management, reducing limb volume and preventing complications (Koca et al., 2020). Patient education and self-management are essential for long-term lymphedema control and patient empowerment (Huertas et al., 2021). Occupational therapy promotes functional independence and adaptation

to daily activities (Sözen & Emir, 2022). Psychological support is essential for holistic recovery, addressing emotional distress that hinders physical rehabilitation (Eidenberger, 2022). Emerging technologies, such as low-level laser therapy and extracorporeal shockwave therapy, show promise for reducing fibrosis and improving lymphatic function in chronic lymphedema (Meer et al., 2023).

Despite advances, significant gaps remain, including the need for standardized rehabilitation protocols, long-term follow-up studies to assess sustained outcomes, personalized rehabilitation approaches, and further research into the role and cost-effectiveness of emerging technologies and tele-rehabilitation (Cai et al., 2025; Ferrara et al., 2023; Freitas-Silva et al., 2010; Mathieu et al., 2022; Torgbenu et al., 2020).

Continued advancements in both surgical techniques and rehabilitation methodologies are imperative to further enhance patient quality of life and functional independence, moving towards a more comprehensive and holistic recovery paradigm (Do et al., 2017). Furthermore, a deeper understanding of the socio-economic and psychological determinants influencing adherence to rehabilitation protocols is crucial for developing more effective and equitable intervention strategies. Recognizing the importance of comprehensive support programs, healthcare providers should prioritize robust rehabilitation pathways that integrate both physical and psychological recovery components to improve patients' overall quality of life and facilitate their return to daily activities and work (Garus, 2025). Such comprehensive approaches should ideally encompass long-term follow-up to address the chronic nature of some complications, such as lymphedema, which often requires sustained management and vigilance (Koca et al., 2020; Miccinilli et al., 2021).

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