JOURNAL OF PALLIATIVE MEDICINE
Volume 26, Number 9, 2023

DOI: 10.1089/jpm.2021.0419

Patient Experience of Photobiomodulation Therapy in Head and Neck Chronic Lymphedema

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Abstract

Purpose: Lymphedema is a common late effect of head and neck cancer treatment that causes various symptoms, functional impairment, and poor quality of life. We completed a pilot, prospective, single-arm clinical trial to determine the feasibility and potential efficacy of the use of photobiomodulation (PBM) therapy for head and neck lymphedema. In this study, we report patients' perceived treatment experience of PBM therapy and provide suggestions to better understand head and neck cancer survivors' experience of PBM therapy.

Methods: Head and neck cancer patients who underwent PBM therapy completed face-to-face semi-structured interviews. Interviews were audio-recorded and then transcribed verbatim. Qualitative content analysis was used to analyze the transcriptions from the interviews.

Results: Among 12 participants who consented for the study, 11 (91.7%) completed the PBM therapy. Participants described positive experiences and unique benefits about the PBM therapy, for example, decreased swelling, reduced tightness, increased range of motion, increased saliva production, and improved ability to swallow. Some participants ($n = 5$, 45.5%) delineated challenges related to traffic, travel time, and distance from study location. Many participants proposed suggestions for future research on PBM therapy, for example, research on internal edema and its relationship with swallowing, and indicated patients with severe lymphedema and fibrosis may be more likely to benefit.

Conclusions: Findings from this study suggested the potential benefits of PBM therapy in treatment of chronic head and neck lymphedema. Rigorously designed clinical trials are needed to evaluate the effect of PBM therapy for head and neck cancer-related lymphedema.

Trial Registration Number and Date of Registration: ClinicalTrials.gov Identifier: NCT03738332; date of registration: November 13, 2018.

Keywords: experience; head and neck cancer; lymphedema; photobiomodulation; qualitative

Introduction

Individuals with locally advanced head and neck cancer often receive aggressive multimodality cancer regimens.[1] These regimens have led to improved overall survival, but at the expense of leaving head and neck cancer survivors at high risk for developing long-term and late side effects.[1,2] One critical, but frequently overlooked and undermanaged, late effect is head and neck lymphedema, which is soft tissue swelling due to abnormal accumulation of lymph fluid in the interstitial spaces.[3,4]

Head and neck cancer and its treatments, such as surgery and radiation, often damage the lymphatic structures (e.g., lymph vessels and lymph nodes) and surrounding soft tissues, limiting the lymphatic system's ability to transport the lymph fluid.[5,6] Accumulated protein-rich lymph fluid in the

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Accepted March 6, 2023.

interstitial spaces can trigger a chronic inflammatory response, which results in a fibrosclerotic process in which fibrotic tissues develop.[5–7] A study found that 75% of head and neck cancer survivors developed lymphedema more than three months post-cancer treatment.[3] The severity of lymphedema was associated with substantial symptom burden, functional impairments, and poor quality of life.[8]

Timely treatment for lymphedema is critical to reduce swelling and minimize its negative impact on overall quality of life. Standard of care for lymphedema is a two-phase complete decongestive therapy (CDT), including an intensive lymphedema therapy phase and a long-term self-care phase.[9–12] During the intensive treatment phase, therapists provide patients with manual lymph drainage (MLD), compression garments, remedial exercises, and meticulous skin care.[9–12] The duration of the CDT administered by lymphedema therapists varies with an average of two to three times per week for usually up to four to eight weeks, depending on the severity of the condition and patient response.[9–12]

Although prospective studies are lacking, findings from two large retrospective reports indicate that ~30%–40% of head and neck cancer survivors still had residual lymphedema after completion of recommended lymphedema therapy,[4,13] which requires patients to conduct long-term self-management of lymphedema to slow its progression into late-stage lymphedema, such as fibrotic tissue formation.[6] Qualitative studies in the head and neck cancer population have shown that patients suffer from long-term symptoms such as difficulty in eating and swallowing, ineffective verbal communication, and psychosocial burdens.[14,15] Currently, there was a lack of an effective treatment for chronic, late-stage head and neck lymphedema.

Photobiomodulation (PBM) therapy (previously named low-level laser therapy) was accepted by the U.S. Food and Drug Administration (FDA) in 2006 as a treatment for breast cancer-related upper extremity lymphedema.[16] Systematic reviews concluded that available evidence supports PBM therapy in the treatment of arm lymphedema among breast cancer survivors.[17,18] Animal model studies suggest that PBM therapy may be effective to treat chronic lymphedema.[19] Given no reports investigating the effect of PBM therapy on head and neck lymphedema, we recently completed a pilot feasibility study investigating the impact of PBM therapy on lymphedema in head and neck cancer survivors.[20]

The findings from our pilot study showed that PBM therapy was feasible and acceptable to treat lymphedema in the head and neck cancer population. These findings were reported elsewhere.[20] In the preexisting PBM therapy literature, there are very few qualitative studies seeking to understand the direct experience of patients with lymphedema. Therefore, in the parent study, we also conducted one-on-one, face-to-face interviews with the study participants who completed the PBM therapy to develop a better understanding of their experience with PBM therapy. The purpose of the article focuses on reporting head and neck cancer survivors' perceived treatment experience of PBM therapy and suggestions for the treatment.

Materials and Methods

Sample

A single-group, pilot, feasibility study design was used. After obtaining approval from the Institutional Review Board and Clinical Trial Scientific Research Monitoring Committee at the study site, the trained research staff members approached potentially eligible participants who were interested in the study. Written consent forms were obtained from all participants before initiating any study activities. Inclusion criteria for participation were as follows: >18 years of age; completion of cancer treatment for histologically proven head and neck cancer (3–18 months post-cancer treatment); currently no evidence of cancer; presence of external head and neck lymphedema; a history of completion of lymphedema therapy; able to speak and read English; and able to provide informed consent.

Patients were excluded if they had any of the following medical conditions that would prohibit the safe implementation of PBM therapy: preexisting skin rash, ulceration, open wound in the treatment area; chronic inflammatory diseases; venous thrombosis; medication that affects body fluid and electrolyte balance; use of high doses of nonsteroidal anti-inflammatory drugs; allergic and other systemic skin diseases; photosensitivity; pregnancy; and/or history of severe trauma. Patients were also excluded if they were in active lymphedema or physical therapy or if they were unable to undergo study-related visits. During the study recruitment period (February 1, 2019 to June 30, 2019), the trained research assistants approached 30 potentially eligible participants and enrolled 12 of them. Patients declined participation due to the following reasons: lack of interest ($n=11$) and time constraints ($n=7$). One participant was withdrawn by the Principal Investigator (first author) due to an unexpected family obligation. Hence, we reported data from a cohort of 11 participants who completed the study.

Study procedure

The detailed procedures for data collection and the study intervention (PBM therapy) were reported elsewhere.[20] In brief, after completing the baseline assessment, participants received PBM therapy twice per week for six weeks. Before each PBM therapy session, participants underwent simple MLD. Once the participants completed the six weeks of PBM therapy, they underwent the post-treatment assessment and then the four-week post-treatment assessment.[20] Throughout the study period, participants were encouraged to maintain their lymphedema and fibrosis self-care at home, as standard of care.

During the last study visit, the participants were interviewed for their perceptions about PBM treatment experience. The interviewers were baccalaureate-prepared research assistants and trained by the Principal Investigator (first author) on the interview process, questioning style, and probing questions to ensure quality, consistency, and fidelity of the interviews. The trained research assistants conducted one-on-one, face-to-face semi-structured interviews by using a standardized script. Interviews were audio-recorded and then transcribed verbatim with identifiers removed. All transcriptions were read and reviewed while simultaneously listening to each audio recording to ensure accuracy.[21] Throughout the study, participants were offered free parking passes during study assessment and intervention visits at the study site.

Study measures

In the parent report, we presented all the study measures collected at baseline, post-treatment assessment, and four-week post-treatment assessment.[20] In this study, we only included the measures that were related to this report.

Sample characteristics. Demographic data such as age, sex, education level, and marital status were collected. Head and neck cancer disease and treatment data such as tumor stage, histology, and treatment type were obtained via chart reviews.

Interview script. An interview guide with 8 open-ended semi-structured questions was employed to elicit participants' experience of PBM therapy and their suggestions for treatment (Appendix A1).

Data analysis

Descriptive statistics (e.g., median, frequency) were used to describe the sample characteristics. Qualitative content analysis was used to analyze the transcriptions from the interviews. The analyst triangulation method of including different coders in data analysis was utilized to establish credibility.[22] The coders included the first author, one master's degree-prepared research staff member, and two bachelor's degree-prepared research staff members. The coders read all transcripts thoroughly and highlighted potential key texts. Then, the coders used codes to label and capture the essence of the statements. Subsequently, the coders organized the codes into a meaningful structure and began to form themes. A constant comparison process was used to find similarities and differences among the codes. Weekly team meetings were held to review the coding status, to discuss any coding discrepancies among the coders, and to reconcile all the codes to ensure consistency and consensus of the coding process. Data saturation was achieved when 10 participants' transcriptions were analyzed.

Results

Sample characteristics

Among 12 head and neck cancer survivors enrolled in the study, 11 of them completed the study. Most of the participants who completed the study were White (91.7%), male (83.3%), median age was 58.4 years, married or living with a partner (58.3%), 50% were employed, and eight (66.7%) of them had an annual household income above $60,000. Half of the participants had oropharyngeal cancer and 66.7% had stage III or IV cancer (AJCC seventh edition, stage III/IVa). Participants all received multimodality cancer treatment, and 25% of them had bilateral neck dissection. Time since completion of head and neck cancer treatment ranged from 3.5 to 16.5 months, with a median of 12.6 months. The median time since diagnosis of lymphedema was 9.3 months, ranging from 3.0 to 15.2 months. Participants' characteristics are summarized in Table 1.

Table 1. Participant Characteristics

Characteristic	*Frequency (%) (N = 12)*
Race	
White	11 (91.7)
Black or African American	1 (8.3)
Sex	
Male	10 (83.3)
Female	2 (16.7)
Education	
≥12th Grade	12 (100.0)
Marital status	
Single/windowed/other	5 (41.7)
Married/living with a partner	7 (58.3)
Employment status	
Employed	6 (50.0)
Unemployed/other	6 (50.0)
Annual household income	
≤$30,000	1 (8.3)
$30,001–60,000	1 (8.3)
>$60,000	8 (66.7)
Do not care to respond	2 (16.7)
Primary tumor site	
Nasal cavity	1 (8.3)
Oral cavity	3 (25.0)
Oropharynx	6 (50.0)
Hypopharynx	1 (8.3)
Salivary gland and other	1 (8.3)
Tumor stage (TNM) at diagnosis	
Stage I	1 (8.3)
Stage II	2 (16.7)
Stage III	3 (25.0)
Stage IV	5 (41.7)
Could not be staged	1 (8.3)
Characteristic of ND	
ND with preservation of jugular vein	12 (100.0)
Neck dissection location	
Unilateral ND	9 (75.0)
Bilateral ND	3 (25.0)
Complete cancer treatment received	
Surgery and radiation	10 (83.3)
Surgery and CCR	2 (16.7)

Characteristic	*Median (minimum, maximum)*
Age (years)	58.4 (32, 75)
Time since HNC treatment ended (months)	12.6 (3.5, 16.5)
Time since diagnosis of lymphedema (months)	9.3 (3.0, 15.2)

CCR, concurrent chemoradiation; HNC, head and neck cancer; ND, neck dissection; TNM, tumor, lymph node, and metastasis.

Completion status of PBM therapy

Among 12 participants who consented to the study, 11 (91.7%) completed the PBM therapy. One patient completed one PBM treatment session and was withdrawn from the study, due to an unexpected family obligation. Regarding the PBM therapy sessions, 50% of the participants ($n = 6$) completed a full course of 12 PBM sessions, 25% of the participants ($n = 3$) completed 11 PBM sessions, and 16.7% ($n = 2$) completed 10 PBM sessions. The reasons for missing one to two PBM treatment sessions included prepaid vacation, doctor appointment, social events, and/or work obligation.

Perceptions concerning PBM therapy

Themes: Participants' perceptions of time spent receiving PBM therapy. Participants ($n = 11$, 91.7%) who completed the PBM therapy articulated that the time spent receiving the PBM treatment was acceptable. The themes identified included the following: the length of each therapy session (around 30 minutes) was satisfactory and felt quick,

Table 2. Participants' Perceptions of Time Spent Receiving Photobiomodulation Therapy

Themes	*Exemplar quotes from participants*
Length of each therapy session (30 minutes) was satisfactory, and felt quick	''It was done within a half hour if I'm not mistaken.'' (ID 1001) ''It was, uh, under thirty minutes from, you know, when walking in to walking out, it was probably twenty minutes, twenty-five minutes of treatment.'' (ID 1002) ''The time frame was fine.'' (ID 1100) ''No, it was pretty, pretty fast.'' (ID 1009) ''It's just, like, to me it was a little too short.'' (ID 1100) ''No, it seemed to go really fast.'' (ID 1120)
Frequency and duration of PBM therapy (two times per week for six weeks) were acceptable	''It's not too long, but it's not too short of a period.'' (ID 1001) ''It might not be manageable, three times, two is probably the perfect timing. Perfect, two a week will be perfect.'' (ID 1009) ''Overall, the timing in it, the frame and the length, I was pleased with.'' (ID 1100)

PBM, photobiomodulation.

Table 3. Positive Experiences of Photobiomodulation Therapy

Themes	*Exemplar quotes from participants*
A good experience	''It was a good experience. I think that it might have, uh, taken away some of the swelling in my, uh, my neck and uh, I think it was a great experience.'' (ID 1004) ''… it was nice, uhm, I think everybody cared, you know, in this project and I think it's done some good.'' (ID 1006) ''Uhm, I, um, I thought it (PBM therapy) was good.'' (ID 1008) ''Very helpful.'' (ID 1009)
Improved lymphedema and/or fibrosis	''… I see improvement in myself, so I'm sure that other people will see the improvement with a longer study …'' (ID 1009) ''Well, I definitely feel like I've gotten an improvement from it, so, yeah.'' (ID 1110) ''No, it didn't increase anything, I feel that it, it at least decreased.'' (ID 1006) ''… for individuals with my condition, I think it was, uhm, it certainly worked, uh, and I certainly would recommend people with uh, not 'gonna step outside my spectrum but, uh, people had similar issues I think it would, uh, be beneficial …'' (ID 1001)
Helpful and beneficial	''It seems to have worked. It helped me out a lot.'' (ID 1006) ''I thought it was a benefit to me …'' (ID 1100) ''Yeah, it's been a big help.'' (ID 1120)
No uncomfortable feelings	''… It was, uh, again, easy to, to, work through and, and … no pain or discomfort of any nature, and, uh, no inconvenience to it, so.'' ''… nothing from the laser (PBM), uh, therapy has created any additional discomfort.'' (ID 1002) ''I didn't really feel anything, no bad after affects or no side effects, whatsoever.'' (ID 1004) ''… so, it was completely painless …'' (ID 1003) ''No, no. It didn't bother me at all.'' (ID 1007) ''No discomfort at all.'' (ID 1009)
Well organized, convenient, easy to manage	''… I really can't think of any substantial changes that you'd make. I mean I think it's well organized, uh, I enjoyed the team I worked with …'' (ID 1001) ''I think it (PBM therapy) was fine from beginning to end.'' (ID 1008) ''I think it (PBM therapy) was handled well. Your team was great. It was professional and I, I can't imagine it, like, being better any other way.'' (ID 1110) ''Uhm … easy to manage, I guess, would be the best way to put it. There was, what I expected to be somewhat, either discomfort or, uh, just in general a hassle as a result of it, that wasn't the case at all.'' (ID 1002)
Well informed, supportive team	''… I enjoyed the team I worked with …'' (ID 1001) ''… more less what I was expecting from the how you guys described it'' (ID 1120) ''… one of the things that I liked was that I was allowed to, like, encouraged to ask a lot of questions, and, like your experience and all about the experiment and what was going on that I always felt like I was welcomed to try to find information that I didn't know.'' (ID 1003) ''And the best part, I forgot to say that the best part of having so many appointments available …'' (ID 1120) ''… it was nice, uhm, I think everybody cared, you know, in this project and I think it's done some good.'' ''I enjoyed it as a matter of fact …. I said before, I'd go again if you wanted me to, so I was happy with it.'' (ID 1006) ''Everybody was great.'' (ID 1008) ''I think you guys did an excellent job.'' (ID 1009) ''Everybody's been great.'' ''I think it was handled well. Your team was great. It was professional and I, I can't imagine it, like, being better any other way.'' (ID 1110)

and the frequency and duration of PBM therapy (i.e., two times per week for six weeks) were acceptable (see Table 2 for exemplar quotes from participants).

Themes: Overall experiences of PBM therapy. Participants ($n=11$, 91.7%) who completed the study delineated overall encouraging experiences about the PBM therapy. The themes included a positive experience, improved lymphedema and/or fibrosis, helpful and beneficial, no uncomfortable feelings, well organized, convenient, and easy to manage, well informed, and supportive team (see Table 3 for exemplar quotes from participants).

Themes: Benefits of PBM therapy. Participants ($n=11$, 91.7%) who completed the study intervention described unique benefits of the PBM therapy. The themes identified included decreased swelling, improved skin elasticity and reduced tightness, increased neck range of motion, symptoms dissipated, improvement in skin condition noticed by others, increased saliva production, improved ability to swallow, no pain when opening mouth, and decreased eardrum swelling (see Table 4 for exemplar quotes from participants).

Themes: Challenges and negative experiences of PBM therapy. Some participants ($n=5$, 41.7%) delineated challenges related to traffic, travel time, and distance from the study location. One participant described an uncomfortable massage table, and another participant reported an initial, minimal tingling sensation during one treatment session (see Table 5 for exemplar quotes from participants).

Suggestions for future research on PBM therapy

Many of the participants ($n=9$, 75%) proposed some suggestions for future research on PBM therapy. The themes included: people with similar issues would benefit, research

Table 4. Benefits of Photobiomodulation Therapy

Themes	*Exemplar quotes from participants*
Decreased swelling	''The swelling has improved as a result.'' (ID 1002)
	''I feel like, uh, the lymphedema has subsided some.'' (ID 1008)
	''… it hasn't been feeling like my face has been swelling.'' (ID 1120)
	''… I think the laser (PBM) has, it's, it's made it much easier to manage it.'' (ID 1120)
Improved skin elasticity and reduced tightness	''Ah, yes, I think it helped … It's not as tight as it was.'' (ID 1008)
	''… I definitely see a, a difference, in my, in my skin, and whatever elasticity.'' (ID 1100) ''… I think it was beneficial to my skin …'' (ID 1100)
	''Just that it appears that my, uh, neck, the skin, it's not quite as stiff, it's softer, and, uh, mostly I notice it whenever I shave (laughter.) I mean, it's uh, just uh, it's softer as opposed to, uh, being more coarse or rough.'' (ID 1001)
	''Oh yeah, I definitely felt that from the time that I started the study until now that it wasn't as tight as it was at the beginning of the study.'' (ID 1004)
	''… it felt stiff when I turned my neck left or right. And now since I've had the laser therapy (PBM therapy), it seems like it, it feels a little bit more like it used to feel, where it isn't so tight when I turn my head left to right.'' (ID 1004)
	''It's not as tight as it was.'' (ID 1008)
	''It felt like after I had left, after I had two or three, uh, uh, therapy sessions, it started, started to release the, the, the jaw, I would feel cramping every now and then …'' (ID 1009)
Increased neck range of motion	''I believe I have more flexibility; it appears that my neck is softer, and um, is, uh, I think I achieved favorable results.'' (ID 1001)
	''… it's helped, it's helped my neck a lot … I guess it can't get any better than what it is. It seems to have worked. It helped me out a lot.'' (ID 1006)
	''… so it's more or less just more flexibility to the skin.'' (ID 1100)
	''I think I have more mobility. I can move more freely.'' (ID 1110)
Symptoms dissipated	''Cramping is gone. I don't have it anymore.'' (ID 1009)
	''I used to feel like, uh, it was a burning sensation when I felt it, no I don't feel that anymore.'' (ID 1009)
Improvement in skin condition noticed by others	''… other people have noticed it, uh, doctor and my wife, that it appears that it's, uh, smaller …'' (ID 1001)
	''… Cause everybody says your skin is soft to the touch … Everybody always compliments me on my skin …'' (ID 1100)
Increased saliva production	''And I definitely feel like that there's certain types of meals where I would need to drink more water than I normally do and, um, I don't need to do that. So, I definitely feel like my saliva production has increased.'' (ID 1110)
Improved ability to swallow	''…. even if there's a, any percentage of a chance that it would help my ability to swallow … I believe, I think I, I've, I've increased my ability to eat since the study because, uh, before the study I was only able to eat eggs and that type of thing. I have since I've participated in the study, been able to eat a hamburger …'' (ID 1004)
No pain when opening mouth	''I would have to pull it and it would be painful and, you know, um, I don't have that problem now.'' (ID 1110)
Decreased eardrum swelling	''I would feel my face was just be more full and would get into my eardrum would feel like it's getting squeezed … And that doesn't seem to be doing that …'' (ID 1120)

Table 5. Challenges and Negative Experiences of Photobiomodulation Therapy

Themes	*Exemplar quotes from participants*
Traffic/travel time/distance from location	''… it was easy, short of the fact that it's in Center City, Philadelphia versus any city. Getting into Center City, market's going to be a challenge for anyone.'' (ID 1002) ''Just traffic, I live far away.'' (ID 1003) ''No, it's just my individual situation, I live, you know, away, so.'' (ID 1004) ''Uhm, I took the train every day, uhm, so, I mean, it's coming into Center City is not the most convenient place to go…'' (ID 1002) Where I, from where I live to Penn, some days you hit certain traffic, and other days you don't hit any. So, it's just something you have to deal with, and it didn't bother me. ID 1008) ''Well, yeah, there, there is traffic, but, yeah, it's a longer drive, but yeah.'' (ID 1120)
Uncomfortable massage table	''… and the bench, whenever you laid on was so hard, I had to bring my own pillow, so I don't know whether you get one of those boosters for the person's back, but I had to bring my own pillow.'' (ID 1100)
An initial, minimal tingling sensation during one session	''No (uncomfortable feelings), it was tingling the one day but that was more funny (Laughter) than anything hurting, like.'' (ID 1120)

on internal edema and swallowing, more likely to help those with severe lymphedema and fibrosis, MLD is an important part of therapy, more training on self-care, increase compensation to participants, and help further education and science (see Table 6 for exemplar quotes from participants).

Discussion

Studies conducted in the breast cancer population indicate that patients with head and neck lymphedema and fibrosis may benefit from PBM therapy. However, limited studies have investigated the effect of PBM on lymphedema and/or fibrosis in head and neck cancer survivors.[23] We therefore conducted a pilot prospective clinical trial.[20] The quantitative data from the study reported elsewhere suggested that PBM is feasible, acceptable, and potentially effective to treat head and neck lymphedema and fibrosis.[20] Indeed, our study found encouraging improvements in patient outcomes. When comparing the baseline (pre-intervention) to four-week post-intervention, we found statistically significant improvements in the severity of external lymphedema, symptom burden, and neck range of motion.[20]

To better understand head and neck cancer survivors' experience with PBM therapy, we conducted one-on-one, face-to-face semi-structured interviews with participants who completed the pilot study. Given the scarcity of qualitative studies on using PBM therapy for lymphedema treatment in cancer survivors, these patient experiences provided valuable insights regarding the timing, benefits, and challenges of PBM therapy, as well as suggestions for future research in this area.

Table 6. Suggestions for Future Research on Photobiomodulation Therapy

Themes	*Exemplar quotes from participants*
People with similar issues would benefit	''… for individuals with my condition, I think it was, uhm, it certainly worked, uh, and I certainly would recommend people with uh, not 'gonna step outside my spectrum but, uh, people had similar issues I think it would, uh, be beneficial.'' (ID 1001) ''I'm sure it's helpful to other people, like the women with breast cancer, maybe it's more helpful for them.'' (ID 1009)
Research on internal edema and its relationship with swallowing	''I did eat more at the end of the study than I did at the beginning. So, maybe there is a correlation between, uh, the swelling inside of your neck and your ability to swallow, that, potentially in the future, uhm, may help patients that have problems swallowing. But that would have to be looked at further.'' (ID 1009)
More likely to benefit those with severe lymphedema and fibrosis	''I'm probably one of the patients that has the least amount of lymphedema, so, you know for me, uh, a slight change, you know, would be, would be noticeable, but it, it may even help someone who has severe lymphedema even more than it would help me. If it helps me and my lymphedema is not that noticeable.'' (ID 1004)
Manual lymph drainage is important	''It kind of feels comfortable. And I imagine that that's helping, just because of what I've been told. I imagine that's been helping me to drain.'' (ID 1003) ''Yeah, yeah, yeah because I do that (manual lymph drainage) at home.'' (ID 1100) ''I spent a lot of time on the self-massage and when somebody else does it, it does feel like uhm, it does feel like that's a positive part of the whole experience.'' (ID 1003)
More training on self-care	''… can you introduce different types of facial massages for the therapy? And then have the patient be trained on that as well?'' (ID 1100)
Increase the compensation to participants	''Um, uh, I would, I would, put more money on the card (laughter).'' (ID 1004)
Help further education and science	''I'm happy and I like to participate in these things to, to help further education and science.'' (ID 1110)

More than 90% of the participants completed the PBM therapy. These numbers indicate that patients were highly motivated to undergo PBM therapy for treating chronic lymphedema and fibrosis. This further supports both the clinical and research need of exploring effective interventions for treating and managing chronic lymphedema and fibrosis among the head and neck cancer survivor population. Participants expressed that the frequency and length of each PBM treatment session, as well as the study duration were acceptable. These results imply that the schedule (two times per week for six weeks) of PBM therapy used in our pilot study was feasible for the participants who enrolled in the study.

Nevertheless, it should be acknowledged that 7 of 30 potentially eligible subjects (23.3%) approached for participation stated time constraints as their reason for not participating. With most of the participants being college-educated (100%) and having an annual household income above $60,000 (66.7%), the participant experiences reported in this study may not have been fully representative of the entire head and neck cancer survivor population. For example, patients of lower socioeconomic status may have found more difficulty with consistently attending twice weekly treatment visits and having confidence in the efficacy of an unfamiliar and new treatment modality.

One of the most noteworthy results from this study was that participants voiced their experiences of PBM therapy, which has not been reported previously. For the first time, our study revealed that participants with chronic head and neck lymphedema and/or fibrosis had positive experiences with the PBM therapy: noting that PBM is a beneficial therapy with no uncomfortable feelings and improved lymphedema and/or fibrosis. These are particularly important findings given that no evidence-based effective interventions are available for treating chronic lymphedema and fibrosis among head and neck cancer survivors.

It is important to recognize that all participants who completed the PBM therapy experienced unique benefits beyond just decreased swelling. They reported other benefits that were essential for their daily quality of life, such as reduced tightness and improved skin elasticity, increased neck range of motion, symptoms (cramping and burning sensation) dissipated, improvement in skin condition noticed by others, increased saliva production, improved ability to swallow, no pain when opening mouth, and decreased eardrum swelling. Most of these benefits (e.g., reduced tightness, improved skin elasticity, increased neck range of motion) were consistent with the findings from our quantitative data and reported in our earlier publication.[20]

Two benefits of the PBM therapy reported by the participants, including increased saliva production and decreased eardrum swelling, were not expected. These findings were critical, given that these are resistant and hard-to-treat symptoms. The underlying mechanisms of PMB therapy on saliva production or eardrum swelling are unknown. A prospective study conducted in patients with hyposalivation, and xerostomia identified that PBM therapy has potential to increase salivary flow rate (both unstimulated and stimulated).[24] The author hypothesized that PBM may improve local microcirculation, induce glandular cell proliferation, and increase cell respiration, adenosine triphosphate (ATP) production, and protein syntheses. Regarding the mechanism of PBM therapy on reducing eardrum swelling, we think that PBM facilitates lymphatic drainage, thereby reducing lymph fluid accumulated in the middle ear. These encouraging findings suggest that PBM could be an additional treatment option to manage resistant symptoms among head and neck cancer survivors.

Previous studies have reported the associations between head and neck lymphedema and local (e.g., tightness, change in skin texture) and systemic (e.g., feeling tired, feeling anxious) symptom burden.[25–27] Further studies are needed to determine whether PBM is impacting the local effects of lymphedema on head and neck function or the individual's systemic chronic inflammatory status, as discussed in our main findings article.[20]

Since our participants had mainly chronic lymphedema (mean ± standard deviation: 10.5 ± 4.5 months), the reported benefits support potential implication of the PBM therapy for cancer patients with chronic lymphedema, including palliative care patients. Lymphedema is a chronic condition and often persists throughout the rest of their lives; therefore, treatments such as PBM therapy could be a critical component for supporting patients' quality of life.

Although no adverse events were reported in the study, a few participants described travel challenges related to PBM therapy despite the steps to ameliorate it (i.e., free parking passes, visits scheduled per participants' availability, and fitting in around other appointments). In future studies, it may be beneficial to evaluate the feasibility of holding intervention sessions through certified therapists at local community centers or palliative day care unit to address transportation and distance barriers and improve the benefit to burden ratio. One participant mentioned our use of an uncomfortable massage table.

To address this issue, we offered pillows to participants in need of lower back support to diminish any uncomfortable feelings during study visits. Alleviating physical stress is critical to ensure muscle relaxation, which can maximize lymphatic drainage and potentially, better treatment outcomes during PBM therapy. In addition, only one participant reported an initial, temporary, minimal tingling sensation during the first treatment session. No other uncomfortable feelings nor adverse events were reported during the study.[20] These findings were encouraging and indicated that PBM is a safe comfortable treatment with no reported lasting discomfort, which makes it an ideal choice for symptom management in cancer patients with high symptom burden.

Most participants made suggestions for future research on PBM therapy, which merit discussion. Several participants noticed that their swallowing difficulties were considerably improved after they completed the PBM therapy. Consistent with this observation, it was reported in the literature that head and neck cancer survivors with lymphedema had difficulty swallowing.[8] Research is needed to prospectively assess the association between internal or external swelling, swallowing difficulty, and PBM therapy. In line with the literature, we hypothesized that if participants underwent simple lymph drainage before the PBM therapy, it would open the lymphatic channels to maximize treatment outcomes. Thus, the protocol included a simple MLD delivered by the study lymphedema therapist directly before application of the PBM therapy.

Participants highly appraised the value of the simple MLD in the study intervention during the qualitative interviews. While patient's reported benefits of manual lymphatic

drainage before PBM, additional research is needed to confirm our hypothesis that manual lymphatic drainage enhances PBM therapy patient outcomes. As such, further study is needed to understand the individual and synergistic contributions of manual lymphatic drainage and PBM therapy on lymphedema outcomes. Furthermore, we encouraged participants to conduct their daily self-care for lymphedema and fibrosis as part of the standard of care. Future research is desired to evaluate the potentially synergistic effect between daily self-care at home and PBM therapy interventions on lymphedema and fibrosis outcomes.

Strengths, limitations, and clinical implications

Strengths. This is the first report that we are aware of to describe patient experience regarding PMB therapy in individuals with head and neck lymphedema and fibrosis. Through semi-structured interviews, the study provided insights and illustrated the potential of PBM therapy. It provided preliminary critical data for future clinical trials to examine the effect of PBM for chronic lymphedema and fibrosis in the head and neck cancer population.

Limitations. There are several limitations within our study. First, the patients enrolled in the study were interested in PBM therapy and able to attend for the necessary sessions; thus, they were a self-selected group and may not be representative of all patients with head and neck cancer-associated lymphedema and fibrosis. Second, most of the participants were male, White, middle-aged adults and had at least some college education; thus, the study findings may not be generalizable to minority populations, older adults, and/or individuals without college education. Third, the study was conducted at one comprehensive medical center; therefore, the results from this study may not be applicable to facilities in rural areas or any other noncomprehensive medical centers. Further studies are warranted to replicate the findings from this report.

Clinical implications. While PBM is an emerging modality for treating chronic lymphedema and fibrosis in the head and neck cancer population, our study results show that patients found PBM to be acceptable, feasible, and quite beneficial. Given that PBM is a simple, well-tolerated, inexpensive, and noninvasive treatment, PBM therapy warrants further investigation in this patient population to confirm our initial findings and to address applicability and utility of PBM in different settings. If the benefits of PBM therapy are confirmed in larger clinical trials, PBM has potential to be widely used to treat head and neck lymphedema and fibrosis.

Conclusions

Findings from this study have provided an understanding of the potential value of PBM therapy in the clinical management of chronic head and neck lymphedema and fibrosis. Of note, patients describe substantial clinical benefits from PBM therapy. However, the limitations must be acknowledged within a small pilot pre–post design clinical trial. Despite the limitations of the study, the encouraging findings from both quantitative and qualitative data indicate that rigorously designed clinical trials are needed to investigate the benefit of PBM therapy.

Acknowledgments

We would like to thank all the participants for their support.

Authors' Contributions

J.D. contributed to the study conception and design. Material preparation and data collection were performed by J.D., A.L., J.N.L., J.C.C, B.A.S., E.M., J.Z., and L.P.A. Data analysis was performed by R.J.Q. and J.C. The first draft of the article was written by J.D. All authors commented on previous versions of the article. All authors read and approved the final article.

Consent to Participate

All participants signed informed consent forms.

Funding Information

This work was supported by the University of Pennsylvania School of Nursing Faculty Research Award.

Author Disclosure Statement

No competing financial interests exist.

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Appendix A1: Interview Guide

1. In general, how would you describe your experience with photobiomodulation therapy?
2. Have you had any uncomfortable feelings from the photobiomodulation therapy?
3. How many sessions did you attend?
4. If you did not complete the recommended number of sessions, what was the reason?
5. Do you feel that it takes too long to complete the photobiomodulation therapy sessions?
6. Do you feel that photobiomodulation therapy helps you manage your swelling and/or scar-like tissues?
7. Do you feel that photobiomodulation therapy helps improve the skin condition in your head and neck region?
8. Do you have any suggestions related to photobiomodulation therapy?