Low-Level Laser Therapy: A Literature Review of the Prevention and Reduction of Oral Mucositis in Patients Undergoing Stem Cell Transplantation

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BACKGROUND: Oral mucositis (OM) is a highly debilitating complication of high-dose chemotherapy and total body irradiation used in conditioning regimens for hematopoietic stem cell transplantation (HSCT). Research has studied low-level laser therapy (LLLT) as an alternative treatment for OM because of its anti-inflammatory activity, biomodulation, and analgesic effects.

OBJECTIVES: This study reviews evidence on the effectiveness of LLLT using diode lasers on the prevention and reduction in severity of OM in patients with cancer undergoing HSCT.

METHODS: A literature search was performed in PubMed®, CINAHL®, Scopus®, and MEDLINE® databases. Six randomized controlled trials and one cohort study met the inclusion criteria.

FINDINGS: The data demonstrate promising outcomes for reducing the incidence and severity of OM using LLLT. Larger, tightly controlled clinical trials are needed in the future.

KEYWORDS
oral mucositis; low-level laser therapy; hematopoietic stem cell transplantation

DIGITAL OBJECT IDENTIFIER
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ORAL MUCOSITIS (OM), DEFINED AS THE INFLAMMATION AND BREAKDOWN of the oral mucosa, is a major treatment-related complication in the oncology population that is characterized by erythema, ulcerations, and pain (Elad et al., 2020). In patients receiving hematopoietic stem cell transplantations (HSCTs), high-dose chemotherapies with or without total body irradiation (TBI) are used as conditioning regimens. Administering these regimens prior to HSCT has direct toxic effects to the cells that comprise the epithelium, connective tissue, extracellular matrix, and vasculature of the oral mucosa (Fulton, 2016). As a result, 60%–85% of patients undergoing HSCT experience the debilitating complication of OM. Comparatively, mucositis develops in about 20%–40% of patients receiving conventional chemotherapy (Oberoi et al., 2014; Peng et al., 2020). Receiving higher doses of chemotherapy, such as those used in conditioning regimens, cell-cycle-phase–specific chemotherapy, fractionated radiation therapy, or chemotherapy combined with radiation therapy, is associated with increased risk of developing OM. Some chemotherapeutics, such as 5-fluorouracil, melphalan, hydroxyurea, and methotrexate, have a higher potential to cause OM (Fulton, 2016). In addition, almost all patients with head and neck cancer receiving radiation therapy develop OM because of the direct insults from radiation therapy targets near or involving the oral cavity (Fulton, 2016; Oberoi et al., 2014; Peng et al., 2020). Symptoms vary from mild changes in sensation to severe oral pain, followed by a sequela of complications. The World Health Organization (WHO, 1979) categorizes the severity of mucositis into the following four grades:

- Grade 1: Mucosa is a normal color without mucositis.
- Grade 2: Erythema and ulcers are present, but solid diet is tolerated.
- Grade 3: Ulcers require a modification in diet to semisolid or liquid diet.
- Grade 4: Deep ulceration is present, with the need for nutritional support.

The severity of mucosal damage peaks 6–12 days post-HSCT, with resolution of uncomplicated mucositis during the following 1–1.5 weeks (Fulton, 2016).

OM can be detrimental to patients undergoing HSCT. With a loss of oral mucosal integrity, patients encounter an increased incidence of secondary

systemic infections, particularly during their neutropenic phase and nadir. OM is associated with a greater risk of 100-day post-HSCT mortality (Silva et al., 2011). It is also associated with increased hospital length of stay, weight loss, dysphagia, malnutrition, severe pain, and dependency on total parenteral or enteral nutrition. Severe OM could result in radiation therapy or chemotherapy dose reductions, risking the possibility of recurrence or progression of oncologic disease (Schubert et al., 2007). Prevention and treatment of OM consists of oral hygiene and rinses with bland solutions, analgesics and anti-inflammatories, antibiotics, cryotherapy, growth factors, topical coating, and anesthetic agents (Ferriera et al., 2015).

Low-Level Laser Therapy

Because of limitations in the prevention and treatment of OM, low-level laser therapy (LLLT) has been an area of research for many years. LLLT was initially suggested for the management of OM based on previous research showing the effectiveness of laser treatments in wound healing (Zadik et al., 2019). Research on the exact pathophysiology of LLLT on OM is ongoing, but LLLT is known to trigger pathways that promote cell differentiation and proliferation, therefore accelerating the regeneration process and pathways that mediate inflammation, pain, and other negative processes (Peng et al., 2020).

Figure 1 depicts one type of LLLT control unit and various handheld probes. Delivery of LLLT typically involves multiple sequential dose administrations in intraoral and extraoral spots. Variability of the delivery is found in wavelength, power output, energy density, number and size of spots, duration, and frequency of treatment. Specific protocols may vary among research studies and institutions; however, the Multinational Association of Supportive Care in Cancer/International Society of Oral Oncology (MASCC/ISOO) clinical practice guidelines (Elad et al., 2020) provide specific protocols based on level I evidence for the use of LLLT in the prevention of OM in patients undergoing HSCT (see Table 1). The use of LLLT is recommended in patients with head and neck cancer receiving radiation therapy with or without chemotherapy based on level I and II evidence (Elad et al., 2020). These clinical practice guidelines define level I evidence as research based on the highest level obtained from meta-analyses of well-designed controlled studies and randomized controlled trials with high power. Level II evidence is based on at least one well-designed experimental study or from randomized controlled trials with low power. The Oncology Nursing Society (n.d.) also recommends LLLT, as well as cryotherapy, oral care protocols, and sodium bicarbonate, in patients undergoing HSCT and in patients with head and neck cancer.

FIGURE 1.
PHOTOMEDICINE CONTROL UNIT AND PROBES

Note. Image courtesy of THOR Photomedicine. Used with permission.

> **"All studies reported that the use of low-level laser therapy resulted in less severe cases of oral mucositis."**

The purpose of this literature review was to evaluate the effectiveness of LLLT using diode lasers on the prevention and reduction in severity of OM in adult patients with cancer undergoing HSCT. With respect to adult patients who receive HSCT, the review aimed to answer the following questions:

- Does the use of LLLT prevent OM?
- Does the use of LLLT reduce the severity of OM?
- Is there an optimal time for LLLT use?

Methods

A systematic literature review of PubMed®, Scopus®, CINAHL®, and MEDLINE® databases was conducted using a combination of the following search terms: *mucositis, stomatitis, laser therapy, low-level laser therapy, phototherapy, stem cell transplant,* and *bone marrow transplant*. Three searches were conducted between January 2020 and July 2021. Results were filtered to include studies published in the English language, and time parameters were not used given the limited amount of research on this topic. Twenty-five additional articles were identified through the systematic review and clinical practice guideline by Zadik et al. (2019). Inclusion criteria were an adult cancer population

receiving allogeneic or autologous HSCT with myeloablative chemotherapy and/or TBI, the use of LLLT, and the outcome measurements of prevention or decreased severity in OM. Systematic reviews, case reports, editorials, or narratives were not included in this literature review (see Figure 2).

Results

From the 145 articles identified in the database searches, 7 studies published from 2007 to 2017 were included in the final synthesis (see Table 2). All studies reviewed were randomized controlled trials, except for a study by Jaguar et al. (2007), which compared a prospectively collected intervention group to a retrospective control group. The WHO Oral Toxicity Scale was used daily to evaluate the incidence and severity of OM in all studies but Schubert et al. (2007), who used the Oral Mucositis Index every three to four days. Scores on the Oral Mucositis Index ranged from 0 to 61, with a score of 25 or higher being equivalent to grade 3 or worse on the WHO Oral Toxicity Scale. Zero adverse outcomes occurred from the use of LLLT in any of the studies reviewed.

All studies reported that the use of LLLT resulted in less severe cases of OM. Statistical significance was achieved in all but two studies (Jaguar et al., 2007; Schubert et al., 2007). Schubert et al. (2007) randomized 70 participants among a placebo group and two intervention groups. LLLT was administered daily from the first day of conditioning to the second day post-transplantation using either 650 nm or 780 nm wavelengths. LLLT using the 650 nm wavelength was superior to 780 nm. In Schubert et al.'s (2007) study, a total of 22 participants received TBI in their conditioning regimen. When adjusted for TBI exposure, the 650 nm group achieved statistical significance for less severe OM scores as compared to no LLLT. At every time point measured, participants in the placebo group had higher OM scores.

Jaguar et al. (2007) was the only prospective study with a retrospective control group (N = 49). The control group underwent HSCT between 1999 and 2000. LLLT using a 660 nm wavelength was administered to patients between January 2003 and September 2004. The researchers did not state the Brazilian hospital's standard preventive oral care protocol for the retrospective group. In addition to LLLT, the prospective intervention group had an oral care protocol consisting of a chlorhexidine gluconate rinse three times per day, cryotherapy before and after chemotherapy, and a lip protector. This study did not find any statistical significance in the severity of OM using LLLT, but the development of grade 2–3 OM was less prevalent in the LLLT group (Jaguar et al., 2007).

In a study by Silva et al. (2011), patients in the intervention group received LLLT with a 660 nm wavelength daily four days prior to and four days following HSCT. Although the LLLT group included two participants receiving TBI as a part of their conditioning, LLLT showed statistical significance in reducing the incidence and severity of OM. In the LLLT group (N = 21), 14 patients developed grade 0–1 OM, 7 patients developed grade 2 OM, and no patients developed grade 3–4 OM. In the control group, 20 of 21 patients developed grade 2–3 OM, and no patients developed grade 4 OM. Of note, patients in the control group who developed grade 3 OM received LLLT as a therapeutic treatment per the study protocol. The patients who received LLLT to treat grade 3 OM had individualized laser prescriptions, and none progressed to grade 4.

Similarly, Salvador et al. (2017) and Silva et al. (2015) had two and three patients, respectively, in the control group who received LLLT therapy per study protocols when they developed grade 3 OM. Both Silva et al. (2015) and Salvador et al. (2017) used LLLT with a wavelength of 660 nm on the first day of conditioning until seven days post-HSCT in 39 and 51 patients, respectively. In the study by Silva et al. (2015), the majority of patients in the intervention group developed grade 1 OM, and no patients developed grade 3 OM, whereas the development of grade 0–3 OM was evenly distributed in the control group. No patients in the control group progressed to a grade 4 OM after receiving LLLT for grade 3 OM. In the study by Salvador et al. (2017), severities based on the WHO Oral Toxicity Scale were higher at all time points for participants in the control groups and statistically significant from day 7 to day 11 post-HSCT.

The study protocol by Ferreira et al. (2015) included LLLT treatment for any control group participant who developed grade 2 OM. In this study of 35 participants, a 650 nm wavelength was used on the first to fifth day of the patient's conditioning regimen. Despite the earlier intervention of LLLT for grade 2 OM in control group participants, grades 3–4 OM (61%) occurred more

TABLE 1.
LOW-LEVEL LASER THERAPY PROTOCOLS TO PREVENT ORAL MUCOSITIS IN PATIENTS RECEIVING HSCT BASED ON THERAPY DURATION

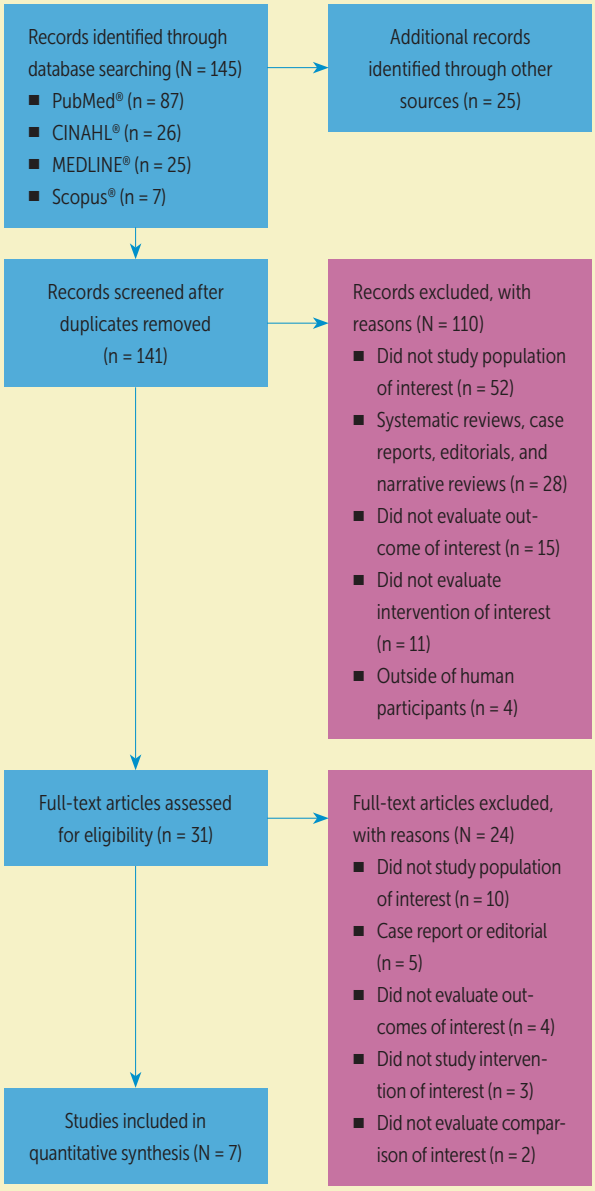
PROTOCOL	FROM THE DAY AFTER CONDITIONING CESSATION FOR 5 DAYS	FROM THE FIRST DAY OF CONDITIONING TO AFTER DAY 2
Wavelength (nm)	632.8	650
Power density (mW/cm^2)	31.25	1,000
Time per spot (seconds)	40	2
Energy density (J/cm^2)	1	2
Spot size (cm^2)	0.8	0.04
Number of sites	18	54–70

HSCT—hematopoietic stem cell transplantation
Note. Based on information from Elad et al., 2020.

frequently in this group than in the intervention group (18%). The development of grade 2 OM was the same in both groups and not affected by the LLLT intervention (Ferreira et al., 2015).

Lastly, in their study of 38 patients, Antunes et al. (2007) used LLLT with a wavelength of 660 nm daily from the first day of conditioning until neutrophil count recovery. Unlike the other studies reviewed, the intervention was received by patients in the control group if they developed grade 4 OM, which occurred in 10 of 19 patients. As compared to 13 of 19 patients in the control group who developed grade 3 or 4 OM, no patients in the intervention group developed grade 3 OM, and 1 of 19 patients developed grade 4 OM.

FIGURE 2.
SEARCH METHODOLOGY



Note. Of the studies included in the quantitative synthesis, 6 were randomized controlled trials, and 1 was a cohort study.

Discussion

All seven studies found decreased frequency of more severe OM cases with LLLT. Six reported statistical significance in the prevention or reduction in severity of OM with the use of LLLT. Except for Schubert et al. (2007), all studies used the same assessment method for grading OM, which increases the generalizability of the findings. Although the statistical significance of a therapy is important, the findings of this literature review support clinical significance and the particularly favorable risk–benefit ratio of LLLT. Despite any limitations and variability within and among the reviewed studies, LLLT is noninvasive and is known to have essentially no long- or short-term side effects, except for the possibility of a slight burning sensation. The long-term risks associated with recurrence, transformation, or progression of malignancy directly from LLLT are a reported concern and an area for future research (Zadik et al., 2019). However, Bezinelli et al. (2021) assessed the long-term safety of LLLT for OM in 693 patients undergoing HSCT and found no association of secondary malignancy from LLLT. LLLT is considered patient-friendly because the device itself is small, handheld, and noninvasive, and it is administered for only a few seconds at each spot in the oral mucosa (Martins et al., 2021).

Although LLLT has been recommended for some time, it remains an underused therapy, particularly in the United States. Barriers to implementing LLLT revolve around the need for trained personnel, perception of cost, regulatory requirements, feasibility, availability of the device, and ease of use. In many of the studies reviewed, dentists were the trained personnel administering LLLT. Institutions would need to clearly delineate who can administer LLLT and ensure inclusion within their privileges (Zadik et al., 2019).

In a cost-effectiveness study by Martins et al. (2021), the average cost was $1,418.72 for the LLLT license, $3,349.75 for the laser equipment, and $25.69 per session per patient. Conversely, it is estimated that the treatment cost for OM can range from $1,700 to more than $40,000 (Martins et al., 2021). Sonis et al. (2001) found that hospital costs were almost $43,000 higher in patients who developed any oral ulceration as compared to those without ulceration. In addition, Bezinelli et al. (2014) found a significant association among OM severity and the use of parenteral nutrition, prescription of opioids, pain in the mouth, and fever, which resulted in a 30% increase in hospital costs. Similarly, Martins et al. (2021) noted that the hospital costs of patients

TABLE 2.
LITERATURE REVIEW (N = 7)

STUDY	DESIGN AND SAMPLE	DURATION AND LLLT SETTINGS	OUTCOMES
Antunes et al., 2007	A single-center RCT of 38 patients in Brazil who received allogeneic or autologous SCT and conditioning with chemotherapy or chemotherapy and radiation therapy; 3 patients in the LLLT group and 5 patients in the control group received TBI, respectively; the control group received the intervention if grade 4 OM developed.	■ Duration: daily from the first day of conditioning until neutrophil count recovery ■ Type: 50 nW InGaA1P diode laser ■ Wavelength: 660 nm ■ Power output and density: 46.7 mW ■ Time per spot: 16.7 seconds ■ Energy density: 4 J/cm^2 ■ Spot size: 0.196 cm^2	Assessment was completed using both WHO grading scales daily. Statistical significance was achieved in reducing the incidence of OM with the use of LLLT. In the LLLT group, the following severities developed: grade 0 or 1 OM (n = 12; 63%), grade 2 OM (n = 6; 32%), and grade 4 OM (n = 1; 5%). In the control group, the following severities developed: grade 0 OM (n = 0), grade 1 OM (n = 2; 10%), grade 2 OM (n = 4; 21%), grade 3 OM (n = 3; 16%), and grade 4 OM (n = 10; 53%). The control group showed OM earlier than the LLLT group and had a longer duration of OM, but these outcomes did not show statistical significance.
Ferreira et al., 2015	A single-center RCT of 25 patients in Brazil who received allogeneic or autologous SCT with chemotherapy conditioning between August 2013 and July 2014; the control group received the intervention if grade 2 OM developed.	■ Duration: daily from the first day to the fifth day of conditioning ■ Type: InGaA1P laser ■ Wavelength: 650 nm ■ Power output and density: 100 mW ■ Time per spot: 20 seconds ■ Energy density: 70 J/cm^2 ■ Spot size: 0.028 cm^2	Assessment was completed using the WHO grading scale on a daily basis. 3 (18%) patients in the LLLT group and 11 (61%) patients in the control group developed grade 3–4 OM, indicating that LLLT prevented severe OM with statistical significance. There was no difference in incidence of OM between the two groups.
Jaguar et al., 2007	A single-center, prospective study of 49 patients in Brazil with a retrospective control group; the control group (N = 25) underwent SCT between 1999 and 2000, at which clinical data were pulled from their files; during this time, LLLT was not a part of the hospital's SCT protocol. Patients in the LLLT group (N = 24) were treated between 2003 and 2004. All patients received allogeneic or autologous SCT and conditioning with chemotherapy or chemotherapy and radiation therapy; 6 patients in the LLLT group and 0 patients in the control group received TBI, respectively.	■ Duration: daily from the first day of conditioning to day 2 post-SCT ■ Type: GaA1a laser ■ Wavelength: 660 nm ■ Power output and density: 10 mW ■ Time per spot: 10 seconds ■ Energy density: 2.5 J/cm^2 ■ Spot size: 0.04 cm^2	Assessment was completed using the WHO grading scale on the first day of conditioning until day 30 post-SCT. Development of grade 2–4 OM was less in the LLLT group as compared to the control group but not statistically significant. All patients developed some grade of mucositis. In the control group, 21 (84%) patients developed grade 3–4 OM. In the LLLT group, 12 (50%) patients developed grade 3–4 OM, but OM developed later and resolved earlier as compared to the control group.
Salvador et al., 2017	A single-center RCT of 51 patients in Brazil enrolled between February 2012 and July 2016 who received autologous or allogeneic SCT with chemotherapy conditioning; those who developed ulcerative OM in the control group received the intervention; outcomes assessed were LLLT's impact of OM severity and its relation to the modulation of the inflammatory response.	■ Duration: daily from the first day of conditioning to after day 7 ■ Type: InGaA1P diode laser ■ Wavelength: 660 nm ■ Power output and density: 40mW ■ Time per spot: 4 seconds ■ Energy density: 4 J/cm^2 ■ Spot size: 0.04 cm^2	Assessment was completed using the WHO grading scale on day 0 until day 20 or discharge. On day 7, 81% of patients in the LLLT group had no OM (grade 0) or grade 1, 18% developed grade 2, and no patients developed grade 3. In the control group, 42% developed no OM or grade 1, 42% developed grade 2, and 16% developed grade 3 on day 7. On days 7–11 post-SCT, severity of OM was significantly lower in those who received LLLT than in the control group. Patients who received LLLT had no OM on discharge, and 19% of patients in the control group were discharged with grade 1 OM.
Schubert et al., 2007	A single-center RCT of 70 patients in Seattle, Washington; prevention of OM was treated using 2 wavelength settings and a laser placebo; 12 patients in the 650 nm group, 4 patients in the 780 nm group, and 6 patients in the placebo group received TBI, respectively.	■ Duration: daily from the first day of conditioning to day 2 post-SCT ■ Types: visible red GaA1A; GaA1As infrared laser ■ Wavelength: 650 nm; 780 nm ■ Power output and density: 40 mW ■ Time per spot: unknown ■ Energy density: 2 J/cm^2 ■ Spot size: unknown	Assessment was completed using the OMI on baseline and then on days 0, 4, 7, 11 ,14, 18, and 21 post-SCT. In the 650 nm group, OM severity was more reduced than in the 780 nm and placebo groups. The mean OMI for day 11 approached statistical significance in the 650 nm group as compared to placebo. When adjusted for those who received TBI, statistical significance was achieved. In the 780 nm group, average OMI scores reduced over time, but patients were just as likely to suffer from moderate to severe OM as compared to the placebo group. The placebo group had higher OMI scores on average at every assessment.

Continued on the next page

TABLE 2. *(CONTINUED)*
LITERATURE REVIEW (N = 7)

STUDY	DESIGN AND SAMPLE	DURATION AND LLLT SETTINGS	OUTCOMES
Silva et al., 2011	A single-center RCT of 42 patients in Brazil who received autologous or allogeneic SCT and conditioning with chemotherapy or chemotherapy and radiation therapy; 2 patients in the LLLT group and 0 patients in the control group received TBI; the control group received the intervention if grade 3 OM developed.	■ Duration: from day 4 pre-SCT to day 4 post-SCT ■ Type: InGaA1P diode laser ■ Wavelength: 660 nm ■ Power output and density: 40 mW ■ Time per spot: 4 seconds ■ Energy density: 0.16 J/cm^2 ■ Spot size: 0.04 cm^2	Assessment was completed using the WHO grading scale daily until day 2 pre-SCT, wounds healed, or count recovery. The use of LLLT between the intervention and control groups was statistically meaningful in reducing OM incidence. No patients who received LLLT developed grade 3–4 OM, but 67% of patients developed grade 0–1 OM. In the control group, 67% developed grade 2 OM and 29% developed grade 3 OM.
Silva et al., 2015	A single-center RCT of 39 patients in Brazil who were recruited between February 2012 and May 2014 and received autologous or allogeneic SCT with chemotherapy conditioning; the control group received the intervention if grade 3 OM developed.	■ Duration: daily from the first day of condition to after day 7 ■ Type: InGaA1P diode laser ■ Wavelength: 660 nm ■ Power output and density: 40 mW ■ Time per spot: 4 seconds ■ Energy density: 4 J/cm^2 ■ Spot size: 0.04 cm^2	Assessment was completed using the WHO grading scale on day 0 until day 20 or discharge. Less severe OM was seen in the LLLT group as compared to the control group, with statistical significance achieved. 60% of patients who received the intervention developed grade 1 OM, and none developed grade 3 or higher. Severity of OM in the control group was evenly distributed among grades (grade 1 = 26%, grade 2 = 26%, grade 3 = 26%, and grade 4 = 21%).

LLLT—low-level laser therapy; OM—oral mucositis; OMI—Oral Mucositis Index; RCT—randomized controlled trial; SCT—stem cell transplantation; TBI—total body irradiation; WHO—World Health Organization

receiving LLLT were lower than the costs for those who did not receive it.

Limitations

To date, few studies have examined the use of LLLT specifically in adult patients undergoing HSCT for the prevention and reduction in severity of OM, with most research being conducted more than 10 years ago. The lack of recent research is a barrier to establishing a foundation for the implementation of LLLT in current practice. Most research was conducted in Brazil, which may have contributed to the lack of implementation in the United States. Although there are a greater quantity and more recently published clinical trials conducted with the head and neck cancer population in comparison to the HSCT population, the head and neck patient population was excluded because it was not the focus of the research question for this literature review. The use of LLLT in the head and neck cancer population has demonstrated promising outcomes; therefore, oncology providers and nurses should extrapolate these outcomes to the HSCT patient population.

Collectively, the included studies varied in oral care regimens, diode laser settings and parameters, timing and duration of LLLT, and the use of LLLT as a crossover intervention in five of the studies. The number of patients who received TBI also differed, and high-dose chemotherapy with TBI is associated with the highest rate of OM (Jaguar et al., 2007). These variabilities make it difficult to draw conclusions for a specific therapy protocol.

No current oral care protocol has been found to be superior to other options, and recommendations from MASCC/ISOO clinical practice guidelines (Elad et al., 2020) vary depending on treatment. It is unknown whether a standard oral care regimen used concomitantly with LLLT produces more favorable outcomes. Ferreira et al. (2015) was the only study without an oral care regimen, and 25 of 35 patients developed grade 2 OM. The patients in the intervention group in Jaguar et al. (2007) received a rigorous oral care regimen; however, no oral care regimen was mentioned for patients in the retrospective control group, which introduces a confounding variable.

The setting and sample sizes included in this review were limitations. The studies ranged from 35 to 70 patients, and only the studies by Schubert et al. (2007) and Ferreira et al. (2015) met their power analysis. Therefore, some of the studies may not have had a large enough sample size to achieve clinical and statistically significant effects from LLLT. Most of the studies were conducted in South America. The samples' ethnicities were not reported, so it is unclear as to which populations the results can be generalized.

In addition, no two studies were identical in the diode lasers settings and parameters. Schubert et al. (2007) reported that at higher wavelengths (780 nm), patients are just as likely to suffer from moderate to severe OM as patients who did not receive LLLT. Jaguar et al. (2007) used a much lower power output of 10 mW and treated fewer regions compared to the other study protocols, which ranged from 40 to 100 mW. The use of a divergent

protocol from the other studies may have also contributed to the lack of statistical significance.

Implications for Nursing

Oncology nurses have a crucial role in ensuring optimal OM prevention and treatment for their vulnerable patient population. By maintaining an active role in reviewing OM research and recommendations, nurses can evaluate how their current practice aligns with this evidence and promote the necessary changes to provide the highest quality of care. Because the use of LLLT is not widely adopted as a standard of practice, nurses can educate other nurses, patients, administration, providers, and transplantation coordinators on LLLT as an option for OM and its effects on patient outcomes. LLLT may also be a preferential option for patients who are nonadherent with their standard oral care regimens, such as frequent mouth rinses (Zadik et al., 2019).

Reducing the incidence and severity of OM may mitigate the sequelae of complications, decreasing the acuity of patients with cancer, the associated risk of 100-day mortality post-HSCT, hospital length of stay, and hospital costs (Peng et al., 2020). When advocating for the implementation of LLLT, nurses can acknowledge that, although administration of LLLT and training of personnel may seem meticulous, this therapy has the potential to provide positive outcomes for patients and financial benefits for hospitals.

Conclusion

This review found clinically and statistically significant prevention and reduction of severity of OM in patients undergoing HSCT following LLLT. Future multicenter, randomized control trials involving larger sample sizes and tight therapy controls are needed to validate the effectiveness of LLLT on OM and its impact on secondary outcomes, such as infection, nutritional needs, opioid use, hospital costs, length of hospitalization, and mortality. LLLT is a noninvasive, patient-friendly modality with a burning sensation as the one known side effect. Based on the statistically significant evidence in the literature and recommendations from the Oncology Nursing Society and MASCC/ISOO, the potential benefit of integrating LLLT should be weighed against the potential risks of OM in patients undergoing HSCT.

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IMPLICATIONS FOR PRACTICE

- Prevent and reduce the severity of oral mucositis (OM) in patients receiving hematopoietic stem cell transplantation using low-level laser therapy as a statistically and clinically effective, noninvasive treatment modality.
- Maintain an active role in reviewing the most current evidence-based practice surrounding the prevention and treatment of OM in this patient population.
- Advocate for the use of low-level laser therapy for the treatment of OM if it is not currently available at the practice setting or institution.

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Certified nurses can claim no more than 1 total ILNA point for this program. Up to 1 ILNA point may be applied to Early Post-Transplant Management and Education OR Quality of Life OR Symptom Management, Palliative Care, Supportive Care, OR Transplant Process and Infusion. See www.oncc.org for complete details on certification.

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