REVIEW ARTICLE

Laser Therapy in the Treatment of Connective Tissue Diseases: A Review

Jeremy A. Brauer, MD,* Elizabeth A. Gordon Spratt, MD,† and Roy G. Geronemus, MD*†

BACKGROUND Connective tissue diseases (CTD), including lupus erythematosus (LE), scleroderma, sarcoidosis, and dermatomyositis, present with clinically unique cutaneous manifestations often resistant to conventional therapy. The use of lasers in the treatment of various dermatologic conditions continues to expand, presenting an opportunity for incorporation of another mechanism of action in the treatment of CTD.

OBJECTIVES To review the use of laser therapy in the treatment of LE, scleroderma, sarcoidosis, and dermatomyositis.

MATERIALS AND METHODS A MEDLINE search was conducted to find articles detailing treatment of CTD with laser therapy.

RESULTS Thirty-nine published articles were identified. The outcomes and results of case reports were reviewed for each CTD when possible.

CONCLUSIONS Laser therapy offers novel and often effective treatment for recalcitrant cutaneous conditions in LE, scleroderma, sarcoidosis, and dermatomyositis. Review of the literature revealed a limited number of reports, many describing outdated technologies and techniques. It is therefore difficult to draw substantial conclusions regarding safety and the known association with photosensitivity. More-recent reports suggest that, with continued evolution of technology and understanding of CTD, lasers will have an expanding role in the treatment of cutaneous manifestations of CTD.

The authors have indicated no significant interest with commercial supporters.

Laser devices are increasingly being used for the treatment of dermatologic conditions, including but not limited to acne and acne scarring, vascular lesions, pigmented lesions, hair and tattoo removal, scar revision, photodamage, and skin rejuvenation. As advances in technology continue to emerge, it is likely that treatments incorporating laser will be employed for an ever-expanding number of skin diseases. Connective tissue diseases (CTD) are medically challenging and often treatment-resistant conditions, and the use of laser therapy in these conditions remains controversial. In this article, the clinical manifestations of several CTD including lupus erythematosus (LE), morphea, scleroderma, sarcoidosis, and dermatomyositis will be reviewed. The evidence presented in the literature as it currently exists for the use of lasers in the treatment of these entities will also be discussed, with a focus on efficacy and complications.

Materials and Methods

In August 2012 and April 2013, MEDLINE was used to search for published case reports, case series, and clinical studies related to the treatment of LE, systemic and localized sclerosis, sarcoidosis, and dermatomyositis using laser therapy. The search yielded 39 articles. The articles were reviewed and summarized into tables.

Laser & Skin Surgery Center of New York, New York, New York; †Department of Dermatology, New York University, New York, New York

ISSN: 1076-0512 • Dermatol Surg 2014;40:1–13 • DOI: 10.1111/dsu.12339

Lupus Erythematosus

Systemic LE (SLE) is a complex autoimmune disorder characterized by diverse clinical presentations and multi-organ system involvement. The most-recent proposed criteria from the Systemic Lupus International Collaborating Clinics include 11 clinical and immunologic criteria. SLE may affect the integument in several ways, and a cutaneous predominance is reflected, with four of the 11 clinical criteria involving skin manifestations (acute cutaneous lupus, chronic cutaneous lupus, oral and nasal ulcers, and nonscarring alopecia).[1]

Acute cutaneous LE (ACLE) is characterized by erythematous, edematous lesions without scale, including the classic malar or butterfly rash over the base of the nose and malar eminences sparing the nasolabial folds.[2] Other lesions of ACLE include a morbilliform eruption, photosensitive eruption, bullous lupus, and the toxic epidermal necrolytic variant of SLE.[1]

Subacute cutaneous LE (SCLE) is classically characterized by symmetric, photodistributed erythematous papules and annular plaques or psoriatic-like plaques with scale. The lesions most commonly occur on the extensor surfaces of the arms, the neck, the shoulders, and the upper chest. Telangiectasias and dyspigmentation may persist upon resolution of lesions of SCLE. Chronic cutaneous LE (CCLE) includes discoid LE (DLE), chilblain LE, tumid LE, and lupus panniculitis. DLE is the most commonly encountered form of CCLE and is characterized initially by erythematous, indurated plaques with adherent scale that progress to peripheral hyperpigmentation, central hypopigmentation, atrophy, and scarring. The lesions are commonly found on the head and neck, including involvement of the conchal bowls and the scalp, resulting in permanent cicatricial alopecia.[2] DLE may have a favorable prognosis, with 5–10% of patients who present with lesions limited to DLE progressing to systemic involvement of lupus.[3]

Chilblain LE is characterized by lesions on acral surfaces commonly precipitated by exposure to cold temperatures or a damp climate. The lesions are erythematous to purple patches or plaques occurring on the fingers, toes, or face (nose). Tumid LE (LE tumidus) is characterized by edematous, indurated plaques reminiscent of urticaria on the face or trunk.[2] Lupus panniculitis presents as mobile, often nontender subcutaneous nodules located on the buttocks, proximal arms, or face. Lupus profundus is characterized by lesions of tumid LE with overlying changes of DLE.[2]

Laser Therapy for LE

Laser therapy has been used to treat cutaneous LE with reports of success. Fourteen published studies and case reports have detailed the efficacy of laser treatment for various forms of cutaneous LE (Table 1). The pulsed dye laser (PDL), with a wavelength of 585–595 nm, has been used in eight studies, including two prospective studies, of 31 cumulative patients. In two of these studies, 12 of 19 patients experienced complete resolution of their cutaneous disease (including tumid LE, SCLE, and DLE), with marked reduction in clinical skin scores, including size, erythema, and edema. No complications were noted.[4,5] In the third prospective study, including 12 patients with DLE, PDL resulted in a statistically significant decrease in the Cutaneous Lupus Erythematosus Disease Area and Severity Index from a mean of 4.4 to a mean of 1.3 after three treatment sessions.[6] Other case series and case reports detailing the use of PDL for cutaneous LE reported successful responses, and the majority of cases had no recurrence over follow-up times of 1–10 months. PDL was associated with transient hyperpigmentation in six patients, permanent pigmentation changes in one patient, and slight scarring in one patient. There were no complications in any other patients ($n = 55$). Raulin and colleagues have discussed the efficacy of PDL in the treatment of cutaneous lesions of LE and documented their experience of successful treatment of LE with PDL in more than 50 patients. The authors acknowledge the

TABLE 1. Laser Therapy for Lupus Erythematosus (LE)

Author, Journal, Year	Study Type	*N*	Condition	Location	Laser, nm	Energy	Pulse Duration, ms	Spot Size, mm	Treatments, *n*	Treatment Schedule	Assessment Protocol	Response	Follow-Up	Adverse Effects
Nunez,[41] Arch Dermatol, 1996	Case series	4	LE telangiectodes, DLE, SLE	Face, trunk, hands	FPDL 585	6.75–7.75 J/cm^2	0.45	5	3–6	NR	Photograph; clearance by three independent doctors	>75% clearance in 4, "excellent"	16 weeks; recurrence NR	None
Nunez,[42] Br J Dermatol, 1995	Case report	1	LE telangiectodes, SLE	Face	FPDL 585	7.25–8.75 J/cm^2	0.45	5	5	NR	Photograph	"Excellent"	16 weeks s recurrence	None
Raulin,[43] Br J Dermatol, 1999	Case series	12	9 DLE, 1 SCLE, 1 erythema, 1 cutaneous LE; 2 SLE	Face, back, hands	PDL 585	3–7 J/cm^2	0.3–0.45	5–10	1–9	Over 1–36 months	Photograph; % clearance rate by 2 independent doctors	Median clearance rate 70%, *n*=9; no response, *n*=3	Median 7 months without recurrence	Transient hyperpigmentation, *n*=2
Baniandres,[44] Laser Surg Med, 2003	Case series	14	8 DLE, 6 SLE; erythema, atrophy, hyperkeratosis, telangiectasia	Face, hands, trunk	FPDL and LPDL; 585 and 595	5–7.75 J/cm^2 FPDL; 6–13 J/cm^2 LPDL	0.45 FPDL; 1.5–10 LPDL	5–7	1–9 sessions	"Usually" 2–3 months	Photograph, % clearance rate by 3 independent reviewers	Average clearance rate >60%	Median 10 months with 3 recurrences	Slight scarring, *n*=1; hypo- or hyperpigmentation, *n*=1; transient hyperpigmentation, *n*=3
Gupta,[45] Clin Exp Dermatol, 2001	Case report	1	SCLE (SLE), erythema	Face	PDL 585	5.3 J/cm^2	0.45	5	4	Every 1 month	Photograph	"Marked improvement"	NR	NR
Truchuelo,[4] J Eur Acad Dermatol Venereol, 2012	Prospective	10	Tumid LE	Face, trunk, extremities	PDL 595	8 J/cm^2	0.5	10	1	NA	Photograph; 2 blinded reviewers assessed size, erythema, edema and pruritus on 4-point scale; biopsy 1 month after treatment	Reduction in lymphocytic infiltrate on biopsy in 9/10 lesion resolved, *n* = 8; erythema resolved, *n* = 8; edema resolved, *n* = 9; pruritus resolved, *n* = 9	6 months without recurrence	None
Diez,[5] Dermatol Surg, 2011	Prospective	9	6 DLE, 2 tumid LE, 1 SCLE	NR	PDL 595	11 J/cm^2	2	7	NR	NR	Biopsy after treatment, clinical by CLASI	Total resolution, *n*=4; mild disease, *n*=4; moderate disease, *n*=1; Majoritywith reducedlymphocytic inflammation and basal damage	4weeks; recurrence NR	None
Erceg,[6] Dermatol Surg, 2009	Prospective	12	DLE	Face, scalp, trunk, extremities	PDL 585	5.5J/cm^2	0.45	7	3	Every 6weeks	Clinical by CLASI, 2 independent reviewers	Significant decline in CLASI from 4.4 to 1.3	6weeks; recurrence NR	Slight hyperpigmentation, *n*=1

TABLE 1. Continued

Author, Journal, Year	Study Type	*N*	Condition	Location	Laser, nm	Energy	Pulse Duration, ms	Spot Size, mm	Treatments, *n*	Treatment Schedule	Assessment Protocol	Response	Follow-Up	Adverse Effects
Levy,[46] J Cut Laser Ther, 2000	Case report	1	Erythema, SLE	Face	Intense pulsed light 515-nm filter	22J/cm^2	NR	NR	2	Every 2months	Photograph	75% improvement	>1year with recurrence; yearly treatment for maintenance	None
Kuhn,[8] Dermatol, 2000	Case report	1	DLE	Face	Argon 514	2W	100	1	5	Every 1month	Photograph	"Complete resolution"	6months without recurrence	None
Zachariae,[9] Acta Derm Venereol, 1988	Case series	5	DLE	Face and other	Argon 514	1–1.7W	200	NR	NR	NR	Three-point scale (some improvement, 60–70% improvement, almost normal skin)	Almost normal skin, *n*=1; 60–70% improvement, *n*=2; some mprovement, *n*=1	NR	"Slight scarring and insignificant pigmentation," *n*=1
Henderson,[10] Laser Surg Med, 1986	Case report	1	DLE	Face	CO_2 10,600	20W	NR	2	5	NR	Photograph	"Dramatic improvement"	2years with recurrence	Splotchy hypopigmentation
Walker,[11] Br J Dermatol, 2000	Case report	1	DLE	Face	CO_2 10,600	16W	NR	NR	1	NA	Photograph	"Smoothing of scars"	16months without recurrence	None
Tremblay,[12] Dermatol Surg, 2001	Case report	1	DLE	Face	Erbium-doped YAG 2,400	10.2–28.3J/cm^2	NR	3–5mm	1	NA	Photograph	"Good cosmetic results, improved cribriform scarring"	>2years without recurrence	None
Park,[13] Dermatol Surg, 2011	Case report	1	DLE	Face	Neodymium-doped YAG 1,064	45J/cm^2	20	5	3	Q3 weeks	Photograph	"Significant improvement"	1year without recurrence	None

DLE, discoid LE; SLE, systemic LE; FPDL, flashlamp pulsed dye laser; NR, not reported; SCLE, subacute cutaneous LE; PDL, pulsed dye laser; LPDL, long-pulse pulsed dye laser; CLASI, Cutaneous Lupus Erythematosus Disease Area and Severity Index; CO_2, carbon dioxide; NA, not applicable; YAG, yttrium aluminum garnet.

lack of use and reporting of lasers in treatment of LE and that laser medicine is not considered in treatment algorithms despite evidence to support that it is well tolerated and effective. Reasons that Raulin and colleagues proposed for PDL not reaching mainstream therapy for cutaneous LE include lack of awareness or interest on the part of dermatologists with little knowledge or experience with lasers or that those with the experience have a greater interest in the treatment of cosmetic and aesthetic concerns.[7]

Continuous-wave lasers, although no longer routinely used as first-line laser therapy for most cosmetic and medical indications, have been shown to result in successful treatment in patients with cutaneous LE. Two studies used the 488/514-nm argon laser in six patients with DLE and achieved complete resolution in two and 60–70% improvement in another two. Slight scarring was noted in one patient.[8,9] The fully ablative carbon dioxide (CO_2) laser, with a wavelength of 10,600 nm, has been reported in two isolated case reports to be successful in improvement of the scarring lesions of DLE, with prolonged remission (1–2 years without recurrence).[10,11]

Fully ablative yttrium aluminum garnet (YAG) lasers have also been used in DLE, with two case reports demonstrating significant cosmetic improvement without adverse effects and 1–2 years without recurrence.[12,13]

LE is associated with cutaneous photosensitivity and is characterized by the development or worsening of lesions after exposure to sunlight. The pathogenesis may be related to ultraviolet-mediated cell apoptosis and chemokine, cytokine, and cellular adhesion molecule–dependent processes.[14] To our knowledge, there have been no reports of the use of lasers in the ultraviolet A or B spectrum, namely, the excimer laser, because wavelengths in these spectrums are known to be photosensitizing in LE, although there have been numerous reports of the use of lasers with wavelengths in the visible light spectrum (PDL, argon, and intense pulsed light (IPL) with a 515-nm filter), which were relatively well tolerated. These findings may support the hypothesis that monochromatic laser light is unlikely to be photosensitizing in LE and, if administered correctly, may be a safe treatment option in select patients.[7]

Adverse events after laser treatment of cutaneous LE have been reported, specifically with CO_2 lasers, argon lasers, and PDL. Several of these were reported in the 1980s and 1990s, with technology, parameters, and techniques that have since become outdated and probably do not reflect current use of generally longer pulse durations and lower fluence settings. Skin fragility remains a concern in this patient population, and there have been reports of blistering and hypopigmentation after laser therapy for port wine stain in patients with SLE.[15] Proposed mechanisms include antibody deposition in nonlesional skin, which primes the skin for a blistering response or other adverse effect.[16] Traditional, fully ablative lasers used in previous reports probably had a greater risk for complications given the fragile nature of the skin in these patients, and the newer fractional ablative and nonablative devices are likely to have a lower side effect profile when used appropriately, although to the best of our knowledge, no studies have been published on the use of fractional laser devices in cutaneous lesions of LE.

Scleroderma and Morphea

Scleroderma encompasses systemic and localized sclerosis, or morphea. Systemic sclerosis is a multiorgan system disease characterized by fibrosis of the skin and other organs, vasculopathy, and autoimmunity with antitopoisomerase antibodies.[17,18] Limited cutaneous systemic sclerosis is characterized by Raynaud's phenomenon, sclerodactyly, and telangiectasias of the skin, with systemic involvement of the gastrointestinal tract and possible pulmonary artery hypertension. It is associated with anticentromere antibodies. Diffuse cutaneous systemic sclerosis is characterized by proximal skin thickening, Raynaud's phenomenon, sclerodactyly, telangiectasias, gastrointestinal involvement, and possible renal crisis and interstitial fibrosis of the lungs.

Localized scleroderma, morphea, represents thickening and fibrosis limited to the skin, subcutaneous tissue, and rarely the underlying bone or nervous system. There is no associated sclerodactyly, Raynaud's, or involvement of internal organs.[17]

Laser Therapy for Scleroderma and Morphea

Eleven studies using laser therapy for various forms of morphea or systemic sclerosis were identified upon review of the literature (Table 2). Four studies discussed the use of PDL, the largest of which was a case series of eight individuals with morphea and associated facial telangiectasias The authors reported that telangiectasias were successfully treated without recurrence from 6 months to 2 years after treatment.[19] The remaining reports noted varying results in patients with en coup de sabre or plaque morphea. The formation of telangiectasias is inherent to the disease process in morphea and scleroderma and may recur. The formation of new telangiectasias is to be expected, especially in individuals in whom the underlying condition is not well controlled. Therefore, clinicians should expect the treatment of telangiectasias associated with these CTD to involve recalcitrance and recurrence.

IPL was used to treat microstomia in four patients [20] with systemic sclerosis, with softening of the skin and an increase in oral aperture in three of the four patients.[21]

Four case reports of the use of ablative and fractional ablative CO_2 lasers demonstrated successful treatment of contractures, rhytides, and calcinosis of the digits in a total of 11 patients with morphea.[20,22–24] Fractional ablative CO_2 laser was successfully used in the treatment of morphea-related joint contracture across the ankle, limiting plantar flexion. The patient reported subjective improvement in range of motion almost immediately after the single treatment session. At 4-month and 1-year follow up visits after the single treatment, she had regained and maintained full plantar flexion with softening of the contracture on palpation without any adverse effects, suggesting that fractional laser therapy may be associated with a good safety profile in the treatment of morphea.[20]

In a report using the 308-nm excimer laser, improvement in the texture and pigmentation of individual plaques of morphea of five individuals was achieved.[25] Severe Raynaud's disease with chronic finger tip ulceration in a patient with scleroderma was successfully treated using the 1064-nm neodymium-doped YAG laser (1,064-nm), with improved mobility and circulation and ultimate healing of ulcerations.[26]

Processes inherent to the pathogenesis of scleroderma and morphea at the molecular level may be relevant to healing and ultimate cosmetic result after laser therapy. Morphea and scleroderma are characterized by a profibrotic state, driven by cytokines including interleukin 4 and 6 and transforming growth factor beta.[17,27] There is also microvascular disease, with injury to the vascular endothelium and perivascular inflammation, increased dermal microvascular pericytes, and replication of the vasculature basement membrane.[28] These processes of microvascular disease and profibrosis, in addition to other factors, may contribute to the presence of poor wound healing in patients with scleroderma and morphea.[29] Precautions should be taken in patients with sclerosis in treatment with laser therapy, especially when using ablative or resurfacing lasers, in which wound healing will be a more prominent factor. Fractional ablative lasers have been used in patients with limited systemic sclerosis without report of problem with wound healing,[22] but this remains an important consideration before undertaking ablative laser treatment. Theoretically, fractional resurfacing lasers may lessen the likelihood of impaired wound healing after therapy because they produce isolated columns of injury rather than broad, uninterrupted areas of injury.

Sarcoidosis

Sarcoidosis is a disease characterized by noncaseating granulomas that may affect multiple organs. The

TABLE 2. Laser Therapy for Morphea or Scleroderma

Author, Journal, Year	Study Type	*N*	Condition	Location	Laser, nm	Energy	Pulse Duration, ms	Spot Size, mm	Treatments, *n*	Treatment Schedule	Assessment Protocol	Response	Follow-Up	Adverse Effects
Eisen,[47] Dermatol Surg, 2002	Case report	1	Plaque morphea	Face	PDL 585	5.0 J/cm^2	10	1.5	4	Every 2 months	Photograph	"Marked softening, improved skin coloration"	6 months without recurrence	None
Kakimoto,[48] Dermatol Surg, 2009	Case report	1	En coup de sabre mimicking port wine stain	Face	PDL 595	8–9 J/cm^2	1.5	7	1	NA	Clinical evaluation	"Complete resolution of erythema"	2 years with recurrence and rediagnosis as morphea	Vesicles, dyspigmentation
Kim,[49] J Dermatol, 2011	Case report	1	En coup de sabre	Face	PDL 595	10 J/cm^2	30	7	2	NR	Clinical evaluation	"Minimal improvement"	NR	None
Ciatti,[19] J Am Acad Dermatol, 1996	Case series	8	Telangiectasias of morphea	Face, neck	FPDL 585	5–7 J/cm^2	0.450	5	1–4	NR	Photograph	"Effective, clearing"	6 months to 2 years without recurrence	None
Comstedt,[21] J Cosmet Laser Ther, 2012	Case series	4	Microstomia of scleroderma	Mouth	Intense pulsed light	11–14 J/cm^2	NR	NR	3–6	Every 4 weeks	Oral opening measured in mm	Improved activities of daily living, no increase in opening, *n* = 2; 3-mm increase in opening, *n* = 1; 6-mm increase in opening, *n* = 1	4 months; recurrence NR	None
Kineston,[20] Arch Dermatol, 2011	Case report	1	Contracture morphea	Ankle	Fractional CO_2 10,600	50 mJ	NR	NR	1	NA	Goniometric measurement	Achieved normal plantar flexion	1 year without recurrence	None
Bottomley,[22] Br J Dermatol, 1996	Case series	6	Calcinosis, LSS	Digits	CO_2 10,600	7.5–10 W	NR	1	1	NA	Pain according to patient report	Complete pain resolution 12/21 lesions, partial improvement 5/21, no improvement 2/21	20 months (median) with recurrence in 2	Infection, *n* = 2
Chamberlain,[23] Dermatol Surg, 2003	Case report	1	Calcinosis, LSS	Digits	CO_2 10,600	13–16 W	NR	3	1	NA	Photograph, patient report	"Significant resolution in symptoms"	3 years without recurrence	None
Apfelberg,[24] Dermatol Surg, 1998	Case series	3	Rhytides, SS	Peri-oral	CO_2 10,600	300 mg/60 W	NR	NR	1	NA	Photograph	"Significant, long-lasting improvement"	12–18 months without recurrence	None
Nistico,[25] Photomed Laser Surg, 2009	Case series	5	Plaque morphea	NR	Excimer 308	1.5 J/cm^2	NR	NR	7 (mean)	NR	Clinical evaluation (complete, partial, no remission)	Partial remission, *n* = 3; slight improvement, *n* = 2	4 months; recurrence NR	None

TABLE 2. Continued

Author, Journal, Year	Study Type	*N*	Condition	Location	Laser, nm	Energy	Pulse Duration, ms	Spot Size, mm	Treatments, *n*	Treatment Schedule	Assessment Protocol	Response	Follow-Up	Adverse Effects
St. Surin-Lord,[26] Dermatol Surg, 2011	Case report	1	Raynaud's phenomenon	Hands	Neodymium-doped yttrium aluminum garnet 1,064	15 J/cm^2	0.30	5	11	Every 2 weeks	Photograph	"Reduced frequency and severity of attacks, less vasospasm and pallor, improved ulcerations, improved fist clench"	NR	None

PDL, pulsed dye laser; NA, not applicable; NR, not reported; FPDL, flashlamp pulsed dye laser; CO_2, carbon dioxide; LSS, localized systemic sclerosis; SS, systemic sclerosis.

lungs are most commonly involved (hilar adenopathy), as well as the lymph nodes and the skin. The exact pathogenesis of sarcoidosis remains unknown, but research indicates that genetics, immune system response, and infectious or environmental exposure may be involved. Cutaneous manifestations of sarcoidosis occur in approximately 25% of patients and include specific lesions in which noncaseating granulomas exist or nonspecific lesions without granulomas.[30] There are more than 20 variants of specific lesions of cutaneous sarcoidosis, including but not limited to papular, psoriasiform, annular, lichenoid, plaque, atrophic, scarring, and verrucous forms.[31]

Lupus pernio is a specific lesion of cutaneous sarcoidosis characterized by violaceous, indurated plaques on the nose and cheeks that may progress to disfiguring ulcerating nodules. It is often associated with chronic progressive systemic sarcoidosis with severe pulmonary involvement.[31]

Laser Therapy for Sarcoidosis

Review of the literature yielded 10 case reports or series of laser therapy for treatment of various forms of cutaneous sarcoidosis (Table 3). PDL was used in five patients, four of whom had considerable or complete improvement, although one patient experienced ulceration in treated and nontreated areas.[32]

The CO_2 laser has been successfully used in the remodeling of lupus pernio of the nose in five patients, with durable responses over many years.[33,34] Of the CTD reviewed, sarcoidosis was found to be associated with the most adverse events from laser treatment. One such report was of expanding scars in a patient who was later diagnosed with isolated sarcoidosis of the skin who had full-face laser resurfacing with an ablative CO_2 laser, indicating that laser therapy may have permanent risk in this disease.[35]

Dermatomyositis

Dermatomyositis is an inflammatory myopathy characterized by muscular weakness and specific

TABLE 3. Laser Therapy for Sarcoidosis

Author, Journal, Year	Study Type	*N*	Condition	Location	Laser, nm	Energy	Pulse Duration, ms	Spot Size, mm	Treatments, *n*	Treatment Schedule	Assessment Protocol	Response	Follow-Up	Adverse Effects
Roos,[50] Dermatol Surg, 2009	Case report	1	Nodular	Back	FPDL 585	6 J/cm^2	0.5	12	2	Every 4 weeks	Photograph	"Complete clearance"	28 months without recurrence	None
Holzmann,[51] Dermatol Surg, 2008	Case report	1	Scar	Cheek	PDL 595	7.6–7.8 J/cm^2	0.5	7	3	Every 6 weeks	Photograph	"Clinical remission, significant flattening"	12 months without recurrence	None
Cliff,[52] J Cutan Laser Ther, 1999	Case report	1	Pernio	Nose	PDL 585	5.6–7.3 J/cm^2	NR	5	6	Every 6 weeks	Photograph	"Considerable improvement"	2 months without recurrence	None
Goodman,[53] Lasers Surg Med, 1992	Case report	1	Pernio	Nose	FPDL 585	5–8 J/cm^2	0.46	5	2	Every 7 months	Photograph	75% improvement	6 months with recurrence	None
Green,[32] Arch Dermatol, 2001	Case report	1	Pernio	Forehead	FPDL 585	6.0–7.1 J/cm^2	NR	5–7	1	NA	Photograph	Ulceration of treated and untreated areas	3 weeks	Ulceration
O'Donoghue,[33] Clin Exp Dermatol, 2006	Case series	3	Pernio	Nose	CO_2 10,600	18 W	NR	6	1	NA	Photograph	"Return of normal contour"	6 years without recurrence, 14 months without recurrence, 9 months with recurrence	Hypopigmentation, subtle atrophic scar,
Young,[34] J Cosmet Laser Ther, 2002	Case series	2	Pernio	Nose	CO_2 10,600	18–19 J/cm^2	200	4–6	1	NA	Photograph	"Excellent response, marked improvement"	7 years with recurrence; 32 months without recurrence	None
Kormeili,[35] Cutis, 2004	Case report	1	Scar	Face	CO_2 10,600	NR	NR	NR	NR	NR	By history	Hypertrophic scars appearing 2 years after laser therapy	NR	Hypertrophic scarring

TABLE 3. Continued

Author, Journal, Year	Study Type	*N*	Condition	Location	Laser, nm	Energy	Pulse Duration, ms	Spot Size, mm	Treatments, *n*	Treatment Schedule	Assessment Protocol	Response	Follow-Up	Adverse Effects
Ekback,[54] Acta Derm Venereol, 2005	Case report	1	Plaque	Cheek	PDL 585; YAG 532	6.75–7;12–16 J/cm^2	0.450; 50	NR	10; 2	Every 7 months	Photograph	"Limited effect with PDL; complete healing with YAG"	3 years without recurrence	None
Grema,[55] Lasers Surg Med, 2002	Case report	1	Scar; traumatic tattoo	elbow/knee	PDL 585; quality-switched ruby 694	5.5–5.6;10 J/cm^2	0.5; 0.000025	7; 6	3; 4	Every 4–6 weeks	Photograph	"No response with PDL; complete resolution with ruby"	3 years without recurrence	None

FPDL, flashlamp pulsed dye laser; PDL, pulsed dye laser; NR, not reported; NA, not applicable; CO_2, carbon dioxide; YAG, yttrium aluminum garnet.

skin findings. There are several forms of dermatomyositis, including adult idiopathic, juvenile, and amyopathic, and it may be associated with malignancy or with another connective tissue disorder.[36] Diagnostic criteria include proximal symmetric muscle weakness, high muscle enzymes, electromyographic or muscle biopsy evidence of myopathy, and a cutaneous eruption typically associated with the disease.[37,38] Patients may have associated myositis-specific antibodies, such as anti-JO 1 (histidyl-tRNA synthetase), which occur in approximately 20–35% of affected individuals.[36]

Classic skin lesions include a symmetric violaceous macular erythema progressing to poikiloderma and induration. Gottron's papules are violaceous papules distributed over joints, and Gottron's sign includes erythematous macules over the same areas. Common lesions also include periungual telangiectasias, a heliotrope periorbital violaceous eruption, and eruptions over the shoulders (the shawl sign) or over the lateral hips (the holster sign). Patients with dermatomyositis may develop hyperkeratotic plaques on the hands with fissures and scale (mechanic's hands). Patients with juvenile dermatomyositis have a high incidence of calcinosis cutis.[36]

Laser Therapy for Dermatomyositis

Five patients with a diagnosis of dermatomyositis in three separate reports were shown to have significant improvement in telangiectasias, poikiloderma, or Gottron's papules after treatment with PDL or argon laser (Table 4).[9,39,40]

Conclusion

The use of lasers in the treatment of cutaneous manifestations of CTD may offer patients long-term benefit with reduction or complete clearance of skin lesions. The majority of the evidence in the dermatology literature for the use of lasers in the treatment of various cutaneous lesions of lupus, scleroderma and morphea, sarcoidosis, and dermatomyositis is largely limited to small case reports and series. Most

TABLE 4. Laser Therapy for Dermatomyositis

Author, Journal, Year	Study Type	*N*	Condition	Location	Laser, nm	Energy	Pulse Duration, ms	Spot Size, mm	Treatments, *n*	Treatment Schedule	Assessment Protocol	Response	Follow-Up	Adverse Effects
Yanagi,[39] Br J Dermatol, 2005	Case series	2	Erythema, poikiloderma, telangiectasia	Face, chest, arms; face, back	PDL 585	6 J/cm^2	450	5	4	Every 3 months	Photograph	"Significant improvement"	No recurrence; interval NR	None
Calvo Pulido,[40] Eur J Dermatol, 2006	Case report	1	Gottron's papules	Fingers, elbows	PDL 595	14 J/cm^2	1.5	7	3	Every 2 months	Photograph	70% improvement	3 years without recurrence	None
Zachariae,[9] Acta Derm Venereol, 1988	Case series	2	Telangiectasias	Face	Argon 514	1–1.7 W	200	NR	NR	NR	Three-point scale (some improvement, 60–70% improvement, almost normal)	"Almost normal appearance"	NR	None

PDL, pulsed dye laser; NR, not reported.

of the disease entities reviewed demonstrated some benefit from treatment with lasers, although not without risk of adverse events, including scarring and dyspigmentation. The greatest number of reports are on laser treatment of cutaneous LE, with pulsed dye, argon, CO_2, and erbium and neocymium-doped YAG lasers and IPL.

Successful treatment of linear and plaque morphea; related telangiectasias, microstomia, sclerotic bands, digital calcification, and ulceration; and perioral rhytides have also been reported using various lasers. Complications occur and have included blistering, erosions, and post-treatment infections. Although most case reports document effective treatment of cutaneous sarcoidosis using PDL, CO_2, neodymium-doped YAG, and quality-switched ruby lasers for nodular, scar type, and lupus pernio, there are notable side effects, including recurrence, ulceration, scarring, and dyspigmentation. Sarcoidosis was associated with the highest incidence of complications after laser therapy, and clinicians and patients should be aware of this risk before laser treatment. Telangiectasias, poikiloderma, erythema, and Gottron's papules associated with dermatomyositis have also been successfully treated using lasers without any report of adverse effects.

Its main limitation, namely the small number of published studies, reflect the importance of this review of the dermatology literature on the use of laser devices in the treatment of CTD. Furthermore, a number of reports were published more than 20 years ago, discussing use of devices, parameters, and techniques that may not be routinely used with current laser treatment. Protocols using longer pulse durations and lower energies are likely to be associated with fewer adverse events. More-recent reports of lasers in the treatment of the four CTD reported herein offer relevant evidence that lasers may be used in CTD safely and with good benefit to patients with these conditions. The predominantly retrospective nature and small sample size of the case reports and series limit this evidence. Better-designed and larger studies are clearly needed in the

treatment of these medically important cutaneous lesions associated with CTD processes.

Although a review of the evidence derived from predominantly case reports and series is promising, randomized controlled trials and reports of treatment using current laser devices, parameters, and techniques are needed to further evaluate and determine the proper placement of lasers in the treatment armamentarium of CTD.

References

1. Petri M, Orbai AM, Alarcón GS, Gordon C, et al. Derivation and validation of the Systemic Lupus International Collaborating Clinics classification criteria for systemic lupus erythematosus. Arthritis Rheum 2012;64(8):2677–86.
2. McCauliffe DP. Cutaneous lupus erythematosus. Semin Cutan Med Surg 2001;20(1):14–26.
3. Rowell NR. The natural history of lupus erythematosus. Clin Exp Dermatol 1984;9(3):217–31.
4. Truchuelo MT, Boixeda P, Alcántara J, Moreno C, et al. Pulsed dye laser as an excellent choice of treatment for lupus tumidus: a prospective study. J Eur Acad Dermatol Venereol 2012;26 (10):1272–79.
5. Diez MT, Boixeda P, Moreno C, González JA, et al. Histopathology and immunohistochemistry of cutaneous lupus erythematosus after pulsed dye laser treatment. Dermatol Surg 2011;37(7):971–81.
6. Erceg A, Bovenschen HJ, van de Kerkhof PC, de Jong EM, et al. Efficacy and safety of pulsed dye laser treatment for cutaneous discoid lupus erythematosus. J Am Acad Dermatol 2009;60 (4):626–32.
7. Raulin C, Hammes S. Commentary: treatment of cutaneous lupus erythematosus using the pulsed dye laser. Dermatol Surg 2011; 37(7):982–84.
8. Kuhn A, Becker-Wegerich PM, Ruzicka T, Lehmann P. Successful treatment of discoid lupus erythematosus with argon laser. Dermatology 2000;201(2):175–77.
9. Zachariae H, Bjerring P, Cramers M. Argon laser treatment of cutaneous vascular lesions in connective tissue diseases. Acta Derm Venereol 1988;68(2):179–82.
10. Henderson DL, Odom JC. Laser treatment of discoid lupus (case report). Lasers Surg Med 1986;6(1):12–15, 44–5.
11. Walker SL, Harland CC. Carbon dioxide laser resurfacing of facial scarring secondary to chronic discoid lupus erythematosus. Br J Dermatol 2000;143(5):1101–2.
12. Tremblay JF, Carey W. Atrophic facial scars secondary to discoid lupus erythematous: treatment using the Erbium:YAG laser. Dermatol Surg 2001;27(7):675–77.
13. Park KY, Lee JW, Li K, Seo SJ, et al. Treatment of refractory discoid lupus erythematosus using 1,064-nm long-pulse neodymium-doped yttrium aluminum garnet laser. Dermatol Surg 2011;37(7):1055–56.
14. Kuhn A, Ruland V, Bonsmann G. Photosensitivity, phototesting, and photoprotection in cutaneous lupus erythematosus. Lupus 2010;19(9):1036–46.
15. Izikson L, Avram M, Tannous Z. Treatment of port wine stains with pulsed dye laser in patients with systemic lupus erythematosus: practical considerations and complications. J Cosmet Laser Ther 2008;10(4):223–25.
16. Alahlafi AM, Wordsworth P, Wojnarowska F. The lupus band: do the autoantibodies target collagen VII? Br J Dermatol 2004;150(3):504–10.
17. Fett N, Werth VP. Update on morphea: part I. Epidemiology, clinical presentation, and pathogenesis. J Am Acad Dermatol 2011;64(2):217–28; quiz 229–30.
18. Broen JC, Coenen MJ, Radstake TR. Genetics of systemic sclerosis: an update. Curr Rheumatol Rep 2012;14(1):11–21.
19. Ciatti S, Varga J, Greenbaum SS. The 585 nm flashlamp-pumped pulsed dye laser for the treatment of telangiectases in patients with scleroderma. J Am Acad Dermatol 1996;35(3 Pt 1): 487–88.
20. Kineston D, Kwan JM, Uebelhoer NS, Shumaker PR. Use of a fractional ablative 10.6-μm carbon dioxide laser in the treatment of a morphea-related contracture. Arch Dermatol 2011;147 (10):1148–50.
21. Comstedt LR, Svensson A, Troilius A. Improvement of microstomia in scleroderma after intense pulsed light: a case series of four patients. J Cosmet Laser Ther 2012; 14(2):102–6.
22. Bottomley WW, Goodfield MJ, Sheehan-Dare RA. Digital calcification in systemic sclerosis: effective treatment with good tissue preservation using the carbon dioxide laser. Br J Dermatol 1996;135(2):302–4.
23. Chamberlain AJ, Walker NP. Successful palliation and significant remission of cutaneous calcinosis in CREST syndrome with carbon dioxide laser. Dermatol Surg 2003; 29(9):968–70.
24. Apfelberg DB, Varga J, Greenbaum SS. Carbon dioxide laser resurfacing of peri-oral rhytids in scleroderma patients. Dermatol Surg 1998;24(5):517–19.
25. Nistico SP, Saraceno R, Schipani C, Costanzo A, et al. Different applications of monochromatic excimer light in skin diseases. Photomed Laser Surg 2009;27(4):647–54.
26. St Surin-Lord S, Obagi S. Scleroderma and raynaud's phenomenon improve with high-peak power laser therapy: a case report. Dermatol Surg 2008;37(10):1531–35.
27. Higley H, Persichitte K, Chu S, Waegell W, et al. Immunocytochemical localization and serologic detection of transforming growth factor beta 1. Association with type I procollagen and inflammatory cell markers in diffuse and limited systemic sclerosis, morphea, and Raynaud's phenomenon. Arthritis Rheum 1994;37(2):278–88.
28. Helmbold P, Fiedler E, Fischer M, Marsch WCh. Hyperplasia of dermal microvascular pericytes in scleroderma. J Cutan Pathol 2004;31(6):431–40.

29. Mulligan-Kehoe MJ, Simons M. Vascular disease in scleroderma: angiogenesis and vascular repair. Rheum Dis Clin North Am 2008;34(1):73–9; vi.

30. Wilsmann-Theis D, Bieber T, Novak N. Photodynamic therapy as an alternative treatment for cutaneous sarcoidosis. Dermatology 2008;217(4):343–6.

31. Haimovic A, Sanchez M, Judson MA, Prystowsky S. Sarcoidosis: a comprehensive review and update for the dermatologist: part I. Cutaneous disease. J Am Acad Dermatol 2012;66(5):699 e1–18; quiz 717–8.

32. Green JJ, Lawrence N, Heymann WR. Generalized ulcerative sarcoidosis induced by therapy with the flashlamp-pumped pulsed dye laser. Arch Dermatol 2001;137(4):507–8.

33. O'Donoghue NB, Barlow RJ. Laser remodelling of nodular nasal lupus pernio. Clin Exp Dermatol 2006;31(1):27–9.

34. Young HS, Chalmers RJ, Griffiths CE, August PJ. CO2 laser vaporization for disfiguring lupus pernio. J Cosmet Laser Ther 2002;4(3–4):87–90.

35. Kormeili T, Neel V, Moy RL. Cutaneous sarcoidosis at sites of previous laser surgery. Cutis 2004;73(1):53–5.

36. Kovacs SO, Kovacs SC. Dermatomyositis. J Am Acad Dermatol 1998;39(6):899–920; quiz 921–2.

37. Bohan A, Peter JB. Polymyositis and dermatomyositis (first of two parts). N Engl J Med 1975;292(7):344–47.

38. Bohan A, Peter JB. Polymyositis and dermatomyositis (second of two parts). N Engl J Med 1975;292(8):403–7.

39. Yanagi T, Sawamura D, Shibaki A, Shimizu H. Treatment for poikilodermatous erythema of dermatomyositis with the pulsed dye laser. Br J Dermatol 2005;153(4):862–64.

40. Calvo Pulido M, Boixeda De Miquel P, Martín Saez E, Fernandez Guarino M, et al. Treatment of Gottron papules of dermatomyositis with pulsed dye laser. Eur J Dermatol 2006; 16(6):702–3.

41. Núñez M, Boixeda P, Miralles ES, de Misa RF, et al. Pulsed dye laser treatment of telangiectatic chronic erythema of cutaneous lupus erythematosus. Arch Dermatol 1996;132(3):354–55.

42. Núñez M, Boixeda P, Miralles ES, de Misa RF, et al. Pulsed dye laser treatment in lupus erythematosus telangiectoides. Br J Dermatol 1995;133(6):1010–11.

43. Raulin C, Schmidt C, Hellwig S. Cutaneous lupus erythematosus-treatment with pulsed dye laser. Br J Dermatol 1999;141(6): 1046–50.

44. Baniandrés O, Boixeda P, Belmar P, Pérez A. Treatment of lupus erythematosus with pulsed dye laser. Lasers Surg Med 2003; 32(4):327–30.

45. Gupta G, Roberts DT. Pulsed dye laser treatment of subacute cutaneous lupus erythematosus. Clin Exp Dermatol 1999; 24(6):498–9.

46. Levy JL. Intense pulsed light treatment for chronic facial erythema of systemic lupus erythematosus: a case report. J Cutan Laser Ther 2000;2(4):195–98.

47. Eisen D, Alster TS. Use of a 585 nm pulsed dye laser for the treatment of morphea. Dermatol Surg 2002;28(7):615–16.

48. Kakimoto CV, Victor Ross E, Uebelhoer NS. En coup de sabre presenting as a port-wine stain previously treated with pulsed dye laser. Dermatol Surg 2009;35(1):165–67.

49. Kim HS, Lee JY, Kim HO, Park YM. En coup de sabre presenting as a port-wine stain initially treated with a pulsed dye laser. J Dermatol 2011;38(2):209–10.

50. Roos S, Raulin C, Ockenfels HM, Karsai S. Successful treatment of cutaneous sarcoidosis lesions with the flashlamp pumped pulsed dye laser: a case report. Dermatol Surg 2009;35(7):1139–40.

51. Holzmann RD, Astner S, Forschner T, Sterry G. Scar sarcoidosis in a child: case report of successful treatment with the pulsed dye laser. Dermatol Surg 2008;34(3):393–96.

52. Cliff S, Felix RH, Singh L, Harland CC. The successful treatment of lupus pernio with the flashlamp pulsed dye laser. J Cutan Laser Ther 1999;1(1):49–52.

53. Goodman MM, Alpern K. Treatment of lupus pernio with the flashlamp pulsed dye laser. Lasers Surg Med 1992; 12(5):549–51.

54. Ekbäck M, Molin L. Effective laser treatment in a case of lupus pernio. Acta Derm Venereol 2005;85(6):521–22.

55. Grema H, Greve B, Raulin C. Scar sarcoidosis—treatment with the Q-switched ruby laser. Lasers Surg Med 2002;30(5): 398–400.

Address correspondence and reprint requests to: Jeremy A. Brauer, MD, Laser & Skin Surgery Center of New York, 323 East 34th Street, New York, New York 10016, or e-mail: jbrauer@laserskinsurgery.com