Chapter 24
Lasers: Special Considerations in Women

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LASER is an acronym for "light amplification by stimulated emission of radiation." Stimulated emission occurs when an excited atom is unsettled by a photon with a frequency corresponding to the energy gap between the excited and ground states. The excited atom goes back to the resting state after the impact, releasing energy as a second photon. Because the incident photon is not absorbed, two coherent photons of same wavelength are emitted. When the above process happens in an optical cavity with an active medium and two opposing mirrors, it allows amplification of light and the production of a laser beam [1].

Over the last four decades, various laser sources have been used in skin diseases, and their role has been steadily increasing in dermatology. Presently, laser technology is helpful in the management of various inflammatory, neoplastic, and pigmentary skin diseases and also for better esthetics.

In this chapter, we shall discuss the use of laser in skin diseases in females. Female skin has some physiological differences when compared to male skin. So a better understanding of the physiological, chemical, and biophysical characteristics of female skin will aid a dermatologist in planning the appropriate laser and the dose of radiation required for treatment. The mechanisms responsible for sex-related differences in dermatoses are mostly undetermined. Hormonal and behavioral factors, race, and environmental differences may contribute to these differences [2, 3].

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A review of available literature has revealed no significant difference between male and female skin in terms of the hydration, adhesion of stratum corneum, and trans-epidermal water loss [2]. However, overall thickness of skin is significantly more in men as compared to women, as noted in various studies, with skin thickness showing linear decrease in males and a constant skin thickness in females till the age of 50 [4]. In recent studies from various parts of the world, women have been found to exhibit less sebum secretion as compared to men [5–7]. Skin pH is lower in females as compared to males as found in various studies [8, 9]. Firooz et al. reported significantly lower skin melanin index and erythema index in female subjects as compared to male subjects [10]. Spectrophotometric studies from diverse populations in Europe, Asia, Africa, and North and South America have shown higher skin reflectance in female skin than that of males, meaning a paler skin in females [2]. Skin elasticity is more in women as compared to men and it is maintained in females till old age [11]. Subcutaneous fat remains identical in thickness in both sexes till puberty but thereafter, it increases significantly more in women due to elevated activity of lipoprotein lipase [3].

We will review the use of lasers in various dermatological conditions occurring predominantly in women which are as follows: Rosacea, melasma, hirsutism, connective tissue diseases, lichen sclerosus, notalgia paresthetica, syringomas, and acne scars.

24.1 Rosacea

Rosacea is a chronic inflammatory disease which mainly affects the centrofacial region and eyes, predominantly in women and individuals with lighter skin types. Rosacea has four types: erythematotelangiectatic (ETTR), papulopustular, phymatous, and ocular [12]. Erythema and persistent telangiectasia are the main complaints in the ETTR type. Lasers particularly have a role in ETTR and various studies (Table 24.1) have shown the role of pulsed dye laser (PDL) and

Table 24.1 Recent studies on use of different lasers in rosacea

Researcher	Lasers used	No. of patients	Results
Campos et al. [15]	Comparison of efficacy of 595 nm PDL v/s multiplexed 595 nm PDL and 1064 nm Nd:YAG laser	27	Equal efficacy of both. Multiplexed PDL/Nd:YAG had better safety profile
Baskan and Belli [16]	PDL	14	Significant improvement in erythema and telangiectasia with long term efficacy
Ustuner et al. [17]	Q-switched potassium titanyl phosphate (KTP) laser and LPNY	37	LPNY laser better for erythema and Q-switched KTP laser better for thin and superficial telangiectasias

Table 24.1 (continued)

Researcher	Lasers used	No. of patients	Results
Bernstein et al. [18]	PDL with 15 mm diameter treatment beam	20	Improves the appearance and favorable safety profile
Kwon and Park et al. [19]	Comparison between PDL and LPNY	20	Both lasers have equal efficacy with PDL being safer
Goo et al. [20]	Q-switched, 595-nm Nd:YAG laser	2	Significant improvement in ETTR lesions
Bernstein and Kligman [21]	High energy, long pulse-duration, 595 nm, PDL	20	Significant decrease in average rosacea score
Lonne-Rahm et al. [22]	Flashlamp PDL, 585 nm	32	Effective in sensitive skin in rosacea

long-pulsed Nd:YAG (LPNY) lasers. Pulsed dye laser (585 nm; 595 nm) is currently the laser of choice for ETTR [13]. However, a significant side effect of PDL is immediate post-procedure purpura and to reduce its occurrence, pulse stacking with a lower fluence can be done while maintaining the high efficacy [14]. CO_2 laser resurfacing has also shown a positive effect in phymatous rosacea, however that subtype is more common in males and so is not discussed in detail here.

24.2 Melasma

Melasma is an acquired hyperpigmentation disorder affecting the photoexposed areas especially the face. It most commonly affects adult females and can worsen during pregnancy. In vitro, estradiol has induced melanogenesis and increased the expression of human melanocortin-1 receptor, which could be contributing to the increased prevalence of pigmentary dermatoses in females. Melasma is usually refractory to treatment and various modalities are tried for its treatment. Most important component of treatment is photoprotection by using sunscreens [23].

Lasers are generally used as second or third line of treatment in refractory melasma. The lasers mentioned below have been used in melasma with variable success: intense pulsed laser (IPL), fractional lasers—both non-ablative and ablative (1540 nm/1550 nm Er: Glass, 2940 nm Er: YAG, 10,600 nm CO_2), fractional lasers with transdermal drug delivery, Q-Switched (QS) Lasers-QS 1064 nm, QS 585/595 nm laser, fractional QSNY laser and fractional QS Ruby 694 nm lasers, and Picosecond lasers [24].

Out of the above list, non-ablative fractional 1550/1540 nm laser (2005) and Lutronic's 1064 nm, Q-switched Nd:YAG laser (2012) have got US FDA approval for the treatment of melasma [25].

Fig. 24.1 Pre- and post-treatment images of a patient with melasma treated with Q switched ND:YAG laser (1064 nm) (image courtesy Dr. Richa Sharma)

The Q-switched (QS) Nd:YAG laser has got the best evidence for use in the treatment of melasma, especially in skin of color (Fig. 24.1). However, till now, no randomized controlled trials (RCTs) have been conducted to compare the effectiveness of the QS Nd:YAG laser (532 nm) to the standard topical treatments [26]. The traditional QSL treatment was based on the principle of selective photothermolysis in which a high fluence was used to destroy the pigment-containing cell. Subsequent release of prostaglandins and cytokines as a result of cell death results in inflammatory state and damage to basement membrane, resulting in relapse, exacerbation of melasma, or pigmentary changes [27].

Nowadays, low fluence or subthermolytic Q-switched treatment (variant of Q-switched laser) is becoming increasingly popular. Here, the fluence is lower and spot size is larger as compared to traditional QS Nd:YAG laser. It destroys the melanosomes and melanin granules within melanocytes and keratinocytes without causing any damage to the cell membrane and nucleus, thus avoiding cell death. It also causes functional downregulation of melanocytes resulting in reduced number of melanosomes [28].

A study from Korea has shown a 50–74% improvement in melasma in Asian patients with the use of low-fluence 1064 nm QS Nd:YAG laser therapy [29]. QS Nd:YAG laser usually shows best results when used in combination with other therapy like oral tranexamic acid or peels [30]. Kauvar [31] has demonstrated good results by using a combination of microdermabrasion and low-fluence QS Nd:YAG laser along with the use of topical depigmenting agents.

Fractional resurfacing lasers create selective columns of microthermal damage in which treated and untreated areas are intermixed. However, short term side effects such as erythema, swelling, and pain are usual with non-ablative fractional lasers at 1440, 1540, and 1550 nm [32]. Tourlaki et al. [33] assessed the efficacy of non-ablative laser along with triple therapy topical cream in treatment of recalcitrant melasma. Melasma Activity Severity Index (MASI) scores were used to assess the response. After 1 month, 67.1% of patients had >75% clearing and 21% had 51–75%

clearing of pigmentation. However, at 6 months, only 21.1% of patients persisted with marked improvement despite continuously using the triple combination cream.

24.3 Hirsutism

Hirsutism is the condition of excessive growth of terminal hairs in a female in the male pattern distribution—beard, moustache, and chest. In women, hirsutism is often seen in endocrine disorders characterized by features of hyperandrogenism; however, "idiopathic" hirsutism (normal values of androgens for age and ethnicity) is also very frequent. The Ferriman and Gallwey scale is used for assessing and quantifying the severity of hirsutism. The treatment of hirsutism is focused on removing the unwanted hairs as well as reducing the androgen drive for vellus-terminal conversion [34].

Excess and/or unwanted hairs are of important medical, social, and cultural concern for females in all races. Removal of hairs can be done by shaving, waxing, depilation, electrolysis, and laser. Laser hair removal is a multifactorial process which causes hair follicle damage while sparing the epidermis due to a complex photothermal reaction via the epidermis–dermis matrix [35]. Thus, laser hair removal is dependent on various laser and tissue parameters such as power, spot size, irradiation time, repetition rate, absorption, scattering coefficients, density, and thermal conductivity [36]. Hair reduction lasers are avoided during pregnancy due to possible risk to the fetus and the medico-legal issues involved; more so, the hyperprolactinemia during pregnancy upregulates melanocyte-stimulating hormone in hair stem cells and may render the laser treatment ineffectual.

The laser hair removal is based on the principle of selective photothermolysis as introduced by Anderson and Parrish. The required energy density (i.e. fluence) for coagulating a hair follicle is directly proportional to the hair shaft diameter [37]. The duration of laser pulse should lie between the thermal relaxation time (TRT) for epidermis (3–10 ms) and the TRT for the hair follicles (40–100 ms) to minimize thermal damage to the hair follicle. The pulse width has a key role in determining selective photothermolysis because if the pulse width is too long, there will be very less time for the heat to dissipate, and the unwanted temperature rise will cause thermal injury to surrounding non-follicular structures, resulting in scarring or dyspigmentation [38]. The spot size should be as large as possible because light penetration gets very efficient with large spot size, due to an almost planar geometry of the "source" of photons [39].

Fitzpatrick skin type I–IV and dark hairs show best results with hair removal lasers because of reduced risk of light absorption by epidermal melanin. Laser hair removal is challenging in patients with Fitz skin type V–VI because the high density of competing chromophore (melanin) in the epidermis can lead to residual pigmentation and scarring. If a wavelength which is slightly absorbed by melanin is used, then clinical efficacy is compromised as the target chromophore for hair removal

Table 24.2 Recent studies on the use of different lasers in hirsutism

Researcher	Lasers used	No. of patients	Results
Shrimal et al. [40]	LPNY and IPL-755 nm for idiopathic facial hirsutism	33	LPNY (1064 nm) is more safe and effective than IPL (755 nm)
Puri [41] Randomized controlled trial (RCT)	Diode laser, Nd:YAG laser and IPL	30	Maximum hair reduction after eight sessions with diode laser (92%), 90% reduction with Nd:YAG and 70% reduction with IPL
Dhalimi and Kadhum [42]	Long-pulsed (ALX) Alexandrite laser and IPL for hair removal	30	Better reduction of facial hairs, longer hair-free intervals, and more patient satisfaction with IPL than ALX
Giambrone et al. [43]	Novel 650 μs pulsed Nd:YAG laser	298	Effective for laser hair removal
Barolet [44] RCT	Low level fluence 810 nm (15 J/cm^2) diode laser	17	Well-tolerated, safe and effective
Rao and Sankar [45]	LPNY laser hair removal in Fitzpatrick skin types IV–VI	150	Safe and effective in dark skinned individuals

Fig. 24.2 Pre- and post-treatment images of a patient with hirsutism treated with Diode laser (image courtesy Dr. Richa Sharma)

laser is melanin in the hair bulb and bulge [35]. Latest studies on the use of hair removal lasers are tabulated in Table 24.2 and a clinical image is shown in Fig. 24.2.

24.4 Lichen Sclerosus

Lichen sclerosus is a chronic inflammatory dermatosis that predominantly affects the anogenital skin and is 6–10 times more frequent in females than males [3]. The disease typically has an inflammatory phase followed by chronic scarring and skin atrophy. The presenting symptom usually is severe and distressing pruritus. Its management consists of topical steroids, immunomodulators, and supportive therapy like stool softeners and topical anesthetics for analgesia [46]. The laser can help in lichen sclerosus by inducing a controlled thermal injury to the superficial skin, which removes the epithelium and papillary dermis and stimulates tissue repair and remodeling [47].

Table 24.3 Recent studies on use of different lasers in lichen Sclerosus

Researcher	Lasers used	No. of patients	Results
Pagano et al. [49]	Fractional microablative CO_2 laser	40	Significant improvement in vulvar itching, dryness, and dyspareunia after two cycles
Hobson et al. [50]	Fractional ablative Er: YAG laser	2	Successful treatment in LS refractory to topical steroids
Gómez and Laynez [51]	Non-ablative, thermal only Er:YAG laser	28	Significant improvement in pruritus, pain, ecchymosis, and hypopigmentation
Ogrinc et al. [52]	Non-ablative Er: YAG laser	40	Better efficacy than topical steroids
Lee et al. [53]	Fractional CO_2 laser resurfacing	4	Successful in achieving remission

A study by Gardner and Ashckenazi showed fractional CO_2 laser to be safe and effective in vaginal lichen sclerosus with improvement in female sexual function index and vaginal dryness [48]. The level of evidence for using CO_2 laser in vaginal lichen sclerosus is 4 and grade of recommendation is C [47]. Recent studies are summarized in Table 24.3.

24.5 Connective Tissue Diseases

Connective tissue diseases can have various dermatologic manifestations which are usually resistant to conventional line of treatments. Lasers offer an advanced treatment modality for these dermatological manifestations like erythema, telangiectasia, and fibrosis.

Pulsed dye laser (585–595 nm) has best evidence for the management of telangiectasias in lupus erythematosus (LE) [54]. Majority of the studies with PDL for the treatment of cutaneous lupus have reported successful results with no recurrence over 10 months follow-up. Ablative lasers like CO_2 laser and Er:YAG laser have been found to be useful in managing the scarring of cutaneous lupus. Non-ablative Nd:YAG laser has demonstrated significant cosmetic improvement as it can target the dermal melanosomes without causing much adverse effects [55]. Response to

Table 24.4 Recent studies on use of different lasers in lupus erythematosus

Researcher	Lasers used	No. of patients	Results
Rerknimitr et al. [56] RCT	PDL, 595 nm	9	Significant improvement in erythema index, texture index, and mCLASI
Bras et al. [57]	PDL, 595 nm	3	Significant improvement of erythema, edema, scaling, and telangiectasia
Ekback and Troilius [58]	PDL, 585 nm, 595 nm	12	Improvement in lesions. Recurrence of lesions—2 cases
Diez et al. [59]	PDL, 595 nm	9	Improvement of erythema and scaling, in all except 1 patient No improvement in pigmentation, scarring and atrophy
Erceg et al. [60]	PDL, 585 nm	12	Decrease in active CLASI No effect on damage CLASI

Table 24.5 Levels of evidence for use of laser in cutaneous lupus erythematosus [61]

PDL	1B—III
IPL (intense pulsed light)	III
Nd:YAG	III
Er:YAG	III
CO_2	III
1450 nm-diode laser	III

the lasers can be assessed by the use of Cutaneous Lupus Erythematosus Disease Area and Severity Index (CLASI). Table 24.4 lists recent studies on lasers in LE and Table 24.5 lists the levels of evidence.

Dermatomyositis is an idiopathic inflammatory myopathy characterized by proximal muscle weakness and specific dermatological findings like confluent violaceous macular erythema, periungual telangiectasias, heliotrope rash, and Gottron's papules. Most of these skin manifestations are resistant to conventional medical therapies [62]. PDL laser has been found to be highly effective for the treatment of telangiectasia and Gottron's papules [63]. For the treatment of telangiectasias in patients with juvenile DM, argon laser has also been found to be effective without any adverse effects [64].

Calcinosis cutis is infrequent and difficult to treat complication of DM. Abrouk et al. [65] in a recent case report showed that the use of picosecond laser immediately followed by fractional ablative CO_2 laser led to the melting of the calcium into a liquid, which was easily removed from the skin leading to significant clinical improvement.

IPL and pulsed CO_2 laser have been reported to improve microstomia associated with systemic sclerosis [66]. Benani et al. [67] have reported in their study on four patients that pulsed CO_2 laser treatment has led to softening of the perioral skin. After 12 months, a gain of 8.5 mm was seen in inter-incisal distance. The side effects observed in their study were transient erythema and dyschromia.

24.6 Syringomas

Syringomas are benign skin appendageal tumors that present as small dome-shaped papules with characteristic angulated borders and often present in a periorbital distribution [68]. However, they have high recurrence rates with any treatment including lasers. A prospective study by Lee et al. [69] showed that use of a pinhole method with an ablative 10,600 nm CO_2 laser on the periorbital skin showed marked to moderate improvement in 86.2% patients. In a study by Wang and Roenigk, treatment of patients with periorbital syringomas with CO_2 laser at high energy resulted in the successful removal of syringomas in all patients and patients remained lesion free for 1–24 months [70]. Further, the use of low energy radiofrequency ablation and CO_2 laser in combination has been found to have maximal tumor destruction and minimal adverse effects, thus producing good cosmetic results [71].

24.7 Acne and Post-acne Scars

Acne vulgaris is an inflammatory disease of the pilosebaceous unit characterized by the presence of non-inflammatory as well as inflammatory lesions [72]. Scarring usually occurs as sequelae of intradermal inflammatory lesions, but may also occur

Fig. 24.3 Pre- and post-treatment images of a patient with post-acne scarring treated with CO_2 fractional laser (image courtesy Dr. Richa Sharma)

Fig. 24.4 Pre- and post-treatment images of a patient with active acne treated with Intense Pulsed Light (IPL) (image courtesy Dr. Richa Sharma)

after more superficial inflamed lesions. Acne scarring can be atrophic or hypertrophic and is formed as a result of insufficient matrix remodeling with decreased deposition of collagen factors and excessive healing response, respectively [73]. Lasers are mainly used in the management of atrophic acne scars and sometimes in active acne as well (Figs. 24.3 and 24.4).

Table 24.6 Recent studies on use of different lasers in post-acne scars

Researcher	Lasers used	No. of patients	Results
Faghihi et al. [77]	CO_2 laser 30 mJ/500 μm	16	Fair or good response in 2/3 of patients
Zhou et al. [78]	CO_2 laser (Han's Laser)	13	MQGS was 2.08/4 for patients MQGS was 2.00/4 for physicians
Reinholz et al. [76] RCT	Fractional Er:YAG and fractional CO_2 laser (5–25 J/S/500 μm)	14	Fractional CO_2 laser more efficacious than Er:YAG laser
Yuan et al. [79] RCT	Lumenis UltraPulse Encore fractional CO_2 laser 20 mJ/10% v/s 20 mJ/20%	10	Improvement in both the groups
Bjørn et al. [80]	Lumenis UltraPulse Encore fractional CO_2 laser	13	No advantage of different treating interval on results or on the postoperative adverse effects
Kim et al. [81]	Lutronic Mosaic CO_2 laser 30–50 mJ/100–200 MTZ/cm	20	Moderate-to-much improved scores in scars

Petrov and Pljakovska [74] in their study on 40 patients showed that fractional CO_2 laser is effective and safe in the treatment of acne scars with best results in dotted and ice pick scars. Approximately six sessions were required and the time interval between two sessions was 1 month. Fractional Er:YAG laser treatment has also shown good efficacy and safety in treatment of acne scars when compared with microneedling [75]. A comparison of fractional Er:YAG and CO_2 lasers in acne scars has shown that fractional CO_2 laser results in better skin smoothening [76].

Table 24.6 summarizes recent work on use of lasers in post-acne scars.

24.8 Notalgia Paresthetica

Notalgia paresthetica (NP) is a chronic, neuropathic often undiagnosed disorder presenting with itching, burning, or pain mostly at the interscapular region (T2–T6 dermatomes). It is more prevalent in female and females usually have severe symptoms and longer course of the disease [82]. The disease has a chronic and relapsing course with poor response to various available treatment options [83]. A prospective study on the use of 308 nm excimer lamp in 11 patients of notalgia paresthetica showed a significantly decreased pruritus among the patients providing benefit in a lingering condition with frequent relapses [84].

24.9 Lasers During Pregnancy and Lactation

Elective laser treatments are generally not advised during pregnancy and can be deferred to be performed postpartum. The indications for laser therapy in pregnancy are cervical carcinoma, urolithiasis, condyloma acuminata, Buschke–Löwenstein tumor, verrucous carcinoma, and acne vulgaris. Wilkerson et al. have not found any definitive proof for spontaneous abortion, fetal malformations, or preterm labor occurring secondary to laser therapy during pregnancy after reviewing the use of PDL, Nd:YAG, 2100-nm holmium:YAG, and 10,600-nm CO_2 lasers [85].

A case of premature rupture of the membranes (PROM) after CO_2 laser therapy for condyloma acuminata at 35 weeks of pregnancy has been reported by Schwartz [86]. Further, there is increased risk of delayed healing, hyperpigmentation, and scarring during pregnancy and proper counselling should be done prior to laser session in a pregnant patient [87]. Based on the review of existing literature, it can be assumed that there is no contraindication of laser therapy during any of the trimesters of pregnancy and fresh guidelines should be formulated regarding use of laser in pregnancy.

Lasers can be used safely during lactation as they do not affect the lactiferous ducts and CO_2 laser has been used for the treatment of acute lactation mastitis without any adverse effects [88]. Hence, lasers can be considered safe during lactation as there is no risk of systemic absorption of any agents in laser therapy.

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