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Original Article

A comparative study of the efficacy of an ultra-picosecond laser versus an ultra-pulsed CO_2 laser in the treatment of xanthelasma palpebrarum

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Abstract: Objectives: To compare the efficacy and safety of the ultra-pulsed carbon dioxide (CO_2) laser and ultra-picosecond laser in managing Xanthelasma palpebrarum (XP). Methods: This retrospective study included 230 XP patients treated from February 2021 to June 2024. Among them, 120 patients received ultra-pulsed CO_2 laser treatment, and 110 received ultra-picosecond laser treatment. Treatment effectiveness was assessed based on lesion clearance rate, recurrence, Vancouver Scar Scale (VSS) scores, and safety profiles, with a focus on complications such as scarring and pigmentary changes. Results: Both lasers achieved high clearance rates (> 95%), with no significant difference between the two groups (83.33% in the ultra-pulsed CO_2 laser group vs. 80.00% in the ultra-picosecond laser group, P = 0.513). However, the ultra-picosecond group required more treatment sessions (4.74 ± 0.56 vs. 3.26 ± 1.32, P < 0.001) but had a lower recurrence rate (6.36% vs. 15.00%, P = 0.036). The ultra-pulsed CO_2 laser group showed a higher incidence of hypertrophic scarring (8.33% vs. 1.82%, P = 0.026) and pigmentary complications (hyperpigmentation: 11.67% vs. 2.73%, P = 0.010; hypopigmentation: 10.83% vs. 3.64%, P = 0.037). A significant difference in erythema incidence was also observed (40.00% vs. 27.27%, P = 0.042). Patient satisfaction levels with the two treatments were comparable (P > 0.05). Conclusions: Both laser therapies were effective in treating XP. However, the ultra-picosecond laser demonstrated superior safety, with fewer complications and lower recurrence rates, despite requiring more treatment sessions.

Keywords: Xanthelasma palpebrarum, ultra-pulsed CO_2 laser, ultra-picosecond laser, laser therapy, dermatology, recurrence rate

Introduction

Xanthelasma palpebrarum (XP) is the most common form of cutaneous xanthoma, typically appearing on the eyelids. These lesions consist of lipid-laden macrophages within the skin [1]. While benign, XP often causes cosmetic concern due to its prominent location on the eyelids and progressive growth [2]. Treatment options range from surgical removal to chemical treatments and laser therapy, each with varying effectiveness, limitations, and potential side effects [3].

Laser therapy has become a popular treatment option, offering a minimally invasive approach that may yield better cosmetic results [4]. Among lasers, the carbon dioxide (CO_2) laser is widely used. Its effectiveness stems from precise horizontal tissue ablation, with high-energy light delivered in ultra-pulses [5, 6]. The ultra-pulsed CO_2 laser allows controlled tissue removal while minimizing damage to surrounding areas, which is crucial for sensitive areas like the eyelids [7]. However, concerns remain, including post-treatment erythema, prolonged recovery times, and the risk of scarring [8].

In recent years, picosecond lasers have emerged as a new option for skin treatments [9]. The ultra-picosecond laser, with its extremely short pulse durations, delivers intense, rapid pulses of laser energy that induce a photomechanical effect rather than a photothermal one. This allows precise targeting and disruption of pigmented lesions without causing collateral thermal damage [10, 11]. This mechanistic distinction theoretically offers an advantage over traditional laser systems like the ultra-pulsed CO_2 laser by potentially reducing recovery times

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and improving cosmetic outcomes [12]. While the efficacy of the ultra-picosecond laser in treating various pigmented lesions, including melasma and tattoos, has been well-documented, its use in XP remains underexplored [13].

Current literature reveals a gap in comprehensive, head-to-head comparisons between the ultra-picosecond laser and the ultra-pulsed CO_2 laser for treating XP [14]. Most studies involve small cohort sizes or lack rigorous comparative designs, limiting the ability to draw robust conclusions about the optimal treatment approach [15]. This study aims to address these gaps by providing a large-scale, real-world clinical comparison of the two laser modalities. Our approach includes detailed evaluations of healing responses, patient satisfaction, and long-term outcomes, which are essential for establishing evidence-based guidelines for XP treatment. By systematically comparing the efficacy and safety profiles of the ultra-picosecond and ultra-pulsed CO_2 lasers, this study seeks to identify the most effective and safest treatment options for XP, thereby significantly contributing to clinical practice.

Research methods

Research design and participants

This retrospective study included 230 XP patients treated at Wuhan No. 1 Hospital between February 2021 and June 2024. Among these, 120 patients received ultra-pulsed CO_2 laser treatment, while the remaining 110 were treated with an ultra-picosecond laser. Ethical approval was obtained from the Institutional Review Committee and Ethics Committee of Wuhan No. 1 Hospital.

Eligible patients met the following criteria: clinical diagnosis of XP [16], completion of 6 months of follow-up, age above 18 years, Fitzpatrick skin types III-IV, and stable disease status. Exclusion criteria included pre-existing scarring or infection at the treatment site, allergy to lidocaine, malignant lesions, systemic immunological diseases, a history of sun exposure within the past month, use of topical retinoids or similar preparations, exposure to other laser treatments or chemical peels in the preceding three months, photosensitive diseases, or pregnancy or lactation.

Treatment methods

Patients in the ultra-pulsed CO_2 laser group underwent a single treatment session using the HL-1R ultra-pulsed CO_2 laser (HEALTH, China), with settings of 10,600 nm wavelength, 100-200 Hz frequency range, and 200-400 μs pulse duration. A continuously adjustable handpiece with a variable spot size (1-2 mm in diameter) and continuous exposure mode was utilized. Patients were instructed to keep their eyes closed during the procedure, with sterile gauze used for additional eye protection. Before laser treatment, anesthesia was administered subcutaneously with a mixture of 100 mL normal saline, 0.1% lidocaine, and 0.4 mL epinephrine using a 1 mL syringe. Charred tissue was carefully removed with gauze soaked in normal saline to expose the treatment areas. The endpoint of therapy was reached when the yellowish fatty tissue was completely removed, revealing the underlying pink tissue. Postoperatively, patients applied fusidic acid ointment as advised until the scabbing phase, typically seen between days five and seven. Patients were also instructed to keep the treated area clean and dry during this period and to follow strict sun protection measures thereafter. Treatments were administered at 4-6-week intervals, allowing complete healing between sessions.

The picosecond laser group followed the same preoperative anesthesia, ocular protection, treatment endpoint criteria, and postoperative care protocols as the ultra-pulsed CO_2 laser group. Treatments were delivered using a 1064 nm PicoWay picosecond laser system (OM-PS03, AOMA, China). The treatment utilized a 1064 nm Zoom flat handpiece with the following settings: 3 mm spot diameter, energy density of 0.25-0.40 J/cm^2, and a frequency of 8 Hz. These parameters were individually adjusted based on each patient's skin tone, age, and tissue response. Patients were evaluated six months after the treatment session, and the number of sessions required to achieve the desired outcome was recorded.

Patient characteristics and lesion assessment

Demographic parameters including age, gender, medical history, and XP severity were systematically recorded. Clinical assessment involved categorizing xanthelasma lesions by

number, size, location, and extent using a grading system [17]. In this system: Grade I indicated lesions confined to the upper eyelid; Grade II, extension to the medial canthus; Grade III, involvement of the medial upper and lower eyelids; and Grade IV, involvement of the medial-lateral aspects of both eyelids.

Lesion size was measured using a caliper to determine length and width at their longest points, with the skin held taut. Lesion height was measured using a mirror device as described by Nagamatsu et al. [18]: a 45° angled mirror was placed beside the lesion base, and the height scale reflected in the mirror was read. For patients with multiple lesions, the maximum height among all lesions was recorded. The number of laser treatment sessions was documented, with some patients requiring 2 to more than 4 sessions based on individual needs.

Biochemical examination

At baseline, patients underwent testing for abnormal serum lipid levels, including total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides. Mixed hyperlipidemia was defined as combined elevation of triglycerides and total cholesterol, following the Fredrickson classification [19]. Patients with abnormal lipid levels were referred to the outpatient department for dietary counseling and/or pharmacological treatment.

Additionally, fasting venous blood samples (5 mL) were collected upon admission, treated with ethylenediaminetetraacetic acid as an anticoagulant, and centrifuged at 2,800 rpm for 15 minutes to isolate serum. Fasting blood glucose (FBG) and 2-hour postprandial blood glucose (2hPBG) were measured using an automated biochemical analyzer (BS-280, Mindray, China).

Treatment effectiveness

The primary outcomes for evaluating treatment effectiveness were lesion clearance rate and recurrence rate. These outcomes were assessed objectively by two independent plastic surgeons using standardized photographs taken before and after treatment. Photographs were captured by a trained technician using a digital camera (D7500, Nikon, Thailand) with consistent settings: fixed 1-meter distance from the patient, uniform background, and lighting. Each patient was photographed from three angles: front, right side, and left side.

All patients were independently evaluated by a senior investigator (blinded to the treatment method) using the following grading system [20]: (1) lesion thickness (Grade 1: flat; Grade 2: mildly elevated; Grade 3: moderately elevated; Grade 4: markedly elevated); (2) lesion color (Grade 1: yellowish; Grade 2: yellowish-orange; Grade 3: orange); and (3) lesion area (in mm^2, calculated as the product of the two longest dimensions).

Lesion clearance was categorized into four levels by comparing preoperative and post-final-treatment photographs: < 50% cleared, 50%-75% cleared, 76%-95% cleared, and > 95% cleared (proportion of cleared area relative to total lesion surface area).

Recurrence was defined as the reappearance of xanthelasma within the previously treated area; new lesions outside treated areas were not considered recurrence.

Complication monitoring

Complications were monitored for 6 months post-procedure. Postoperative photographs were independently reviewed by two ophthalmologists to identify complications (e.g., hypertrophic scars, pigmentary changes, Koebner-like phenomena). Disagreements between the two ophthalmologists were adjudicated by a senior ophthalmologist.

Immediate treatment related adverse events

All patients were assessed immediately after each laser session for treatment-emergent erythema, edema, burning pain, and pruritus, which were documented within medical records.

Scar evaluation using the Vancouver Scar Scale (VSS)

Scar outcomes were assessed using the VSS, which evaluates color, height, vascularity, and pliability [21]. Each parameter was scored as follows: color (0: normal skin color; 3: very dark); height (0: flat; 3: hypertrophic); vascularity (0: no visible vessels; 3: numerous vessels); and pliability (0: soft; 3: hard). All assessments were performed by an independent dermatologist.

Table 1. Comparison of demographic and basic data between the two groups

Parameters	Ultra-pulsed CO_2 laser group (n = 120)	Ultra-picosecond laser group (n = 110)	t/χ^2	P
Age (years)	43.48 ± 8.41	43.23 ± 8.22	0.227	0.821
Gender (Female, %)	91 (75.83%)	79 (71.82%)	0.480	0.488
Hypertension [n (%)]	24 (20.00%)	24 (21.82%)	0.115	0.735
Diabetes [n (%)]	50 (41.67%)	50 (45.45%)	0.335	0.563
Hyperlipidemia [n (%)]	76 (63.33%)	75 (68.18%)	0.598	0.439
Duration of xanthelasma (months)	3.16 ± 1.24	2.95 ± 1.54	1.177	0.240
Location of xanthelasma [n (%)]			1.966	0.374
Upper eyelid	57 (47.50%)	60 (54.55%)		
Lower eyelid	10 (8.33%)	5 (4.55%)		
Upper and lower eyelids	53 (44.17%)	45 (40.91%)		
Mean size of lesions (mm^2)	10.08 ± 1.05	10.16 ± 1.23	0.537	0.592
Grade [n (%)]			1.504	0.681
I	100 (83.33%)	88 (80.00%)		
II	6 (5.00%)	10 (9.09%)		
III	9 (7.50%)	8 (7.27%)		
IV	5 (4.17%)	4 (3.64%)		
Fitzpatrick skin type [n (%)]			0.262	0.609
III	52 (43.33%)	44 (40.00%)		
IV	68 (56.67%)	66 (60.00%)		
Involved eye [n (%)]			0.062	0.803
Unilateral	20 (16.67%)	17 (15.45%)		
Bilateral	100 (83.33%)	93 (84.55%)		
Lesion height [n (%)]			0.489	0.484
≤ 2 mm	113 (94.17%)	101 (91.82%)		
> 2 mm	7 (5.83%)	9 (8.18%)		
Family history of similar lesions [n (%)]	17 (14.17%)	17 (15.45%)	0.076	0.783
Medication [n (%)]			1.032	0.597
Diet control	42 (35.00%)	32 (29.09%)		
Anti-lipid medication (statins)	26 (21.67%)	28 (25.45%)		
Unknown	52 (43.33%)	50 (45.45%)		
Time of onset [n (%)]			0.192	0.661
Initial onset	113 (94.17%)	105 (95.45%)		
Recurrence	7 (5.83%)	5 (4.55%)		

Patient satisfaction assessment

Treatment satisfaction was evaluated in both groups using a hospital-developed questionnaire scored out of 100 points. Satisfaction levels were categorized as: Very Satisfied (90-100 points), Satisfied (60-89 points), and Dissatisfied (< 60 points), with higher scores indicating greater satisfaction.

Statistical analysis

Data were analyzed using SPSS 29.0 (SPSS Inc., Chicago, IL, USA). Normally distributed measurement data were expressed as mean ± standard deviation and compared between groups using the independent-samples t-test. Categorical data were presented as n (%) and analyzed using the chi-square test. A *p*-value < 0.05 was considered statistically significant.

Results

Comparison of demographic and basic data

There were no significant differences in baseline characteristics between the ultra-pulsed CO_2 laser group and ultra-picosecond laser group (all P > 0.05; **Table 1**). Specifically, the

Table 2. Comparison of Biochemical profiles between the two groups

Parameters	Ultra-pulsed CO_2 laser group (n = 120)	Ultra-picosecond laser group (n = 110)	t	P
Total cholesterol (mg/dL)	244.57 ± 84.63	238.43 ± 79.14	0.567	0.572
HDL-C (mg/dL)	42.75 ± 7.85	43.51 ± 6.32	0.812	0.418
LDL-C (mg/dL)	109.36 ± 22.09	114.67 ± 29.17	1.544	0.124
Triglycerides (mg/dL)	129.84 ± 42.65	126.68 ± 41.56	0.568	0.570
FBG (mg/dL)	109.32 ± 43.35	102.54 ± 35.26	1.305	0.193
2hPBG (mg/dL)	145.67 ± 78.21	134.63 ± 40.15	1.362	0.175

HDL-C: High density lipoprotein cholesterol; LDL-C: Low-Density Lipoprotein Cholesterol; FBG: Fasting Blood Glucose; 2hPBG: 2h Postprandial Blood Glucose.

two groups were comparable in terms of age, gender distribution, comorbidities (hypertension, diabetes, hyperlipidemia), duration and size of xanthelasma, lesion location, grading, Fitzpatrick skin type, and other parameters (e.g., lesion height, family history). These results confirm balanced baseline characteristics, providing a reliable basis for subsequent efficacy comparison.

Comparison of biochemical profiles

No statistically significant differences were observed in biochemical profiles between the two groups (all $P > 0.05$; **Table 2**). This included total cholesterol, HDL-C, LDL-C, triglycerides, FBG, and 2hPBG, indicating similar metabolic status at baseline.

Comparison of degree of improvement in area, color, and thickness of XP lesions

Pre-treatment lesion area, color grade, and thickness grade showed no significant differences between the groups (all $P > 0.05$; **Figure 1**). However, post-treatment differences were observed: the ultra-pulsed CO_2 laser group achieved a significantly greater reduction in lesion area ($P = 0.031$) and lesion thickness ($P = 0.001$), while the ultra-picosecond laser group demonstrated significantly superior color improvement ($P = 0.013$).

Comparison of clearance rate

High clearance rates (> 95%) were achieved in both groups, with 83.33% in the ultra-pulsed CO_2 laser group and 80.00% in the ultra-picosecond laser group. No significant difference was observed in clearance rates between the two groups ($P = 0.513$; **Table 3**).

Comparison of treatment sessions and recurrence rate

Clinical photographs of a patient with bilateral XP lesions are shown in **Figure 2**, demonstrating progressive clearance following ultra-picosecond laser treatment.

The ultra-picosecond laser group required significantly more treatment sessions than the ultra-pulsed CO_2 laser group ($t = 11.224$, $P < 0.001$; **Table 4**). However, the recurrence rate was significantly lower in the ultra-picosecond laser group ($\chi^2 = 4.418$, $P = 0.036$).

Comparison of complications

The ultra-pulsed CO_2 laser group had a significantly higher incidence of hypertrophic scars ($P = 0.026$), hyperpigmentation ($P = 0.010$), and hypopigmentation ($P = 0.037$) compared to the ultra-picosecond laser group (**Table 5**). Koebner-like phenomena were rare and did not differ significantly between groups (1 case in the ultra-pulsed CO_2 group vs. none in the ultra-picosecond group). These findings suggest the ultra-picosecond laser was associated with a lower risk of pigmentary changes and scarring.

Comparison of immediate side effects during treatment

Significantly more patients in the ultra-pulsed CO_2 laser group developed erythema compared to the ultra-picosecond laser group ($P = 0.042$; **Table 6**). No significant differences were observed in the incidence of edema ($P = 0.597$), burning pain ($P = 0.726$), or itching ($P = 0.055$, approaching but not reaching statistical significance).

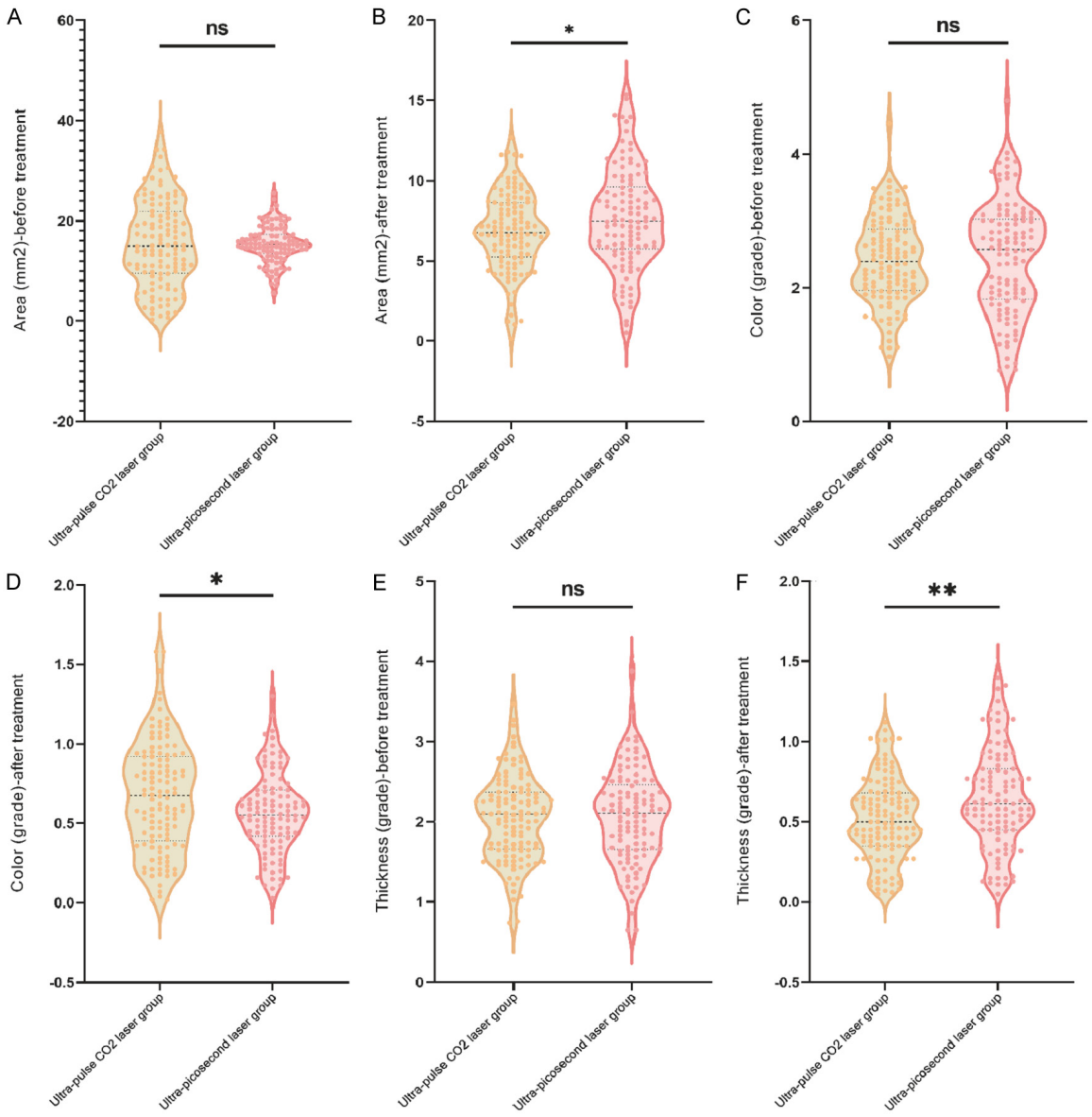

Figure 1. Comparison of Degree of Improvement in Area, Color, and Thickness of XP Lesions between the two groups. A: Area (mm^2) before treatment; B: Area (mm^2) after treatment; C: Color (grade) before treatment; D: Color (grade) after treatment; E: Thickness (grade) before treatment; F: Thickness (grade) after treatment. ns: no significant difference; *: $P < 0.05$; **: $P < 0.01$.

Comparison of VSS scores

VSS scores differed significantly between groups in terms of color ($P = 0.047$), height ($P = 0.029$), and vascularity ($P = 0.029$), with higher scores in the ultra-pulsed CO_2 laser group (**Table 7**). No significant difference was found in plasticity ($P = 0.732$).

Comparison of patient satisfaction

Overall patient satisfaction rates were comparable between the ultra-pulsed CO_2 laser group (85.83%) and the ultra-picosecond laser group (88.18%; $P = 0.597$; **Table 8**), with high levels of satisfaction in both groups.

Discussion

In the present study, we compared the efficacy and safety of ultra-picosecond lasers versus ultra-pulsed CO_2 lasers in treating XP. First, the underlying mechanisms contributing to the observed outcomes warrant discussion. The ultra-pulsed CO_2 laser operates at a wavelength of 10,600 nm, which is absorbed by tissue

Table 3. Comparison of clearance rate between the two groups

Parameters	Ultra-pulsed CO_2 laser group (n = 120)	Ultra-picosecond laser group (n = 110)	χ^2	P
< 50%	0 (0.00%)	0 (0.00%)	0.427	0.513
50-75%	0 (0.00%)	0 (0.00%)		
76-95%	20 (16.67%)	22 (20.00%)		
> 95%	100 (83.33%)	88 (80.00%)		

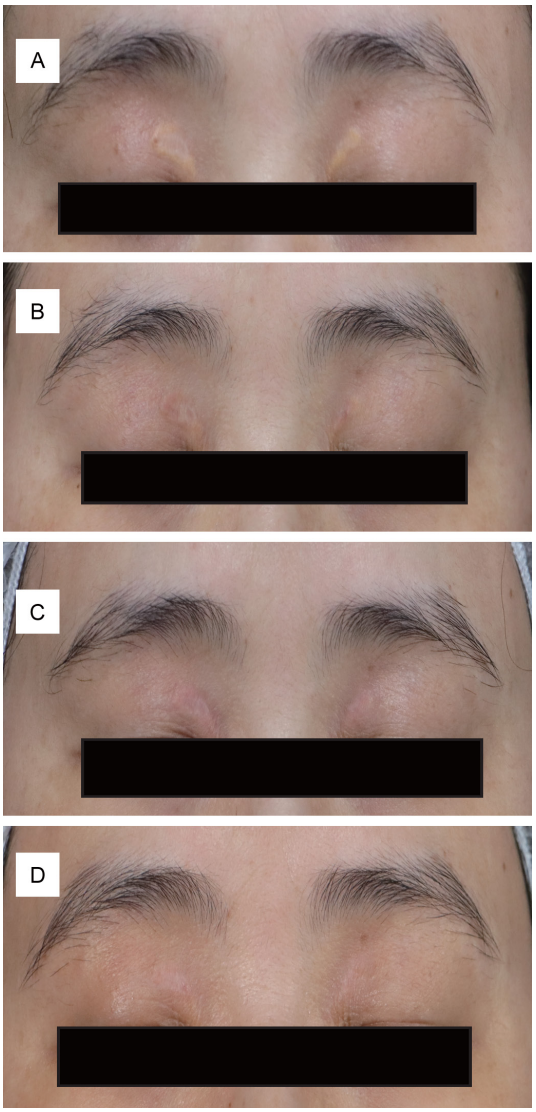

Figure 2. A patient with bilateral XP lesions. A: Before treatment; B: After 1st session; C: After 2nd session; D: 1 month after 3 sessions treatment of picosecond laser with complete removal of lesions. XP: Xanthelasma palpebrarum.

water, enabling effective ablation through vaporization [22, 23]. This explains its superior performance in reducing lesion thickness and area, as evidenced by significantly smaller post-treatment dimensions - consistent with its established role in remodeling severe scars [24]. However, the CO_2 laser's thermal properties, while enabling aggressive ablation, elevate the risk of hypertrophic scarring and pigmentary changes, aligning with findings from previous studies [25]. The higher rates of hyperpigmentation and hypopigmentation in the CO_2 laser group likely result from post-inflammatory pigmentary alterations, a common consequence of deeper dermal injury affecting underlying skin structures [26]. VSS assessments further confirmed inferior outcomes in the CO_2 laser group compared to the ultra-picosecond group, with higher scores in color, height, and vascularity indicating poorer scar quality.

The ultra-picosecond laser, utilizing 1064 nm wavelength energy, acts via photoacoustic effects [27], precisely targeting pigmentation while limiting heat diffusion to adjacent tissues. This aligns with prior research showing that picosecond lasers reduce risks of pigmentary changes and scarring compared to traditional ablative methods [28]. Although requiring more treatment sessions, the ultra-picosecond laser achieved a lower recurrence rate - an advantage attributed to its precision in targeting both melanin and lipid-laden cells in xanthelasma, thereby minimizing residual lesion tissue that could regrow [29, 30].

Both modalities demonstrated significant efficacy, with clearance rates exceeding 95%, consistent with previous research highlighting the ultra-pulsed CO_2 laser's high efficiency via tissue vaporization [31]. The ultra-pulsed CO_2 laser achieved these results in fewer sessions, owing to its aggressive tissue-removal capacity, which enables substantial reductions in lesion size and thickness per session [32]. However, this efficiency comes with a higher risk of adverse effects (e.g., scarring), a critical concern given the eyelid's sensitivity [33].

Differences in treatment session requirements also offer insights for patient management. Ultra-picosecond laser therapy, while requiring

Table 4. Comparison of treatment sessions and recurrence rate between the two groups

Parameters	Ultra-pulsed CO_2 laser group (n = 120)	Ultra-picosecond laser group (n = 110)	t/χ^2	P
Treatment sessions	3.26 ± 1.32	4.74 ± 0.56	11.224	< 0.001
Recurrence rate [n (%)]	18 (15.00%)	7 (6.36%)	4.418	0.036

Table 5. Comparison of complications between the two groups

Parameters	Ultra-pulsed CO_2 laser group (n = 120)	Ultra-picosecond laser group (n = 110)	χ^2	P
Hypertrophic scar [n (%)]	10 (8.33%)	2 (1.82%)	4.926	0.026
Hyperpigmentation [n (%)]	14 (11.67%)	3 (2.73%)	6.700	0.010
Hypopigmentation [n (%)]	13 (10.83%)	4 (3.64%)	4.343	0.037
Koebner-like phenomena [n (%)]	1 (0.83%)	0 (0.00%)	None	1.000

Table 6. Immediate side effects between the two groups

Parameters	Ultra-pulsed CO_2 laser group (n = 120)	Ultra-picosecond laser group (n = 110)	χ^2	P
Erythema	48 (40.00%)	30 (27.27%)	4.148	0.042
Edema	17 (14.17%)	13 (11.82%)	0.279	0.597
Burning Pain	24 (20.00%)	20 (18.18%)	0.123	0.726
Itching	41 (34.17%)	25 (22.73%)	3.670	0.055

Table 7. Comparison of VSS scores between the two groups

Parameters	Ultra-pulsed CO_2 laser group (n = 120)	Ultra-picosecond laser group (n = 110)	t	P
Color	1.47 ± 0.46	1.35 ± 0.42	1.993	0.047
Height	0.93 ± 0.30	0.85 ± 0.28	2.193	0.029
Plasticity	1.86 ± 0.55	1.83 ± 0.53	0.342	0.732
Vascularity	1.07 ± 0.33	0.98 ± 0.31	2.194	0.029

Table 8. Comparison of patient satisfaction between the two groups

Parameters	Ultra-pulsed CO_2 laser group (n = 120)	Ultra-picosecond laser group (n = 110)	χ^2	P
Very satisfied	32 (26.67%)	30 (27.27%)		
Satisfied	71 (59.16%)	67 (60.91%)		
Dissatisfied	17 (14.17%)	13 (11.82%)		
Satisfaction rate [n (%)]	103 (85.83%)	97 (88.18%)	0.279	0.597

more sessions, may involve greater initial time investment and perceived inconvenience [34]. However, it yields superior long-term aesthetic outcomes, with reduced scarring, pigmentary alterations, persistent erythema, and lower recurrence rates - key considerations for XP patients, whose motivations are predominantly cosmetic [35]. This longer treatment timeline reflects a strategic focus on gradual yet safer lesion clearance, avoiding immediate postoperative complications, a priority emphasized in previous studies evaluating laser treatments [36].

Notably, patient satisfaction was comparable between the two groups despite their differing profiles. This suggests that while the ultra-pulsed CO_2 laser offers quicker results, patients also value the ultra-picosecond laser's favorable safety profile. Satisfaction with laser treatments depends not only on clearance speed but also on factors like side effects,

healing time, and post-treatment skin texture [37, 38]. The ultra-picosecond laser's lower rates of pigmentary changes, hypertrophic scarring, and recurrence likely balanced the need for more sessions, indicating that patients holistically weigh immediate results against long-term safety and aesthetics when assessing treatment success.

These findings have implications for clinical practice: clinicians should tailor laser selection to individual patient profiles, weighing the priority of rapid results against long-term cosmetic outcomes [39]. For patients prone to scarring or with darker skin types (where pigmentary changes are more conspicuous), the ultra-picosecond laser is preferable [40]. In contrast, the ultra-pulsed CO_2 laser remains a viable option for patients seeking fewer interventions, provided they are fully informed of the higher risk of adverse skin reactions [41].

When drawing these conclusions, it is crucial to acknowledge the limitations of this study and point out directions for future research. The single-center design, which is affected by the demographic characteristics of local patients and operator-dependent techniques, may restrict the generalizability of the results. Retrospective data collection brings the risk of selection bias, although strict inclusion criteria have alleviated confounding factors to a certain extent. The six-month follow-up period is insufficient to evaluate long-term recurrence and persistent pigment changes, especially the late scarring related to ultra-pulsed CO_2 laser treatment. Although our sample size is sufficient and the follow-up period is consistent, extending the follow-up period beyond six months can provide insights into the long-term efficacy and recurrence patterns of each laser modality. In addition, further comparative studies that include patient-reported outcome measures in addition to clinical evaluations will deepen our understanding of the factors influencing subjective satisfaction.

In conclusion, this study provides evidence that both the ultra-picosecond laser and the ultra-pulsed CO_2 laser are effective in the treatment of XP, and each has unique advantages that should guide clinical decision-making. The ultra-pulsed CO_2 laser may achieve faster lesion clearance, while the ultra-picosecond laser has a better safety profile, with fewer complications and a lower recurrence rate - these attributes may improve long-term patient satisfaction. As laser technology continues to develop, ongoing research and evidence-based practice improvements will further optimize the treatment paradigms for this common and challenging dermatological condition.

Disclosure of conflict of interest

None.

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References

[1] Zhimin W, Hui W, Fengtao J, Wenjuan S and Yongrong L. Clinical and serum lipid profiles and LDLR genetic analysis of xanthelasma palpebrarum with nonfamilial hypercholesterolemia. J Cosmet Dermatol 2020; 19: 3096-3099.

[2] Yee DA, Zhou AE and Khachemoune A. Examining treatment strategies for xanthelasma palpebrarum: a comprehensive literature review of contemporary modalities. Arch Dermatol Res 2024; 316: 149.

[3] Xu Q, Yao Z, Yu X, Ying J, Zhu J, Lu L, Hu Z, Jiang H and Wang H. A scoring-based clinical grading model for xanthelasma palpebrarum: predicting treatment frequency and prognosis. Arch Dermatol Res 2024; 316: 614.

[4] Wang D, Mao Z, Li Z, Gao W, Qu Y, Li X, Jiang Y and Lin X. Carbon dioxide laser excision as a novel treatment for large xanthelasma palpebrarum: long-term efficacy and safety. Br J Ophthalmol 2025; 109: 427-432.

[5] Varghese KJ, Singh SP, Qureshi FM, Shreekumar S, Ramprasad A and Qureshi F. Digital patient education on xanthelasma palpebrarum: a content analysis. Clin Pract 2023; 13: 1207-1214.

[6] Tuan H, Chen Y, Yang S, Liu D, Chen D and Zhao Y. A Comparison of efficacy and safety of fractional carbon dioxide laser and fractional Er:YAG laser for the treatment of xanthelasma palpebrarum: a two-center randomized split-face controlled trial. Photobiomodul Photomed Laser Surg 2021; 39: 131-136.

[7] Singh A, Tiwary PK, Jha AK, Zeeshan M and Ranjan A. Successful treatment of xanthelasma palpebrarum with a combination of radiofrequency ablation and wound suturing. J Cosmet Dermatol 2020; 19: 3286-3290.

[8] Simões Pires V, Wender IO, Santos MF, Sartori GL, Vivian A and Dallagnese G. Xanthelasma palpebrarum after hyaluronic acid injection in the lower eyelid: a case report and review of the literature. J Cosmet Dermatol 2021; 20: 2750-2752.
[9] Scarano A, Inchingolo F, Scogna G, Leo L, Crisante A, Greco Lucchina A and Lorusso F. Xanthelasma palpebrarum removed with atmospheric plasma technique: 11-year follow up. J Biol Regul Homeost Agents 2021; 35 Suppl 1: 181-185.
[10] Sapra S, Tran JV, Gurm H and Eleuterio M. Treatment of xanthelasma palpebrarum using trichloroacetic acid 80. J Clin Aesthet Dermatol 2024; 17: 17-22.
[11] Rubins S, Ritina I, Jakus J and Rubins A. Plasma sublimation for the treatment of xanthelasma palpebrarum. Acta Dermatovenerol Alp Pannonica Adriat 2020; 29: 55-57.
[12] Rothstein BE and Cohen JL. An updated workup for patients with xanthelasma palpebrarum. Dermatol Surg 2021; 47: 1170-1171.
[13] Rai A, Karki S, Prasad Sah S, Narayan Kamat L and Pradhan M. Dyslipidemia in patients with xanthelasma palpebrarum visiting the department of dermatology of a tertiary care centre: a descriptive cross-sectional study. JNMA J Nepal Med Assoc 2022; 60: 529-532.
[14] Ponomarev IV, Topchiy SB and Shakina LD. Successful treatment of xanthelasma palpebrarum grade III with copper vapour laser radiation (578 nm). Indian J Dermatol Venereol Leprol 2025; 91: 236-237.
[15] Ponomarev IV, Topchiy SB and Shakina LD. Successful treatment of xanthelasma palpebrarum with copper vapor laser radiation at 578 nm. J Cosmet Dermatol 2023; 22: 3522-3523.
[16] Rohrich RJ, Janis JE and Pownell PH. Xanthelasma palpebrarum: a review and current management principles. Plast Reconstr Surg 2002; 110: 1310-1314.
[17] Lee HY, Jin US, Minn KW and Park YO. Outcomes of surgical management of xanthelasma palpebrarum. Arch Plast Surg 2013; 40: 380-386.
[18] Nagamatsu S, Sasaki A, Uchiki T, Kawamoto H and Yokota K. An angled mirror device facilitates measurement of skin lesion height. Plast Reconstr Surg Glob Open 2020; 8: e3233.
[19] LE WJFsDiGMteNYMH. Xanthomatoses and lipoprotein disorders 2008; 1272.
[20] Esmat SM, Elramly AZ, Abdel Halim DM, Gawdat HI and Taha HI. Fractional CO_2 laser is an effective therapeutic modality for xanthelasma palpebrarum: a randomized clinical trial. Dermatol Surg 2014; 40: 1349-1355.
[21] Thompson CM, Sood RF, Honari S, Carrougher GJ and Gibran NS. What score on the vancouver scar scale constitutes a hypertrophic scar? Results from a survey of north American burn-care providers. Burns 2015; 41: 1442-1448.
[22] Park JH, Ryu SI and Kim IH. Clinical efficacy of 1,444 nm Nd:YAG laser for xanthelasma palpebrarum. J Cosmet Laser Ther 2020; 22: 141-145.
[23] Park HS and Choi JW. Association between xanthelasma palpebrarum and the risk of ischemic heart diseases: a nationwide register-based cohort study. J Dermatol 2023; 50: e406-e408.
[24] Park H, Lee SB, Chung JH and Park SH. Effective treatment of xanthelasma palpebrarum using Er:YAG laser. Lasers Med Sci 2025; 40: 7.
[25] Paasch U, Zidane M, Baron JM, Bund T, Cappius HJ, Drosner M, Feise K, Fischer T, Gauglitz G, Gerber PA, Grunewald S, Herberger K, Jung A, Karsai S, Kautz G, Philipp C, Schädel D, Seitz AT and Nast A. S2k guideline: laser therapy of the skin. J Dtsch Dermatol Ges 2022; 20: 1248-1267.
[26] Namazi N, Amani M, Haghighi Morad M and Namazi N. Is normolipidemic xanthelasma palpebrarum an independent risk factor of atherosclerosis? Int J Clin Pract 2021; 75: e14958.
[27] Nakamura H, Matsuzaki T, Ito KR, Nakagawa R, Asano LM, Nishikido H, Haga H and Kataoka TR. Possible roles of human mast cells in the formation of xanthelasma palpebrarum. Pathol Int 2023; 73: 406-412.
[28] Malekzadeh H, Ormseth B and Janis JE. A practical review of the management of xanthelasma palpebrarum. Plast Reconstr Surg Glob Open 2023; 11: e4982.
[29] Lustig-Barzelay Y, Kapelushnik N, Goldshtein I, Leshno A, Segev S, Ben-Simon GJ and Landau-Prat D. Association between xanthelasma palpebrarum with cardiovascular risk and dyslipidemia: a case control study. Ophthalmology 2025; 132: 164-169.
[30] Lobato-Berezo A, March-Rodríguez Á, Pujol RM and Fernández-Figueras MT. Hemosiderotic Xanthelasmas. A new clinicopathological variant of xanthelasma palpebrarum or a localized variant of xanthosiderohistiocytosis of the eyelids? Am J Dermatopathol 2023; 45: 646-649.
[31] Elgarhy LH, El-Tatawy RA, Abdelaziz D and Dogheim NN. Pulsed dye laser versus ablative fractional CO(2) laser in treatment of old hypertrophic scars: clinicopathological study. Wound Repair Regen 2021; 29: 417-424.
[32] Lin Y and Wu L. Aesthetic surgical treatment of large xanthelasma palpebrarum. Aesthetic Plast Surg 2024; 48: 4828-4832.

[33] Lin X, Hu H, Qian Y, Jie X, Nie B, Zhao YZ, Wang H and Jiang H. Intralesional injection of bleomycin in the treatment of xanthelasma palpebrarum: a clinical study. J Cosmet Dermatol 2020; 19: 2125-2130.
[34] Lee H and Cho S. Dyslipidemia may not be clinically relevant in treating xanthelasma palpebrarum: a retrospective pilot study. Dermatol Ther 2020; 33: e13589.
[35] Konstantinou MP, Evangelou G, Hegazy S, Krasagakis K and Bulai-Livideanu C. Comparison of the efficacy and safety of continuous CO(2) laser and 1064 nm Q-switched Nd:YAG laser for the treatment of xanthelasma palpebrarum. Int J Dermatol 2023; 62: e120-e122.
[36] Noyman Y, Friedman HO, Lapidoth M, Harris Rimon G, Solomon-Cohen E, Snast I, Rozenblat M, Mimouni D and Levi A. Efficacy and safety of non-fractional ablative carbon dioxide laser resurfacing for the treatment of rhinophyma - a retrospective cohort and questionnaires-based study. Lasers Med Sci 2025; 40: 261.
[37] Kim YG, Oh JW, Lee KC and Yoon SH. Clinical association between serum cholesterol level and the size of xanthelasma palpebrarum. Arch Craniofac Surg 2022; 23: 71-76.
[38] Hu W, Liu Y, Lian C and Lu H. Genetic insight into putative causes of xanthelasma palpebrarum: a Mendelian randomization study. Front Immunol 2024; 15: 1347112.
[39] Goyal P, Gupta V, Aithal S, Meena D and Dhillon KS. Assessment and predictors of metabolic syndrome in patients of xanthelasma palpebrarum: an observational study. Dermatol Pract Concept 2024; 14: e2024218.
[40] Ergun SB and Kurt B. Complete blood cell count-derived inflammation biomarkers in patients with xanthelasma palpebrarum. Beyoglu Eye J 2024; 9: 33-37.
[41] Choi EJ, Oh TM and Han HH. A modified surgical method combined with blepharoplasty design for treatment of xanthelasma palpebrarum. Biomed Res Int 2020; 2020: 4803168.