Comparison of 532 nm Potassium Titanyl Phosphate Laser and 595 nm Pulsed Dye Laser in the Treatment of Erythematous Surgical Scars: A Randomized, Controlled, Open-Label Study

Terrence C. Keaney, MD, Elizabeth Tanzi, MD, and Tina Alster, MD

BACKGROUND The pulsed dye laser (PDL) has long been used for treatment of erythematous and hypertrophic scars. Its effectiveness has been attributed in large part to its vascular-specificity. The vascular-specific potassium titanyl phosphate (KTP) laser has also been reported to be clinically effective for scars, but has not been compared to the PDL.

OBJECTIVE To compare the safety and clinical efficacy of a 532-nm KTP laser versus a 595-nm PDL in improving the appearance of erythematous surgical scars.

METHODS Twenty patients with matched bilateral erythematous surgical scars or a single linear erythematous scar measuring longer than 5 cm were enrolled in the study. Single scars were divided into equal halves with each half randomized to receive 3 successive treatments at 6-week intervals with either a 532-nm KTP laser (*Excel V*; Brisbane, CA) or a 595-nm PDL (*Cynergy*; Cynosure Inc., Chelmsford, MA) at equivalent laser parameters. Bilateral matched scars were similarly randomized to receive three 532-nm KTP or 595-nm PDL treatments. Clinical efficacy was evaluated 12 weeks after the third (final) laser treatment by independent, blinded photographic scar assessments. Secondary evaluations included final investigator and subject treatment/satisfaction assessments, Vancouver scar scale (VSS) scores, subject scar symptoms, intraoperative pain scores, and incidence of side effects.

RESULTS Clinical improvement of erythematous surgical scars was observed with both 532-nm KTP and 595-nm PDL systems. No statistically significant differences between the 2 treatment arms were noted in the independent, blinded photographic scar assessments, investigator and subject treatment/satisfaction assessments, subject scar symptoms, and intraoperative pain scores. The KTP arm produced statistically significant improvement for the vascularity component of the VSS only. Side effects were limited to mild treatment discomfort and minimal transient post-treatment erythema and purpura. No vesiculation, infection, scarring or other adverse events were experienced. Subject satisfaction surveys mirrored the observed clinical effects.

CONCLUSION The-532 nm KTP laser is comparable in efficacy and safety to the 595-nm PDL laser in the treatment of erythematous surgical scars.

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Scars occur after cutaneous injury and can lead to both functional and quality of life impairment. Scars have different clinical presentations leading to keloid, hypertrophic, or atrophic scars.[1] Various lasers have been used for scars, but the pulsed dye laser (PDL) has emerged as the gold standard laser treatment for surgical scars. A systematic review found the most evidence supporting the use of the PDL for laser treatment of scars.[2] Subsequent to initial studies over 20 years ago that reported clinical and textural improvement of scars after PDL irradiation,[3,4] many additional studies have further documented that the PDL provides significant long-term improvement of scar erythema, pliability, thickness, and pruritus.[5,6]

Washington Institute of Dermatologic Laser Surgery, Washington, DC

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Because the effectiveness of the PDL has been attributed to its vascular-specificity, other lasers that target oxyhemoglobin may effectively treat scars. The potassium titanyl phosphate (KTP) laser is a vascular-specific laser with a 532 nm wavelength that closely corresponds to the first absorption peak of hemoglobin at 542 nm. As such, the KTP laser has been shown to be effective for scar treatment, but no comparative study with PDL has been performed. This study examined the safety and clinical efficacy of a 532-nm KTP laser versus a 595-nm PDL in improving the appearance of erythematous surgical scars.

Methods

Twenty adults with matched bilateral erythematous surgical scars or a single linear erythematous scar measuring longer than 5 cm were enrolled in the study. Only patients with skin Phototypes I to IV and scars less than 24 months post surgery were enrolled.

The study had 2 arms consisting of a 532-nm KTP laser treatment arm and a 595-nm PDL laser active control arm. Single scars were divided into equal halves with each half randomized to receive 3 successive treatments at 6-week intervals with either a 532-nm KTP laser (*Excel V*; Cutera) or a 595-nm PDL (*Cynergy*; Cynosure Inc.). Bilateral matched scars were similarly randomized to receive three 532-nm KTP or 595-nm PDL treatments. Randomization assignments were prepared before study commencement and placed in sequentially numbered, sealed, opaque envelopes. Treatment arm allocation was made only when a subject presents for the first treatment. Laser parameters were fixed at equivalent low fluences and short pulse durations. The 532-nm KTP laser settings were 4.6 J/cm^2, 3 ms, and a 7-mm spot size, whereas the 595-nm PDL settings were 4.5 J/cm^2, 2 ms, and a 7-mm spot size. Epidermal cooling was achieved with sapphire contact cooling with the KTP laser and forced cooled air (Zimmer MedizinSystems, Irvine, CA) with PDL laser. All treatments were performed by the same treatment physician.

Clinical efficacy was evaluated by independent masked physician assessment of improvement of each scar side as compared with baseline. This assessment was based on the review of matched digital photographs obtained at baseline and 12 weeks after the third laser treatment. Secondary evaluations were also performed. Final investigator physician global assessment (PGA) scores were performed based on a 5-point scale ranging from very significant improvement to no improvement. Before each treatment, Vancouver scar scale (VSS) assessments of vascularity, pigmentation, pliability, and height were performed. At the final follow-up visit, subjects were asked to complete a questionnaire where they documented the scar improvement on a 5-point scale and assessed overall treatment satisfaction. Safety was evaluated by measuring pain severity associated with laser treatment and continuous monitoring of adverse events (AEs).

Results

Twenty patients (19 females, 1 male, age range: 31–70 years, mean age: 50 years) with Fitzpatrick skin Types

TABLE 1. Demographics and Scar Characteristics

Subjects (*n*)	20
Mean age (Range)	50 (31–70)
Gender, *n* (%)	
Females	19 (95)
Males	1 (5)
Fitzpatrick skin type, *n* (%)	
I	1 (5)
II	13 (65)
III	5 (25)
IV	1 (5)
Scar age (months)	
Mean (±SD)	6.9 (±3.5)
Minimum	1
Median	6.5
Maximum	14
Scar location, *n* (%)	
Abdomen	6 (30)
Breast	6 (30)
Back	2 (10)
Ankle	1 (5)
Arm	1 (5)
Axilla	1 (5)
Chest	1 (5)
Foot	1 (5)
Knee	1 (5)

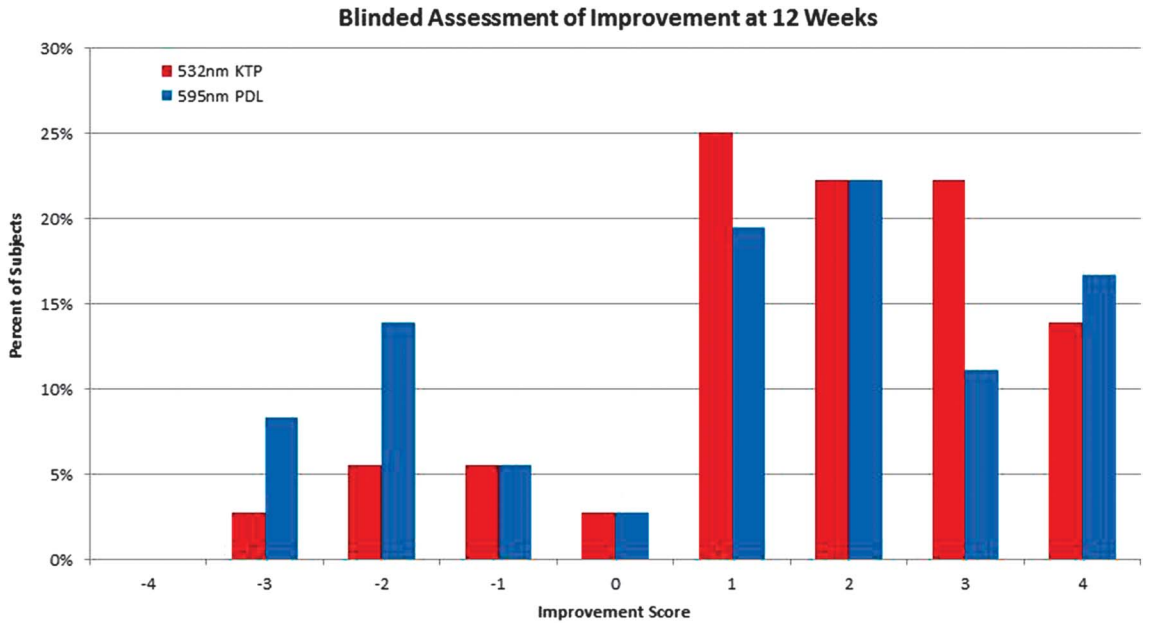

Figure 1. Blinded assessment of improvement at 12 weeks.

I to IV were enrolled in this institutional review board approved randomized, controlled, open-label study comparing 532-nm KTP and 595-nm PDL lasers for the treatment of surgical scars (Table 1). All scars were in nonfacial locations with most located on the abdomen and breast. Scar ages ranged between 1 and 14 months (mean 6.9 months). The scar length ranged from 3.7 to 57 cm, and the average combined scar length was 19.5 cm.

Nineteen subjects completed the series of 3 laser treatments and 18 subjects completed the study treatments and follow-up. One subject withdrew from the study after the first laser treatment and another subject was lost to follow-up after the third laser treatment.

Blinded reviewers' photographic assessments at 12 weeks post final treatment indicated a median improvement score of 2.0 for 532-nm KTP (95% CI: 1.0–2.5) and a median improvement score of 1.5 (95% CI: 0.0–2.0) for 595-nm PDL (Figure 1). The difference in assessments were not statistically significant (p-value = .3140). Both the investigator and

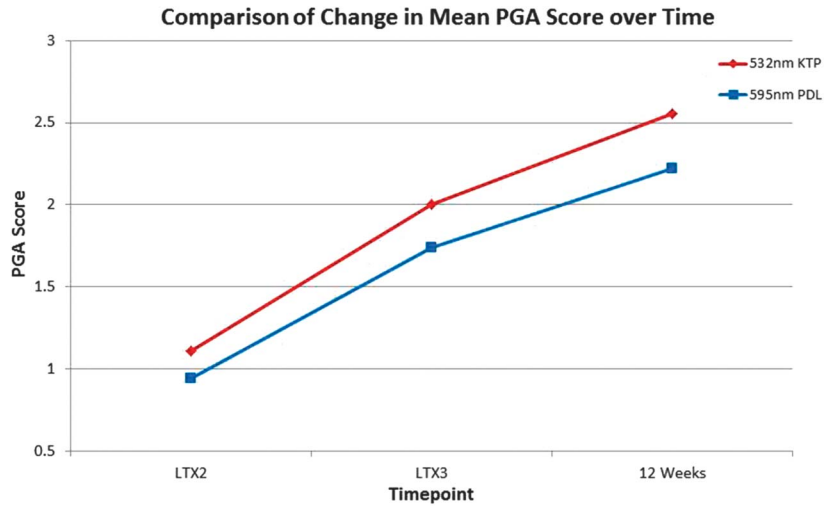

Figure 2. Comparison of change in mean PGA score over time.

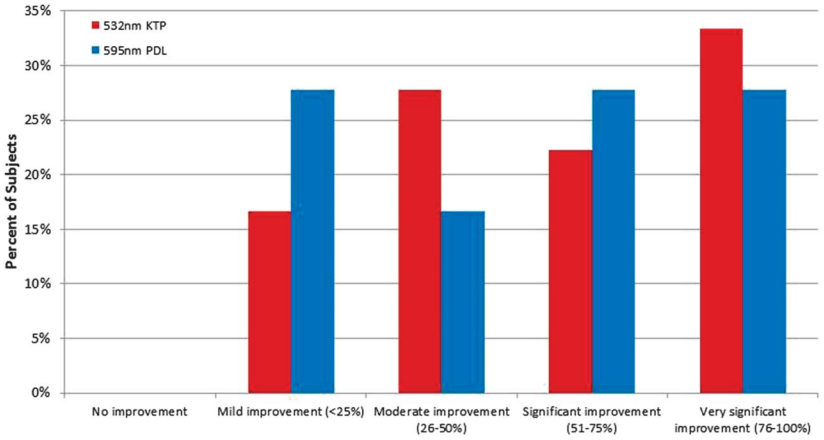

Figure 3. Subject's global assessment score.

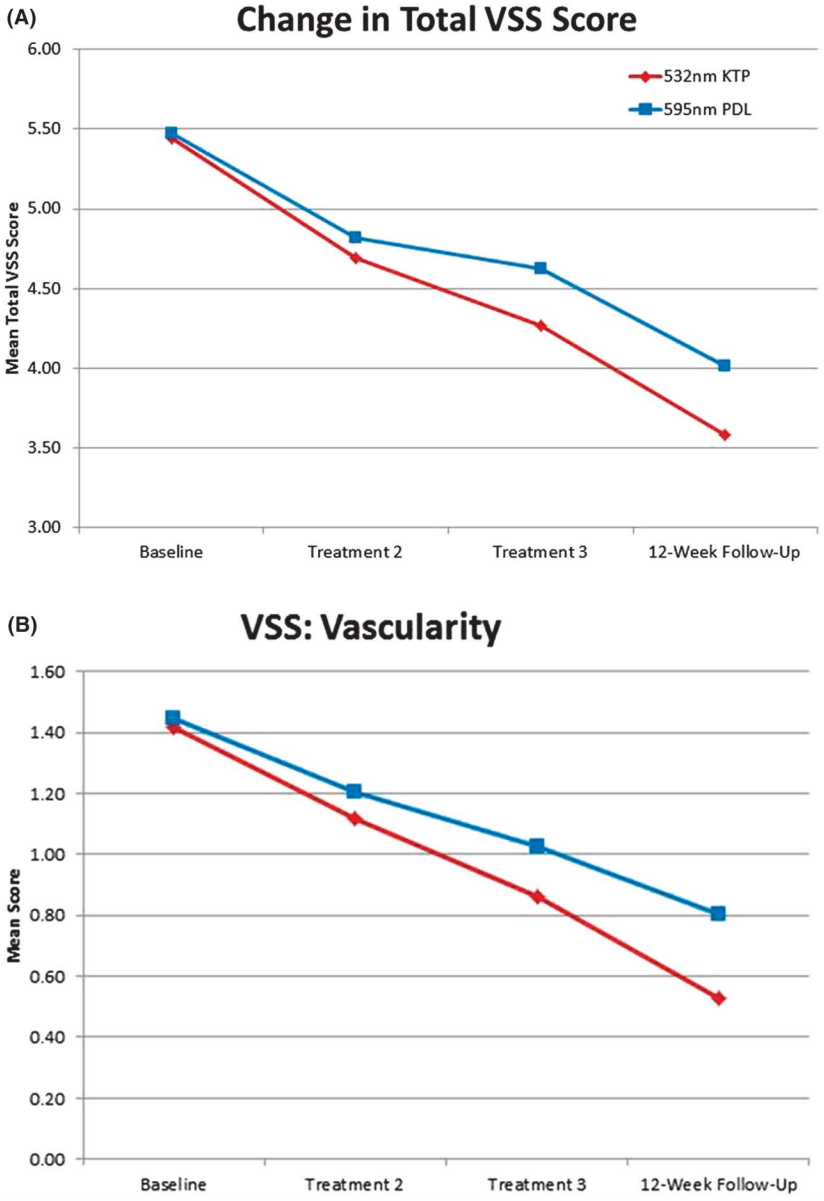

Figure 4. (A) Vancouver scar scale (VSS). (B) Vancouver scar scale (VSS) vascularity component.

TABLE 2. Subject Adverse Effects

Adverse Effects	*532 nm KTP, n = 19*	*Mean Duration (days)*	*595 nm PDL, n = 19*	*Mean Duration (days)*
Erythema, *n* (%)	9 (47)	5	7 (37)	5
Edema, *n* (%)	2 (11)	2	2 (11)	1
Purpura, *n* (%)	3 (16)	6	1 (5)	4
Crusting, *n* (%)	2 (11)	5	0 (0)	n/a
Burning Sensation, *n* (%)	1 (5)	7	1 (5)	2
Total number of Subjects with AEs (%)	10 (53)	—	8 (42)	—

subject noted improvement in both arms with no statistically significant difference between the 2 treatments. The mean PGA scores were 2.6 for the 532-nm KTP and 2.2 for the 595-nm PDL (Figure 2). The mean subject global assessment score was 2.7 and 2.6 for the 532-nm KTP and 595-nm PDL, respectively (Figure 3). Improvement in VSS scores compared with baseline was statistically significant for each arm independently, but no statistically significant difference was noted between the treatment arms (Figure 4A). The KTP arm produced statistically significant (p-value = .0463) improvement for the vascularity component of the VSS only (Figure 4B).

Both treatments were well tolerated despite different mechanisms of cutaneous cooling (Table 2). Side effects were limited to mild treatment discomfort and minimal transient post-treatment erythema and purpura. The intraoperative mean pain scores were 2.4 for the 532-nm KTP and 1.0 for the 595-nm PDL. No vesiculation, infection, scarring, or other AEs were experienced (Figure 5).

Discussion

Angiogenesis is an essential step in the development of scars. Laser treatment targets the vascular proliferation that occurs in the early phase of scar formation. Using the principles of selective thermolysis,[7] vascular lasers target oxyhemoglobin that has absorption peaks at 542 and 577 nm. Although the exact mechanism of action is not understood, laser absorption by oxyhemoglobin generates heat in the blood vessels leading to coagulation necrosis, hypoperfusion, and hypoxia.

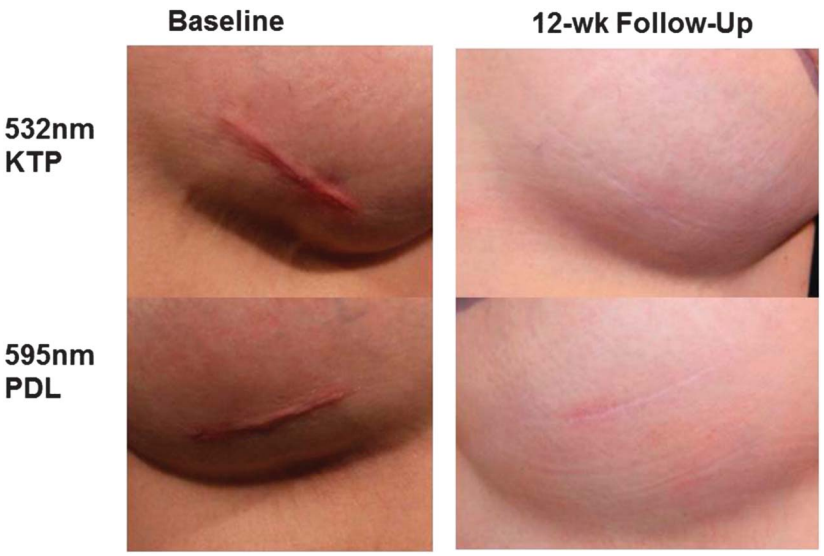

Figure 5. Clinical results.

Vascular injury may also result in collagenase release, dissociation of disulfide bonds, collagen fiber realignment, and inhibition of pro-scar cytokines such as transforming growth factor β 1 and platelet derived growth factor.[8,9]

The PDL has long been considered the gold standard treatment for a wide variety of vascular lesions and scars because of its selective absorption by oxyhemoglobin.[10] Similarly, the vascular-specific 532-nm KTP laser has been shown to be useful for skin rejuvenation, acne vulgaris, and port–wine stains.[11–13] One prospective controlled study documented the efficacy of the KTP laser for the treatment of thyroidectomy scars.[14]

This study is the first comparison of 2 vascular-specific lasers for the treatment of surgical scars. Comparative effectiveness research in laser medicine is rare. The PDL and KTP lasers have only been compared in the treatment of capillary malformations wherein the KTP laser was shown to be less effective.[15] Comparative effectiveness studies of laser treatments for scars have been performed between different laser categories (vascular laser vs fractional ablative and nonablative laser resurfacing).[16,17] To design a fair comparative effectiveness study, the treatment parameters were fixed using similar non-purpuric, low fluence, and short pulse durations that have previously been shown to be effective for PDL treatment of scars.[18]

The results of this study documented improvement in scar assessments by both the PDL and KTP lasers. Blinded reviewers, investigator and subject assessments showed no statistically significant difference between PDL and KTP lasers. The KTP treatment arm only showed statistically significant improvement in the vascularity component of the VSS. The KTP treatment was reported to be more painful and resulted in increased erythema and edema. The 532-nm KTP wavelength has the potential for enhanced absorption in melanin compared with the PDL, thereby increasing the risk of epidermal injury and pigmentary change. Despite this potential risk, no bullae or vesiculation was noted in either treatment arm.

In conclusion, this study demonstrates that the 532-nm KTP laser is as safe and as effective as the 595-nm PDL for the treatment of surgical scars. The KTP was slightly more effective at reducing scar erythema which may be due to enhanced oxyhemoglobin absorption. Although not seen in this study, the KTP laser may be limited in the treatment of hypertrophic scars because of the limited depth of penetration seen with the shorter 532 nm wavelength.

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Address correspondence and reprint requests to: Tina Alster, MD, Washington Institute of Dermatologic Laser Surgery, 1430 K Street, NW Suite 200, Washington, DC 20005, or e-mail: talster@skinlaser.com