Accepted: 3 May 2023

DOI: 10.1002/lsm.23676

CLINICAL REPORT

How efficient is laser therapy for telangiectasias, spider veins, and cherry angiomas?—A study using dynamic optical coherence tomography

Katrin Harst MD | **Julia Welzel MD** | **Sandra Schuh MD, MSc**

Department of Dermatology and Allergology, Augsburg University Hospital, Augsburg, Germany

Correspondence
Sandra Schuh, MD, MSc, Department of Dermatology and Allergology, Augsburg University Hospital, Augsburg, Germany.
Email: sandra.schuh@uk-augsburg.de

Abstract

Objectives: A clinical study to investigate the effectiveness of pulsed dye laser (PDL) versus Nd:YAG laser in the treatment of telangiectasias, spider veins and cherry angiomas. Dynamic optical coherence tomography (D-OCT) was introduced as an innovative follow-up tool for evaluation of blood flow within superficial vessels and to allow visualization of morphological changes of the vasculature in vivo. The final aim of this study was to demonstrate a possible treatment benefit comparing both laser types.

Materials and Methods: Vessel structures of 102 skin lesions were documented photographically and dermoscopically. Subsequently, lesions were imaged using optical coherence tomography before laser therapy (a), directly after the treatment (p) and after a follow-up 4–6 weeks after laser treatment. All lesions were treated using either a 595 nm PDL or a 1064 nm Nd:YAG laser. Two main vessel parameters, namely density and diameter, and their possible changes during follow-up were observed in 150/300/500 µm penetration depth using D-OCT and were subsequently compared between both treatment groups. Other analyzed vessel parameters were depth of the plexus, mean diameter, mean density, top edge of the vessel, columns, and spikes.

Results: Both laser types are suitable options for the treatment of vascular skin lesions, with the most significant effect on cherry angiomas. PDL shows better results treating smaller vessels in upper skin regions, in comparison to Nd:YAG laser, achieving better results on deeper vessels, like spider veins. Using the applied laser settings, there was no statistically significant effect on telangiectasias.

Conclusion: D-OCT represents a new, noninvasive imaging method to evaluate blood flow and vessel morphology in the follow-up of telangiectasias, spider veins, and cherry angiomas, which underwent laser therapy.

KEYWORDS

cherry angioma, dynamic optical coherence tomography, Nd:YAG laser, pulsed dye laser, spider vein, superficial blood flow, telangiectasia, vessel morphology

INTRODUCTION

In recent years, there is a rising demand for more suitable and individualized alternatives to surgical intervention in the treatment of vascular skin lesions. Laser treatment is an adequate option when it comes to less invasive procedures, particularly to treat unpleasant superficial ectasias. There is a broad variety of different lasers, which were established recently for the treatment of skin lesions caused by dilated vessels. The 585/595 nm pulsed dye laser (PDL), which causes microvessel destruction through selective photothermolysis is considered the gold standard for the treatment of facial telangiectasias[1,2] but has shown a significant positive effect on cherry angiomas as well.[3,4] When it comes to the treatment of ectasias in deeper vessels, such as spider veins, the 1064 nm Nd:YAG laser could demonstrate its superiority.[5–8] Hence, it also shows good results on superficial cherry angiomas.[5,9] Beside the applied wavelength of the laser (the longer the wavelength the greater the penetration depth[10,11]), fluence, spot size, and pulse duration also play a pivotal role for the success of a laser therapy and should therefore be chosen individually.

There are several case studies reported in the literature, showing a clear benefit of laser treatment for superficial skin lesions. Hence, in most of the reported cases, a successful treatment was solely assumed by optical or clinical assessment. Therefore, a more accurate and comprehensive analysis of laser effects or a possible ongoing conversion process was nearly impossible. Optical coherence tomography (OCT) is an imaging tool, enabling visualization of the epidermis and the papillary dermis. Its application is pain-free, noninvasive, and allows real-time in vivo imaging of the skin up to a penetration depth of about 2 mm. It was developed in the 1990's and is based on the Michelson interferometry.[12–14] Before its introduction to skin imaging in dermatology in the year 1997, it was primarily used in the field of ophthalmology.[14–18] Dynamic OCT (D-OCT) is an innovative noninvasive further development of OCT and enables real-time visualization of skin vessels, their morphology and the blood flow in vivo, without any known side effects. Therefore, D-OCT appears to be helpful in the evaluation of laser treatment effects on vascular skin lesions. Hence, OCT and D-OCT are rather new imaging tools, so there are only a few case reports available, gathering OCT outcome data for laser treatment of vascular skin lesions.

Dynamic OCT or OCT angiography is based on the conventional OCT and adds repeated measurements of the same spot to the imaging algorithm. During this process, moving pixels are separated from nonmoving ones and are assigned to blood flow (=moving blood cells). The D-OCT image is generated parallel to the structural OCT image and is layered on top. Therefore, an evaluation of the tissue structure as well as of the vessel morphology and blood flow at the same time is possible. Moving structures are depicted by red color, to allow a better differentiation from static tissue. Active blood flow is displayed as a red vessel structure, while the color intensity gets stronger with increasing blood flow.[15,16,18,19]

In this clinical study, we hypothesized that introducing D-OCT as a diagnostic tool to the pre-interventional imaging and follow-up of laser-treated vascular skin lesions would tackle the need for a more comprehensive follow-up and may allow the evaluation of possible ongoing conversion processes in vascular lesions. Provided with objective outcome results, obtained from D-OCT imaging, 595 nm PDL and 1064 nm Nd:YAG laser were compared in terms of treatment efficiency for the named vascular lesions.

TABLE 1 Patients' characteristics.

Patient	Age (years)	Sex	Skin lesion	Laser therapy
1	52	F	T/V/H	PDL/Nd:YAG
2	61	M	T	Nd:YAG
3	70	M	T	Nd:YAG
4	62	F	T/V/H	PDL/Nd:YAG
5	65	M	T	PDL
6	85	F	T	Nd:YAG
7	55	F	T	PDL
8	85	M	T/H	PDL/Nd:YAG
9	67	M	T/H	PDL/Nd:YAG
10	54	F	T/H	PDL/Nd:YAG
11	28	F	T	PDL/Nd:YAG
12	40	F	H	Nd:YAG
13	64	F	V/H	PDL/Nd:YAG
14	45	F	V	Nd:YAG
15	61	F	V/H	PDL/Nd:YAG
16	39	F	V/H	PDL/Nd:YAG
17	39	F	V/H	PDL/Nd:YAG
18	50	F	V	PDL/Nd:YAG
19	64	F	T/V	PDL/Nd:YAG
20	62	F	V/H	PDL/Nd:YAG
21	34	F	V	PDL/Nd:YAG
22	44	F	T/V/H	PDL/Nd:YAG
23	30	F	V/H	PDL/Nd:YAG
24	33	F	V	PDL/Nd:YAG
25	25	F	V/H	PDL/Nd:YAG
26	27	F	V/H	PDL/Nd:YAG
27	66	M	T/V/H	PDL/Nd:YAG

Abbreviations: F, female; H, hemangioma; M, male; Nd:YAG, Nd:YAG laser; PDL, pulsed dye laser; T, telangiectasia; V, spider vein.

MATERIALS AND METHODS

Study population and follow-up

A cohort of 27 adult volunteers (mean: 52 years of age; range: 25–85 years of age) with vascular skin lesions were recruited at the University Hospital Augsburg between

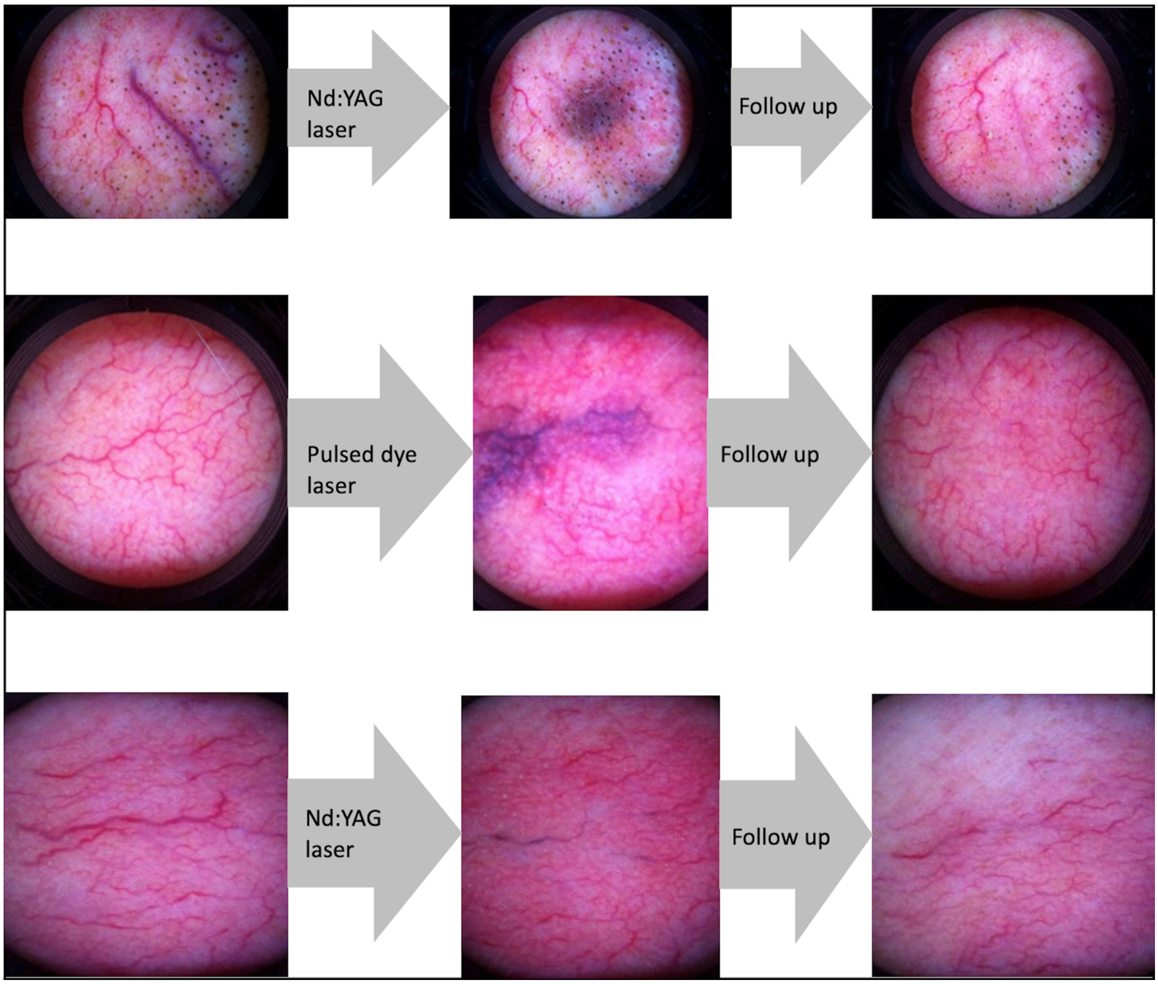

FIGURE 1 Photo documentation of facial telangiectasias using DermLiTe® adapter. Left: before laser therapy. Middle: directly after laser therapy. Right: follow-up after 4–6 weeks.

February and June 2018 (Table 1). Twenty-one of the patients were female, six were male. They all showed either skin type 2 or 3 on the Fitzpatrick scale. A total of 102 vascular skin lesions was randomly chosen by the examiners, including 29/102 telangiectasias, 41/102 spider veins, and 32/102 cherry angiomas (Table 1). Exclusion criteria were applied as follows: dilated vessels treated by laser up to 3 months in advance, pregnancy, tanned skin, and allergic reactions to former laser treatments. All lesions were imaged before the treatment (a), right after treatment (p), and at a follow-up (FU) of 4–6 weeks after laser therapy (pp, Figures 1–3), using D-OCT (Figures 4–6) and by taking clinical and dermoscopy photos, using an Apple® iPhone 4 (Apple) with a DermLite® adapter (3. Gen dl1). By taking clinical and dermoscopic images of the lesion before therapy and using landmarks as a guide, we were able to accurately retrieve lesions even after healing. This study was approved by the local ethics committee (EU Grant No. 621015) and all patients gave informed consent before enrollment.

OCT, D-OCT, and OCT-parameters

In this study, a VivoSight® OCT device with dynamic mode (Michelson Diagnostics), accompanied by the manufacture's software tool was used. The device integrated a class 1 laser providing light of wavelength 1305 nm and a penetration depth of up to 2 mm. The device also featured a handheld probe, providing a 6 mm × 6 mm × 2 mm field of view and can be placed directly on the skin. By this technique, the use of ultrasound gel or other index-matching agents to improve the image quality is obsolete. To optimize the scanning depth and focus range, it is possible to use different kinds of spacers. A single 3D-scan, including 120 cross-sectional pictures (=vertical images) takes about 30 s. During skin imaging, the probe should be held as still as possible in contact to the skin without pressure, to prevent insufficient imaging quality. Besides the cross-section view, an enface view (=horizontal image) can be displayed. Imaging is mostly limited to a depth of 500 µm because of increasing speckle noise

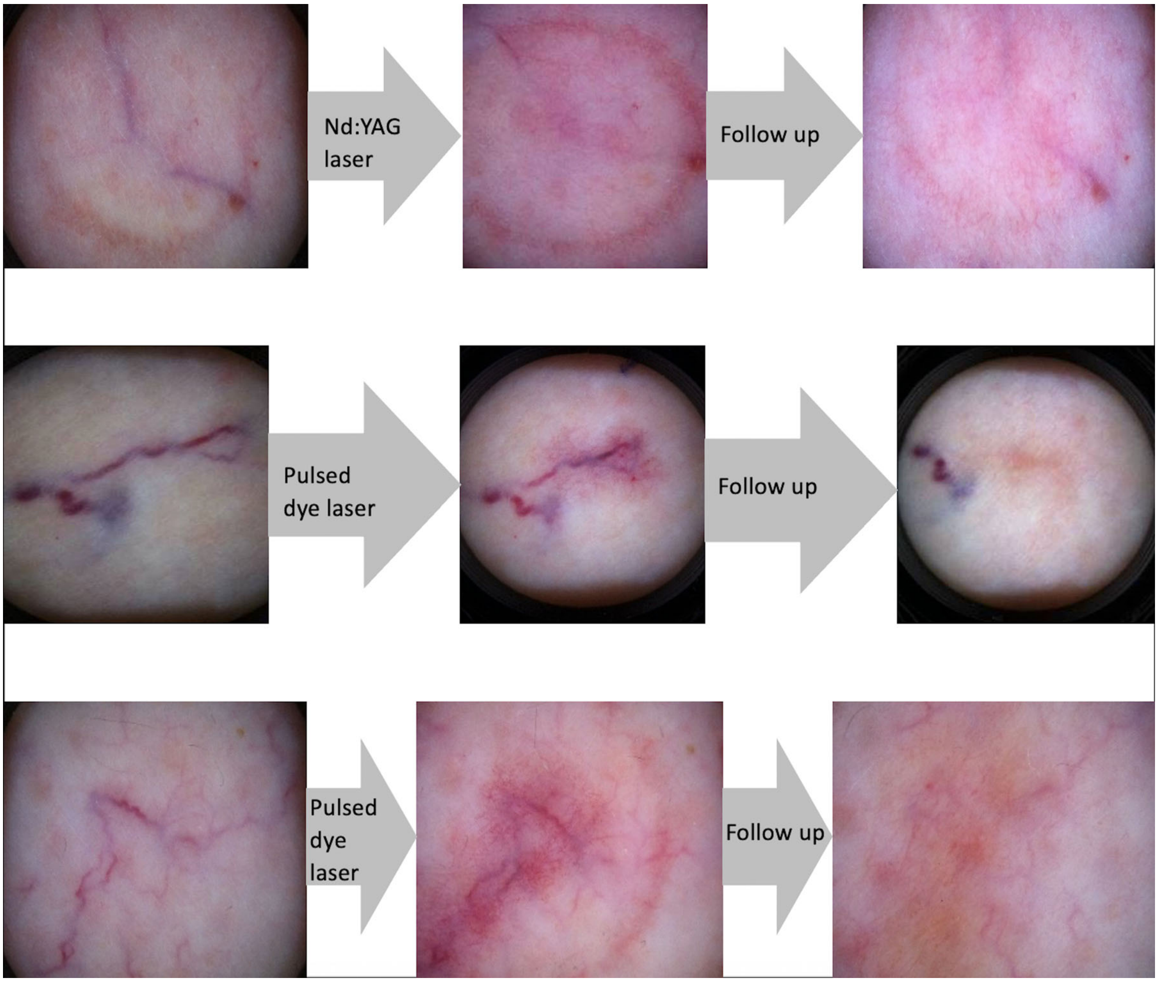

FIGURE 2 Photo documentation of spider veins using DermLiTe® adapter. Left: before laser therapy. Middle: directly after laser therapy. Right: follow-up after 4–6 weeks.

within deeper skin layers. For evaluation of the skin vasculature and possible changes after laser treatment, several parameters were used as following: On the enface view, both parameters, density, and diameter were assessed for three standardized depths (150/300/500 µm). With increasing blood flow, the vessel density (red color) increased as well. The distribution of the vessel density was defined on a 1–3 scale: 0 = *no vessel*, 1 = *sparse*, 2 = *medium*, 3 = *dense intensity*. These parameters were evaluated in relation to the observed vessels and did not include the surrounding ones.

Vessel diameter (of the main vessel) was measured on the same imaging site in all scans (a, p, and pp) and compared to a reference image. The vessel diameter classification was determined on a 1–3 scale: 1 = *small vessel*, 2 = *medium vessel*, 3 = *large vessel*. In cherry angiomas, this parameter did not describe only one vessel, but the whole conglomeration of vessels, which formed the angioma.

In cross-sectional images, three patterns were described: spikes, columns, and top edge of the main vessel. Spikes are small vessels which directly point toward the skin surface. Columns are larger vessels with a higher blood flow. Both patterns were analyzed according to 0 = *no pattern* and 1 = *pattern detectable*. The top edge of the target vessel was measured manually by the examiner. There were several vasculature parameters, which were determined by the OCT software such as plexus depth, density (OCT), and diameter (OCT). All these patterns were averaged to one D-OCT scan, so there was only one value for each scan and no distinction between the target vessel and the surrounding ones.

Laser settings

Each lesion was only treated once during the initial consultation, using either PDL or Nd:YAG laser. Skin lesions were either treated using the VBeam® 595 nm PDL (Candela Corp.) with the following settings: 7 mm spot size; 9.0 J/cm^2 fluence, 3 ms pulse duration; or using the GentleYAG Pro® 1064 nm Nd:YAG laser (Candela Corp.) with the following settings: 6 mm spot size; 130 J/cm^2 fluence; 20 ms pulse duration. The reported laser settings were applied in accordance with the manufacturer's

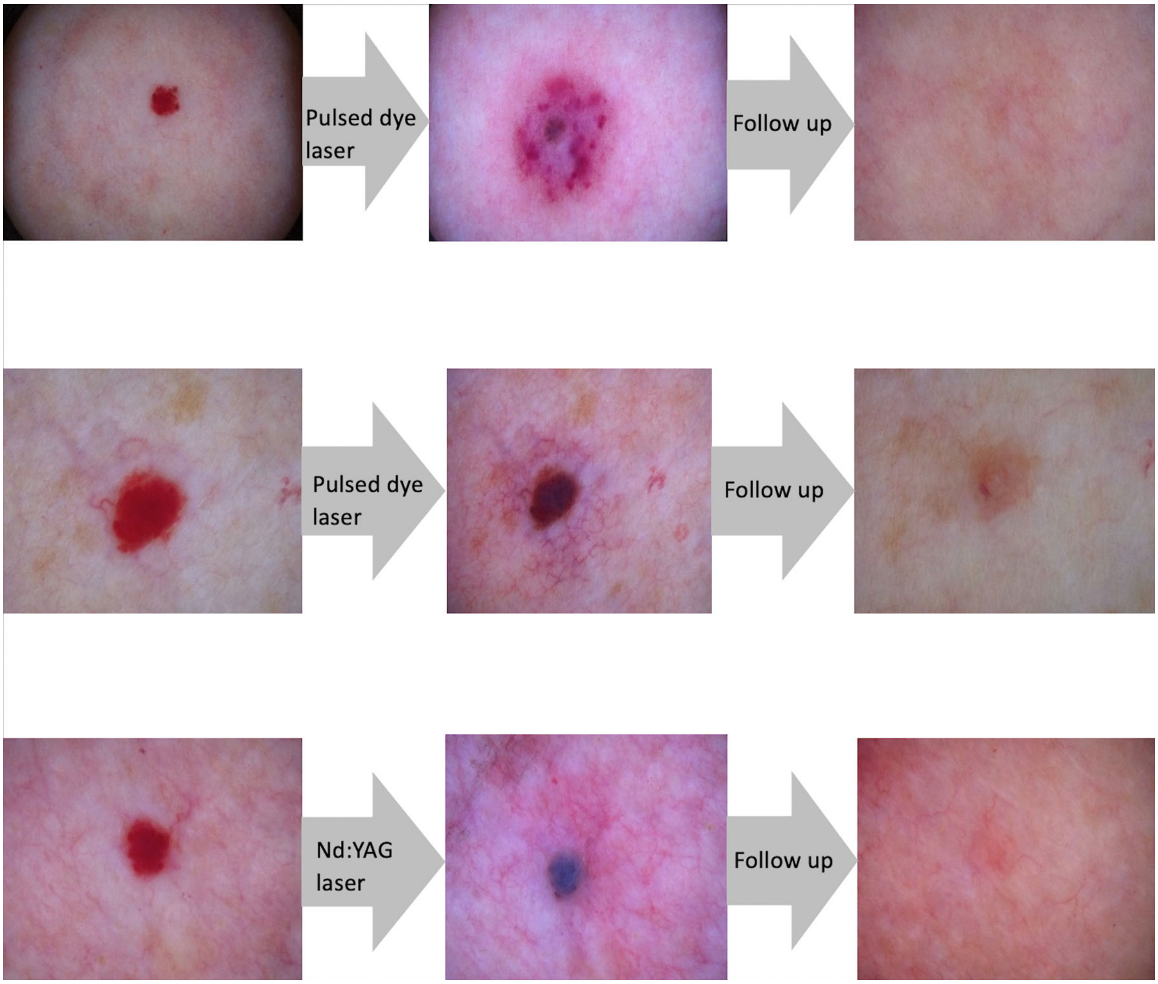

FIGURE 3 Photo documentation of cherry angiomas using DermLiTe® adapter. Left: before laser therapy. Middle: directly after laser therapy. Right: follow-up after 4–6 weeks.

instructions. There was no individual optimization of laser settings to the measured vessel size or depth of the vessel.

RESULTS

All 102 skin lesions were treated with laser therapy and imaged using D-OCT. 51/102 (50%) skin lesions were treated using PDL, 51/102 (50%) were treated using Nd:YAG laser. In the group of telangiectasias 11/29 (37.9%) were treated using PDL and 18/29 (62.1%) using Nd:YAG. For spider veins, 19/41 (46.3%) received treatment with PDL and 22/41 (53.7%) with Nd:YAG. For cherry angiomas, 21/32 (65.6%) were lasered using PDL and 11/32 (34.4%) using Nd:YAG laser (Table 1).

1. ***All lesions: PDL versus Nd:YAG***

   Density: There was a reduction of blood flow in all depths (150/300/500 µm) directly after laser treatment and 6 weeks after, regardless of which laser was used (Figure 7). For PDL, there was a slightly better effect in a depth of 150 µm, compared to 300 and 500 µm. For 300 and 500 µm, the Nd:YAG laser achieved better results (Figure 7).

   Diameter: At the FU examination both laser treatments caused a reduction of the vessel diameter. To some extent, PDL led to a better reduction for all depths (Figure 7).

   Columns and spikes: Six weeks after the laser treatment, a significant reduction of columns was observed for both PDL and Nd:YAG laser, with a slightly better effect in favor of PDL. Spikes were only reduced after application of Nd:YAG laser.

   Top edge of vessels: Both laser types caused a deeper positioning of the vessels in the skin directly after treatment. At the FU, just after PDL treatment the depth increase was statistically significant (Figure 8).

   Density OCT: No significant difference was observed after treatment and after 6 weeks follow-up irrespective of the used laser type.

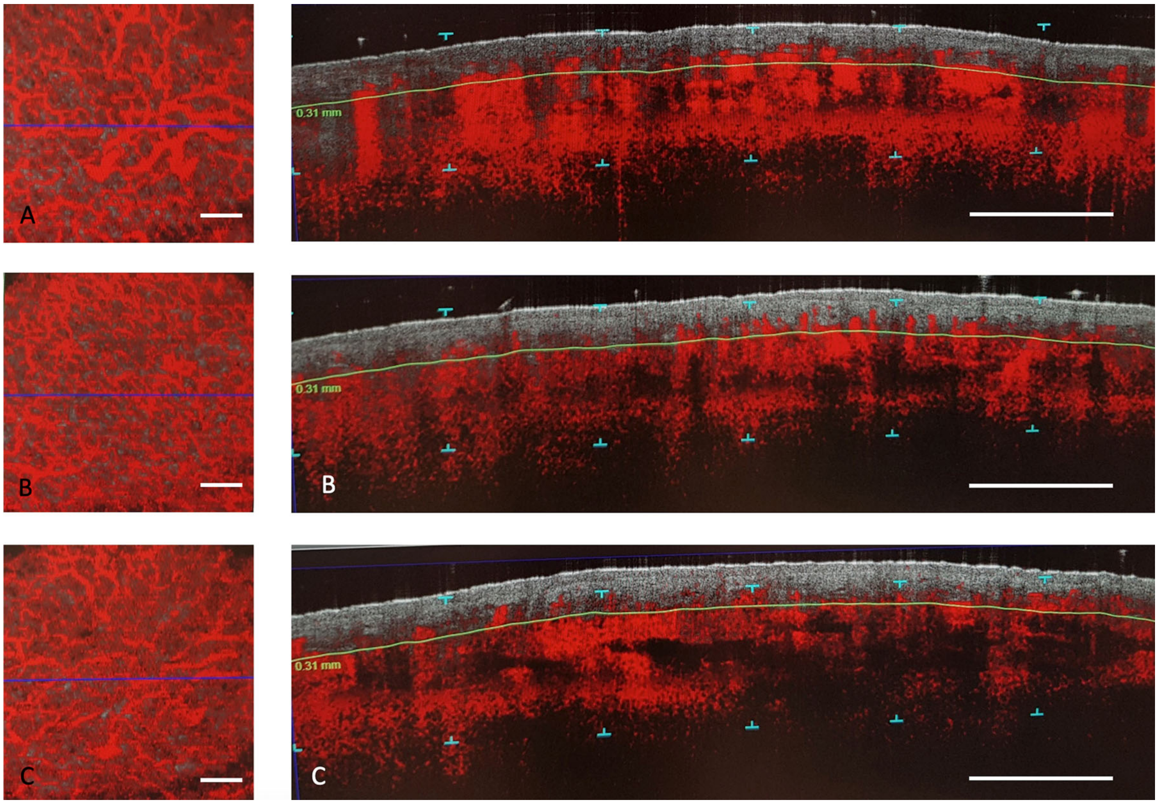

FIGURE 4 Dynamic optical coherence tomography (D-OCT) image of a facial telangiectasia at 310 µm. En-face mode (left; 6 mm × 6 mm). Slice mode (right; 6 mm × 2 mm), scale bar equals 1 mm. (A) Before laser treatment. (B) Directly after laser treatment. (C) Follow-up after 4–6 weeks.

Diameter OCT: A significant reduction for both laser therapies was observed, but to some degree PDL performed better (Figure 9).

Plexus depth: Directly after laser therapy, a decreasing depth of the upper plexus was found. This effect was reversible after 6 weeks.

2. ***Telangiectasia: PDL versus Nd:YAG***

Density: For both lasers, there was a significant reduction of blood flow directly after treatment at 300 µm (Figures 4 and 7). At the FU this observation was no longer detectable (Figure 4). At 500 µm, only the Nd:YAG showed a positive effect on the density directly after treatment. This impact was diminished after 6 weeks as well. There was no impact on density after PDL and Nd:YAG at 150 µm depth.

Diameter: There was a significant reduction of the vessel diameter at 300 µm directly after therapy and after 6 weeks (Figures 4 and 7). In this situation, PDL worked distinctly better than Nd:YAG. Both laser types had a significant impact on the diameter at 500 µm after treatment, but just the Nd:YAG could produce a remaining effect at the FU. There was no impact on diameter after PDL and Nd:YAG at 150 µm depth.

Columns, spikes, top edge: Right after treatment using PDL, a significant reduction of columns was observed. At the FU, this effect was reversible. There was no effect after PDL or Nd:YAG after 6 weeks in comparison to the initial setting. No statistically significant effect was observed for spikes and top edge of vessel. Mean value of the top edge was 154 µm, so no effect at 150 µm depth was expected.

Density (OCT): At the FU just the Nd:YAG laser generated a decreasing blood flow but both laser types achieved no statistically significant effect after laser therapy (Figure 10).

Diameter (OCT): A significant reduction after both laser treatments was examined right after therapy (Figure 11). At the follow-up, there was only a nearly significant difference to the initial findings after Nd:YAG (Figure 11).

Depth of plexus: Directly after Nd:YAG laser treatment, there was a significant decrease of the depth. 12/18 (66.6%) telangiectasias in the facial region showed a more superficial position after 6 weeks. At the FU and after PDL treatment, in only

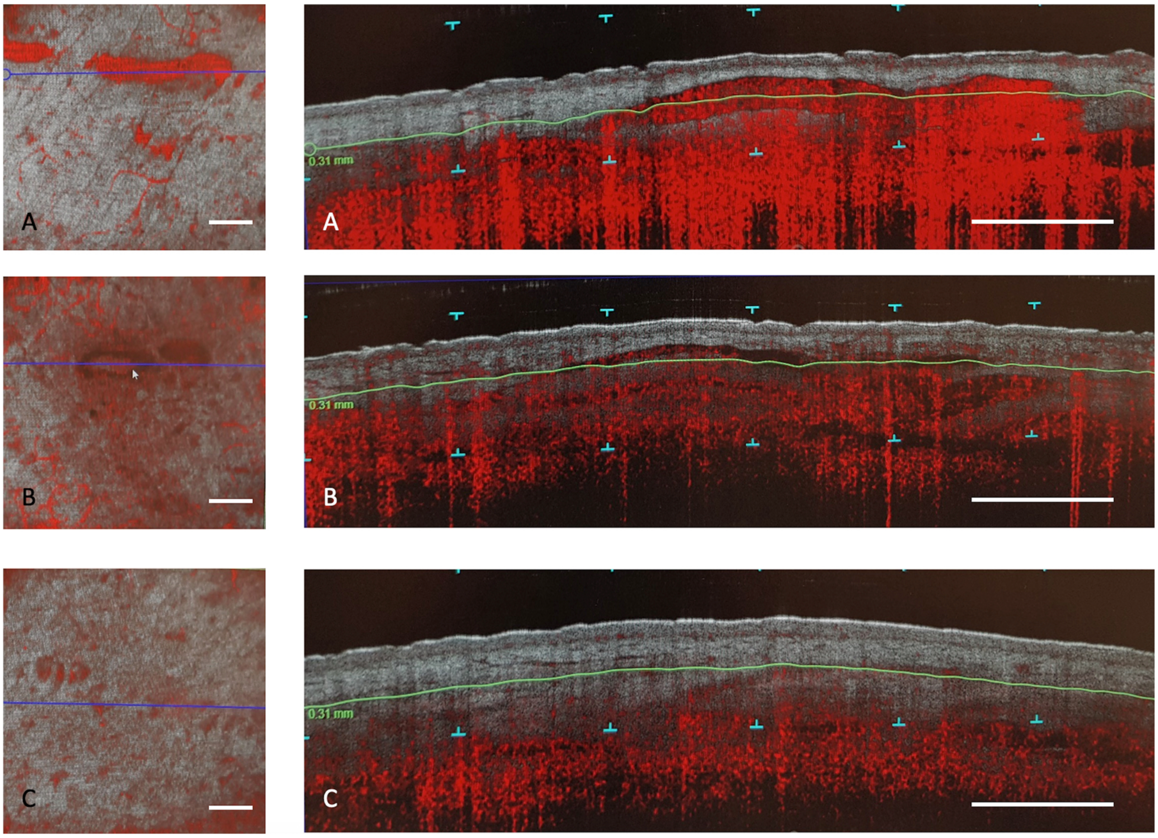

FIGURE 5 Dynamic optical coherence tomography (D-OCT) image of a spider vein at 310 µm. En-face mode (left; 6 mm × 6 mm). Slice mode (right; 6 mm × 2 mm), scale bar equals 1 mm. (A) Before laser treatment. (B) Directly after laser treatment. (C) Follow-up after 4–6 weeks.

5/11 (45.5%) an improvement was observed. For Nd:YAG laser 6/18 (33.3%), for PDL 6/11 (54.5%) lesions showed an increasing depth.

3. ***Spider vein: PDL versus Nd:YAG***

The mean top edge of spider veins was calculated with 252 µm, therefore no statistically significant effect was expected at 150 µm.

Density: For Nd:YAG laser, a significant reduction of blood flow was observed in a depth of 300 and 500 µm directly after treatment and after 6 weeks FU (Figures 5 and 7).

Diameter: Diameter was reduced significantly after both laser therapies (directly, after 6 weeks FU) at both depths (300/500 µm) (Figures 5 and 7). Effects after PDL were slightly better.

Columns, spikes, top edge: There was a significant impact on the columns 6 weeks after laser therapy, but no effect on spikes and the top edge of vessels.

Density (OCT): Right after laser therapy, both lasers caused an increasing blood flow in the tissue. After 6-week FU this effect was reversed, so in comparison to the initial findings there was no statistically significant difference.

Diameter (OCT): Only PDL treatment caused a reduction of the vessel diameter from 13/19 (68.4%) at the follow-up (Figure 12).

Depth of plexus: Directly after therapy and for both lasers, the plexus was located more superficial within the skin layers (Figure 13). At the FU after 6 weeks, the plexus lay slightly deeper than before therapy, but the effect was not statistically significant (Figure 13).

4. ***Cherry angioma: PDL versus Nd:YAG***

Density: At 150 µm and directly after treatment, both laser types affected the blood flow in a positive way. At the FU, only PDL could reproduce this impact. In 20/21 (95.2%) angiomas, the blood flow was reduced by PDL. At 300 µm, a decreasing blood flow at the FU after both therapies was witnessed (Figure 6 and Figure 7). At 500 µm, only PDL showed a significant positive effect after 6 weeks.

Diameter: A significant difference was found at 150 µm at the FU for both therapies in comparison to

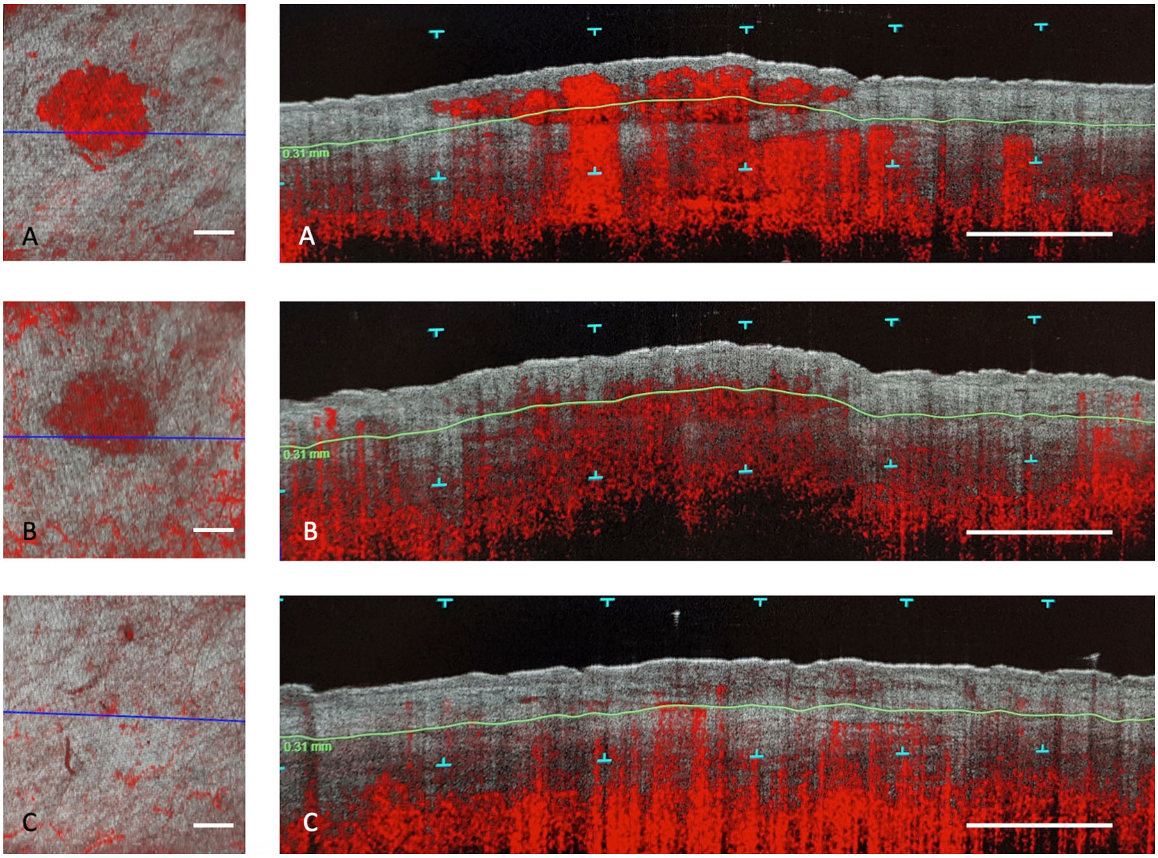

FIGURE 6 Dynamic optical coherence tomography (D-OCT) image of a cherry angioma at 310 µm. En-face mode (left; 6 mm × 6 mm). Slice mode (right; 6 mm × 2 mm), scale bar equals 1 mm. (A) Before laser treatment. (B) Directly after laser treatment. (C) Follow-up after 4–6 weeks.

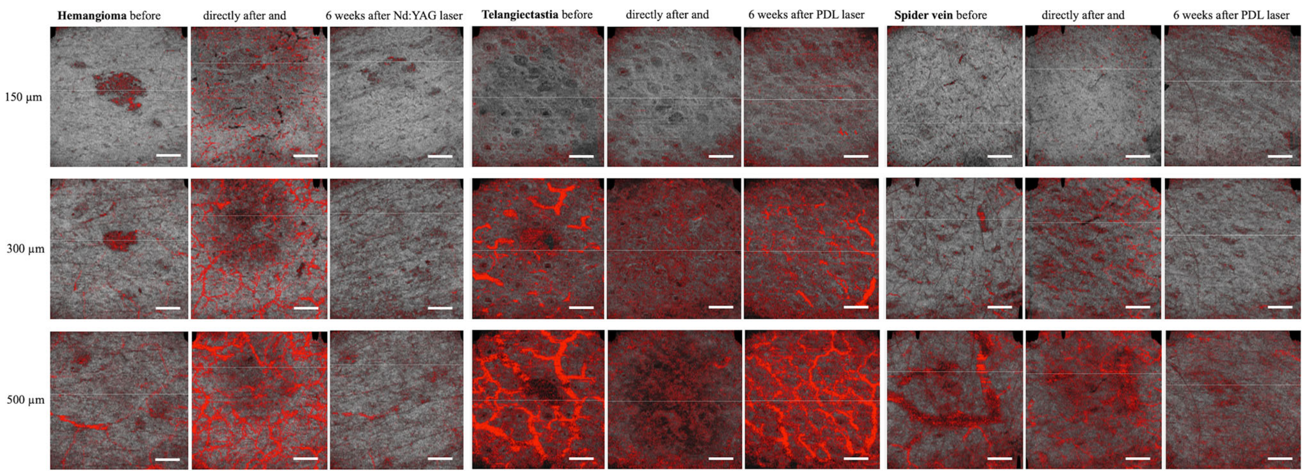

FIGURE 7 Dynamic optical coherence tomography (D-OCT) images of a hemangioma at 150, 300, and 500 µm after Nd:YAG laser therapy, of a telangiectasia at 150, 300, and 500 µm after pulsed dye laser (PDL) laser therapy and of a spider vein at 150, 300, and 500 µm after PDL laser therapy; scale bar equals 1 mm.

the initial findings (Figure 7). Only the PDL affected the diameter at 300 and 500 µm statistically significant in a positive way.

Columns, spikes, top edge: Only PDL treatment, led to a significant reduction of columns after therapy and at the follow-up. There was no effect on spikes irrespective of the laser type used. For both laser types and, right after treatment, the top edge of the vessels, was found significantly deeper than before the treatment (Figure 14). At the FU this effect was reversible, so there was no statistically significant

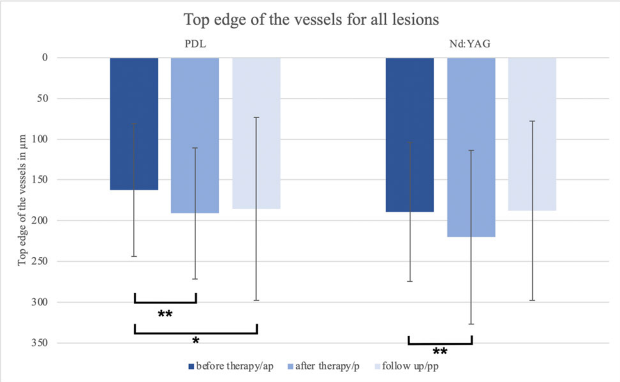

FIGURE 8 Mean value ± standard deviation of the top edge of the vessels for all lesions. *$p < 0.025$: ap–pp, **$p < 0.025$: ap–p.

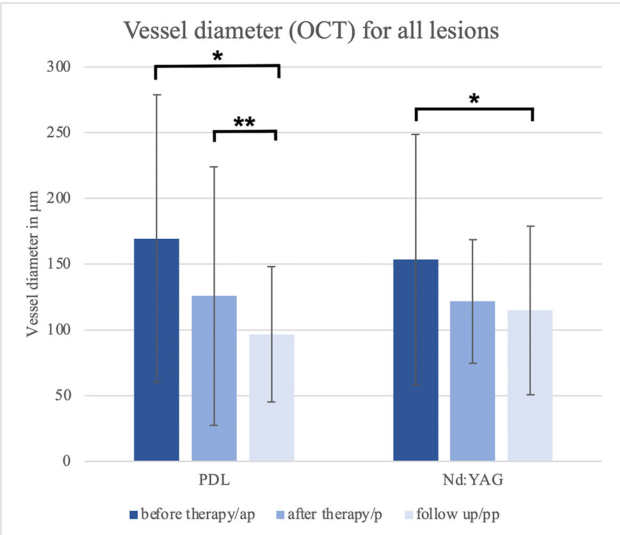

FIGURE 9 Mean value ± standard deviation of the vessel diameter (optical coherence tomography) for all lesions. *$p < 0.025$: ap–pp, **$p < 0.025$: ap–p.

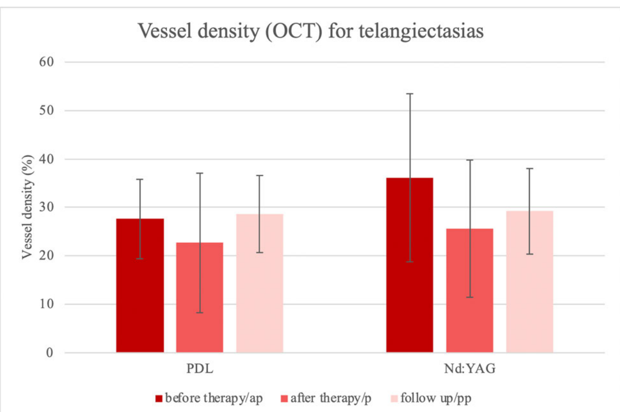

FIGURE 10 Mean value ± standard deviation of the vessel density (optical coherence tomography) for telangiectasias.

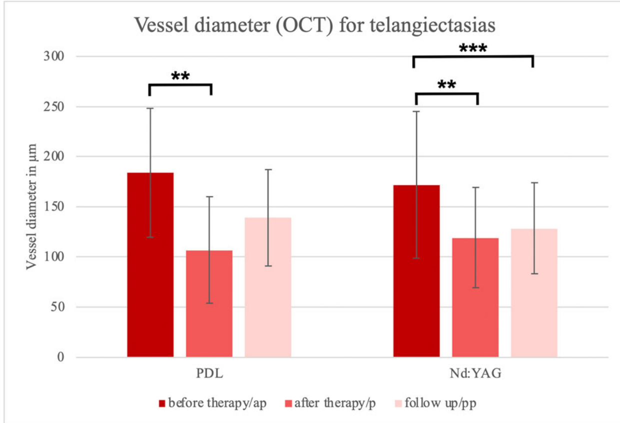

FIGURE 11 Mean value ± standard deviation of the vessel diameter (optical coherence tomography) for telangiectasias. **$p < 0.025$: ap–p, ***$p < 0.025$: p–pp.

improvement in comparison to the initial findings (Figure 14).

Density (OCT): Only right after Nd:YAG therapy, there was a significant increase of blood flow. Particularly, the outer regions of the vessel conglomeration showed a vascular dilation.

Diameter (OCT): Both laser types caused a reduction of the vessel diameter right after therapy and at the FU, but only for PDL, there was a statistically significant effect (Figure 15).

Depth of plexus: Right after treatment the plexus was located higher within the skin layers in contrary to the FU, where no significant difference to the finding before therapy was detected.

DISCUSSION

Laser therapy is a well-established therapy modality in the treatment of skin lesions caused by dilated vessels and its beneficial impact was proven in several clinical trials. In 1993, Ruiz-Esparza et al. treated mainly facial telangiectasias with a PDL and could evoke good to very good results after just one consultation.[20] In 2002, Rogachefsky et al. published their results of a clinical trial in which they treated telangiectasias and reticular veins on the legs using Nd:YAG laser. 71% of all treated vessels showed significant improvement.[10] Pancar et al. examined cherry angiomas from 45 volunteers, which were treated with Nd:YAG laser in 2011. Good results were reported after a single treatment for 44 patients.[9]

The named clinical trials suggest the beneficial use of laser treatment for small, dilated vessels. Still, satisfactory therapy outcome was only assessed by visual and/or clinical examination in the majority of the published

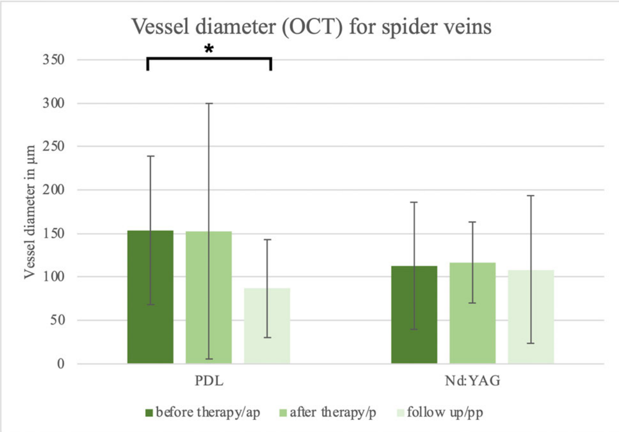

FIGURE 12 Mean value ± standard deviation of the vessel diameter (optical coherence tomography) for spider veins. *$p < 0.025$: ap–pp.

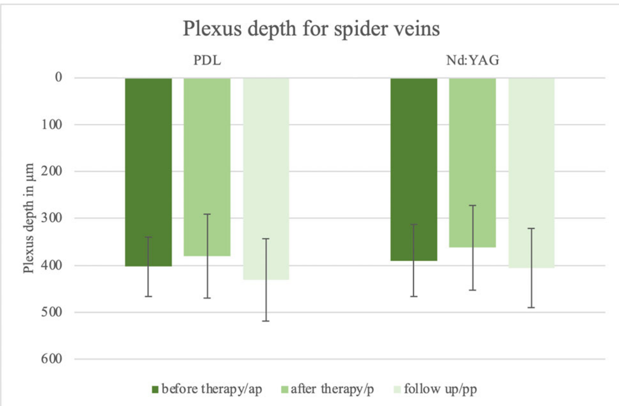

FIGURE 13 Mean value ± standard deviation of the plexus depth for spider veins.

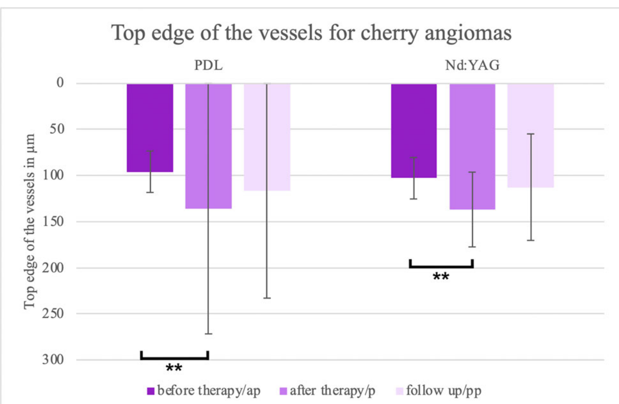

FIGURE 14 Mean value and standard deviation of the top edge of the vessels for cherry angiomas. **$p < 0.025$: ap–p.

cases. Therefore, collection of unambiguous data for objectified evaluation of the treated vessels and their changes throughout the FU was challenging or even impossible.

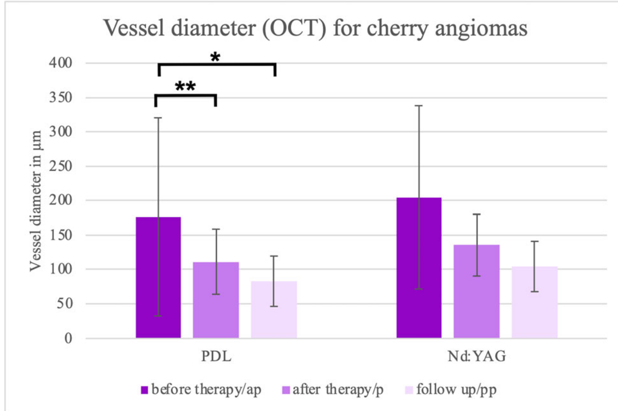

FIGURE 15 Mean value and standard deviation of the vessel diameter (optical coherence tomography) for cherry angiomas. *$p < 0.025$: ap–pp, **$p < 0.025$: ap–p.

In this clinical case study, we were able to proof that PDL and Nd:YAG laser are suitable therapy modalities for the treatment of superficial dilated vessels. Overall, the most significant effect was found for cherry angiomas, regardless of the laser type, but PDL generating slightly better results. In contrary, there was almost no statistically significant effect on facial telangiectasias. In a clinical trial, conducted by Gao et al., the beneficial use of PDL for facial ectasias in a cohort of 160 patients was proven.[21] In comparison to our study, Gao et al. used longer pulse duration and more treatment cycles. So, more light could act on the target chromophore and therefore had a greater effect.[21]

For small varicose veins, both laser types had a positive effect on blood flow and diameter. Nd:YAG laser treatment demonstrated better results on deeper vessels, while PDL showed a higher impact on superficial vessels. This may be explained by the fact, that the Nd:YAG laser emits light of wavelength 1064 nm, which penetrates deeper into the tissue and therefore probably has a better effect on deeper lying vessels with higher diameter.[11] PDL emits light of wavelength 595 nm with oxyhemoglobin being the targeted chromophore. Therefore, superficially located vessels are the main target of this laser.[1,2] These findings correspond to a clinical study conducted by Christiansen et al., where a significant improvement of 28 leg telangiectasias after Nd:YAG therapy was demonstrated. In contrast, in this study laser parameters were adapted to the treated vessels or the desired outcome.[6]

CONCLUSION

To get meaningful evidence, which laser performs better for which lesion, further studies with a larger cohort, a longer FU period, adaptable laser parameters and more cycles of laser therapy are required. Nevertheless, D-OCT is a valuable imaging technique to evaluate vessel morphology, blood flow, and repercussion of laser therapy without any known negative side effects. From our findings we suggest that D-OCT may be a helpful imaging tool to optimize and personalize laser treatment parameters to prevent ineffective laser treatment and to reduce negative side effects to the patients' health eventually.

ACKNOWLEDGMENTS

Open Access funding enabled and organized by Projekt DEAL.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ORCID

Katrin Harst http://orcid.org/0000-0001-9070-6688
Julia Welzel http://orcid.org/0000-0002-6099-7418
Sandra Schuh http://orcid.org/0000-0002-1470-7619

REFERENCES

1. Hare McCoppin HH, Goldberg DJ. Laser treatment of facial telangiectases: an update. Dermatol Surg. 2010;36(8):1221–30.
2. Kwon WJ, Park BW, Cho EB, Park EJ, Kim KH, Kim KJ. Comparison of efficacy between long-pulsed Nd:YAG laser and pulsed dye laser to treat rosacea-associated nasal telangiectasia. J Cosmet Laser Ther. 2018;20(5):260–4.
3. Aghassi D, Anderson RR, Gonzlez S. Time-sequence histologic imaging of laser-treated cherry angiomas with in vivo confocal microscopy. J Am Acad Dermatol. 2000;43(1 Pt 1):37–41.
4. Raulin C, Karsai S. Lasertherapie der Haut. Berlin, Heidelberg: Springer; 2013. p. 182.
5. Adamič M, Troilius A, Adatto M, Drosner M, Dahmane R. Vascular lasers and IPLS: guidelines for care from the European Society for Laser Dermatology (ESLD). J Cosmet Laser Ther. 2007;9(2):113–24.
6. Christiansen K, Drosner M, Bjerring P. Optimized settings for Nd:YAG laser treatments of leg telangiectasias. J Cosmet Laser Ther. 2015;17(2):69–76.
7. McCoppin HH, Hovenic WW, Wheeland RG. Laser treatment of superficial leg veins: a review. Dermatol Surg. 2011;37(6):729–41.
8. Wheeland RG. Clinical uses of lasers in dermatology. Lasers Surg Med. 1995;16(1):2–23.
9. Pancar GS, Aydin F, Senturk N, Bek Y, Canturk MT, Turanli AY. Comparison of the 532-nm KTP and 1064-nm Nd:YAG lasers for the treatment of cherry angiomas. J Cosmet Laser Ther. 2011;13(4):138–41.
10. Rogachefsky AS, Silapunt S, Goldberg DJ. Nd:YAG laser (1064 nm) irradiation for lower extremity telangiectases and small reticular veins: efficacy as measured by vessel color and size: efficacy as measured by vessel color and size. Dermatol Surg. 2002;28(3):220–3.
11. Ross EV, Domankevitz Y. Laser treatment of leg veins: physical mechanisms and theoretical considerations. Lasers Surg Med. 2005;36(2):105–16.
12. Fujimoto JG. Optical coherence tomography for ultrahigh resolution in vivo imaging. Nat Biotechnol. 2003;21(11):1361–7.
13. Mogensen M, Thrane L, Joergensen TM, Andersen PE, Jemec GBE. Optical coherence tomography for imaging of skin and skin diseases. Semin Cutan Med Surg. 2009;28(3):196–202.
14. Welzel J. Optical coherence tomography in dermatology: a review. Skin Res Technol. 2001;7(1):1–9.
15. Schuh S, Holmes J, Ulrich M, Themstrup L, Jemec GBE, De Carvalho N, et al. Imaging blood vessel morphology in skin: dynamic optical coherence tomography as a novel potential diagnostic tool in dermatology. Dermatol Ther. 2017;7(2):187–202.
16. Ulrich M, Themstrup L, de Carvalho N, Manfredi M, Grana C, Ciardo S, et al. Dynamic optical coherence tomography in dermatology. Dermatology. 2016;232(3):298–311.
17. Welzel J, Lankenau E, Birngruber R, Engelhardt R. Optical coherence tomography of the human skin. J Am Acad Dermatol. 1997;37(6):958–63.
18. Welzel J, Schuh S. Optische Kohärenztomographie bei Pathologien der Haut. Ophthalmologe. 2018;115(6):524–7.
19. Themstrup L, Welzel J, Ciardo S, Kaestle R, Ulrich M, Holmes J, et al. Validation of dynamic optical coherence tomography for non-invasive, in vivo microcirculation imaging of the skin. Microvasc Res. 2016;107:97–105.
20. Ruiz-Esparza J, Goldman MP, Fitzpatrick RE, Lowe NJ, Behr KL. Flash lamp-pumped dye laser treatment of telangiectasia. J Dermatol Surg Oncol. 1993;19(11):1000–3.
21. Gao L, Qu H, Gao N, Li K, Dang E, Tan W, et al. A retrospective analysis for facial telangiectasia treatment using pulsed dye laser and intense pulsed light configured with different wavelength bands. J Cosmet Dermatol. 2020;19(1):88–92.

How to cite this article: Harst K, Welzel J, Schuh S. How efficient is laser therapy for telangiectasias, spider veins, and cherry angiomas?—A study using dynamic optical coherence tomography. Lasers Surg Med. 2023;55:625–635. https://doi.org/10.1002/lsm.23676