CASE REPORT

RED LIGHT-EMITTING DIODE (LED) THERAPY-ASSISTED HEALING IMPROVES RESULTS OF Er:YAG LASER ABLATION OF PLANTAR VERRUCAE

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The aim of this study was to evaluate red light-emitting diode (LED) therapy to assist wound healing and pain attenuation following Er:YAG ablation of plantar verrucae. Over the past two-and-a-half years, the principal author (MAT) has treated 141 cases of plantar warts under local anesthesia in 133 patients with Er:YAG laser ablation followed by red light therapy to assist wound healing. The Er:YAG laser (29 J/cm^2, 2.0 J/pulse, 350 μs pulsewidth, 3 mm collimated handpiece) is used first to precisely ablate the verrucous tissue till normal architecture is seen. Immediately after treatment a red LED therapy system is applied (633 nm, 20 min, 126 J/cm^2) to the wound and surrounding area. LED therapy at the same parameters is repeated on postoperative days 2, 3, 6 and 10. A representative plantar verruca case is presented. Following precise and clean ablation of the plantar verrucae with clear margins into normal skin architecture with the Er:YAG system, minimal secondary thermal damage is seen: the LED system is then immediately used at the above parameters. After the first treatment session, patients are usually able to walk normally without any pain, even those who have bilateral verrucae, and no exudate is usually seen from postoperative day 3 and thereafter, which is in the authors' experience completely different from cases treated with laser ablation only, whether CO_2 or Er:YAG. By postoperative day 6 the wounds have shrunk noticeably and are filled with healthy granulation tissue, and by day 15 they have usually completely healed with minimal scarring. At the 12-month follow-up recurrence rates have been less than 8% (11/141). From the authors' experience in 141 cases, visible red LED therapy has given excellent and pain-free healing in these difficult-to-treat lesions with very low recurrence rates following Er:YAG laser precise and speedy ablation of plantar verrucae with minimal thermal damage to surrounding tissue.

Key words: Verruca pedis, pain control, red LED therapy, wound healing, Er:YAG ablation, athermal phototherapy

Introduction

Verrucae, and plantar verrucae in particular, have been long recognized as being problematic lesions to treat successfully, with high recurrence rates. The use of carbon dioxide laser surgery offered better treatment and lowered recurrence rates,[1-3] but plantar warts (verruca pedis) tended to be more recalcitrant than in the case of common warts (verruca vulgaris). The Er:YAG laser offered even better treatment, but plantar warts still accounted for the highest recurrence rates.[4] However, the addition of a topical cytostatic (antimitotic) preparation (podophyllotoxin) in combination with the Er:YAG laser was reported to improve the plantar wart recurrence rates.[5] The author believed that the use of higher fluences and repetition rates would speed up the procedure and minimize viral dissemination. Coupled with this, the antiviral properties of red laser energy have been successfully demonstrated,[6,7] in addition to the efficacy of light in the red waveband for enhancing wound healing and attenuating pain and discomfort.[8] The recent development of higher-powered and quasimonochromatic light-emitting diodes (LEDs)[9] has added a new tool to the surgeon's phototherapeutic armamentarium. We present herein red LED phototherapy to control postoperative pain, accelerate wound healing and as a possible antiviral therapy to help prevent recurrence following the application of Er:YAG laser ablation for plantar verrucae. A representative case report is presented.

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Subjects and Methods

Over the past 2-an-a-half years, 504 cases of verrucae have been treated in 405 patients (225 males, 180 females, mean age 58±5.85 yrs, range 12 yrs to 75 yrs) with Er:YAG ablation followed by red light therapy. For the first 6 months, the 633 nm red phototherapy was delivered by a scanned HeNe laser, and for the last 2 years by a 633 nm LED-based phototherapy system. There have been 222 cases of verrucae of the hands and arms, 141 cases of plantar verrucae, 96 on the legs and knees, 36 on the arms and 9 on the elbows. The 141 plantar verrucae in 133 patients formed the subjects for this study.

Er:YAG Laser

With the verruca under general anesthesia with epinephrine, the Er:YAG laser is indicated (Derma-K, Lumenis, Yokneam, Israel), set to 29 J/cm^2, 2.0 J/pulse, 350 μs pulsewidth, repetition rate of 12 Hz, and is used with the 3 mm collimated handpiece. Starting in the center of the macroscopically visible part of the wart and working out towards the periphery and down into the affected tissue, the verrucous tissue is cleanly and precisely ablated layer by layer till normal tissue architecture, identified with the help of magnifying loupes can be seen on the sides and base of the wound. A dedicated surgical suction system is used to evacuate the somewhat considerable plume created by the Er:YAG laser, and the surgeon and staff all wear surgical masks. The wound is usually larger in area than is apparent from the macroscopic appearance of the wart pretreatment, quite deep and very clean, and there are no macroscopic signs of secondary thermal damage as might be expected with the CO_2 laser.

Fig 1: Phototherapy of the treated area with the Omnilux revive 633 nm red LED-based system.

Red LED therapy system

Immediately after Er:YAG treatment, a red LED-based phototherapy system (Omnilux© revive®, Photo Therapeutics, Fazely, UK) is applied to the treated area (633 nm, 126 J/cm^2, 20 min) as seen in Figure 1. The patient usually returns for further LED therapy session at the same parameters on postoperative days 2, 6 and 10.

Wound care

After the first LED session, the wound is dressed with flumetasone gentamycin (Flutanol®) ointment and a

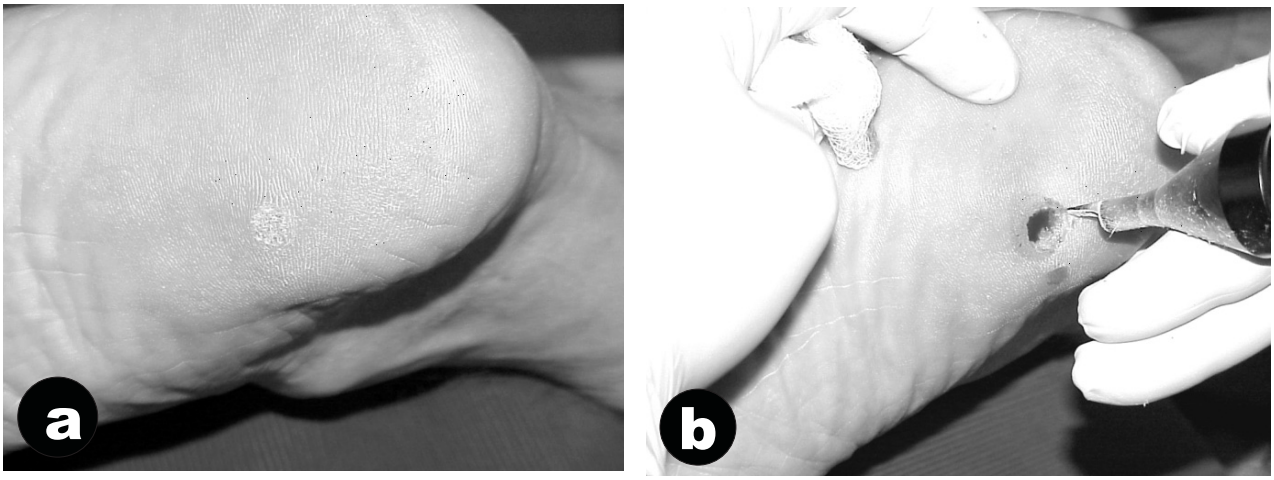

Fig 2: Pre- and intraoperative findings in a plantar wart on the left heel of a 71-year-old male. **(a):** Preoperative condition. **(b):** Immediately postoperatively, the lesion circumference is much larger than the pretreatment macroscopic findings would have suggested, but despite the lack of residual thermal damage associated with the Er:YAG laser, no bleeding is seen yet. Note the flakes of laser plume adhering to the handpiece.

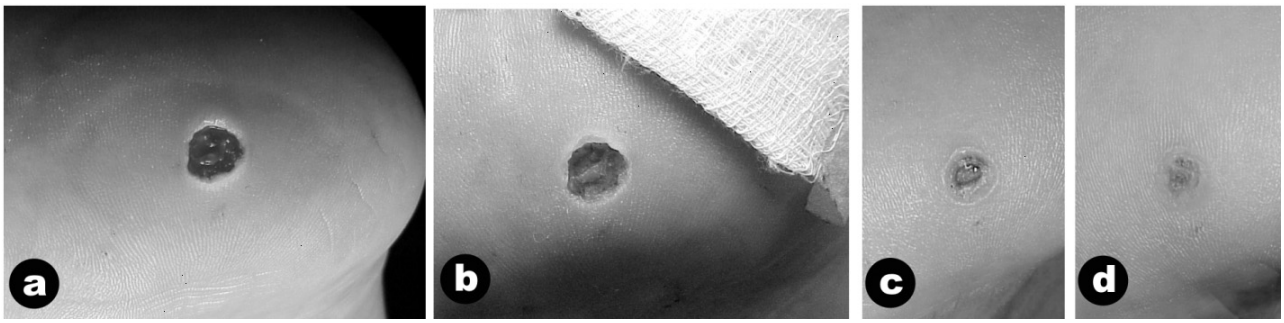

Fig 3: The postoperative evolution of the wound. **(a):** Forty-eight hours after surgery the wound is extremely clean and clear of exudate, with no signs of thermal necrosis at the wound margins. **(b):** Three days postoperatively, all exudation has stopped as seen from the condition of the gauze dressing in place since the previous day. Granulation tissue is starting to appear in the wound bed. **(c):** At 6 days postoperatively, the wound has started to close withy reepithelization advancing from the wound margins. **(d):** The wound has almost closed by the 10th postoperative day.

gauze pad to gather the exudate, and covered with sterile cling film [Easy Dressing[10]] in the occlusive dressing technique. Patients return 48 hours later, the dressing is removed, the wound gently patted dry with gauze, and the wound redressed following the second session of red LED therapy at the same parameters as for the first session. Patients return on the following day (postoperative day 3), and the dressing is removed. From this point on no dressing is used. Patients return for wound follow-up on postoperative days 6, 10 and 15, then at 1, 3 and 6 months after the operation.

Representative case report:

The patient was a 71-year-old male with a plantar wart on his left heel, which had first appeared 3 years previously, but had started to enlarge and become painful causing gait disturbance. The pretreatment findings are seen in Figure 2a. The Er:YAG laser was indicated as described above. The findings after ablation are seen in Figure 2b, with minimal bleeding. Immediately after the Er:YAG treatment, the red LED therapy system was used at the parameters described above, and the wound was dressed as described with the Easy Dressing technique.[10] Following dressing of the wound, the patient was able to walk without any problem, and was virtually pain free.

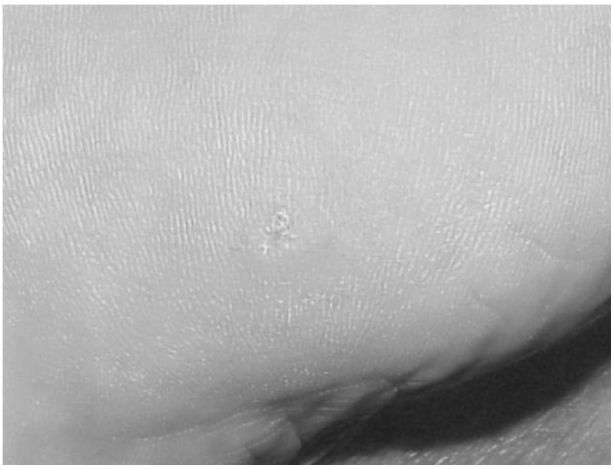

Fig 4: Skin condition is excellent by the 15th postoperative day, with clearly visible normal skin lines and minimal scarring.

The patient returned 48 hours later, the dressing was removed and the wound gently patted dry with gauze, (Figure 3a) followed by red LED therapy, and the wound was redressed. The patient was now totally pain free, and walking normally with normal weight-bearing on the affected heel.

On postoperative day 3, the gauze pad revealed no exudate (Figure 3b) and no further dressing was applied thereafter. The patient received LED therapy at his request, and then again on postoperative days 6 and 10 by which time the wound was clearly healing well (Figure 3c and 3d).

Figure 4 shows the excellent condition at postoperative day 15. At the time of writing, with a 6-month follow-up, there has been no sign of recurrence.

Discussion

Although the CO_2 laser quickly became popular for the removal of verrucae in the 1980's and 1990's, and was certainly more successful than conventional methods, recurrence was still seen particularly in recidivist plantar warts. In addition, the characteristics of the CO_2 laser/tissue interaction at 10,600 nm give some degree of coagulation of the surrounding tissue, known now as residual thermal damage (RTD), and while this certainly assures a dry field, it also tends to somewhat compromise swift wound healing because of the zone of photothermally-damaged and compromised tissue around the

wound which lengthens the wound healing process since the RTD is itself an extension of the actual wound.

The Er:YAG laser, on the other hand, has a much higher absorption rate in water at 2,940 nm than the CO_2, almost 10 times higher, so that it can very rapidly, accurately and cleanly ablate tissue with absolutely minimal deposition of a few micrometers of RTD.[11,12] When this very important characteristic is coupled with an extremely high power density (29 J/cm^2 for 350 μs gives a power density just under 83,000 W/cm^2) and the high repetition rate (12 Hz) used in this case, not only is the entire procedure accomplished extremely rapidly, but despite the lack of coagulation in surrounding tissues, the field remains dry and bleeding does not occur until later as can be seen in Figure 1b where the dry field is visible. In previous reports the parameters have been much lower, such as a repetition rates of 8 to 15 Hz and fluences from about 5 to 11 J/cm^2 with the same 3 mm diameter spot size.[4,5] At the parameters in the present study with a fluence almost 3 times the maximum in the previously quoted study, the entire procedure is extremely rapid so that viral dissemination is minimized, and cytostatic preparations have not been required.

Very often plantar warts, particularly those of the heel, are much deeper and involve much more tissue than their macroscopic appearance would suggest,[13] the so-called pyramidal effect. Because the Er:YAG allows the surgeon to ablate layer by later until normal tissue architecture can be seen and accurately identified because of the lack of RTD, all of the verrucous tissue can be eliminated particularly if magnifying loupes are used to aid in identification between verrucous and normal architecture, an important consideration in preventing recurrence.

Fig 5: The laser plume generated by the Er:YAG laser as a result of the almost explosive laser/tissue interaction associated with this wavelength. This is picture not taken from the present case but from a case of Becker's Nevus treated with the Er:YAG laser.(16) The need for efficient smoke evacuation, filtration and a surgical mask is clear for all in the treatment room.

The Er:YAG laser, due to its almost explosive light/tissue interaction, creates a considerable plume of smoke, steam and feathery tissue fragments (Figure 5), which can also be seen adhering to the handpiece in Figure 2b. Considerable evidence has appeared that the CO_2 laser plume contains viable viral particles, with laser surgeons and nurses reporting papilloma infections of the airways and hands following CO_2 laser ablation of warts.[14,15] It has, however, been suggested that no viable fragments of papilloma viral DNA were found in the Er:YAG plume.[16] From the point of comfort, however, even aside from that of safety, when working with the Er:YAG in viral or otherwise infected tissue, a dedicated powerful evacuation system is a must as is the use of masks.

As for the 633 nm red LED therapy, a considerable body of evidence already exists regarding the efficacy of the HeNe laser at 632.8 nm used in low level laser therapy (LLLT) in a variety of fields pertinent to the current case, such as in pain attenuation, wound healing and antiviral properties. The energy density delivered by the LED therapy system used in the present study (126 J/cm^2 over an active area of approximately 400 cm^2) is well over that delivered by HeNe laser systems, and it is neither scanned nor applied in a point-by-point manner. Accordingly the photon energy delivered is clinically very useful, and the system is operated in the hands-off manner allowing the clinician to attend to other patients while the LED therapy is being delivered. At 15 days after the surgery, the wound had healed with an almost invisible scar and a very nicely regenerated epithelium (Figure 3). Other authors have suggested a longer healing time,[3] and more scarring than we saw in our patient, who was in fact 71 years of age at which stage wound healing tends to slow down in any event. Three months has been suggested as the 'danger zone' for recurrence,[4] but after a 6-month follow-up no recurrence can be seen in our patient.

Conclusion

Although this retrospective study was not controlled, from the previous extensive experience of the author with his treatment of verrucae, particularly plantar verrucae, over several years previous to the application of the Er:YAG/red LED therapy combination, it is clear that this combination gives superior results in all aspects of patient comfort and quality of life, pain control,

wound healing and recurrence. This combination of ablative laser and athermal phototherapy would appear to be an excellent alternative to other treatment modalities for plantar warts.

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