

## REVIEW ARTICLE

# Laser and light therapy for facial warts: a systematic review

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## Abstract

Facial verruca plana, or flat warts, are benign skin papillomas caused by human papillomavirus infections. A large portion of cases are refractory to treatment and can cause psychosocial distress in patients. Laser and light modalities offer an alternative therapeutic approach that has not been extensively explored. We systematically reviewed PubMed for studies describing treatment of facial verruca plana using lasers, photodynamic therapy and infrared coagulation. Final inclusion and review of eighteen studies suggests laser and light therapies to have considerable potential in the treatment of this recalcitrant condition. In particular, yttrium aluminium garnet lasers, infrared coagulation and photodynamic therapies have been reported to demonstrate efficacy. Further studies with larger power are required to determine which method should be established as the alternative treatment of choice for recalcitrant facial verrucae.

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## Conflicts of interest

None declared.

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## Introduction

Cutaneous warts (verrucae) are benign skin papillomas caused by human papillomavirus (HPV) infections. Verrucae most often occur in paediatric and young adult populations and spread through contact, affecting up to 10% of the population.<sup>1</sup> There are over 150 types of HPV, and types 3 and 10 most commonly manifest as facial verruca plana, also known as the facial flat wart.<sup>2,3</sup>

Verrucae present as papules with hyperkeratotic surfaces that can appear alone or in a group. Facial verrucae plana can be smooth or slightly elevated, either skin-coloured or with brown pigmentation, and most commonly found on the cheeks and forehead. Histopathology usually shows hyperkeratosis and acanthosis in the epidermis, a basket-weave appearance in the stratum horny layer and koilocytes in the upper stratum malpighii.<sup>4</sup> Diagnosis is often made clinically, and can be further verified by scraping off hyperkeratotic debris to reveal 'seeds' of thrombosed capillaries.<sup>5</sup>

Though verrucae normally have a 60% spontaneous remission within 2 years,<sup>6</sup> some can persist years despite treatment and cause significant psychosocial effects. Those with impaired cell-

mediated immunity are prone to have more extensive or recalcitrant warts. Treatment is based on several variables including location, patient goals, immune status and pain tolerance. Common verrucae are usually treated with salicylic acid or liquid nitrogen but vary in clearance and pain tolerability.<sup>7</sup> 5-fluorouracil and tretinoin can also be used for flat warts; however, these may cause a localized inflammatory reaction and scaling respectively. While these therapies demonstrate efficacy for common warts, facial warts create a special niche that require cosmetically excellent treatment while considering pain tolerance.

Laser and light-based therapies expand treatment options for afflicted patients. Pulsed dye lasers (PDL) have been used successfully to treat spider telangiectasias, psoriatic plaque and erythematous acne scars in addition to warts.<sup>8–10</sup> This technique uses a 585-nm wavelength theorized to cause selective photothermolysis of oxyhemoglobin in the wart microvasculature and destroy large, dilated blood vessels within the dermal papillae.<sup>11</sup>

Photodynamic therapy (PDT) is used in conjunction with the photosensitizer 5-aminolevulinic acid (ALA) or 5-methylaminolevulinic acid (MAL) that is topically applied, causing protoporphyrin IX accumulation in the treated area.<sup>12</sup> Subsequent irradiation of the lesion with red light at 633-nm wavelength

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creates cytotoxic radicals that selectively cause apoptosis of the treated keratinocytes.<sup>13</sup>

The yttrium aluminium garnet (YAG) laser is another option, and the frequency-doubled Q-switched (FDQS) neodymium-doped (Nd)  $\pm$  YAG laser can be used at 532-nm wavelength to target melanin in pigmented warts. The laser causes death in melanin-containing cells and subsequent epidermal sloughing.<sup>14,15</sup> The Holmium:YAG laser emits energy at a 2140-nm wavelength which is absorbed by water and liquidates warts through a photothermal mechanism.<sup>16</sup> Electrocoagulation (EC) uses high-frequency currents produced from an electric cautery device to thermally destroy targeted tissue. Alternatively, infrared coagulation (IRC), a less commonly used modality, utilizes non-coherent infrared light produced from tungsten halogen bulbs to deliver heat and cause thermal injury to the contacted skin.<sup>17</sup>

This paper examines laser and light approaches in treating recalcitrant facial warts. The main therapeutic modalities that will be discussed are lasers, photodynamic therapy, EC and IRC. These methods show promising results and may be an effective solution for cases of facial verrucae that have previously received unacceptable outcomes.

## Methods

A systematic review of the available literature relevant to light and laser treatment of facial warts was performed up to 15 January 2016 using the National Library of Medicine's PubMed Database. The search terms 'facial wart', 'verruca plana', 'plane wart', 'facial verruca' and 'flat wart' were used. Only articles written in English and performed on human subjects were reviewed. The search returned a total of 1070 articles. Screening by titles and abstracts left a total of 38 articles that were reviewed in full-text version. Further exclusion upon full-text review due to studies not providing relevant information regarding light and laser treatment for facial warts left 18 articles that were included in this review. Search results were also cross-referenced with the SCOPUS database, which did not yield additional articles.

## Results

### Pulsed dye lasers

A total of eight studies on PDL for the treatment of verrucae (Table 1) were found with 205 patients (71 men, 118 women) treated.<sup>11,18–23</sup> Treatment number varied from 1 to 7 and spot size ranged from 2 to 10 mm. Laser wavelength was at 585-nm with a fluence range from 6 to 14 J/cm<sup>2</sup>. Transient pigmentation, purpura, erythema and superficial infection occurred in various patients. Follow-up periods extended up to 66 months.

Tan *et al.*<sup>11</sup> used a flashlamp PDL to treat 39 patients. Twenty-eight (72%) cases achieved clearance after an average of 1.68 treatments. Seven (18%) demonstrated a 80–95% reduction

and four saw a 50% reduction. Mild discomfort intra-procedure was the only reported adverse event. One had recurrence at 3 months follow-up.

Combined flashlamp-pumped PDL (FPPDL) was used to treat facial verrucae on a man with AIDS.<sup>18</sup> While initial treatment produced marked improvements, the patient developed new warts concurrent with a lowering CD4+ count the following month. After antiviral regimen modifications, a rise in CD4+ count was accompanied by wart clearance maintained through 7-month follow-up. This suggests that AIDS patients with warts refractive to traditional treatment may require close monitoring of antivirals with concurrent FPPDL ablation for optimal results.

Kenton-Smith and Tan<sup>19</sup> treated 28 patients with 103 recalcitrant and 20 simple warts. Clearance was 92% in recalcitrant warts (average 2.1 sessions) and 75% in simple warts (average 1.6 treatments). Eight patients did not achieve complete remission, yet refused further treatment. One developed mild hypopigmentation and another developed blisters, swelling and superficial infection that responded to antibiotics.

Another study<sup>20</sup> using FPPDL to treat four patients with refractory lesions and eight treatment-naïve patients demonstrated complete clearance in all, with the majority achieving remission after two pulses. Only one required multiple sessions. No lasting side-effects were seen and no recurrences were reported at 24-month follow-up.

Wu *et al.*<sup>21</sup> treated 36 total areas on 28 patients, with almost half having tried two or more therapies unsuccessfully. Complete clearance was achieved in 64% of areas, with 13 recalcitrant areas showing a 46% clearance. Four treatments on average were administered with 4.9 weeks interval. Recurrence was reported in 36% of patients and complications included erythema ( $n = 20$ ), blistering ( $n = 4$ ) and scarring ( $n = 4$ ). In a follow-up survey, 72% of patients reported PDL to be comparable to or less painful than cryotherapy.

Another study<sup>22</sup> reported PDL treatment of facial verruca on four Indian patients with skin types IV and V. After 2–4 sessions, all lesions resolved completely and only transient pigmentation was noted. No recurrence was reported at 6-month follow-up.

Efficacy and tolerance of PDL compared to CO<sub>2</sub> laser has also been examined in 61 paediatric cases.<sup>23</sup> A 75% clearance rate was reported after an average of 3.1 sessions. Notably, warts affecting the face and perineum were most likely to clear after one treatment. Side-effects were minimal and included hypopigmentation (8%), immediate pruritus (3%), hyperpigmentation (2%) and mild scarring or blistering (2%). Recurrence was 8% at 66-month follow-up.

Grillo *et al.*<sup>24</sup> reported PDL treatment in 32 patients with facial warts, 24 of which were refractory to prior therapies. Fourteen (44%) noted complete clearance, and the remaining 18 (56%) had excellent responses. Three (9%) had focal

Table 1 Pulsed dye lasers

Author (year)	Patients in study	Male	Female	Number of treatments	Laser type	Total lesions treated	Spot size (mm)	$\lambda$ (nm)	Laser fluence and power ( $J/cm^2$ )	Outcome	Side-effects	Follow-up
Tan et al. (1999)	39	14	25	1–3	PDL	–	5	585	6.25–7.5	- 28 (72%) had complete clearance, 7 (18%) had reduction between 80–95%, 4 had reduction of 50%.	- 1 recurrence at 3-month follow-up	1–16 months
Roark, Pandya (1998)	1	1	0	3	PDL + PI	–	5 and 7	585	8	- Complete clearance	- None	7 months
Kenton-Smith, Tan (1999)	28	10	18	1–7 (avg 2.1) recalcitrant 1–2 (avg 1.6) simple	PDL	123	5 or 7	585	6–9	- Recalcitrant warts had 92% clearance - Simple warts had 75% clearance	- Mild hypopigmentation and superficial infection	3–15 months (avg 7.2)
Vargas et al. (2003)	12	–	–	1–3	PDL	–	5	585	9–13	- All had full resolution	- None	10–33 months
Wu et al. (2003)	28	11	17	1–12 (avg 4)	PDL	–	2–10	585	7–9.75	- 64% clearance of all areas treated - 46% clearance of recalcitrant areas	- Transient erythema, blistering, pain - 4 had scarring - 36% recurrence	–
Khandpur, Sharma (2008)	4	–	–	2–4	PDL	–	5	585	5.5–7.5	- All warts completely resolved	- Transient hyper/hypopigmentation	3–4 weeks
Sethuraman et al. (2010)	61	28	33	2–6	PDL	–	5 or 7	585	6.5–9.5	- 75% had complete clearance	- 8% had hypopigmentation, 2% had hyperpigmentation, 2% each had mild scarring and blistering	12–66 months
Grillo et al. (2014)	32	7	25	1–2	PDL	382	5 or 7	585	9 or 14	- 14 (44%) had complete clearance - 18 (56%) had excellent response	- Transient purpuric response - 4 recurrences at 12-month follow-up	Every 4 months for 12 months

PDL, pulsed dye laser;  $\lambda$ , wavelength.

hyperpigmentation that disappeared within 3 months. Recurrence was 13% at 12-month follow-up.

### Photodynamic therapy

A total of seven studies on PDT for wart treatment were found (Table 2)<sup>25–31</sup> with 109 patients treated. Six studies utilized ALA as a photosensitizer while one study used MAL. Application period was 1.5–6 h followed by red light of 630–700-nm wavelengths at a fluence range of 37–126 J/cm<sup>2</sup>. Patients received 1–4 treatments, in total. The most commonly reported complications were transient hyperpigmentation and erythema, with recurrence occurring in four patients.

Mizuki *et al.*<sup>25</sup> used 20% ALA-PDT on a male with multiple facial verrucae plana refractory to cryotherapy and dinitrochlorobenzene. Complete resolution was achieved after two sessions with only transient hyperpigmentation. There was no recurrence at 5-month follow-up.

Lin and Xiang<sup>26</sup> treated three patients using 20% ALA-PDT. The first achieved complete remission 1 week after receiving four sessions. Pruritus and burning occurred initially but decreased with further sessions. The second patient exhibited elimination of most warts by the fourth session, except on the cheeks, which was then treated with Er:YAG laser combined with 20% ALA-PDT. The patient showed complete clearance after 1 month following treatment. Minimal hyperpigmentation had occurred but disappeared following topical tretinoin use. The third patient achieved complete remission 1 week after receiving three treatments. Focal post-inflammatory hyperpigmentation was found but faded with topical tretinoin use.

Lu *et al.*<sup>27</sup> administered 10% ALA-PDT on 18 patients with facial verruca. After two sessions, 17 (94.4%) patients had complete resolution with 16 (88.9%) patients reporting satisfaction with the results. Common side-effects included itching, stinging and thin crust formation around the treatment areas, with 12 (66.6%) patients experiencing transient hyperpigmentation. One case recurred at 6-month follow-up.

Caucanas *et al.*<sup>28</sup> used ALA-PDT to treat a male on years-long immunosuppressive therapy with diffuse facial warts previously refractory to cryotherapy. Three treatments resulted in complete clearance after 8 days. Pain subsided within 2 h after illumination, and redness decreased after several days. No recurrence occurred at 1-year follow-up.

Burtica *et al.*<sup>29</sup> initially treated a man with recalcitrant facial warts with topical 80% trichloroacetic acid and 0.05% isotretinoin solution for 1 month to reduce wart thickness. Subsequently, MAL-PDT was used and produced 60% and 100% clearance after the first and second session respectively. Complications included transient local erythema and a mild burning sensation. There was no recurrence at 1-month follow-up.

Li *et al.*<sup>30</sup> treated a total of 6146 lesions in 55 patients. ALA-PDT at concentrations of 5%, 10% and 20% were used and applied for 4 h. Three sessions were done at 2-week intervals for

a total dose of 339 J/cm<sup>2</sup>. Mean overall clearance was 74.1%, 68.8% and 64.6% at 4, 8 and 12 weeks respectively. Clearance was lowest in the 5% ALA group, while the 20% group showed elevated incidences of temporary hyperpigmentation. Regardless of the ALA concentration used, skin-coloured lesions were more responsive to PDT.

Qian *et al.*<sup>31</sup> utilized a step-up regimen for 30 patients. The first session included 5% ALA for 1.5 h with 10 min of irradiation. The second session at 2 weeks used 10% ALA for 3 h with 20 min of irradiation. The third took place 15 days later using 20% ALA for 3 h with 20 min of irradiation. Patients with fulminant lesions ( $n = 10$ ) exhibited 100% cure rate at day 15, with no recurrence at 6-month follow-up. After the first session, this group complained of more severe reactions, including crusting, desquamation and redness that disappeared within 1 week. Patients with stable or slowly progressing lesions ( $n = 20$ ) achieved complete remission after completing the entire regimen. Only 10% of these patients reported similar side-effects after the first session. Patients reported less adverse events with subsequent treatments as the concentration of ALA was raised.

### Yttrium aluminium garnet laser

A total of two studies using the YAG laser for the treatment of verrucae were found (Table 3) with 49 patients treated.<sup>32,33</sup> The first used the FDQS Nd ± YAG laser and the second used the Holmium:YAG laser. Both studies noted transient pigmentary changes post treatment.

Li *et al.*<sup>32</sup> used the FDQS Nd ± YAG laser to treat seven patients with facial verruca. All cases had a disease duration of 5–10 years that had been previously refractory to medical therapy. After one treatment, two patients experienced transient hyperpigmentation. At 6-month follow-up, pre- to post-treatment comparison demonstrated the absence of recurrence, pigment changes and texture changes.

Yang *et al.*<sup>33</sup> used the Holmium:YAG laser to treat 62 warts in 42 patients in a prospective single-arm study. All facial warts achieved clearance after one treatment and had an average wound healing time of 10.3 days. Reported adverse events included mild atrophic scarring ( $n = 4$ ) and slight pigmentary changes ( $n = 7$ ) that had diminished by the 6-month follow-up. Two patients had experienced recurrence at that time.

### Electrocoagulation vs. infrared coagulation

One study compared the use of standard EC to IRC therapy (Table 4).<sup>34</sup> Sixteen patients were treated with both EC and IRC and two with IRC alone. Forty-nine warts were randomly selected for either treatment and evaluated for changes in wart size, healing time and clearance. At 6-month follow-up, cure rates were 68.2% for EC and 66.7% for IRC. Seven (31.8%) warts treated with EC developed a bacterial infection, but no complications were seen with IRC. Recurrence rates were 31.8% and 33.3% in EC and IRC treatment groups

**Table 2** Photodynamic therapies

Author (year)	Patients in study	Male	Female	Number of Treatments	Photosensitizer	Length of PS application	Light source	$\lambda$ (nm)	Laser fluence and power (J/cm <sup>2</sup> )	Outcome	Side-effects	Follow-up
Mizuki <i>et al.</i> (2003)	1	1	0	2	5-ALA	6 h	500 W metal halide lamp	630 and 700	120	- Complete clearance	- Transient hyperpigmentation	5 months
Lin, Xiang (2008)	3	1	2	4	5-ALA	2 h	LED	633 $\pm$ 6	126	- 2 had complete clearance, 1 needed additional YAG:Er treatment to achieve complete clearance - 17/18 (94.4%) complete clearance	- Transient hyperpigmentation, erythema, exfoliation	1–3 months
Lu <i>et al.</i> (2010)	18	5	13	2–3	5-ALA	4 h	Laser	635	120	- Transient pruritus, erythema, oedema, hyperpigmentation - 1 recurrence		3 and 6 months
Caucanas <i>et al.</i> (2010)	1	1	0	3	5-ALA	3 h	Red light	634	37	- Complete clearance	- None	1 year after last treatment
Burtica <i>et al.</i> (2013)	1	1	0	2	MAL	2 h	LED	630	37	- Complete clearance	- None, no recurrence	1 year
Li <i>et al.</i> (2014)	55	12	43	3	5-ALA	4 h	LED	633	113 339 cumulative dose	- Mean overall clearance: 74.1%, 68.8%, and 64.6% on Week 4, 8, and 12	- 20% group showed higher incidence rate of transient hyperpigmentation - 4 (16.7%) recurrences	4, 8 and 12 weeks
Qian <i>et al.</i> (2014)	30	-	-	1–3	5-ALA	1.5, 3 h	LED	633 $\pm$ 6	126	- Fulminant warts had 100% clearance - Stable/slowly progressive warts had 75% clearance	- Transient erythema, exfoliation, crusting, exudation, hyperpigmentation	15 days, 1 and 6 months

5-ALA, 5-aminolevulinic acid; CR, clearance rate; PS, photosensitizer; PDT, photodynamic therapy; MAL, 5-methyl-aminolevulinic acid;  $\lambda$ , wavelength.

**Table 3** YAG laser

Author (year)	Patients in study	Male	Female	Number of treatments	Laser type	Total lesions treated	Spot size (mm)	$\lambda$ (nm)	Laser fluence and power ( $J/cm^2$ )	Outcome	Side-effects	Follow-up
Li <i>et al.</i> (2001)	7	1	6	1	FDQS Nd-YAG	-	3	532	2.5	- Complete clearance	Two had transient hyperpigmentation	6 months
Yang <i>et al.</i> (2013)	42	-	-	1	Holmium:YAG laser	64	-	2140	1.2-1.5	- 100% clearance	- 4 warts had mild atrophy scar, 7 warts had slight pigmentary change - 2 recurrences	2-4 weeks 6 months

FDQS, frequency-doubled Q-switched;  $\lambda$ , wavelength; YAG, yttrium aluminium garnet.

**Table 4** Electrocoagulation and infrared coagulation

Author (year)	Patients in study	Male	Female	Number of Treatments	Laser type	Total lesions treated	Spot size (mm)	$\lambda$ (nm)	Laser fluence and power ( $J/cm^2$ )	Outcome	Side-effects	Follow-up
Piskin <i>et al.</i> (2004)	18	9	9	1	EC	22	-	-	-	- 68.2% clearance at end of follow-up period - 7 (31.8%) had bacterial infection	- Exudation immediately post-application - 7 (31.8%) had bacterial infection	6 months
					IRC	27	-	-	-	- 66.7% clearance at end of follow-up period - 9 (33.3%) had recurrence at 6-month follow-up	- Bullae developed within 1-3 days - 9 (33.3%) had recurrence at 6-month follow-up	

EC, electrocoagulation; IRC, infrared coagulation;  $\lambda$ , wavelength.



respectively. In choosing between these two modalities, clearance rate should be considered in conjunction with the side-effect profile.

## Discussion

Laser treatments have improved from non-selective ablative therapies such as the CO<sub>2</sub> laser to modalities like PDL, which works on the principle of selective thermolysis. PDL was the most used alternative treatment modality and had high clearance rates to recalcitrant areas. Unfortunately, this method is limited by cost, inconvenience of multiple visits and pain. Combination treatment of PDL with triple-drug antiviral therapy may prove useful in patients suffering from recalcitrant warts due to HIV infection, which causes a deficiency in the underlying cell-mediated immunity.<sup>18</sup>

A range of 5–20% ALA photosensitizer was used in several studies. A comparison of all three concentrations in one study suggests 10% ALA to be the optimal concentration for both efficacy and side-effect profile.<sup>30</sup> Those unable to tolerate ALA may use MAL, as it was seen to offer a similarly favourable outcome and side-effect profile in one case report.<sup>29</sup> More studies with higher power should be done to compare MAL to ALA.

Both the FDQS Nd ± YAG laser and the Holmium:YAG laser provided complete clearance to treated subjects. However, a mild atrophic scar was noted after use of the Holmium:YAG laser, which is not a complication seen with other treatments.<sup>33</sup> The apparent efficacy of single sessions with the YAG lasers offers more convenience than PDT or PDL therapy, which generally require multiple sessions. Additionally, one case reported the use of Er:YAG laser on flat warts that did not respond to ALA-PDT alone, and only the combination of both enabled resolution of the lesions.<sup>26</sup>

## Conclusion

Recalcitrant warts can be challenging to treat and often prove frustrating to both medical provider and patient alike. Laser and light therapies may offer an alternative treatment with clear potential. A total of 381 patients were included in this review, with the majority of the cases treated using ALA-PDT and PDL. Further studies with larger power are required to determine which method should be established as the light and laser treatment of choice for recalcitrant verrucae.

## References

- Rowson KE, Mahy BW. Human papova (wart) virus. *Bacteriol Rev* 1967; **31**: 110–131.
- James WD, Berger T, Elston D. *Andrews' diseases of the skin: clinical dermatology*. Elsevier Health Sci 2015; Pennsylvania, PA; 12th ed.: 359–417.
- Kiyofumi E. [HPV-associated cutaneous lesions]. *Uirusu*. Japan; 2008; **58**: 173–182.
- Ross BS, Levine VJ, Nehal K, Tse Y, Ashinoff R. Pulsed dye laser treatment of warts: an update. *Dermatol Surg* 1999; **25**: 377–380.
- Lee D-Y, Park J-H, Lee J-H, Yang J-M, Lee E-S. The use of dermoscopy for the diagnosis of plantar wart. *J Eur Acad Dermatol Venereol* 2009; **23**: 726–727.
- Glover MG. Plantar warts. *Foot Ankle* 1990; **11**: 172–178.
- Kwok CS, Gibbs S, Bennett C, Holland R, Abbott R. Topical treatments for cutaneous warts. *Cochrane database Syst Rev* 2012; **9**: CD001781.
- Tan E, Vinciullo C. Pulsed dye laser treatment of spider telangiectasia. *Australas J Dermatol* 1997; **38**: 22–25.
- Zelickson BD, Mehregan DA, Wendelschfer-Crabb G, Ruppman D, Cook A, O'Connell P et al. Clinical and histologic evaluation of psoriatic plaques treated with a flashlamp pulsed dye laser. *J Am Acad Dermatol* 1996; **35**: 64–68.
- Alster TS, McMeekin TO. Improvement of facial acne scars by the 585 nm flashlamp-pumped pulsed dye laser. *J Am Acad Dermatol* 1996; **35**: 79–81.
- Tan OT, Hurwitz RM, Stafford TJ. Pulsed dye laser treatment of recalcitrant verrucae - a preliminary report. *Lasers Surg Med* 1993; **13**: 127–137.
- Fabbrocini G, Di Costanzo MP, Riccardo AM, Quarto M, Colasanti A, Roberti G et al. Photodynamic therapy with topical delta-aminolevulinic acid for the treatment of plantar warts. *J Photochem Photobiol, B* 2001; **61** (1-2): 30–34.
- Rossi R, Brusino N, Ricceri F, Grazzini M, Dindelli M, Lotti T. Photodynamic treatment for viral infections of the skin. *G Ital Dermatol Venereol* 2009; **144**: 79–83.
- Kilmer SL, Wheeland RG, Goldberg DJ, Anderson RR. Treatment of epidermal pigmented lesions with the frequency-doubled Q-switched Nd: YAG laser. A controlled, single-impact, dose-response, multicenter trial. *Arch Dermatol*. 1994; **130**: 1515–1519.
- Tse Y, Levine VJ, McClain SA, Ashinoff R. The removal of cutaneous pigmented lesions with the Q-switched ruby laser and the Q-switched neodymium: yttrium-aluminum-garnet laser. A comparative study. *J Dermatol Surg Oncol* 1994; **20**: 795–800.
- Yang C-J, Liu S-X, Liu J-B, Wang Z-Y, Luo D-F, Zhang G-L et al. Holmium laser treatment of genital warts: an observational study of 1500 cases. *Acta Derm Venereol*. 2008; **88**: 136–138.
- Walker NPJ, Lawrence CM, Barlow RJ. *Physical and laser therapies*. In *Rook's Textbook of Dermatology*. Blackwell Publishing, Inc., Oxford, UK; 2008: 4025–4048.
- Roark TR, Pandya AG. Combination therapy of resistant warts in a patient with AIDS. *Dermatol Surg* 1998; **24**: 1387–1389.
- Kenton-Smith J, Tan ST. Pulsed dye laser therapy for viral warts. *Br J Plast Surg* 1999; **52**: 554–558.
- Vargas H, Hove CR, Dupree ML, Williams EF. The treatment of facial verrucae with the pulsed dye laser. *Laryngoscope* 2002; **112**: 1573–1576.
- Wu C, Langan S, Kilmurray M, Lawlor D, Watson R. Efficacy of pulsed-dye laser for viral warts—an internal audit. *Ir Med J* 2003; **96**: 82–83.
- Khandpur S, Sharma VK. Efficacy of pulsed dye laser in cosmetically distressing facial dermatoses in skin types IV and V. *Indian J Dermatol* 2008; **53**: 186–189.
- Sethuraman G, Richards KA, Hiremagalore RN, Wagner A. Effectiveness of pulsed dye laser in the treatment of recalcitrant warts in children. *Dermatologic Surg* 2010; **36**: 58–65.
- Grillo E, Boixeda P, Ballester A, Miguel-Morrondo A, Truchuelo T, Jaén P. Pulsed dye laser treatment for facial flat warts. *Dermatol Ther* 2013; **27**: 31–35.
- Mizuki D, Kaneko T, Hanada K. Successful treatment of topical photodynamic therapy using 5-aminolevulinic acid for plane warts. *Br J Dermatol* 2003; **149**: 1087–1088.
- Lin M-Y, Xiang L-H. Topical 5-aminolevulinic acid photodynamic therapy for recalcitrant facial flat wart in Chinese subjects. *J Dermatol* 2008; **35**: 658–661.
- Lu Y-G, Wu J-J, He Y, Yang H-Z, Yang Y-D. Efficacy of topical aminolevulinic acid photodynamic therapy for the treatment of verruca plana. *Photomed Laser Surg* 2010; **28**: 561–563.

- 28 Caucanas M, Gillard P, Vanhooetghem O. Efficiency of photodynamic therapy in the treatment of diffuse facial viral warts in an immunosuppressed patient: towards a gold standard? *Case Rep Dermatol* 2010; **2**: 207–213.
- 29 Burtica EC, Magnano M, Loi C, Bardazzi F, Patrizi A. Photodynamic therapy with 5-methylaminolevulinic acid in the treatment of multiple warts of the face. *J Dermatolog Treat* 2013; **24**: 137–138.
- 30 Li Q, Jiao B, Zhou F, Tan Q, Ma Y, Luo L *et al*. Comparative study of photodynamic therapy with 5%, 10% and 20% aminolevulinic acid in the treatment of generalized recalcitrant facial verruca plana: a randomized clinical trial. *J Eur Acad Dermatology Venereol* 2014; **28**: 1821–1826.
- 31 Qian G, Wang S, Deng D, Yang G. Is the step-up therapy of topical 5-aminolevulinic acid photodynamic therapy effective and safe for the patients with recalcitrant facial flat wart? *Dermatol Ther* 2014; **27**: 83–88.
- 32 Li Y, Yang K. Treatment of recalcitrant-pigmented flat warts using frequency-doubled Q-switched Nd-YAG laser. *Lasers Surg Med* 2001; **29**: 244–247.
- 33 Yang C, Liu S, Yang S. Treatment of facial recalcitrant verruca vulgaris with holmium: YAG laser: an update. *J Cosmet Laser Ther* 2013; **15**: 39–41.
- 34 Piskin S, Aksoz T, Gorgulu A. The treatment of common warts with infrared coagulation. *J Dermatol* 2004; **31**: 989–992.