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Evidence-based review of hair removal using lasers and light sources

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Abstract

Background Unwanted hair growth remains a therapeutic challenge and there is a considerable need for an effective and safe treatment modality.

Objective From an evidence-based view to summarize efficacy and adverse effects from hair removal with ruby, alexandrite, diode, and Nd:YAG lasers and intense pulsed light (IPL).

Methods Original publications of controlled clinical trials were identified in Medline and the Cochrane Library.

Results A total of 9 randomized controlled (RCTs) and 21 controlled trials (CTs) were identified. The best available evidence was found for the alexandrite (three RCTs, eight CTs) and diode (three RCTs, four CTs) lasers, followed by the ruby (two RCTs, six CTs) and Nd:YAG (two RCTs, four CTs) lasers, whereas limited evidence was available for IPL sources (one RCT, one CT). Based on the present best available evidence we conclude that (i) epilation with lasers and light sources induces a partial short-term hair reduction up to 6 months postoperatively, (ii) efficacy is improved when repeated treatments are given, (iii) efficacy is superior to conventional treatments (shaving, wax epilation, electrolysis), (iv) evidence exists for a partial long-term hair removal efficacy beyond 6 months postoperatively after repetitive treatments with alexandrite and diode lasers and probably after treatment with ruby and Nd:YAG lasers, whereas evidence is lacking for long-term hair removal after IPL treatment, (v) today there is no evidence for a complete and persistent hair removal efficacy, (vi) the occurrence of postoperative side-effects is reported low for all the laser systems.

Conclusion The evidence from controlled clinical trials favours the use of lasers and light sources for removal of unwanted hair. We recommend that patients are pre-operatively informed of the expected treatment outcome.

Introduction

Unwanted hair growth remains a therapeutic challenge and there is a need for an effective, safe, and non-invasive treatment modality capable of removing hairs on a long-term basis. Excess hair growth covers a broad range of severity and may present as hypertrichosis or hirsutism. Hypertrichosis means excess hair growth at any body site, whereas hirsutism presents as excess hair growth in women at androgen-dependent sites. However, hair removal treatments are for a large part performed for cosmetic reasons to people with normal hair pattern, and considerable amounts of time and financial resources are spent to achieve hair-free appearances.

Several traditional treatments are offered for hair removal including shaving, plucking, waxing, chemical depilatories and electrolysis.[1,2] None of these treatments are ideal as the efficacy is limited, painful and tedious, and there may be a risk of side-effects such as skin irritation, infection, allergic and irritant dermatitis as well as scarring.[1]

Photo-epilation has, over the recent years, become increasingly propagated. The available lasers and light sources operate in the red or near-infrared wavelength regions: ruby laser (694 nm), alexandrite laser (755 nm), diode laser (800–810 nm), Nd:YAG (neodymium:yttrium-aluminium-garnet) laser (1064 nm), and noncoherent intense pulsed light (IPL) (590–1200 nm).[3–5] The mechanisms by which these devices induce selective damage to hair follicles are based on the concepts of selective photothermolysis.[6] The red and near-infrared wavelengths allow for selective absorption by melanin combined with deep penetration into the dermis and pulse durations shorter or equal to the thermal relaxation time of the hair follicles (about 10–50 ms) confine the thermal damage to the hair follicles.[7]

The literature on laser and photo-epilation is of varying quality and the majority of clinical trials have uncontrolled before-and-after design. Clinical results seem impressive and patients do have great expectations. However, controlled clinical trials have not been evaluated from an evidence-based point of view. The objective of this paper was therefore to summarize the efficacy and adverse effects of photo-epilation and to provide laser surgeons with improved information, which is recommended to be discussed with patients before treatment.

Methods

Identification of studies

Original publications were identified through searches in Medline (1990–March 2004) and the Cochrane Library of controlled clinical trials using text words and the Medical Subject Headings (MeSH) database: 'laser', 'light', 'hair', 'clinical trial', 'lasers/therapeutic use (MeSH)', 'light (MeSH)', 'hair removal (MeSH)' and 'controlled clinical trials (MeSH)'. Moreover, we evaluated cited references from reference lists and lists of contents in *Acta Dermato-Venereologica*, *Archives of Dermatology*, *British Journal of Dermatology*, *Journal of the American Academy of Dermatology*, *Journal of the European Academy of Dermatology and Venereology*, and *Lasers in Surgery and Medicine*. Included studies were restricted to English-language articles.

Criteria for including studies

Study design Controlled studies were included whether randomized or not.

Measures of efficacy Objective and subjective measures of hair reduction, i.e. reduction in hair counts, hairiness and patient satisfaction. Objective reduction in hair counts was determined by serial, controlled, reproducible hair counts of the treated areas. Subjective reduction in hairiness was determined by a subjective overall impression of the hair reduction. Patient satisfaction reflects an overall satisfaction with the treatment outcome. Moreover, side-effects were evaluated, when reported in a controlled manner. Hair reduction estimated up to 6 months after treatment was considered as 'short-term efficacy' and beyond 6 months postoperatively as 'long-term efficacy'.

Population Both patients and healthy human volunteers were included when the sample size was at least 10 individuals.

Types of intervention Any laser or light source was used for epilation: alexandrite laser, diode laser, intense pulsed light source, Nd:YAG laser and ruby laser.

Types of comparative intervention No treatment, (ii) traditional treatments such as electrolysis, shaving, or waxing, (iii) lasers or light sources different from the experimental intervention.

Evaluation of data quality

Each study was evaluated according to study design, randomization and blinded response evaluation. Studies were classified as either randomized controlled clinical trials (RCTs) or nonrandomized controlled clinical trials (CTs). If no information was given about the randomization method, studies were classified as having unclear randomization.

Results

A total of 9 RCTs and 21 CTs were identified (Tables 1 and 2). In the RCTs, different randomization methods were applied (coin tossing, blinded card draw, list of random allocation, clockwise rotation) and response evaluations were performed blinded in most of the studies (Table 1). The hair removal efficacy was assessed mainly as short-term efficacy up to 6 months postoperatively, although one study evaluated the long-term efficacy up to 9 months postoperatively (Table 1). In the CTs, hair removal efficacy was evaluated as both short-term and long-term, of which five studies had follow-up evaluations of up to 12 months postoperatively or longer (Table 2). Only a few of the CTs made blinded response evaluations (Table 2).

Ruby laser

The hair removal efficacy after ruby laser treatment was evaluated in one RCT and five CTs (Tables 1, 2). Two

Table 1 An overview of clinically controlled, randomized trials (RCTs) in laser and photoepilation

Study	Intervention	Comparative intervention	Study design Randomization method Blinded response evaluation	Subjects *N*, age, hair colour, treatment site, skin type	Follow-up	Major results
Allison *et al.*, 2003[8]	• **Ruby laser** 2 tx	• **Ruby laser** 3 tx	• Coin tossing • Blinding unclear	• *n* = 69 • Age: unmentioned • Hair colour unmentioned • Lip, axilla, legs • Skin types I–III	• 8 months	• 5 months postop: (i) 3 tx upper lip: overall 18.5% hair reduction (ii) 2 tx upper lip: overall 6.3% hair reduction
Fiskerstrand *et al.*, 2003[9]	• **Diode laser** 3 tx	• **Diode laser** 3 tx	• Randomization unclear • Blinding unclear	• *n* = 29 • Age: 23–69 years • Upper lip • Brown-black hair colour • Skin types II–IV	• 6 months	• 6 months after first tx: 49% vs. 48% hair reduction with the two different diode laser systems (p = ns)
Goh 2003[10]	• **Long-pulsed Nd:YAG laser** 1 tx	• **IPL,** 1 tx	• Randomization unclear • Blinding unclear	• *n* = 11 • Age: unmentioned • Black hair colour • Face, axilla, legs • Skin types IV–VI	• 2, 6 weeks	• 6 weeks postop: (i) 64% (IPL) and 73% (Nd:YAG laser) of patients obtained < 20% hair reduction (p = ns) (ii) Postinflammatory pigmentation: 45% (IPL) and 0% (Nd:YAG laser)
Hussain *et al.*, 2003[11]	• **Alexandrite laser** 1 tx	• **Alexandrite laser** 2–3 tx	• Randomization unclear • + blinding	• *n* = 144 • Age: 18–48 years • Axilla, extremities, face • Asian patients • Skin types III–V	• 1, 2, 3, 6, 9 months	• 9 months postop: (i) 3 tx: overall 55% hair reduction (ii) 2 tx: overall 44% hair reduction (iii) 1 tx: overall 32% hair reduction
Lehrer *et al.*, 2003[12]	• **Alexandrite laser** 1 tx + **preop. shave**	• **Alexandrite laser** (1 tx) + **preop. wax**	• Coin tossing (personal communication) • + blinding	• *n* = 13 • Age: 19–42 years • Back • Brown–black hair colour • Skin types I–III	• 1 month	• In 12 of 13 subjects the reduction in hairiness was better in wax + laser-treated areas than shave + laser-treated areas
Baugh *et al.*, 2001[13]	• **Diode laser** 24, 38, 48 J/cm^2	• **Shave**	• Clockwise rotation (personal communication) • + blinding	• *n* = 36 • Mean age: 31 years • Back, thigh, bikini area • Brown–black hair colour • Skin types I–IV	• 1, 3 months	• Fluence-dependent hair reduction significantly better than shave • A mean hair reduction of 43% (1 month postop, mean of 1.6 tx) and 34% (3 months postop, mean of 2.0 tx) at the highest fluence level

Table 1 *Continued*

Study	Intervention	Comparative intervention	Study design Randomization method Blinded response evaluation	Subjects *N*, age, hair colour, treatment site, skin type	Follow-up	Major results
Handrick and Alster, 2001[14]	• **Alexandrite laser** 3 tx	• **Diode laser** 3 tx	• Blinded card draw • + blinding	• $n = 20$ • Age: 20–60 years • Axilla • Brown–black hair colour • Skin types I–IV	• 1, 3, 6 months	• 6 months postop: (i) similar hair reduction (37–46%) for the two lasers (ii) similar clinical improvement scores on a 0–4 arbitrary scale (3.4–3.5 corresponding to > 51% improvement) • Side-effects: (i) pain: alexandrite laser mild to moderate; diode laser moderate to severe (ii) slightly more hyperpigmentation and blistering after diode laser than alexandrite laser (iii) no scarring or atrophy
Haedersdal *et al*., 1999[15]	• **Ruby laser** 1 tx	• **Shave**	• List of random allocation • + blinding	• $n = 17$ • Age: unmentioned • Pubic region • Red-blonde-brown-black	• 3 months	• Side-effects: (i) hyperpigmentation: 1/51 laser areas, 0/17 shave control areas (ii) hypopigmentation: 5/51 laser treated areas, 1/17 shave control areas (iii) no texture changes
Nanni and Alster, 1997[16]	• **Q-switched Nd:YAG laser** 1 tx ± preop. wax, carbon solution	• **Wax**	• Blinded card draw (personal communication) • + blinding	• $n = 12$ • Mean age: 32 years • Face, truncus, legs • Brown-black hair colour • Skin types I–IV	• 1, 3, 6 months	• 3 months postop: (i) overall –2–21% hair reduction (ii) better clearing for Q-switched Nd:YAG laser treated areas vs. wax alone • 6 months postop: full hair regrowth in all test areas • Patient subjective evaluations of hair density closely approximated hair count data

tx, treatment; IPL, intense pulsed light; postop, postoperative(ly); ns, not significant.

Table 2 An overview of clinically controlled, nonrandomized trials (CTs) in laser and photoepilation

Study	Intervention	Comparative intervention	Subjects No, age, hair colour, treatment site, skin type	Blinded response evaluation	Follow-up	Major results
Elman *et al*., 2000[17]	• **Ruby laser** 1 tx 20 msec	• **Ruby laser** 1 tx 1 msec	• *n* = 16 • Age: unmentioned • Hair colour: unmentioned • Back, leg • Skin type IV	• Unmentioned	• 3 months	• Side-effects: less epidermal damage with 20 msec pulse duration (escar, pigmentary changes) than 1 msec pulse duration
Polderman *et al*., 2000[18]	• **Ruby laser** 3 tx	• **Wax** 3 tx • **Electrolysis** 3 tx • **Untreated control**	• *n* = 30 • Age: mean 30 years • Blond-brown-black hair colour • Face, arm, pubes region • Skin types I–III	• Unmentioned	• Up to 12 months after first tx	• 2–4 months after last tx: (i) 38–49% before–after hair reduction in laser treated areas vs. no significant reduction for electrolysis, wax or untreated control • 12 months after first tx: (i) no significant hair loss at all
Sommer *et al*., 1999[19]	• **Ruby laser** 1 tx	• **Ruby laser** 4 tx	• *n* = 51 • Mean age: 39 years • Hair colour: unmentioned • Facial hirsutism • Skin types I–IV	• No blinding	• 1, 3, 6, 9, 12 months	• 1 tx: 20%, 35%, 42% and 41% hair reduction (mean) at 3, 6, 9 and 12 months postop • 4 tx: 55%, 59%, 61% hair reduction (mean) at 3, 6 and 9 months postop • 1 vs. 4 tx: 3, 6 and 9 months postop (p = sign) • Patient satisfaction closely approximated hair count data
Dierickx *et al*., 1998[20]	• **Ruby laser** 1 tx + preop wax or shave	• **Shave** • **Wax**	• *n* = 13 (→ 7 at 2 years) • Age: unmentioned • Brown-black hair colour • Back, thigh • Skin types I–III	• Unmentioned	• 1 and 2 years	• 1 and 2 years postop: (i) 4/7 persons still had obvious, significant hair loss after ruby laser tx
Walther *et al*., 1998[21]	• **Ruby laser** 1, 2, and 3 tx	• **Shave**	• *n* = 15 • Age: 20–38 years • Hair colour: brown-black • Back, thigh • Skin types II–III	• Unmentioned	• 1, 2, 3 months	• 3 months postop: (i) complete regrowth with no difference between laser treated areas (1, 2 and 3 tx) and shave control
Grossman *et al*., 1996[22]	• **Ruby laser** 1 tx + preop wax or shave	• **Shave** • **Wax**	• *n* = 13 • Age: unmentioned • Brown-black hair colour • Back, thigh • Skin types I–III	• Unmentioned	• 1, 3, 6 months	• 3 months postop: (i) significant less regrowth in laser treated areas vs. shave and wax • 6 months postop: (i) 4/13 persons less than 50% regrowth, 5/13 complete hair regrowth
Freedman and Early, 2000[23]	• **Alexandrite laser**, structured tx protocol (no = 4 tx)	• **Alexandrite laser**, variable tx protocol (mean no tx = 2.5)	• *n* = 200 • Age: 19–63 years • Hair colour: unmentioned • Face, truncus, extremities • Skin types I–IV	• Unmentioned	• 3 months	• Significant better hair reduction in the structured tx protocol (mean 78%) than the variable tx protocol (mean 48%) • Patient satisfaction closely approximated hair count data

Table 2 *Continued*

Study	Intervention	Comparative intervention	Subjects No, age, hair colour, treatment site, skin type	Blinded response evaluation	Follow-up	Major results
Freedman and Early, 2000[24]	• **Alexandrite laser**, physician-treated (mean no tx =3.5)	• **Alexandrite laser, nurse-treated** (mean no tx = 3.3)	• *n* = 100 • Age: mean 36–41 years • Hair colour: unmentioned • Face, truncus, extremities • Skin types I–IV	• Unmentioned	• 3 months	• Similar hair reduction in physician-treated (mean 74%) and nurse-treated patients (mean 70%) • Similar patient satisfaction in physician- and nurse-treated groups • Similar self-reported transient side-effects
Görgü *et al*., 2000[25]	• **Alexandrite laser** 3 tx	• **Electrolysis** 4 tx	• *n* = 12 • Age: unmentioned • Hair colour: unmentioned • Axilla • Skin types: unmentioned	• Unmentioned	• 6 months after first tx	• Significant better hair reduction with alexandrite laser (mean 74%) than electrolysis (mean 35%) • Alexandrite laser less painful than electrolysis • 12/12 patients preferred alexandrite laser to electrolysis
Boss *et al*., 1999[26]	• **Alexandrite laser** 2-msec, 3 tx	• **Alexandrite laser** 20-msec, 3 tx	• *n* = 18 • Age: mean 36 years • Hair colour: unmentioned • Face, neck, truncus, extremities • Skin types I–IV	• Unmentioned	• 6 months	• By global assessment 13/18 subjects reported no difference between the two pulse durations • Similar blistering and hypopigmentation with the two tx modalities
Goldberg and Akhami, 1999[27]	• **Alexandrite laser** 2-msec, 3 tx	• **Alexandrite laser** 10 msec, 3 tx	• *n* = 14 • Age: 19–51 years • Hair colour: brown-black • Face, neck, truncus, extremities • Skin types I–III	• Unmentioned	• 6 months	• Similar hair reduction for 2-msec (mean 33%) and 10-msec (mean 34%) alexandrite laser • No pigmentary changes or scarring
Nanni and Alster, 1999[28]	• **Alexandrite laser** 5-msec, 1 tx 10-msec, 1 tx 20-msec, 1 tx	• **Shave**	• *n* = 36 • Age: 18–68 years • Hair colour: gray, blonde, brown-black • Lip, back, legs • Skin types I–V	• Yes	• 1 week, 1, 3, 6 months	• 3 months postop: (i) significant better hair reduction in all laser treated areas (27%, mean) than shave (–3%, mean) (ii) similar regrowth for 5, 10 and 20 msec-pulse durations. • 6 months postop: (i) no significant hair reduction in laser or shave areas.
Rogers *et al*., 1999[29]	• **Alexandrite laser** 1 tx	• **Q-switched Nd:YAG laser** + carbon solution, 2 tx	• *n* = 15 • Age: unmentioned • Hair colour: blond-brown • Axilla • Skin types I–III	• Unmentioned	• 1, 2, 3 months after first tx	• 3 months postop: (i) alexandrite laser 19% hair reduction (mean), Nd:YAG laser 27% hair reduction (mean)
Bäumler *et al*., 2002[30]	• **Diode laser** 8 mm spot, 3 tx	• **Diode laser** 12-mm spot, 3 tx 14-mm spot, 3 tx	• *n* = 20 • Age: 20–42 years • Hair colour: unmentioned • Legs • Skin types I–III	• Unmentioned	• 1, 3 months	• 3 months postop: (i) hair reduction: 8 mm spot 33% (mean), 12 mm spot 46% (mean), 14 mm spot 45% (mean) (p = ns)

Table 2 *Continued*

Study	Intervention	Comparative intervention	Subjects No, age, hair colour, treatment site, skin type	Blinded response evaluation	Follow-up	Major results
Chan *et al*., 2001[31]	• **Diode laser** 1 tx	• **Long-pulsed Nd:YAG laser** 1 tx	• *n* = 15 • Age: 19–47 years • Axilla, legs • Chinese patients, skin types IV–V	• Yes	• 1–6 weeks and 9 months	• Pain: (i) Nd:YAG laser more painful (7.8) than diode laser (5.3) (VAS 0–10) • 9 months postop: (i) similar and substantial regrowth for both laser systems (mean 9.1, VAS 0–10)
Eremia and Newman, 2001[32]	• **Diode laser** 4 tx	• **Alexandrite laser**, 4 tx	• *n* = 15 • Age: 18–35 years • Hair colour: unmentioned • Axilla • Skin types I–V	• Unmentioned	• 12 months	• Significant and similar hair reduction for alexandrite laser (85% reduction) and diode laser (84% reduction)
Lou *et al*., 2000[33]	• **Diode laser** 1 tx, 20 msec	• **Shave** • **Diode laser**, 2 tx, 5–20 msec	• *n* = 50 → 18 at end of study • Age: unmentioned • Hair colour: brown-black • Back, extremities • Skin types II–IV	• Unmentioned	• 1, 3, 6, 9, and average 20 months	• Average 20-month follow-up: (i) laser vs. shave: significant hair reduction in laser-treated areas (13–36%) vs. shave (–7%) • 1 vs. 2 tx: better hair reduction from 2 tx (34–53%) vs. 1 tx (28–33%)
Lorenz *et al*., 2002[34]	• **Long-pulsed Nd:YAG laser** 1–5 tx	• **Shave**	• *n* = 29 • Age: 22–40 years • Hair colour: blond-brown-black • Legs • Skin types I–IV	• Unmentioned	• 3, 6, 12–16 months	• 12–16 months postop: (i) 5 tx: 40% of patients obtain greater than 50% hair reduction (ii) 1 tx: 100% of patients have less than 25% of hair reduction (iii) shave: no hair reduction • Side-effects: no pigmentary changes, one atrophic scar
Goldberg and Silapunt, 2001[35]	• **Long-pulsed Nd:YAG laser** 1 tx, 50 J/cm^2	• **Long-pulsed Nd:YAG laser** 1 tx, 80, 100 J/cm^2	• *n* = 15 • Age: 28–49 years • Hair colour: brown-black • Axilla, bikini regions • Skin types II–IV	• Yes	• 3 months	• 3 months postop: (i) mean hair reductions of 29% (50 J/cm^2), 29% (80 J/cm^2) and 27% (100 J/cm^2) (p = ns) (ii) side-effects: blistering at highest fluence level (n = 2), no pigmentary changes or scarring
Fournier *et al*., 2000[36]	• **Long-pulsed Nd:YAG laser** 1 tx	• **Shave**	• *n* = 14 • Age: 22–60 years • Hair colour: unmentioned • Extremities, bikini lines • Skin types I–IV	• Unmentioned	• 1, 3 months	• 3 months postop: (i) 24% hair reduction vs. 0% at control site
Bjerring *et al*., 2000[37]	• **IPL**, 3 tx	• **Ruby laser** 3 tx	• *n* = 31 • Mean age: 39 years • Hair colour: unmentioned • Chin, neck • Skin types II–IV	• Unmentioned	• 6 months	• 6 months postop: (i) IPL: 94% of patients obtained hair reduction (mean 49%) (ii) ruby laser: 55% of patients obtained hair reduction (mean 21%) • Patients' subjective evaluation closely approximated hair count data

tx, treatment; IPL, intense pulsed light; postop, postoperative(ly); VAS, visual analogue scale; ns, not significant.

studies reported significantly better short-term hair reduction vs. electrolysis, wax, shave and untreated control areas,[18,22] whereas one study reported complete hair regrowth 3 months after shaving and one to three ruby laser treatments.[21] No long-term hair reduction was obtained 12 months after three ruby laser treatments,[18] whereas Dierickx *et al*. found obvious hair loss in four of seven individuals 1 and 2 years after one ruby laser treatment.[20] In patients with facial hirsutism, repetitive treatments (no. of treatments = 4, mean 61% hair reduction) resulted in significantly better hair reduction than a single treatment (mean 42% reduction) up to 9 months postoperatively.[19] Side-effects have been reported with low incidences in one RCT and one CT, hypopigmentation being the most frequently reported adverse reaction in pigmented skin[15] and less epidermal damage being found for 20 ms pulse duration vs. 1 ms pulse duration in skin of dark complexion.[17]

Alexandrite laser

The hair removal efficacy after alexandrite laser treatment was evaluated in three RCTs and eight CTs (Tables 1 and 2). Three studies evaluated the laser-assisted efficacy vs. conventional therapies up to 6 months postoperatively.[12,25,28] In comparison with shaving, the short-term hair removal efficacy was transiently superior after one alexandrite laser treatment 3 months postoperatively, whereas complete regrowth was seen 6 months postoperatively.[28] Three treatments with the alexandrite laser (mean 74% reduction) were more efficient than four treatments of electrolysis (mean 35% reduction) 6 months postoperatively and all of 12 patients preferred laser treatment to electrolysis because of higher efficacy and less pain.[25] Moreover, the short-term reduction in hairiness improved in 12/13 persons improved when wax epilation was performed before alexandrite laser treatment.[12] A large study (n = 144 Asian patients) evaluated the hair removal efficacy after repetitive treatments up to 9 months postoperatively and found a significantly improved short-term and long-term clearing after two and three treatments (overall 55% hair reduction) vs. a single treatment (overall 32% hair reduction) with the alexandrite laser.[11] Two studies compared the alexandrite laser with the diode laser and similar hair removal efficacies were found up to 12 months after three to four alexandrite laser treatments vs. three to four diode laser treatments.[14,32] However, limited sample sizes (n = 15, 20) introduce a risk of type-2 error. In one of the studies, slightly more pain, blistering and hyperpigmentation were seen after diode laser than after alexandrite laser, whereas no scarring or atrophy occurred at all.[14] Variations in pulse durations did not influence the hair removal efficacy or the occurrence of side-effects.[26,27] Nurse treatment vs. physician treatment resulted in similar patient satisfaction and treatment outcomes.[24]

Diode laser

The hair removal efficacy after diode laser treatment was evaluated in three RCTs and four CTs (Tables 1 and 2). The efficacy was significantly better than shaving in both short-term and long-term studies.[13,33] Two repetitive treatments with the diode laser (34–53% hair reduction) were superior to a single treatment (28–33% hair reduction) at an average follow-up time of 20 months.[33] Two studies compared the diode laser with the alexandrite laser and similar treatment outcomes were seen (see Alexandrite laser section).[14,32] One study compared the diode laser with the Nd:YAG laser and similar, almost complete hair regrowth was seen for both lasers 9 months postoperatively.[31] The immediate pain scores (visual analogue scale, range 0–10 cm) were higher for the Nd:YAG laser (7.8) than the diode laser (5.3).[31] Different spot sizes (8, 12 and 14 mm) did not influence the short-term hair removal efficacy 3 months postoperatively[30] and two different diode laser systems had similar treatment outcomes 6 months postoperatively.[9]

Nd:YAG laser

The hair removal efficacy after Nd:YAG laser treatment was evaluated in two RCTs and four CTs (Tables 1 and 2). Three studies evaluated the laser-assisted efficacy vs. conventional therapies.[16,34,36] The long-pulsed Nd:YAG laser was superior to shaving in both short-term and long-term studies,[34,36] and the short-pulsed Q-switched Nd:YAG laser was transiently superior to wax epilation 3 months postoperatively, whereas full regrowth was seen 6 months postoperatively.[16] Repetitive treatments improved the long-term treatment outcome with 40% of patients obtaining greater than 50% hair reduction 12–16 months after five treatments vs. 100% of patients obtaining less than 25% of hair reduction after one treatment.[34] The short-term hair removal efficacy was limited and similar for long-pulsed Nd:YAG laser and IPL treatment[10] as well as for Q-switched Nd:YAG laser and alexandrite laser.[29] Application of increasing fluences in a short-term study did not improve the hair removal efficacy, but resulted in blistering.[35]

IPL

The hair removal efficacy after IPL treatment was evaluated in one RCT and one CT (Tables 1 and 2). The

studies evaluated the efficacy vs. long-pulsed Nd:YAG laser[10] and ruby laser.[37] One treatment with long-pulsed Nd:YAG laser and IPL resulted in similar, limited hair removal efficacy 6 weeks postoperatively, whereas IPL treatment more often resulted in postinflammatory pigmentation as compared with the Nd:YAG laser.[10] Three treatments with IPL were superior to three treatments with the ruby laser evaluated 6 months postoperatively by hair counts (mean hair reductions of 49% and 21%, respectively) and patients' subjective evaluations.[37] Using questionnaires, patients scored higher adverse reactions for the IPL treatment than the ruby laser (pain, discomfort, crusting and time until skin normalizes).

Discussion

The practice of evidence-based medicine intends to integrate the current best available evidence from systematic research with clinical experience when making decisions about the care of individual patients.[38] The present study establishes important evidence for hair removal by lasers and light sources with 9 identified RCTs and 21 nonrandomized CTs. Five different lasers and light sources were evaluated and the best available evidence was found for the alexandrite (three RCTs, eight CTs) and the diode (three RCTs, four CTs) lasers, followed by the ruby (two RCT, six CTs) and Nd:YAG (two RCTs, four CTs) lasers, whereas limited evidence was available for IPL photo-epilation (one RCT, one CT). The methods used to evaluate hair reduction efficacy in the included studies were considered valid and clearly defined. Professional participants counted the number of hairs before and after treatment, and hairiness, patient satisfaction and side-effects were evaluated from specified predetermined criteria. Nevertheless, this review does not take into account that a variety of factors can influence laser hair removal outcomes. These factors may be related to the laser and IPL devices (wavelength, fluence, spot size, pulse duration, skin cooling and possible effect on the hair bulb) and to individual skin or hair characteristics (endocrine dysfunction, anatomical region, skin pigmentation, hair colour, hair thickness, hair growth cycle and depth of follicles). The fact that these variables have not been taken into consideration may introduce bias and uncertainty in interpretation of the results. However, the included material is relevant to the clinical situation and some of the patient characteristics have been outlined in Tables 1 and 2. Only studies of English language were included. Although considered of minor relevance in this review, the authors are aware that this may have introduced bias of publication.[39]

From this systematic review the authors conclude that substantial evidence exists for a partial short-term hair removal efficacy up to 6 months after treatment with ruby laser, alexandrite laser, diode laser, Nd:YAG laser and IPL. The efficacy is improved when repetitive treatments are given[8,11,19,33,34] and there is substantial evidence that the short-term efficacy from photo-epilation is superior to conventional treatments with shaving,[13,22,28,33,34,36] wax epilation[16,18,22] and electrolysis.[18,25] The long-term hair removal efficacy beyond 6 months postoperatively and onwards was evaluated in one RCT and seven CTs (Tables 1 and 2) and considerable evidence was found for a long-term hair removal efficacy after repetitive treatments with the alexandrite laser (two to four treatments) and the diode laser (two to four treatments).[11,32,33] Moreover, it seems as if repetitive treatments with ruby laser (three to four treatments) and long-pulsed Nd:YAG laser (five treatments) are capable of inducing long-term hair reduction as well, although the results with the ruby laser are not unambivalent (probably because of different pulse durations) and although only one study evaluates the long-term efficacy from Nd:YAG laser treatment.[18,19,34] Evidence is lacking for long-term hair removal after IPL treatment. The best long-term hair reduction was reported for the alexandrite and diode lasers after four repetitive axillary treatments with 84–85% hair reduction 12 months postoperatively (maximum tolerated fluences).[32] However, the overall results from long-term studies with follow-up times beyond 6 months postoperatively are not unambivalent. It is estimated that a partial hair reduction of approximately 50% can be achieved from three to five repetitive treatments up to 1 year postoperatively.[11,19,32,34]

Concerning permanent hair reduction, the FDA has given the definition that 'permanent hair reduction refers to a significant reduction in the number of terminal hairs after a given treatment, which is stable for a period of time longer than the complete growth cycle of hair follicles at the given body site'.[7] Unfortunately, this definition has lead to unrealistic patient expectations because of misrepresentations in newspapers and advertisements. From the patients' point of view, a permanent hair reduction means that hairs do not regrow and that the reduced hairiness lasts persistently. Using this concept of permanency, no clinical trials have recognized evidence for a permanent efficacy after photo-epilation as no studies have extended the follow-up times beyond 2 years and only three CTs had follow-up times beyond 1 year.[20,33,34] The relative efficacy from individual lasers and light sources was compared in two RCTs[10,14] and four CTs.[29,31,32,37] Two studies compared the alexandrite laser vs. the diode laser and similar, substantial treatment outcomes were obtained after repetitive treatments 6 and 12 months postoperatively.[14,32] The Nd:YAG laser was compared vs. the alexandrite laser,[29] the diode laser[31] and IPL treatment[10]

and similar, limited treatment outcomes were obtained 6 weeks to 9 months after one to two treatments. However, these studies have limited sample sizes (n varies from 11 to 20 individuals) and there is therefore a risk of introducing a type-2 error or, in other words a risk of missing a true difference between the different laser systems. This risk has to be taken into consideration when concluding on the relative efficacy from the different lasers and light sources. One study compared IPL treatment with the ruby laser and a superior efficacy was obtained from IPL treatment 6 months postoperatively (n = 3 treatments).[37] The occurrence of side-effects was reported low after treatment with all lasers and IPL sources.

For obvious reasons it is important that patients and laser surgeons do have realistic preoperative expectations to the treatment outcome from laser and photo-epilation. The authors recommend that patients and laser surgeons make use of this systematic, evidence-based review to gain information about hair removal efficacies and side-effects from different lasers and IPL sources. We suggest that patients are preoperatively informed that (i) epilation with lasers and light sources induces a partial short-term hair reduction up to 6 months postoperatively, (ii) the efficacy is improved when repeated treatments are given, (iii) the efficacy is superior to conventional treatments (shaving, wax epilation, electrolysis), (iv) evidence exists for a partial long-term hair removal efficacy beyond 6 months postoperatively after repetitive treatments with alexandrite and diode lasers and probably after treatment with ruby and Nd:YAG lasers, whereas evidence is lacking for long-term hair removal after IPL treatment, (v) today there is no evidence for a complete and persistent hair removal efficacy after laser and photo-epilation.

Key points

- Important evidence exists for photo-epilation with a total of 28 identified controlled trials.
- There is substantial evidence for a partial, short-term hair removal efficacy up to 6 months after treatment with ruby, alexandrite, diode, and Nd:YAG lasers and intense pulsed light.
- Hair removal with lasers and light sources is superior to conventional treatments such as shaving, waxing and electrolysis.
- Repetitive treatments improve the efficacy from photo-epilation.
- Evidence exists for a partial long-term hair removal efficacy beyond 6 months after repetitive treatments with alexandrite and diode lasers.
- Today, there is no evidence for a complete and persistent hair removal efficacy.
- It is recommended that patients are preoperatively informed of the expected treatment outcome.

Questions

1 Which lasers and light sources are available for photo-epilation?
2 What does the concept of selective photothermolysis mean?
3 What is hirsutism?
4 What is hypertrichosis?
5 In which wavelength ranges do lasers and light sources operate for hair removal?
6 What does evidence-based medicine mean?
7 Which lasers and light sources have hair removal efficacy up to 6 months postoperatively?
8 Which lasers and light sources have hair-removal efficacy beyond 6 months postoperatively?
9 Does repeated treatments influence the treatment outcome?
10 How is the efficacy from photo-epilation as compared with the efficacy from shaving, waxing and electrolysis?
11 Which physical parameters of lasers and light sources influence the treatment outcome?
12 Which individual skin and hair variables influence the treatment outcome?
13 Is the level of evidence similar for the available lasers and light sources for photo-epilation?
14 Does evidence exist for complete and persistent hair removal?

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