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ORIGINAL ARTICLE

What else than eyes need special protectors during laser hair reduction sessions?

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Abstract

Complications of laser hair reduction should be classified not only to skin and ocular complications but to skin, ocular, and scalp hair complications. Do not forget the plumes. Awareness about laser dangers is very critical. In this way, able to progress the security of both patients and laser providers. Does Nd: YAG cause more bad effect than Alexandrite on scalp hair melanin of laser providers and why? The study aimed at detecting the effect of cumulative exposure to scattered beam during laser hair reduction on the laser providers which may cause unexpected scalp hair melanin affection. The study included 150 female subjects: One hundred medical personnel engaged in laser-assisted hair reduction procedure; half of them were wearing head cover (hijab) and 50 female subjects not dealing with hair reduction laser systems (half of them were wearing hijab). Two laser devices were used: Alexandrite laser (GentleLase PRO® 755 nm, Candela Corp., Wayland, MA, USA) and neodymium-doped Yttrium Aluminium Garnet (Nd: YAG) (Synchro HP 1064 nm, Deka M.E.L.A s.r.l., Calenzano (FI), Italy) laser. A significant higher number of grey hairs in medical personnel ($P < 0.001$) was evident at the initial examination and at each follow-up visit thereafter. The number of grey hairs at initial assessment, after 6 months and after 1 year, was significantly higher in medical personnel dealing with Nd: YAG laser than those using long-pulsed Alexanderite laser ($P < 0.001$ each). A noteworthy positive correlation was found between working years, grey hair number at the start of study, and the progression (excess) in number of grey hairs after 1 year regardless of the laser system used. It seems that scalp hair pigment needs specific protection as does the eye pigment. Greater attention should be paid to possible long-term hazards particularly on service providers.

Keywords Grey hairs · Alexandrite · Nd: YAG laser

Introduction

Laser hair reduction is one of the foremost common applications of laser cosmetic surgery. This laser methodology utilizes photo-ablation destruction of hair follicles to expel undesirable hairs. Laser-assisted hair reduction was approved by the FDA in 1995 [1]. Most lasers utilized for hair reduction work at high levels of emission and are subsequently categorized as profoundly dangerous class (3B and 4) [2]. The hair matrix melanin absorbs light of particular wavelengths that fall in the range between 600 and 1100 nm. Henceforth, long-pulsed Alexandrite (755 nm) and Nd: YAG (1064 nm) photo-thermally damage hair follicles [3].

Physiological aging of hair differs across the various races of peopleLaser is known to be a collimated sort of light; nevertheless, soon upon its collidance with the surface of skin, it may diverge or scatter as it penetrates deeper through the ensuing layers [4]. On encountering skin surface, laser beam may be transmitted, reflected, scattered, or absorbed at different layers [5]. Reflection happens at all interfaces of media through which laser beam traverses, such as sapphire tip or optical glass, air, water jelly, and skin surface. Approximately speaking, 4 to 7% of visible light that meets the surface of the skin is reflected by the stratum corneum [6]. Exposure to the laser beam is not limited to direct beam exposure. Reflections may be just as damaging as exposure to the primary beam. A surface that can reflect the laser

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beam in many directions is called a diffuse surface. Although these reflections do not have the full power or energy of the primary beam, they can still be harmful, especially for high-powered lasers [7].

The typical cutaneous adverse effects of laser hair reduction are pain, temporal erythema, perifollicular oedema, blisters, burn or even permanent scarring, colour change, and premature greying of hair [8] **&** [3]. Ocular trauma can occur by direct exposure of the eye to laser beam or by beam reflection. Melanin targeting lasers may lead to retinal harm or destruction. For safety purposes, the warning signage should not only be used inside the laser room, but rather in both, inside and outside. The hazard of ocular damage can be relieved by wavelength particular filtering glasses for all parties present within the laser room [9]. Hazards may not only affect the patients, but occupational risks may also involve the service provider. These incorporate exposure to the laser plume which entails the particulate debris, vapours, and smoke produced during a laser hair reduction procedure. The laser plume is known to be carcinogenic and teratogenic. These adverse effects are mainly attributed to ambient exposures to ultrafine particles (UFP) [10].

Physiological aging of hair differs across the various races of people: Caucasians begin in the mid-30 s, while Asians in late 30 s and Africans, latest in mid-40 s [11]. Full extend of colour variations from normal to white can be seen both among different persons and even in the hair of the same person. The perception of hair colour is primarily influenced by the physical hair shaft characteristics and with mere relationship to the genuine shaft chromaticities [12]. White hair is totally devoid of melanocytes or pigmentation, whereas grey hair has few holding on colour with aberrantly distributed melanosomes [13].

The pathogenesis of hair greying has extensively been studied by molecular research and decreased functional melanocytes within the hair bulb of anagen hair follicles with resultant melanin loss which is the main hallmark of hair turning grey. Imperfect melanosomal transfers to cortical keratinocytes and melanin incontinence due to melanocyte degeneration are also accepted to contribute to premature greying of hair, which is usually progressive and persistent, with few incidental reports of self-pigment recovery [14]. Pollution, contamination, UV light, and psycho-emotional or inflammatory stress contribute to oxidative stress produced outside the follicle melanocytes and may increase internal oxidative stress and exaggerate the hair follicle melanocyte antioxidant capacity resulting in accelerated terminal destruction in the ageing hair follicle [15] **&** [16]. The interaction of UV-A light with topically applied psoralen generates superoxide radicals that have been shown to induce greying of hair in mice [17].

Patients and methods

The protocol for this prospective cohort multicentre study was approved by the Research Ethics Committee Faculty of Medicine, Egypt, and was in accordance with the tenets of the Declaration of Helsinki. Informed consent was obtained from each subject prior to participation. Medical personnel from 8 dermatology laser centres were involved in the study for a 1-year-period from January 2019 to January 2020.

The study included 150 female subjects: 100 medical personnel engaged in laser-assisted hair reduction procedure (half of them were hijabis) and 50 age-matched healthy female subjects not dealing with hair reduction laser systems (half of them were hijabis).

Inclusion criteria implicated medical personnel aged 25–3 years (mean 29 ± 2.61 years), working regularly for about 8 h per day (at the least), and 4 to 6 days per week for about 1–5 years (mean 4.43 ± 2.21 years). Two laser devices were used by the medical personnel involved in the study: 50 medical personnel used the long-pulsed Alexandrite laser (GentleLase PRO® 755 nm, Candela Corp., Wayland, MA, USA), and 50 medical personnel used the Nd: YAG laser (1064 nm) (Synchro HP, Deka M.E.L.A s.r.l., Calenzano (FI), Italy).

The exclusion criteria encompassed any noticeable progressive premature hair greying (PHG) before starting to work in the laser field, i.e. family history of PHG, pigmentary skin disease as vitiligo, alopecias except AGA, metabolic syndrome, obesity, diabetes mellitus, hypertension, thyroid disease, anaemia, vitamin D deficiency, osteoporosis, or excessive misuse of cosmetic dyes.

All subjects were evaluated before being indulged in the study, and every 6 months thereafter for a 1-year-study period by detailed clinical history, examination of scalp hair for number, and distribution of grey hair and photography for documentation and objective clinical evaluation by two blinded dermatologists.

Statistical analysis

The collected information was arranged and analysed utilizing the Statistical Package for Social Science (SPSS 20.0). Categorical information was expressed as number and percentage; continuous variables were expressed as mean and standard deviation for normally distributed data, while median and inter quartile range (IQR) were used for the unconventional data set. Suitable tests of significance were calculated. Comparison between 2 groups was done using the unpaired *t* test or Mann Whitney test when it was suitable. ANOVA test or Kruskal Wallis test were utilized

Table 1 Difference between medical personnel and non-medical personnel as regarding number of grey hairs and hair greying progression

Parameter	Medical personnel (groups 1 and 2) [$n=100$] Median (IQR)	Non-medical personnel (group 3) [$n=50$] Median (IQR)	z = Mann Whitney test	*P*
No of grey hair/0	23(26)	0(2)	9.910	.000**
No of grey hair/6 m	30(30)	1(2)	9.83	.000**
No of grey hair/1 y	38.5(37)	2(4)	9.51	.000**
Progression (excess) in grey hairs	22(26.5)	2(5)	8.23	.000**

for comparing more than 2 bunches. Chi-square test was used when it was indicated. Spearman correlation analysis was done. The acknowledged level of significance in the work was 0.05 ($P<0.05$).

Results

Subjects enrolled in the study were basically divided into three groups: group 1, medical personnel dealing with long-pulsed Alexandrite laser-assisted hair reduction system; group 2, medical personnel dealing with Nd: YAG laser-assisted hair reduction system; and group 3, healthy age-matched females not dealing with laser-assisted hair reduction systems.

A significantly higher number of grey hairs is evident in medical personnel (groups 1 and 2) ($P<0.001$) both, at the initial examination (i.e. before being enrolled in the study) and at each follow-up visit from there on (Table 1). Eyebrows were affected only in 6 medical personnel as eyebrows are mostly covered with the protective eye goggles.

The three groups were age-matched; however, there was a significant positive correlation between the years of work and number of grey hairs in groups 1 and 2 ($t=0.405$, $P=0.686$). The number of grey hairs at initial assessment, after 6 months and after 1 year, is significantly higher in medical personnel dealing with Nd: YAG laser (group 2) than those using long-pulsed Alex laser (group 1) ($P<0.001$ each) (Table 2).

The number of grey hairs at the start of study and greyness progression was correlated with the duration of work in years. There is a statistically significant positive correlation between the working years and number of grey hairs at the start of study and the progression (excess) in the number of grey hairs after 1 year regardless of the laser-assisted laser hair reduction system used (Table 3).

Covering hair with Hijab did not appear to be protective against laser effect on hair colour. There was not any significant difference in progression of hair greying between covered and non-covered hair in either groups utilizing Nd: YAG or Alexandrite lasers (Table 4). The hair appears to need special protective cover like the protective eye goggles.

About 62.0% of group 1 subjects and 52.0% of group 2 subjects had thinning of hair shaft. However, this was found in only 20.0% of group 3. Telogen effluvium is evident in 70.0% of subjects in group 1 and 82.0% of subjects in group 2; meanwhile, only 42.0% of subjects in group 3 show telogen effluvium (Table 5).

Table 2 Difference between operator personnel using Alex, operator personnel using YAG, and healthy subjects as regarding number of grey hairs

Parameter	(Group 1) [$n=50$] Median (IQR)	(Group 2) [$n=50$] Median (IQR)	(Group 3) [$n=50$] Median (IQR)	K.W	*P*	Test# (*P*)
Age (mean ± SD)	29.50 ± 2.72	29.22 ± 2.50	29.12 ± 2.99	$F=0.256$	0.774	$t=.534$ *P* (0.594)
Working years (mean ± SD)	4.34 ± 2.41	4.52 ± 2.01	—			$t=.405$ *P* (0.686)
No of grey hair/0	22 (21)	25.5 (26)	0 (2)	K.W = 98.7	.000**	$z=1.11$ *P* (0.265)
No of grey hair/6 m	27 (22)	32 (29)	1 (2)	K.W = 98.27	.000**	$z=1.78$ *P* (0.075)
No of grey hair/1 y	35.5 (34)	41 (41)	2 (4)	K.W = 91.10	.000**	$z=1.05$ *P* (0.293)

K.W Kruskal Wallis test, *F* ANOVA test, *t* Student *t* test, *IQR* interquartile range, # comparison between Alex and YAG laser, *z* Mann Whitney test

Table 3 Correlation between duration of work/years, No of grey hairs at start of study, and No of extra grey hair after 1 year

	Duration of work/years	
	r	*P*
No of grey hair (at start of study) $n=100$	0.561	.000**
No of extra grey hair (after 1 year) $n=100$	0.485	.000**

r Spearman correlation coefficient

Discussion

Laser hair reduction is not risk-free, and its adverse impacts are not limited to the patients but may also extend to service providers. Adequate training and good safety measures are vital to minimize these hazards. Induced greying of hair is a disturbing and disfiguring condition that can cause noticeable interference with social adjustment and acceptance.

Rasheed (2009) [18] found that premature greying of a patient's hair performing laser (recorded in 16.8% of patients) affects primarily patients over the age of 40 (approximately 85.7% of such cases). Also, it influences those with now existing issue of premature greying of hair perturbing either the scalp or face (92.9% of cases). He found that it was not reversible indeed after the laser sessions were stopped. On the other hand, as a result of inflammatory response, transitory or lasting leukotrichia was reported to occur especially after intense pulsed light (IPL) hair reduction. In a study of 821 patients, leukotrichia created in 29 treated patients which was reversible only in nine of them within 2–6 months [19].

Partial and spontaneous greyness reversal may develop in the early stages of it, whereby melanogenesis in de-activated bulbar melanocytes is re-started during anagen of the same hair growth cycle. Radiation or cytokine-triggered stimulation of melanocytes in the external root sheath may contribute to reversal of greyness [20].

In this research, the number of grey hairs throughout all intervals, at the beginning of the study (26 vs 2), at 6 months (30 vs 2) and at 1 year (37 vs 4), was all found to be significantly higher in medical personnel dealing with laser-assisted hair reduction systems than non-medical personnel ($P<0.001$ each) Also, the progression was found to be predominantly higher among them (26.5 vs 5), ($P<0.001$). Eyebrows were affected in 6 cases only (merely 2–3 hair) as eyebrows are mostly covered with the protective eye goggles.

Rasheed claimed that the increased number of grey hairs has been reported to occur in a clear-cut quickened rate with the starting of laser sessions. Accelerated hair greying was frequently kept to the laser treated regions, supposing that laser beam had played a chief role in provoking aging of the hair follicle. Probably the laser-induced thermal insult has a preferential accelerated senescence effect on vulnerable follicles [18].

On the other hand, Liew explained the occasional finding of grey hair after laser treatment by the targeted damage of the hair follicle melanocytes or suppressive effect of melanogenesis [21]. As greying is only an incidental finding, it is supposed that greyness occurs only with the presence of hair follicles that have large melanin granules. Indeed, those are sufficient to be specifically targeted by the moderately long-pulsed duration of the hair reduction laser. On the other hand, the laser-induced thermal destruction might have triggered some sort of structural alteration of hair matrix cells disturbing melanin transfer rather than having a direct effect on melanogenesis itself [22].

Al Taleb et al. (2019) [1] suggested that the absence or presence of reflective surfaces/floors in the laser room are important measures of the degree of laser beam reflection. The preceding may occur with specular reflection which mimics a mirror-like reflection of light waves. This means that the incident and reflected ray's angles are similar. Consequently, the collimated coherent properties of the laser are preserved. It may also encompass diffuse reflection in which the incident ray is scattered at numerous angles. They reported that about 68/94 (72.3%) laser service providers

Table 4 Difference between operator personnel using Alex and operator personnel using YAG as regarding covering hair with higab

Group	(Group 1) non-covering hair ($n=25$) Median (IQR)	(Group 1) covering hair ($n=25$) Median (IQR)	M.W test (z)	*P*	(Group 2) non-covering hair ($n=25$) Median (IQR)	(Group 2) covering hair ($n=25$) Median (IQR)	M.W test (z)	*P*
Age (mean ± SD)	29.56 ± 2.75	29.44 ± 2.75	$t=0.154$	0.878	29.28 ± 2.55	29.16 ± 2.51	$t=0.167$	0.868
Working years (mean ± SD)	4.52 ± 2.67	4.16 ± 2.15	$t=0.524$	0.603	4.64 ± 2.09	4.40 ± 1.95	$t=0.418$	0.678
No of grey hair/0	20 (18)	23 (29)	1.27	0.203	22 (18)	33 (34)	1.65	0.099
No of grey hair/6 m	22 (20)	28 (30)	0.932	0.351	31 (28)	33 (39)	0.962	0.336
No of grey hair/1 y	35 (39)	36 (32)	0.272	0.876	41 (38)	41 (46)	0.767	0.443

M.W Test Mann Whitney test

Table 5 Difference between operator personnel using Alex and operator personnel using YAG as regarding other hair problems

		(Group 1)	(Group 2)	(Group 3)	X^2	*P*	Test# (*P*)
Thinning of hair shaft	Not affected	19	24	40	19.47	.000**	X^2 (1.02) *P* (0.313)
		38.0%	48.0%	80.0%			
	Affected	31	26	10			
		62.0%	52.0%	20.0%			
Hair falling (telogen)	Not affected	15	9	29	18.44	.000**	X^2 (1.97) *P* (0.160)
		30.0%	18.0%	58.0%			
	Affected	35	41	21			
		70.0%	82.0%	42.0%			

had reflective floors inside the laser rooms; 57/94 (60.6%) providers did not have any type of recognizable proof or caution for the laser room; and 56/94 (59.6%) providers did not educate patients to maintain a strategic distance from coordinate, looking into the laser beam coming from the machine or reflected from any surface even while wearing a protective eyewear, which suggests that indeed with wave selective protection laser beam, reflection may have great detrimental effects.

There was significantly positive correlation between working years and number of grey hair ($t=0.405$, *P* 0.686). The number of grey hairs at the start of the study ($r=0.56$, *P* 0.000) and greyness progression ($r=0.485$, *P* 0.000) were correlated with the duration of work**.**

Ladies usually begin turning grey around the edge of the hairline. The rate and progress of greyness depend on genetics. Marked early greying is often noticed among kinships. The advance of greying is also profoundly variable, not only on distinctive region of the scalp but moreover across the body. This may reflect varieties in unique melanocyte precursor seedings during melanoblast migrations in embryogenesis or in differences of niche quality [20]. Repeated laser exposure appears to accelerate progression of hair greyness in medical personnel dealing with laser-assisted hair reduction systems.

In this study, the Nd: YAG laser effect on hair greying was found to be significantly higher than that of Alexandrite laser ($P<0.001$ each). The Nd: YAG lasers are frequently recommended for darker skin types as for the deeper penetration of the laser beam as compared to other lasers, therefore lowering the risk of epidermal interference. However, higher fluence is usually needed to damage the follicular growth centres, as these wavelengths are not readily absorbed by melanin [23]. The long-pulsed Nd: YAG produces less epidermal destruction with sufficient follicular injury compared to the other laser and light systems [24].

In this study, we found that covering hair with Hijab did not appear to be protective against laser effect on hair colour. There was no significant difference in progression of hair greying between covered and non-covered hairs in either groups utilizing Nd: YAG or Alex lasers.

It is essential to set clear enlightening on utilizing the particular protective eye goggles upon entering the laser room to abolish any hazard of coincidental eye harm from direct and reflected laser beam. All authorized personnel entering the area of the laser must be obliged to put on protective eyewear. Similarly, the scalp hair might need a special protective cover as covering hair with ordinary Hijab did not appear to reduce the possible detrimental effect of laser-assisted hair reduction systems on hair colour.

Although special goggles do not provide maximum protection as safety checklist says, avoiding direct stare into the laser beam emitted from the laser device, or reflected from any surface (even when wearing protective goggles), should always be emphasized. Reflective objects such as jewellery, watches, instruments, or mirrors to intercept the laser beam should never be permitted into the laser area [1].

Thinning of the hair shaft was noticed in about 62.0% and 52.0% of medical personnel using Alexandrite and Nd YAG laser systems, respectively, while only noticed in 20.0% of the age-matched non-medical personnel. Telogen effluvium was reported in 70.0% and 82.0% of medical personnel using Alexandrite and Nd: YAG, respectively, and only in 42.0% of the non-medical personnel.

This finding supported by this suggested that mechanism of work of laser devices in hair reduction transitory hair loss occurs by initiation of a telogen-like condition in which hair follicles are to be rested. Histologically, most hair follicles are in telogen 1 month following the session [3]. Also, supported by [25], who found a period of alopecia enduring from several weeks to a many month until part of hair follicles recoup and get into another anagen cycle.

Conclusion

Awareness of laser-induced hazards is quite important to properly keep the safety of both patients and service providers. The popularity and efficacy of laser hair reduction systems are undoubted nowadays. Nonetheless, greater attention should be paid to possible long-term hazards particularly on service providers.

Scalp hair and eye pigments seem to need specific protection. Larger controlled studies should be designated to investigate this point more vigorously. Long-term follow-up studies are urgently needed to determine whether these effects on scalp hair pigment are irreversible or not. Do we need to adjust safety guidelines during laser-assisted hair reduction procedures done by medical personnel in private practice? A question to shed the lights on.

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Declarations

Ethical approval The manuscript has been read and approved by all the authors, and each author believes that the manuscript represents honest work.

Conflict of interest The authors have declare no competing interests.

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