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### **Comparative study between Ruby, Alexandrite and Diode lasers in hirsutism**

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### **Abstract**

**Background:** Hirsutism is a common problem for which laser is being the treatment of choice. Several lasers with varying wavelengths, pulse durations, energy fluences and skin cooling systems, are currently used for hair removal. However, the ideal laser parameters and group of patients who respond better after treatment remain largely unknown. Objectives: A prospective study to evaluate the long term efficiency and safety of three different (Ruby, Alexandrite, Diode) laser hair reduction systems and to determine which candidates respond better for hair reduction.

**Methods:** 171 female patients with Fitzpatrick skin types II- IV with the problem of hirsutism, in the beard area were divided into three groups. Group one included 60 patients, who were treated by ruby laser; group two included 51 patients who were treated by Alexandrite laser whereas the third group included 60 patients who were treated by diode laser. Detailed history, Hormonal assay and abdomino-pelvic ultrasonography were performed to differentiate between idiopathic and pathological hirsutism. Treatment was

performed in multiple sessions with an interval of 4 weeks using either: ruby laser, long pulsed Alexandrite laser or diode laser. Hair thickness and rate of hair reduction and re-growth were recorded by using Hair counts and photographs before treatment and after 1,3,6,9 &12 months from the initial treatment.

**Results:** All patients had reduction in hair count and delayed hair re-growth. Patients less than 30 years of age responded better than those more than 30 years regardless of the other clinical factors or the type of laser used. There was a significant statistical difference between them at 6 and 12 months follow up ( $P < 0.05$ ). Patients with hirsutism due to any underlying cause responded as the idiopathic ones. Medical treatment (antiandrogen drugs) during the course of laser sessions had no role in improving the results. Concerning laser parameters, the three lasers used were found to have positive results in hair reduction.

**Conclusion:** The three types of lasers showed variable degrees of improvement concerning the percentage of hair reduction and the rate of hair re-growth. The best results were obtained with diode followed by the Alexandrite. Ruby laser produced the poorest results. The least complications were observed with the diode laser, followed by the Alexandrite. Age plays an important role in the efficacy of laser hair removal diode laser proved to be the most effective and safest laser in this study.

## Introduction

Hirsutism is defined as the growth of terminal hair in a woman in sites at which it is usually considered a male secondary characteristic e.g. chin and beard area. The severity of hirsutism depends on the underlying disorder resulting in excess production or increased availability of the potent or weak androgens (testosterone, dehydroepiandrosterone (DHEA) and androstenedione).

Hirsutism may result from ovarian and/or adrenal overproduction of androgens or some exogenous medications. Polycystic ovarian syndrome is the underlying disorder in the majority of women who present with hirsute. It is characterized by a typical ultrasound appearance of the ovaries and a variable endocrine and clinical picture [1].

Hirsutism may be idiopathic, due to androgen receptors hypersensitivity, or hereditary. It may result from an increased end organ ability to produce dihydrotestosterone (DHT) from weaker androgens.

Many temporary hair removal methods exist, including shaving, tweezing, wax epilation and chemical depilatories. Most of these methods are tedious, others are invasive or time consuming such as

Electrolysis and thermolysis or take a long time to produce an effect. Other methods may interfere with hormonal profile or desire for pregnancy such as antiandrogens. The need for a rapid, permanent reduction and noninvasive method for hair removal has led to the development of various lasers. Hair removal lasers generally work on the principle of selective photothermolysis, based on selective absorption of laser energy by the components of the hair follicle. The target chromophore is melanin contained by the follicle, which has a broad absorption spectrum. Several lasers with different wavelengths have been able to take advantages of this approach. These lasers range from the short end of the spectrum with 694 nm ruby laser[2], to the middle, with the 755 nm Alexandrite[3] and 810 nm diode[4], to the long end with the 1064 nm Nd:YAG laser[5].

The laser Wavelength determines both the amount of energy absorbed by the target and the surrounding tissue in function of their color/pigment and the depth of penetration. In addition to wavelength, effective fluence (the fluence delivered at the target depth) is also influenced by the spot size and pulse width. Larger spot sizes and longer wavelengths are more efficient at delivering a greater proportion of their energy to target tissues as the depth of the target increases [6]. Pulse width is the amount of time (in milliseconds) over which the total energy (in joules) contained in one pulse is delivered to the surface of the skin. For hair removal, the optimum pulse duration is approximately equal to the thermal relaxation time (TRT) of the hair follicle. The TRT is defined as the time required for an object to cool to half the temperature achieved immediately following laser exposure. For human terminal hair, TRT varies from about 10 to 100 milliseconds [7].

Even laser light with selective photothermolysis and perfect specificity for melanin can cause damage to the skin surrounding the hair follicles, as the epidermis also contain melanin. The use of an epidermal cooling strategy, allows the delivery of sufficient laser energy to damage the hair follicle while avoiding and minimizing damage to the surrounding skin.

## **Patients and methods**

171 hirsute female patients with Fitzpatrick skin types II-IV were included in this study. Their ages ranged from 17-50 years (mean 32 years). Informed consent had been obtained from each patient prior to treatment. The area studied was the beard, even if there were other areas affected and treated.

Comprehensive history and examination were performed in

order to detect any hormonal disturbance or underlying disorder, if any leading to growth of excess hair.

Abdomino-pelvic sonography and Hormonal assay were done as a routine investigation. These included level of Testosterone, Dehydroepiandrosterone sulphate (DHEA-S), plasma Cortisol and Prolactin.

Treatment was performed using either one of 3 types of lasers. The first group were exposed to ruby laser (EpiTouch Silk, Sharplan) at 694 nm and 1.2 ms pulse duration, at fluences of 25-40 J/cm<sup>2</sup> through different spot size (3,5,6mm). The second group were exposed to Long pulsed Alexandrite laser (LPIR, Cynosure) at 755 nm and 20 ms pulse duration, at fluences of 10-25 J/cm<sup>2</sup> (average 20 J/cm<sup>2</sup>) through 7-10 mm spot size at 1 Hz. The third group was exposed to diode laser (Light Sheer, Star Med / Coherent) at 800 nm and 5-30 ms pulse duration, at fluences of 10-40 J/cm<sup>2</sup> through a 9 mm spot size at a repetition rate 1-2 pulses/ sec. Fluence was determined, prior to the initial treatment session, by the maximum fluence tolerated according to the patient pain threshold and by the minimal resulting erythematous reaction, without any evidence of burn.

Treatment was done in multiple sessions with an interval of 4 weeks and continued till a patient satisfactory hair count was reached or hair reduction ceased in two consecutive sessions.

In case of ruby and Alexandrite lasers, a cooling gel or ice packs were applied to the skin surface few seconds before and after treatment. In case of diode laser, the integrated sapphire contact cooling hand piece was used.

Post operative care for all patients included applying ice directly following laser sessions for a few minutes, sun avoidance, prophylactic topical antibiotics and sun screen cream with SPF 30 or more.

All patients were instructed to leave the hair unshaved ten days prior to treatment and to stop hair removal methods apart from shaving or using depilatory cream between sessions. Areas of unwanted hair growth were identified and marked. It was measured using a transparency grid divided into equal squares; the area of each is 1 cm<sup>2</sup>. The terminal hairs in 10 squares were counted and the mean was calculated every time.

The differences between the mean before treatment and at 1, 6, and 12 months periods were determined. The primary outcome measure was the percentage of hair reduction, defined as the percentage of each difference with respect to the initial hair count before treatment. Other secondary outcome measures were the rate of hair regrowth, complications including hyperpigmentation, white

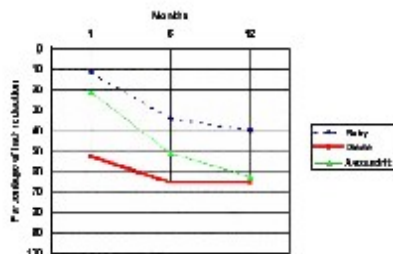
hair and recurrence.

## Results

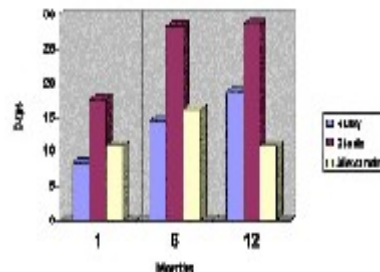
The clinical characteristics for the three groups were comparable ([table 1](#)). The mean number (mean +/- SD) of treatment sessions in the idiopathic hirsutism group were 6.33 +/- 1.2, 4.03 +/- 2.08 and 3.56 +/- 1.21 for the ruby, Alexandrite and diode groups respectively. In the pathologic hirsutism group, they were 6.10 +/- 1.29, 4.60 +/- 2.32 and 3.58 +/- 1.32 respectively.

An immediate erythematous skin response was observed in all laser treated beard areas. All laser treated areas displayed a delay in hair regrowth. The results recorded for patients treated and followed up for 6 and 12 months revealed generally that patients whose ages were less than 30 years gave better response for laser treatment than those whose ages were more than 30 years regardless the other clinical factors and the type of laser used ([Table 1](#)). There was a significant statistical difference between them at 6 and 12 months follow up ( $P < 0.05$ ). The best results were obtained when diode laser was used. In this case there was also a significant statistical difference between those of age less than 30 years and those above 30 years at 6 months follow up ( $P < 0.05$ ). Poor response was observed when ruby laser was used.

Polycystic ovarian syndrome accounted in 20% of the causes of hirsutism (35 out 171). There were no significant statistical differences between patients either with or without hormonal disturbance, polycystic ovary, family history and taking medical treatment in the form of antiandrogens during laser sessions on percentage of hair reduction. The results shown in [table 2](#) indicate that there was no significant difference in the response between idiopathic patients and pathological groups. However, better results were obtained when diode laser was used for treatment.



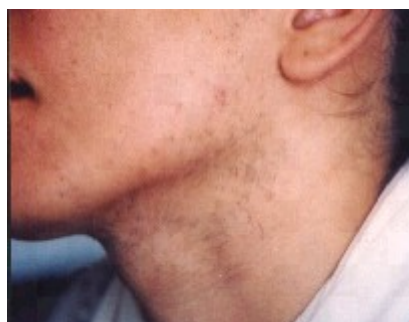
**Fig. 1: Percentage of Hair Reduction at 1, 6 and 12 months follow up**



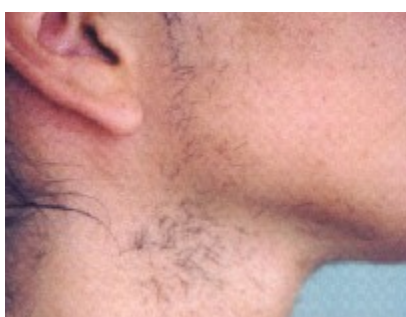
**Fig. 2: Percentage of Hair Regrowth at 1, 6 and 12 months follow up.**



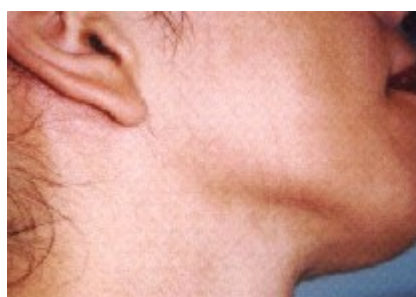
**Fig 3a: Left side before treatment.**



**Fig 3b: Same side after ruby laser treatment .**



**Fig. 4a: Right side of the patient before treatment.**



**Fig. 4b: Same side after diode laser treatment.**



**Fig. 5a: Before treatment.**



**Fig. 5b: After Alexandrite laser treatment**

## Discussion

In this study the diode laser induced a significant rapid reduction of hair growth that increased on long term follow up. The percent of hair reduction was significantly the least in the ruby group, 11.25, 20.17 and 39.67 percent at one, six and 12 months respectively. Alexandrite laser gave results (21.08, 51.08 and 62.35 respectively) intermediate between those obtained with diode and

ruby laser. In addition, the duration of hair re-growth was shortest in the ruby group and longest in the diode group.

The results of our study showed marked correlation between the percentage of hair reduction due to laser treatment and patient's age irrespective of the underlying pathology. Patients below 30 years of age responded better than older patients. This does not agree with the findings of Liew et al, where they reported no correlation between the efficacy of ruby laser treatment and age [2]. The age related improvement may be explained by the increased tyrosinase activity in middle age, which is responsible for formation of the end product melanin chromophore, through the production of an intermediate compound, dopaquinone, from the precursor tyrosine [8]

The lack of any significant statistical difference between the response of pathological groups and idiopathic groups suggests that the inherent susceptibility of hair to laser irradiation is more important in hair destruction than the physiology of hair growth [9]. It is interesting to note that medical treatment in the form of anti-androgens did not improve nor accelerate laser treatment response. This finding conform to Lumachi , Rondinone, report [10] as anti-androgen drugs have only a suppressive and not curative effect that wears off a few months after cessation of therapy.

This study included the largest number of treated subjects who were followed for long duration. Other studies showed a reduction in hair growth after 2 years, however the patients number was too small [11]. Other prospective controlled studies had either a smaller number of subjects or shorter follow up duration [12].

In the current study, the evaluation was done objectively by measuring the percentage of hair reduction and rate of hair re-growth, by counting the hairs through a transparency grid. Other studies based their evaluation on either subjective assessment or histo-pathological evaluation). The invasive histological evaluation, used by others [9] would have been unacceptable in our study, in the beard area, for cosmetic reasons.

Other studies measured the change in hair diameter using very sophisticated computerized image analysis systems [13]. The evaluation in our study was simple, objective and can be repeated.

However, in our study the sessions were continued till a patient satisfactory hair count was reached or hair reduction ceased in two consecutive sessions. This is different from Most published studies were the response was studied after a pre set number of treatment sessions.

The results obtained in our study represent the maximum

benefit that can be gained from the treatment. Despite that the rate of hair reduction in Alexandrite and diode groups was nearly equal at 12 months, the diode laser proved to be more effective, as the number of sessions were fewer.

Other studies reported improvement in the treatment of aesthetic hair or looked at many sites [9]. Our study assessed the pathological and looked at one site. It is the largest study assessing the hirsutism in the beard area, the most distressing site in women, where it is thick, coarse with short anagen duration. These are expected to have a different response to laser treatment.

A variety of factors had influenced the results of hair reduction between the three laser systems. Ruby laser (694nm) produced the poorest result in this study despite it is the most absorbed by the chromophore melanin. This can be explained by fact that the longer the wavelength, the greater depth of penetration.

The Alexandrite and diode lasers (at Wavelengths of 755 nm and 800 nm respectively) have 1-1.5 mm greater depth of penetration than the ruby laser and exert their effect on the hair follicle by applying the principles of selective photothermolysis. These Wavelengths are able to penetrate deep into the dermis and selectively target follicular melanin [14]. In addition, the used 20 msec pulse duration of Alexandrite and 30 msec pulse duration of diode laser in this study lie above the thermal relaxation for the epidermis, which is estimated to be 3-10 msec and below the thermal relaxation time of the hair follicles, which is estimated to be 40-100 msec, thereby optimizing selective destruction of hair follicle.

In this study the shortest ruby laser pulse duration (1.2 msec) was used. Changing pulse duration may affect the response to the ruby laser. Long duration pulsed ruby lasers were recently developed.

The better results obtained with the diode laser may have been enhanced partly by the cooling effect of the integrated sapphire and the pressure exerted by it on the skin. Sapphire is ideal, as it has excellent thermal characteristics and operates as a heat sink removing heat from the epidermis [15]. This enables the target structures to be heated more efficiently, so that less fluences are required, resulting in less thermal load on the epidermis [16]. The latter effect is not present in the other two lasers where only cooling without pressure effect was exerted.

The possibility of using a larger spot diameter in the diode and Alexandrite lasers adds the advantage of covering a larger area over a short time, and also increases the depth of penetration.



Our findings confirm the value of laser in hair reduction in the beard area of patients with Fitzpatrick skin types II - IV. In our study series of 171 patients that extended over 12 months, there were very few complications in the form of hyperpigmentation, white hair and recurrence. The best results were obtained with diode followed by the Alexandrite. Ruby laser produced the poorest results. The least complications were observed using the diode laser, followed by the Alexandrite. The highest rates of complications occurred in the ruby group (6.7 to 8.3). Accordingly ruby laser is no longer used in the management of hirsutism in our center and diode laser has become the laser of choice. Although we are much encouraged by the hair reduction in hirsutism by the diode and the Alexandrite laser, this work only studied the beard area. Further study on other body sites in hirsutism is needed.

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