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Technology assessment of long-pulsed Alexandrite laser device for hair removal: A systematic review

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ABSTRACT

Introduction: Excessive hair removal is one of the issues discussed specifically in cosmetics. To this end, various methods are available, such as the electrolysis, chemicals, etc., but each of these methods provides advantages and disadvantages. Alexandrite laser device laser is one of the most popular systems available and suitable for skin type's I–IV. In this study we aimed to evaluate this device to determine whether it can be used as an alternative device for other devices. *Materials and Methods:* A comprehensive search was conducted in 6 July 2019 via Medline (PubMed), Cochrane Library, Scopus, CRD, NIHR HTA, web of science, Clarivate and ProQuest databases using PICO-based selected keywords. Afterwards, the retrieved studies were selected by two reviewers. Studies with no inclusion criteria were excluded. Then, selected studies were assessed by two evaluators using CASP International tool. Finally, five studies were selected and the obtained data were meta-analyzed by RevMan 5.2 software. In order to compare the costs and outcomes, the Incremental Cost-effectiveness Ratio (ICER) index and the sensitivity analysis were implemented. Results: This method is effective and safe. Short-term complications in Diode laser are more than the Alexandrite, Whereas Nd:YAG lasers and Intense Pulsed Optical Systems(IPLs) generally show less complications than Alexandrite. Patient satisfaction was not different between any of the methods. There was no difference between the long-pulsed Alexandrite laser, Diode laser, and IPL systems in light of therapeutic effects, but the only significant difference was seen in reduction rate of the mean amount of hair. The long-pulsed Alexandrite laser reduced it 16.62% more than the Nd:YAG laser.

Keywords: Alexandrite laser, Incremental Cost-effectiveness Ratio, Diode laser, Intense Pulsed Optical Systems

1. INTRODUCTION

Nowadays removal of excessive hair is one of the most discussed issues in cosmetics and therapeutics. Unwanted and excessive hair is a common aesthetic problem in many cultures. On the other hand, hirsutism (excessive growth of hair in the androgen-dependent regions) and hypertrichosis (excessive hair density in each area of the body) may have an adverse effect on mental health by causing depression and anxiety (Phillips, 2009; Gan and Graber, 2013).

Before the advent of lasers, various treatments for skin Pigmentation disorders including covering the skin with make-up, whitening with chemicals, peeling (skin peeling), cryotherapy, skin scrubbing, and etc. were used. Removal of hair using traditional methods can improve the individual's quality of life (Gan and Graber, 2013); But many of these techniques provide temporary solutions for excessive hair. Although electrolysis may permanently remove hair, it is slow, operator-dependent and it may have variable outcomes.

The rapid advances in laser technology over the last decades have led medical researchers to take advantage of this technology in a variety of therapeutic areas and successful treatments have led to an ever-increasing use of this technology. The early utilization of this technology dates back to the 1990s. Laser therapy has been introduced as a standard treatment for the removal of excessive hair. This method, leads to a longer period of hairlessness in contrast to other methods.

In the past decade, different lasers with wavelengths with high absorbance by melanin and nanosecond wavelengths were more effectively and quickly provided for the treatment of these lesions (Wang et al., 2006). In 1996, the 694-nanometer Ruby laser was the first laser device to be officially studied for hair removal. Long-term treatment, for several minutes on the face and up to several hours for the back, has limited the use of this laser. Shortly thereafter, the Neodymium or Nd:YAG laser was the first laser treatment for hair removal approved by the Food and Drug Administration (FDA) in 1997 (Ishikawa et al., 2004). At the same time, the Alexandrite laser machine was also approved by the FDA in the same year (Administration) and was used by dermatologists and hair and beauty experts.

Now with the supply of a variety of devices to remove hair, the posed question is that which one of these methods has higher efficacy and cost-effectiveness. Alexander's laser machine is one of those devices that have recently entered the consumer market with beauty, skin and hair applications. Therefore, the above-mentioned device should be evaluated for safety, effectiveness and cost-effectiveness. To this end, this study examines the safety, effectiveness, and cost-effectiveness of Alexander's laser in comparison to conventional methods for removing hair.

2. METHOD

The present study is a type of health technology assessment (HTA). The treatment intervention of high-power Alexandrite laser was compared with conventional methods in terms of safety, effectiveness, ethical considerations and, finally, analyzed by means of cost-effectiveness. Data of the study has been derived from secondary data and through systematic review and meta-analysis.

First, a systematic review was carried out to find the studies conducted in evaluating the high-power Alexandrite laser device for the removal of excessive hair. For this purpose, the clinical question (PICO) was designed and related keywords were selected based on this and the search formula was determined. Then the search was conducted and also updated in 6 July 2019 via Medline (PubMed), Cochrane Library, Scopus, CRD, NIHR HTA, web of science, Clarivate and ProQuest databases. The keywords "Hair Removal", "Alexandrite Laser", "Nd:YAG", "Diode" and "IPL" were selected based on the PICO designed to search for documents and data. These keywords were searched based on Medical Subject headings (MeSH) and free texts. Appropriate search formulas were synthetized using selected keywords, as well as Boolean operators based on synonyms, using truncation, time limitation, limiting the type of study to meta-analysis, systematic reviews, health technology assessment, and Randomized Control Trials (RCT) were determined. In most databases, the final formula for the search for the following formula was determined but, considering the specific circumstances and characteristics of some databases, this formula was changed. ("Hair Remov* "OR Epilat*) AND ("Alexandrite Laser") AND "(Nd:YAG" OR "Neodymium-doped yttrium aluminium garnet" OR "Diode" OR "IPL" OR "intense pulsed light").

This search was conducted in Medline (via Ovid), PubMed (clinical queries), Cochrane Library (including CENTRAL, DARE) and health technology assessment databases such as CRD database and NIHR HTA. In order to find the dissertations in this field, the proQuest database was searched. The studies inclusion criteria include all randomized clinical trials, systematic reviews, meta-analyses and economic evaluations that compare long-pulsed Alexandrite laser with other light techniques to eliminate excessive hair in terms of the means of terminal hair reduction or the sustainability of therapeutic effects of removing hair or side effects after treatment, and the minimum follow-up period is 6 months.

The exclusion criteria of the studies should not include a long-pulse Alexandrite laser comparative arm solely. For example, long-pulsed Alexandria laser should be used in combination with other hair removal techniques. The other reason was the use of Q-Switched Alexandrite in the study. This type of laser is commonly used for Pigmentation disorders. Afterwards, retrieved studies were selected by two independent professional evidence-based reviewers and were critically appraised. The validity and reliability were determined using CASP's worksheets, and the selected studies were analyzed using the RevMan v.5.2 software in terms of probabilistic risk of bias and meta-analysis was conducted in possible cases. Finally, the selected studies were provided to specialists as well as to economists to be studied in terms of clinical safety, efficacy and cost-effectiveness.

In this research, evaluations were conducted from the perspective of the Ministry of Health and Medical Education as a public provider and considering the above viewpoints and differences in other alternative methods, all costs and outcomes were identified and analyzed. In order to analyze the direct and indirect costs associated with each of the alternatives investigating the conducted studies, international standards and guidelines, and eventually establishing focused discussion groups by getting advice from dermatologists and experts in the supply chain of laser devices and beauty and hospital experts, the required resources as well as their complications and consequences were determined.

In addition, ICER incremental cost-efficacy index was used to compare the costs and outcomes of each of the alternatives. The current indicator will help calculate the additional costs imposed on the system by a unit of increasing effectiveness (reduction of complications) and provide a suitable criterion for decision making to the policy maker. Also, sensitivity analysis was carried out to investigate the effects of different values and variables on the impact of each intervention using different scenarios.

3. RESULTS

From 271 articles obtained from searching the references, 107 cases were duplicated titles. 145 articles were removed by reviewing the title. After selecting the retrieved studies in a stage by stage way, 28 articles reached the abstract review stage from among which 5 articles included Traditional Review, 3 articles were the guide to use laser and its safety in the treatment of excessive hair and a non-English and non-Persian article with a low sample size were excluded and 19 articles were selected to full-text studies. From these articles, 5 RCTs with non-related research questions, a systematic review study of 2007 lacking a proper search strategy and unclear inclusion and exclusion criteria of studies and therefore were excluded. From the remaining articles, 5 cases lacked inclusion criteria due to a follow-up for less than 6 months, or combinations of comparable lasers or retrospective study structures that were excluded from the study. In the next stage, 8 papers remained, all of which were RCT and the CASP checklist and the RCT evaluation table in REVMAN software were used to evaluate these articles. Among these articles, one was about a particular

subgroup of patients, and the selection bias was very effective on the outcome. Three other problems were encountered in blinding and randomization, statistical tests and very inadequate reports. Finally, five RCTs were selected. The complete review of the accepted papers is presented in Table 1.

Table 1 Evaluating the risk of bias evaluation in the studies used in the report

Study Type of bias	Davoudi (2008)	Toosi (2006)	Ghaly (2006)	Handrick (2001)	Ayatollahi (2019)
Random sequence generation (selection bias)	Low risk	Unspecified risk	Low risk	Low risk	low risk
Allocation Covering (Selection Bias)	Low risk	Unspecified risk	Low risk	Low risk	Low risk
Blinding contributors and personnel (implementation bias)	Low risk	Unspecified risk	Low risk	Unspecified risk	low risk
Blinding in the assessment of the results (detection bias)	Low risk	Low risk	Low risk	Low risk	Low risk
Incompleteness of the outcome (attrition bias)	High risk	Low risk	Unspecified risk	Unspecified risk	low risk
Selected report (Survey report)	Low risk	Low risk	Low risk	Low risk	low risk
Other biases	Low risk	Low risk	Unspecified risk	Unspecified risk	Low risk

In terms of safety in 1997, for the first time Finkel et al. reported the effective removal of excessive hair on the face, arms, legs, and abdomen using the 755 nm long pulsed Alexander laser. In this study which lasted 15 months; Pre-treatment hair counts and follow-ups per square centimeter was determined to determine the success level. The 755 nm long pulsed laser technology is effective in removing unwanted hair, whether the hair is light or dark. These results indicated the necessity of treatments for several times to achieve the desired result. Side effects are minimal and transient. Therefore, this method seems to be safe with proper treatment and low complications.

In the effectiveness section, several comparisons were performed:

A: The studies were related to the comparison between the Long-Pulsed Alexandrite Laser and Diode laser:

The study conducted by Toosi et al. (2006) compared Long-Pulsed Alexandrite and Intense Pulsed Light systems (IPL) and Diode Laser (Toosi et al, 2006) and the study of Handrick and Alster (2001) compared Alexandrite Long-Pulsed and Diode laser (Handrick and Alster, 2001).

The most common cases of short-term complications include peri-follicular edema and transient erythema. A case of tiny blister was observed in the Diode group and one case of vesicle production was observed in Alexandrite group. The pain in Alexandrite was low to moderate and moderate to moderately intense in the diode. However, numerical criteria and a method for measuring pain were not mentioned and no evidence of persistent complications, such as osteoporosis, was reported.

In addition, Ayatollahi et al. (2019) also compared 755-nm diode laser with conventional 755-nm Alexandrite laser. They assessed hair reduction by counting hairs per square centimeter, 6 months after the last treatment and also evaluated treatment outcomes by images, using Physician Global Assessment scale (GAS) and patient satisfaction using visual analogue scale (VAS). They also measured skin biophysical criteria such as erythema and skin sebum. The results of this study showed significant reduction in both groups (-35% in Alexandrite laser and -33% in Diode laser (p= 0.85). They didn't observe any adverse effects in both groups but subject satisfaction was higher in Alexandrite laser group (Ayatollahi et al., 2019).

Due to the incomplete report of the data in the study by Handrick, the standard deviation of the data was not measurable, and therefore meta-analysis was not applicable (Handrick and Alster, 2001). Therefore, the result of the most powerful study, that is the one conducted by Toosi which had a lot of participants, is considered as the base for the treatment (Toosi etal., 2006). Comparing the therapeutic effects between the treatment methods after 6 months, no statistically significant difference was found between these therapeutic methods on the mean reduction in the amount of hair measured: Alexandrite (68.75 ± 16.92%), IPL (66.96 ± 14.74%), Diode (71.71 ± 18.12%),(P = 0.194, F = 1.653)

B. Studies related to the comparison between Nd:YAG and Long-Pulsed Alexandrite Lasers:

The study conducted by Davoudi et al. (2008) compared the Alexandrite Long-Pulsed and Nd:YAG laser (Davoudi et al., 2008) and the study conducted by Ghaly (2006) compared Long-Pulsed Alexandrite and Nd:YAG laser and IPL (Ghaly, 2006):

Short-term complications included little pain, which was more common in Alexandrite. Pain was observed in 40% of cases of Alexandrite and 17.5% in Nd:YAG lasers. The pain in Nd:YAG laser and IPL were reported as a feeling of burning and a brief discomfort, and in Alexandrite laser, it was felt as needle-punching and with high intensity but tolerable. Due to the difference of the two studies in pain reporting methods, the results did not have the ability of aggregation and integration. No chronic or persistent symptom, such as scarring or atrophy, was reported by the patient at long term. There was no difference in satisfaction and acceptance of patients between devices.

The combination of the therapeutic effect through meta-analysis indicated that in the combination of two studies using the Random Effect Model, the Mean Difference of the two studies was obtained as 16.62 and, in the range, [3.69, 29.55], with statistically significance and P = 0.01 (figure 1).

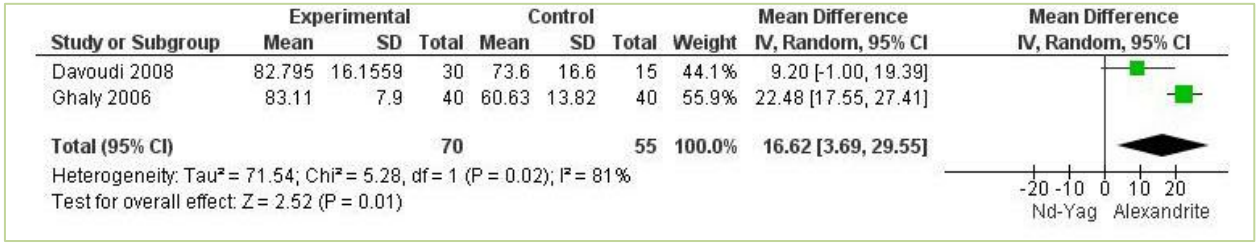

Figure 1 Forest plot of comparison between the Long-Pulsed Alexandrite and Nd: YAG Laser

C. The studies related to the comparison between Long-Pulsed Alexandrite Laser and IPL:

Includes the study conducted by Toosi et al. (2005) who compared the Long-Pulsed Alexandrite and Diode laser and the IPL (Toosi et al., 2006). The study conducted by Ghaly (2008) comparing Long-Pulsed Alexandrite and Nd:YAG laser and IPL) (Ghaly, 2006). Common short-term complications include little pain, which was most commonly found in Alexandrite. Pain was detected in 40% of cases of Alexandrite and IPL in 12.5% of cases.

Pain in Nd:YAG lasers and IPLs was reported as a burning sensation and a brief discomfort, and in Alexandrite laser, it was felt as needle-punching and more intense but tolerable. Due to the difference of the two studies in the pain reporting methods, the results did not have the ability of aggregation and integration. No chronic or persistent symptoms such as scar or atrophy were reported by the patient at long term. There was no difference regarding satisfaction and acceptance of patients between devices.

The combination of therapeutic effects of meta-analysis indicated that in the combination of two studies using the Random Effect Model, the Mean Difference of the two studies in the domain of [-10.50, 39.72] and P = 0.25, was obtained to be 14.61 which is statistically insignificant (figure 2).

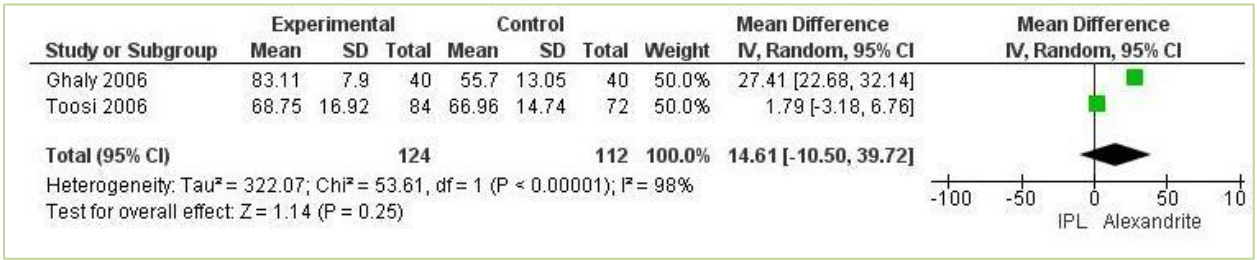

Figure 2 Forest plot of comparison between the Long-Pulsed Alexandrite and Intensive Pulsed Light systems (IPLs)

In economic evaluation, as there is no significant difference between these two devices in terms of complications and desirability, the main consideration will be the cost discussion. The incurred costs will include direct costs, productivity costs, and other non-tangible costs. One rate has been used in order to reduce the costs. For this purpose, we will use the index or the ratio of the cost-effectiveness ratio of the increase will be used. (Health Information and Quality Authority, 2010; Philips, 2009; Drummond, 2015).

$$\text{ICER}=\frac{(cost\ of\ A-cost\ of\ B)}{(effect\ of\ A-effect\ of\ B)} \quad \text{or} \quad \text{ICER}=\frac{incremental\ costs}{incremental\ effects\ (benefits)}$$

One of the most obvious principles in the analysis of the cost-effectiveness and its economic analysis is the selection of appropriate assumptions for analysis. The results of the study indicated that there is no significant statistical difference in side effects and therapeutic effect between the two groups. Therefore, one of the important assumptions in this analysis was that the incremental effects were considered a unit in two-by-two analyses. Because in most clinical trials, laser treatment with Alexandrite had a better short-term outcome, we considered the therapeutic effects of Alexandrite one unit more than the therapeutic effects of the rest of the devices. The calculations of Table 2 indicate that 3375.12 units of extra charge for the use of the Alexandrite laser device will increase 1 unit in quality of life. Economically, the Alexandrite Laser has no economic advantage over a diode laser.

Table 2 Incremental cost-effectiveness ratio for the Alexandrite laser device compared to diode laser device

	The current value of the costs	Incremental cost	Incremental effects	The ratio of incremental efficacy cost
Alexandrite	4928.571	3357.143	1	3357.143
Diode laser	1571.428		1	

In Table 3, the ratio of the cost-effective incremental cost for an Alexandrite laser device in comparison to the ND: YAG device increases costs by 2357.151 units, with an increase of 1 unit of effective lifetime. The economic analysis suggests that the use of Alexandrite as an alternative for ND: YAG is not economical.

Table 3 Incremental cost-effectiveness ratio for the Alexandrite laser device compared to ND: YAG device

	The current value of the costs	Incremental cost	Incremental effects	The ratio of incremental efficacy cost
Alexandrite	4928,571	2357.151	1	2357.151
ND:YAG	2571.42		1	

The results presented in Table 4 also indicate the lack of economic justification and the lack of cost effectiveness of replacing the Alexandrite laser device with the IPL device.

Table 4 Incremental cost-effectiveness ratio for the Alexandrite laser device compared to IPL device

	The current value of the costs	Incremental cost	Incremental effects	The ratio of incremental efficacy cost
Alexandrite	4928.571	357.151	1	357.151
IPL	4571.42		1	

In analyzing sensitivity, since the government's policy was on single rating of the energy, and projections indicate an increase in the reference exchange rate to 3100, the two rates of 3100 and 3000 were considered as reference rates of analyzing sensitivity (table 5). Also, given the high probability of lowering interest rates, two rates of 18 and 15 percent were considered as leverages for changing economic analysis. Four scenarios were proposed for this purpose.

Table 5 Sensitivity analysis between different scenarios

Scenarios	New cost in Alexandrite device	Device ND:YAG	IPL	Diode
1	7473.1026	3896.3832	6935.2748	2384.4736
2	7557.92032	3940.54864	7014.06996	2411.5751
3	7207.0797	3757.8624	6688.1411	2299.4722
4	7283.02999	3797.41048	6758.69847	2323.7403

According to the calculations in the table above, there is no change in economic analysis in the circumstances of the mentioned scenarios.

4. DISCUSSION AND CONCLUSION

In the current systematic review and meta-analysis, we included only RCTs. During the databases searching, we found other trials which compared two or more lasers for removing extra hair. They evaluated the different device effect in various areas of the same subjects. We didn't include these trials in our systematic review due to the lack of randomization, blinding of participants or personnel as well as the lack of allocation concealment. The findings of mentioned trials are summarized below:

Khoury et al. (2008) evaluated the safety and efficacy of combining 755- and 1,064-nm wavelengths during 3 treatments at 4- to 6-week intervals for axillary hair removal. Alexandrite laser was used for the left upper axilla quadrants. Nd: YAG laser for left lower axilla, combination Alexandrite, and Nd: YAG laser for right upper axilla, and diode laser for the right lower quadrant. Eighteen subjects out of 20 completed the study. The greatest hair reduction was seen with the Alexandrite laser (70.3%) and combination of Alexandrite and Nd: YAG laser (67.1%). The efficacy of diode laser and Nd: YAG in hair reduction was lesser than the two mentioned method 59.7% and 47.4% respectively (Khoury et al., 2008).

Paasch et al. (2015) compared the efficacy, tolerability, and subject satisfaction after using 755 nm diode HR mode and scanned 755 nm Alexandrite laser for chest and axillary hair removal on a 47 years old male patient with skin type II and with dark brown coarse hair. In this study, both systems showed high efficacy in hair reduction with no severe adverse effects (88.8 % 755 nm diode laser vs. 77.7 % 755 nm Alexandrite laser). However, the authors didn't report the standard deviation of the data (Paasch et al., 2015).

AL-Dhalimi and Kadhum(2015) compared long-pulsed Alexandrite laser and IPL for face hair removing. He showed that, after six treatment sessions, IPL-treated sides had longer median hair-free intervals compared with ALX-treated sides. Also, hair reductions in the IPL group compared with ALX-treated sides at 1, 3, and 6 sessions were statistically significant. Post inflammatory hyper pigmentation in 10% of patients was present which one of them on the ALX-treated sides and the others on the right side. It was more severe on the right side and both the patients had skin type IV. Slight stinging and burning sensation at the time of the treatment were recorded in all patients. Except for hyperpigmentation, the other complications were transient and tolerated by the patients (Al-Dhalimi and Kadhum, 2015).

Grunewald et al. (2013) compared the efficacy, tolerability, and subject satisfaction of a continuously linear-scanning 808nm diode laser on right axilla with skin types I–IV of 31 patients with Alexandrite 755nm laser for left axilla hair removal. Mean age of 28 women was 31.2 ± 9.3 years, and 30.3 ± 4.9 years for 3 adult men. They used 6 treatments session at 4-week intervals. Both sides showed a significant reduction in axillary hair (left side: 72.16%, right side: 71.30%) after the 6th treatment ($P<0.05$). However, this reduction amount was not statistically significant when compared to two lasers. Alexandrite was accompanied with more transient complications including erythema and perifollicular edema (Grunewald et al., 2014).

Hussain et al. (2003) in his study, compared the safety and efficacy of cooled 40-ms Alexandrite laser with fluences of 16 to 24 J/cm2 on hair removal in 144 Asian subjects with skin type III to V. Three treatment for 35 subjects, two treatments for 35 subjects on 66 anatomic sites, and single treatment for 74 subjects with 124 anatomic sites were done. Hair reduction was 55%, 44% and, 32% respectively at the end of 9 monthsfollowed up. There was no scarring or long-term pigmentary changes in subjects (Hussain et al., 2003).

Karaca et al. (2012) used the SHR mode IPL system, Alexandrite laser and Nd: YAG laser randomly in three sessions on 25 female participants with skin types II–IV for hair removal on the cruris and evaluated by a blinded assessor every 6 (mean age 32.85 years)

weeks and 6 months after the last session. Among 21 subjects that completed the trial, hair reduction was 50% for the IPL system, 53% for Alexandrite and 39% for the Nd: YAG lasers after 6 weeks and 40%, 49% and 34% after 6 months respectively. Pain according to VAS was lowest in Alexandrite laser (3.90), in comparing to 5.71 for IPL system and 6.95 for Nd: YAG systems. Patient satisfaction was higher in Alexandrite laser in comparing to IPL and Nd: YAG lasers (37 versus 33 and 27 respectively) ($p<0.05$). Erythema and perifollicular edema after some treatment sessions were transient (Karaca et al., 2012).

McGill et al. (2007) in a randomized study, compared 6 treatment session of Alexandrite Laser and IPL system for facial hair removal in 38 women with polycystic ovary syndrome (PCO) and followed them 1, 3 and 6 months. At the end of treatment Alexandrite laser showed longer median hair-free intervals in comparing to IPL (7 weeks vs. 2 weeks; $P<0.001$). Hair reduction was significantly larger on the Alexandrite side compared to the IPL side at 1, 3 and 6 months (52%, 43% and 46% vs. 21%, 21%, and 27%; $P<0.001$ respectively). Patient's satisfaction according to linear analogue scales (LAS) was significantly higher for Alexandrite laser than the IPL in three- time period (8.7, 7.8 and 7.7 vs. 5.7, 5.1 and 5.1; $P=0.002$) (McGill, 2007).

Rao and Goldman (2005) compared three different laser systems at 6- to 8-week intervals on 20 female patients. Alexandrite laser, diode laser, and Nd:YAG laser, each for three session and rotational treatment consisting of a single session was used for each patient. At the 3-month follow-up, hair reduction was 59.3± 9.7% in Alexandrite laser, 58.7 ± 7.7% in diode 31.9 ±11.1% for Nd:YAG laser and 39.8 ± 10.1% in rotational regimens. Tolerability of Alexandrite and diode laser was equal and Nd: YAG laser was uncomfortable among them. Diode laser was the first device according to patient satisfaction and then Alexandrite laser, rotational therapy, and Nd: YAG lasers were in the next rank (Raoand Goldman, 2005).

Rogers et al. (1999) in a comparative study on 15 subjects used Alexandrite laser for the right axilla and two treatments with the topical suspension assisted Nd: YAG laser for the left side. Finally, 13 participants completed the study. The mean percentage hair reduction after 2 months was 55% following Alexandrite laser and 73% for the Nd: YAG laser-treated regions ($p=0.029$). After 3 months, the reduction was 19% for Alexandrite and 27% for Nd: YAG laser ($P=0.030$). Erythema and edema were prevalent in patients. Side effects were more common in Alexandrite laser (Rogerset al., 1999).

The results of our study showed that, in the field of safety, side effects are minimal and transient. This method is safe considering the proper treatment and low side effects. Generally short-term transient effects in the diode laser were greater than that of the Alexandrite, while in the Nd: YAG laser and IPL, they were generally lower than that of the Alexandrite. No serious complications have been observed in the long term and the methods are not different in this case. There was no difference between the methods in patient satisfaction. There was no difference in the therapeutic effect of the comparison between long-pulsed Alexandrite laser with diode laser and IPL, the only significant difference was in the mean of hair loss that was obtained through comparing to the Long-Pulsed Alexandrite and Nd: YAG lasers where the Alexandrite laser reduced its rate by 16.62% than the Nd: YAG laser.

The results of economic analysis using the cost-effectiveness analysis and sensitivity analysis indicate that, economically, the Alexandrite laser device has no economic advantage in terms of cost effectiveness compared to other alternative methods. This analysis has been conducted based on the assumptions and current conditions of the device and technology available on the Alexandrite laser device. If some changes occur in the therapeutic effects or technology of the device and its final cost, the results of the analysis will change. In this study, using standard texts and according to the international guidelines, the analysis of cost efficacy was investigated to estimate the monetary value of therapeutic interventions, costs and therapeutic effects of using Alexandrite laser device. The results indicated that extra costs for using the Alexandrite laser device is not effective compared to other therapeutic approaches. In other words, the use of this laser instead of other methods is not economically justifiable. This conclusion is achieved taking into account the therapeutic effects and economic analysis. We also used a sensitivity analysis to introduce uncertainty effects on the analysis. The items that can be used to construct the sensitivity leverage are the currency fluctuations of the reference currency, the fluctuations in the discount rate, the probability fluctuations and the payroll of the workforce. In this analysis, two factors of exchange rate and interest rate changes as factors affecting economic and sensitivity analyses. In other words, two factors affecting the analysis, which are the macroeconomic policies of the country, were analyzed Taking into account the government's economic policies in the coming year and comprehensive analysis in this section, after scenario making, cost efficiency calculations were re-conducted. Based on the results of this section, potential changes also did not affect the economy of this device. In the end, the results of the economic analysis indicated that the Alexandrite laser device has no economic advantage in terms of cost effectiveness than other alternative methods.

Conflict of interest

The authors declare no conflict of interest.

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