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Evaluation of Heat on the Teeth During Upper Lip Laser Epilation: Clinical Experiment

Üst Dudak Lazer Epilasyonu Sırasında Dişlerde Oluşan Isının Değerlendirilmesi: Klinik Deney

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ABSTRACT Objective: The temperature of adjacent tissues during epilation has long been the subject of research. However, there is no literature on the heat that occurs in the teeth during laser epilation of the upper lip. This study measured the increase in the heat of the teeth during upper lip laser epilation. **Material and Methods:** The study included 51 patients. Three heat measurement sensors were placed on the labial surface of the anterior teeth. Before starting the procedure, the first measurement was taken, and the maximum values were recorded as °C. After the procedure, a visual analog scale (VAS) was applied. Paired samples t-tests and one-way ANOVA ($p<0.05$) test were applied for the statistical analysis. **Results:** A statistically significant difference was determined between the maximum and initial heat in the 3 sensors ($S1_F$ 36±1.7, $S1_{Max}$ 40.8±2.3, $S2_F$ 36.3±0.9, $S2_{Max}$ 40.3±1.8, $S3_F$ 36.3±0.9, $S3_{Max}$ 40.7±2.9). No statistically significant difference was determined between the 3 sensors in the distribution of the maximum and initial heat ($p>0.05$). A statistically significant difference was determined regarding the distribution of VAS values in the teeth and lips ($p<0.001$). The pain felt in the upper lip (6±2) was significantly greater than the pain felt in the teeth (5±2) ($p<0.001$). **Conclusion:** The increase in heat during upper lip laser epilation can be said to be safe for the dental pulp. The sensitivity and pain experienced during the procedure are due to the heat increase. The use of a white-coloured appliance is recommended during upper lip laser epilation.

Keywords: Heat; enamel; pulp; diode laser; epilation

ÖZET Amaç: Epilasyon sırasında komşu dokularda oluşan ısı her zaman araştırma konusu olmuştur. Ancak üst dudağın lazer epilasyonu sırasında dişlerde oluşan ısı ilgili literatür bulunmamaktadır. Bu çalışma, üst dudak lazer epilasyon sırasında dişlerde oluşan ısı artışını ölçmek amacıyla yapılmıştır. **Gereç ve Yöntemler:** Çalışmaya 51 hasta dâhil edildi. Ön dişlerin labial yüzeyine 3 adet ısı ölçüm sensörü yerleştirildi. İşleme başlamadan önce ilk ölçüm yapılmış ve maksimum değerler °C olarak kaydedilmiştir. İşlem sonrasında görsel analog skala [visual analog scale (VAS)] uygulandı. İstatistiksel analiz için paired samples t-testi ve one-way ANOVA ($p<0,05$) testi uygulandı. **Bulgular:** Üç sensörde ($S1_F$ 36±1,7, $S1_{Max}$ 40,8±2,3, $S2_F$ 36,3±0,9, $S2_{Max}$ 40,3±1,8, $S3_F$ 36,3±0,9, $S3_{Max}$ 40,7±2,9) maksimum ve başlangıç ısıları arasında istatistiksel olarak anlamlı bir fark belirlendi. Maksimum ve başlangıç ısıların dağılımında 3 sensör arasında istatistiksel olarak anlamlı bir fark tespit edilmedi ($p>0,05$). Dişlerde ve dudaklarda VAS değerlerinin dağılımına göre istatistiksel olarak anlamlı fark saptandı ($p<0,001$). Üst dudakta hissedilen ağrı (6±2) dişlerde hissedilen ağrıdan (5±2) anlamlı olarak fazlaydı ($p<0,001$). **Sonuç:** Üst dudak lazer epilasyonu sırasında ısı artışının diş pulpası için güvenli olduğu söylenebilir. İşlem sırasında yaşanan hassasiyet ve ağrı ısı artışından kaynaklanmaktadır. Üst dudak lazer epilasyon sırasında beyaz renkli aparey kullanılması önerilebilir.

Anahtar Kelimeler: Isı; mine; pulpa; diyot lazer; epilasyon

Epilation is the most frequently applied laser procedure in dermatology.[1] During the procedure, the laser beam passes through the skin to the hair follicle. The intense heat produced damages the hair follicle, causing a permanent reduction in hair number and quality. Selective tissue destruction occurs due to the desired effect on the chromophore, with limited heat created in the target tissue without spreading to the surrounding tissues when the optimal wavelength, pulse duration, and rate parameters are used. The hair stem cell must be destroyed to obtain a successful result with epilation.[2]

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The laser beam has the properties of scattering on the skin, absorption, reflection, and transmission. The majority of complications related to laser treatment result from thermal injury leading to absorption. Reflection complications are rarely seen. The most common skin reactions are pain, temporary erythema, perifollicular oedema, thermal burns, blisters, hyperpigmentation, permanent hypopigmentation, and scarring. Occasionally, urticaria, acneform lesions, long-term erythema and oedema, paradoxical hypertrichosis, early hair greying, hyperhidrosis, and ocular damage can occur.[3-5]

The increased heat in tissues during laser application and whether or not this increase is safe have been the subject of research in laser applications.[6] Heat transfer in teeth occurs in daily life and during dental treatments. The daily thermal environment of teeth varies in a wide heat range (-5 °C-76.3 °C).[7-9] External heat applied to the teeth can cause damage to the dental tissues to varying degrees, depending on the degree of heat increase and duration.[10] Heat produced in the teeth during dental treatments can damage the enamel, dentin, and dental pulp. The heat within the dental pulp should not exceed 42 °C; otherwise, there is an increased risk of irreversible damage.[7]

Pain scores have become the most accurate and reliable measure of assessing a patient's pain and response to pain treatment. The visual analog scale (VAS) is the most widely used tool for estimating both severity of pain and to judge the extent of pain relief. The healthcare worker asks the patient to select a point on a line drawn between 2 ends to express how intense they perceive pain. The VAS is an easy-to-use instrument which does not warrant using a sophisticated device. It is also susceptible to detecting treatment effects, and parametric tests can analyse its results.[11]

Although there have been studies on some side effects of the diode laser used for epilation procedures, there have been no studies of the effects on teeth. This study aimed to observe the heat increase created in teeth by the diode laser applied to remove upper lip hairs. The study's null hypothesis was that the increase in heat occurring in the teeth during diode laser epilation of upper lip hairs would not be significant.

MATERIAL AND METHODS

Approval for the study was granted by the Afyonkarahisar Clinical Research Ethics Committee (date: September 10, 2015; no: 2011-KAEK-2). The present study was conducted following the principles of the Declaration of Helsinki.

PATIENTS

The study sample was selected randomly from patients who presented at the Dermatology Clinic of Afyon Kocatepe University for hair removal. Written informed consent was obtained from all study participants. The study included 51 females aged 20-30 years, with Fitzpatrick skin Type III-IV and upper lip hair varying in colour from light brown to black. The mean age of the patients was 24.12 years. A dermatologist evaluated all the patients. The study exclusion criteria were defined as age <18 years, being pregnant or breastfeeding, having a wound, infection, or scar, a history of recurrent herpes infection, the presence of prosthetic restoration in teeth no 11, 12, 13, 21, 22, 23, or devitalised teeth. None of the patients had any contraindications for laser treatment.

Of the patients included in the study, two had orthodontic braces, and five had seven composite fillings. The skin type was Fitzpatrick III in 32 and Fitzpatrick IV in 19.

LASER SYSTEMS

The diode laser used was a Midepi Hironic diode laser system (Korea) with short pulse, 808nm wavelength, 20W output power, light exposure adjustable at 5-60 J/cm^2, pulse duration of 30 milliseconds, and a semi-conductor of spot size 9x9 mm. Cooling of the tissue where the laser was applied was provided by the sapphire tip cooled to +4 °C.

TREATMENT PROTOCOL

A thin layer of treatment gel was applied to provide smoother movement of the tip and better cooling of the region. The laser application tip was placed on the skin surface with moderate pressure to smooth the skin, empty cutaneous blood vessels, and, most im-

portantly, approach the skin surface of the targeted hair roots. Laser application was performed so that one pulse was applied to each hair root. After each pulse, the application tip was lifted, and then the other pulse was delivered. In this way, the overall upper lip was scanned. During laser application, the pulses overlapped by 10-20%. After the application, a control appointment was arranged with the patient 15 days later.

The parameters used in the laser treatment procedure, which varied according to the skin and hair type of the patient, were applied in stages (Table 1).

The increase in heat was measured and recorded using a digital heat measurement device, comprising three heat-sensitive sensors (DS18B20, Maxim Integrated Products Inc. Dallas Texas USA) (S1, S2, S3), a digital temperature indicator (Kaftek, Türkiye), and computer software (Figure 1). This device was developed and tested in the Biomedical Engineering Department of Afyon Kocatepe University. Sensors measured in the heat range of -55 °C to + 125 °C, with a margin of error of ±0.5 °C. Thirteen data points were obtained per second. The sensors were calibrated at the factory. The system used an external 5 V adapter. The digital heat indicator had a 2x16 alphanumeric LCD display. 9600 baud data was sent from the heat meter to the computer via an RS232 connection. The data obtained through the sensors were transferred to the computer and recorded.

The sensors were placed on the labial surfaces of teeth 13, 21, and 23 and fixed with lip pressure. Because; teeth 13 and 23 due to its location close to the comissura; Since it is close to the midline (Since the surfaces of the sensors in contact with the tooth were flat, they could not be placed between teeth 11 and 21.), it was placed on teeth number 21. There was no intraoral function during the measurement, and the pressure during laser application did not change the position of the sensors. For these reasons, it was sufficient to keep the sensors fixed with lip pressure. For every patient, measurements were taken from these three points. Before starting the procedure, the initial intraoral heat was recorded ($S1_F$, $S2_F$, $S3_F$). Then, the heat was measured for 1 minute during the procedure and recorded (Figure 2). The maximum heat measured for 1 minute in this period were recorded ($S1_{Max}$, $S2_{Max}$, $S3_{Max}$).

TABLE 1: Phasedly applied laser parameters.

Power	Shot speed (Hz)	Pulse type	Hair thickness
20	1	Short	Medium
21	1	Short	Medium
19	1	Short	Medium
18	1	Short	Medium
10	2	Short	Thin

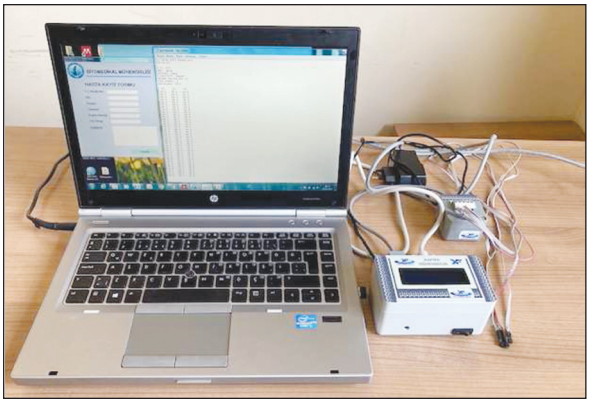

FIGURE 1: Digital heat measurement device, comprising 3 heat-sensitive sensors, a digital temperature indicator and computer software.

FIGURE 2: During laser application; digital measurement and recording of heat.

EVALUATION OF PAIN

For the subjective evaluation of the pain formed in the teeth and lips by the heat generated by laser application, a VAS was used. The scale is marked from 0 to 10. where 0 indicates no pain, 5 represents a

moderate level, and 10 is intolerable. The scale was given to the patients immediately after the procedure, and they were instructed to mark the highest level of pain felt. The scale was completed separately for the upper lip and the teeth.

STATISTICAL ANALYSIS

Data obtained in the study were analysed statistically using MedCalc Statistical Software version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2013). Conformity of the data to a normal distribution was assessed with the Shapiro-Wilk test. The paired comparisons of initial and maximum recorded heat for each sensor and the paired samples t-test was used. One-way ANOVA was applied to compare the initial and maximum values between the sensors. Student's t-test was applied to compare the VAS values for the teeth and lip. The level of statistical significance was set at $p<0.05$.

RESULTS

The data showed a normal distribution according to the Shapiro-Wilk test. A statistically significant difference was determined between the maximum and initial heat in the three sensors ($S1_F$ 36±1.7, $S1_{Max}$ 40.8±2.3, $S2_F$ 36.3±0.9, $S2_{Max}$ 40.3±1.8, $S3_F$ 36.3±0.9, $S3_{Max}$ 40.7±2.9) (paired samples t-test $p<0.001$, Table 2, Figure 3). No statistically significant difference was determined between the 3 sensors in the distribution of the maximum and initial heat (one-way ANOVA $p>0.05$, Table 3).

A statistically significant difference was determined regarding the distribution of VAS values in the teeth and lips (Student's t-test $p<0.001$). The pain felt in the upper lip (6±2) was significantly greater than the pain felt in the teeth (5±2) (Student's t-test $p<0.001$, Table 4, Figure 4).

In the subjective evaluations made on the VAS, the patients with orthodontic braces and composite restorations reported more pain in teeth 11, 12, 13, 21, 22, and 23 than other patients.

SIDE EFFECTS

No patient reported any momentary or long-term side effects of the procedure. No burns, hyperpigmentation, or hypopigmentation were seen in any patient.

DISCUSSION

The upper lip is the most common area for laser epilation, and pain and discomfort have been associated with epilation procedures in this region.[12] To the best of our knowledge, there have been no reports in the literature on the side effects of laser treatment in dermatology affecting hard tissues such as the teeth. Therefore, this study aimed to determine whether or not the teeth are affected by laser treatment applied to the upper lip. The null hypothesis of the study was that the increase in heat occurring in the teeth during diode laser epilation of upper lip hairs would not be significant was rejected. A statistically significant increase was found between the initial heat values and the maximum values recorded in sensors S1, S2, and S3 ($S1_F$ 36±1.7, $S1_{Max}$ 40.8±2.3; $S2_F$ 36.3±0.9, $S2_{Max}$ 40.3±1.8; $S3_F$ 36.3±0.9, $S3_{Max}$ 40.7±2.9).

There is different information in the literature about the lower and upper heat values that may occur

TABLE 2: Mean, standard deviation, minium, maxium and median value.

	S_F $\bar{X}$+SD Median (Minimum-maximum)	S_{Max} $\bar{X}$+SD Median (Minimum-maximum)	p value
S1	36±1.7 36.5 (26-37.5)	40.8±2.3 40.5 (37-48.5)	**<0.001**
S2	36.3±0.9 36.5 (34-38)	40.3±1.8 40 (37.5-45.5)	**<0.001**
S3	36.3±0.9 36.5 (34-38)	40.7±2.9 40.5 (37-55.5)	**<0.001**

S_F: Initial temperature value; S_{Max}: Maxium temperature value; S1: Sensor 1; S2: Sensor 2; S3: Sensor 3; SD: Standard deviation.

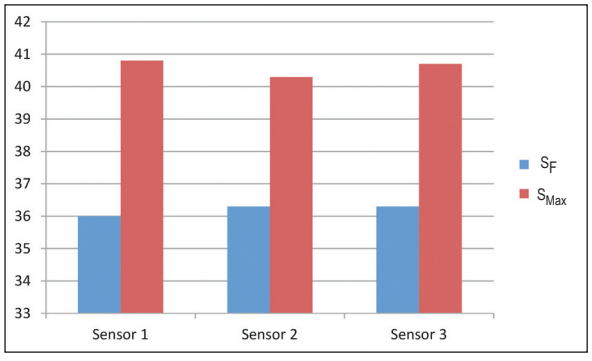

FIGURE 3: Mean of the initial and maximum temperatures recorded in the sensors. S_F: Initial temperature value; S_{Max}: Maxium temperature value.

in the mouth. According to some studies, the thermal environment of the teeth in daily life is in a wide heat range (-5°C to 76.3°C).[13,14] In a study by Eroğlu and Baydır on 50 patients to determine extreme intraoral heat values, they reported that the highest upper limit heat value was 53.78°C, and the lowest lower limit heat value was 6.07°C.[15] Baldissara et al. reported that a temperature increase of 8.9°C-14.7°C was necessary for the development of thermal damage in the dentin and pulp.[16] Sozzi et al. stated that, for the vitality of the tooth not to be lost, the heat increase in the pulp should not exceed 5.5°C.[17] In studies on rhesus monkeys, Zach and Cohen reported that there was irreversible pulp damage in 15% of the animals with a 5.6 °C increase in heat, 60% with an 11°C increase, and 100% when the heat increased by 16.6°C.[18] The total duration of the increased heat and the storage of harmful heat is important.[19] Eriksson et al. stated that 42°C is a critical heat when maintained for 1 minute.[20] In the current study, the maximum heat increase was 4.8°C. From examining these increases in the enamel, no strong evidence could be found that the pulp had suffered irreversible damage during laser epilation of the upper lip.

Current restorative techniques are based on the adhesive properties of dental restorative materials that function at -5 °C to 55 °C. Thermophysical differences between the tooth and the restorative material cause thermal stresses to develop in the bonding interface. Together with the stresses caused by chewing, these thermal stresses can induce the degeneration of the bonding interface between the tooth and the restorative material. Thus, the lifetime of the restoration can be reduced.[7]

The thermal behaviour of restored teeth is significantly different from that of healthy teeth due to the different thermal properties (thermal conduction, thermal expansion) of restorative materials and dental structures.[21] Bicalho et al. reported that heat and humidity conditions significantly affect contraction in restored teeth.[22] In the current study, patients with composite restorations felt greater pain, which could have been due to contraction, and it can be considered that this may cause failures in composite restorations in the future.

The pain score on the VAS is a single dimension measurement of pain intensity; this scale is widely used in various adult populations, including patients with rheumatic diseases.[23] In this study, the VAS was applied separately to the lip and teeth. The pain felt by patients during the procedure showed a difference in VAS responses. The pain felt in the upper lip (6±2)

TABLE 3: Mean, standard deviation, minium, maxium and median value of temperature variation between sensors.

	S1 $\bar{X}$+SD Median (Minimum-maximum)	S2 $\bar{X}$+SD Median (Minimum-maximum)	S3 $\bar{X}$+SD Median (Minimum-maximum)	p value
S_F	36±1.7 36.5 (26-37.5)	36.3±0.9 36.5 (34-38)	36.3±0.9 36.5 (34-38)	0.372
S_{Max}	40.8±2.3 40.5 (37-48.5)	40.3±1.8 40 (37.5-45.5)	40.7±2.9 40.5 (37-55.5)	0.440
Difference	4.82±2.3 5 (1.5-11.5)	3.96±1.72 3.5 (1-9)	4.39±2.8 4 (0.5-20)	0.179

S1: Sensor 1; S2: Sensor 2; S3: Sensor 3; SD: Standard deviation; S_F: Initial temperature value; S_{Max}: Maxium temperature value.

TABLE 4: VAS distributions measured in teeth and lip.

	Teeth X̄+SD Median (Minimum-maximum)	Lip X̄+SD Median (Minimum-maximum)	p value
VAS	5±2 5 (2-8)	6±2 6 (3-9)	**<0.001**

VAS: Visual analog scale; SD: Standard deviation.

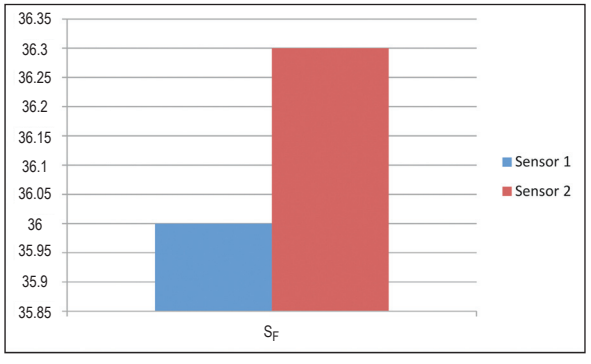

FIGURE 4: Visual analogue scale distributions measured in teeth and lip.

was significantly greater than the pain felt in the teeth (5±2). Heat transfer in the teeth is affected by various factors such as the tooth geometry, thickness of the dentin and enamel, the type of dental restorative material used, and pulpal blood circulation.[11,13] The greater pain felt in the teeth by the patients with orthodontic braces and composite restorations can be explained by the factors affecting heat transfer in the teeth. However, the pain and epidermal damage during laser epilation is associated with the presence of several factors. Although the epidermal and follicular melanin content plays an important role, it has also been associated with higher fluence, larger spot size, the pain threshold of the patient, the complexion of the patient, and differences in pain perception in different areas of the body.[24-28] Rogachefsky et al. reported that pain after treatment was related to the selected parameters and the manual instrument's speed when moved over the skin and treatment area.[29] In a study by Akinturk and Eroglu postoperative pain was evaluated in 50 females, half of whom were administered piroxicam gel during the procedure, and half with saline for a placebo effect. The piroxicam gel group reported significantly lower VAS scores.[30] Guardiano and Norwood found no significant difference between eutectic mixture of local anesthetics and topical lidocaine in respect of postoperative pain but reported that the VAS scores of the male subjects were higher than those of the females.[31]

To overcome the effect of heat production, precooling should be applied to the tissue with air and water.[32] Sudhir et al. reported that patient comfort increased by placing a wooden spatula wrapped in gauze under the lip.[12] It was understood from the current study that patients were affected by the heat created in the teeth during laser epilation. To eliminate or minimise this effect, it can be recommended that a white-coloured plate prepared by dentists is placed over the teeth.

LIMITATIONS

Measurements were performed only during laser application. After the procedure, the sensors were removed from the mouth. The time required for the intraoral temperature to return to normal was not assessed. The effect of hair colour on the heat generated was not evaluated. Studies need to investigate the long-term effects of upper lip laser application on the pulp.

CONCLUSION

1. According to the results obtained in this study, the temperature increases during upper lip laser epilation can be said to be safe for the dental pulp.

2. Patients with composite restorations or orthodontic braces are more sensitive to the same temperature increases.

3. Sensitivity and pain due to the temperature increase are only experienced during the procedure.

4. Using a white-coloured appliance is recommended to eliminate sensitivity at the moment the patient feels it during upper lip laser epilation.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Server Mutluay Ünal;* ***Design:*** *Server Mutluay Ünal, Hilal Çiftçi Asutay;* ***Control/Supervision:*** *Server Mutluay Ünal, Hilal Çiftçi Asutay, Serhat Emre Özkır, Mehmet Biçer;* ***Data Collection and/or Processing:*** *Server Mutluay Ünal, Hilal Çiftçi Asutay, Serhat Emre Özkır, Mehmet Biçer;* ***Analysis and/or Interpretation:*** *Server Mutluay Ünal, Hilal Çiftçi Asutay;* ***Literature Review:*** *Server Mutluay Ünal, Hilal Çiftçi Asutay;* ***Writing the Article:*** *Server Mutluay Ünal, Hilal Çiftçi Asutay, Serhat Emre Özkır;* ***Critical Review:*** *Server Mutluay Ünal, Hilal Çiftçi Asutay, Mehmet Biçer;* ***References and Fundings:*** *Server Mutluay Ünal;* ***Materials:*** *Server Mutluay Ünal, Hilal Çiftçi Asutay.*

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