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Temperatures of Different Face Regions of Healthy People Measured by a Thermal Camera*

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Abstract: Body temperature is an important indicator that may indicate the possibility of the existence of various pathological conditions and diseases. In the head and neck area, an infrared camera allows accurate temperature measurements of all regions of interest. The analysis of temperature characteristics of the region of interest of the head and neck in healthy subjects in terms of comparison of values in relation to the side of the face in the same person, and the comparison of values relative to the sex of the subjects is the topic of this research. These analyses are performed to create temperature maps of the face and determine physiological values. The research was conducted with the participation of 30 healthy people, 16 women and 14 men of different ages. Thermal imaging was performed in controlled conditions with infrared thermographic camera Varioscan 3021ST, while the software package IRBIS Professional 2.2 was used for thermogram analysis. Results show that the temperatures in female subjects at the submandibular region are significantly lower than in male subjects with an average temperature difference of 0.46°C, and the temperatures in female subjects at the supraorbital region are on average 0.5°C higher than in male subjects.

Keywords: Face thermal Map, Infrared radiation, Thermal imaging.

1 Introduction

Since ancient times (Hippocrates), the measurement of body temperature has been used to determine the existence of various diseases. Hippocrates performed measurements either by pressing his hand or using linen blankets that would change colour in contact with a person's skin with a high body temperature [1]. These linen blankets were the first primitive thermograms.

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Throughout history, there have been several attempts to make a measuring device that will measure the temperature, first of the air and then of the human body. The First attempt was in 1592. when Galileo made a kind of thermometer which he called the "air thermoscope" [2]. Santorio, from the University of Padua in 1626. invented the first device that could measure body temperature [3], while the thermometer on the principles on which today's thermometers operate was created by Gabriel Fahrenheit in 1723. [4]. Since then, the measurement of body temperature as an indicator of the existence of disease has come into mass use. In 1872. Wunderlich in Germany introduced fever measurements as a routine medical practice in 1951. it has become customary to take daily body temperature measurements on all hospital patients [1].

Infrared thermography, first developed for military purposes in the mid-1960s [5], has found its application in various fields of medicine (diagnosis of breast tumors, melanoma, peripheral vasculopathies, etc.).

The maxillofacial region is an area that can be affected by many pathological conditions, very different from each other. According to some research, 56.3% of all pathological conditions are inflammatory processes (82.5% are acute and 17.5% are chronic), while neodontogenic inflammatory processes account for 16% and 13% are tumors and tumors of similar formation [6]. Therefore, establishing a timely diagnosis in clinical practice is imperative for successful treatment, and there is a constant need to develop new, more modern, and more affordable diagnostic tools. The following diagnostic tools are standardly used for diagnostic purposes in maxillofacial surgery: ultrasound examination, ultrasound-guided needle spiral biopsy (FNAC), computed tomography (CT), positron emission computed tomography (PET CT), and nuclear magnetic resonance (NMR). These tools have their disadvantages and advantages. The ideal diagnostic tool must meet the following conditions: to be non-invasive, harmless to the patient, sensitive and precise in the presentation of structures, with fast processing and obtaining findings with low procurement and maintenance costs, and relatively easy handling. Ultrasound and NMR are non-invasive examination techniques that do not involve exposure of the patient to radiation. Ultrasound finding depends on its accuracy and the experience of the attending physician, while in NMR the economic aspects are what, despite all the advantages, limit the wide application. The thermal imaging camera, whose application is based on detecting infrared rays emitted by all bodies with a temperature above absolute zero, represents a new diagnostic possibility for detecting diseases of the maxillofacial region.

All bodies with temperatures above absolute zero emit infrared radiation. This radiation is part of the electromagnetic spectrum, and its wavelength is in the range of 0.7 μm to 1000 μm. Pathological conditions lead to changes in tissue metabolism. These changes are reflected in changes in microcirculation, i.e. in the system of arteries and veins that vascularize certain tissue, which alters the vascular tone of microcirculation and blood flow through the affected tissue. This leads to changes in tissue temperature, which is reflected in changes in the infrared radiation of the tissue. A thermal infrared camera can detect changes in infrared radiation consisting of a complex system of optical lenses, photosensors, and electronic blocks for calculation and visualization. The surface of the skin is visualized on the screen with a spectrum of colors. By thermograms analysis, qualitative and quantitative, it is possible to determine the values of temperature asymmetry, representing the difference in temperature values measured bilaterally in certain homologous regions of the body. Availability of pathological changes is characterized by one of the three qualitative thermographic signs: the appearance of abnormal zones of hyper-or hypothermia, alteration of normal thermotopography of the vascular pattern, and changes of the temperature gradient in the examined zone [6]. Although the first research dates back to the mid-1970s [7], it is only in the last decade that this issue has been approached more seriously. For the development of diagnostic software for the thermograms analysis with pathological conditions, it is necessary to determine the temperature patterns and temperature map of the face and neck region in healthy people, which is the main goal of this paper.

The possibilities of the thermal imaging camera as a diagnostic tool in the head and neck region diseases have only recently been studied. Only a few studies in the relevant literature deal with this issue [1, 6 – 11]. The results we present here are only a part of a larger scientific research project that studies the possibilities of a thermal imaging camera in diagnosing salivary gland tumors and intraoral carcinomas. In addition to examining the possibility of establishing a thermal imaging camera as a reliable, accurate, safe and relatively inexpensive diagnostic tool for tumor diseases of the maxillofacial region, the research objectives are to determine the temperature characteristics of the region of interest [12 – 15]. Also, some other objectives are:

– quantitative and qualitative analysis of obtained thermograms by different methods for image processing and analysis;
– defining the physiological value of the difference in temperature of symmetrical points in the regions of interest that will be obtained by analyzing the thermograms of a group of healthy subjects;
– formation of a database that will contain data on temperature distribution, sex, age, and pathohistological findings for each patient and which will be used as a basis for creating software for the classification of salivary gland diseases.

2 Measurements and Methods

Measurements presented in this paper were performed at the Clinic for dental medicine Niš, maxillofacial surgery. Thirty healthy persons, students, and employees of the Clinic, 16 females and 14 males, aged 20 to 49 years, were examined. Excluding criteria for participation in the research were taken from similar studies [8, 16], and they included:

– existence of acute infections of the upper respiratory tract;
– facial injuries as well as exposure to strong sunlight, which has led to sunburn in the last 12 months;
– dentogenic treatments in the last four months;
– treatments with vasoactive substances as well as hormonal therapy, which includes contraceptive pills;
– sports activities 2 hours before the measurement.

All patients underwent the same thermographic protocol based on The American Academy of Thermology (AAT) [17], and the medical infrared imaging guidelines outlined by Ring and Ammer [18] and Ammoush et al. [8], including:

– The examining physician explains the dental/systemic health necessity for performing infrared Dental/Systemic Health Imaging and responds to questions and concerns about any aspect of the examination.
– The patient should not have contact with any objects if that body part is being imaged. In addition, no clothing or garments should be worn over any region that is under study.
– Shower or bathe the morning of the test to ensure that the skin is as clean as possible.
– Avoid placing any material of any kind on the skin, such as any skin lotions, deodorants, preparations, moisturizers, liniments, makeup, hair spray, hair cream, topical analgesics, etc.
– Nicotine was discontinued four hours before imaging, and no drinking hot or cold water 10 to 15 minutes before measurement.
– Control for the distance between the subject and camera (~1 m). Room temperature (23-24°C) (was recorded using a mercury thermometer).
– Absence of direct solar or electric lighting and heaters.
– Subjects were asked to remain in a sitting position for approximately 15 minutes before imaging. During this adaptation process, the patients did not undertake any physical activity, chew or touch their facial skin.
– Room area ~15 m^2.
– Relative humidity of 50–70%.

The infrared thermographic camera Varioscan high-resolution model 3021 (Jenoptik, Germany) was used. The infrared thermographic camera detected infrared radiation from the skin of the face region directed by the lens system toward the photosensor, where its energy was transformed into electrical impulses that provided visualization of skin temperature values on the display as a range of colours. The camera has a thermal resolution of ±0.03°C, temperature range from –40 to 1200°C, and spectral range 8–12 μm. Absolute accuracy of the temperature measurements (factory calibrated) up to 100°C, at an ambient temperature of 22 ± 2°C, is less than ±2 K; otherwise, the accuracy is less than ±1% of full-scale value. Digital images of the skin temperature variations were analyzed by IRBIS Professional 2.2. graphics-oriented software package (InfraTec GmbH, Dresden, Germany).

Fig. 1 – *Experimental set-up for the thermal measurement.*

Experimental set-up for the thermal measurement at the Clinic for Dental Medicine Niš, maxillofacial surgery is shown in Fig. 1. On the camera display range of colors is visible, indicating real-time skin temperature.

On the obtained thermograms, 31 points of the regions of the interest of face and neck were marked (Fig. 2) [16]. Point no. 1 is located on the medial line of the face, while all other points are symmetrical on identical positions on the left and right sides.

The points at which the measurements were performed are shown in **Table 1**.

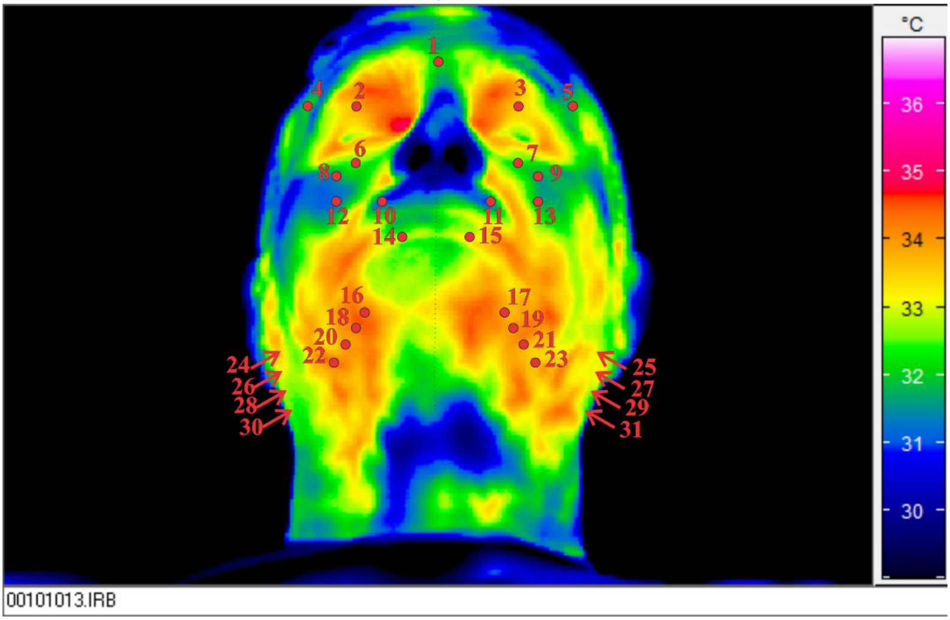

Fig. 2 – *Thermogram with marked points to be measured.*

Table 1
Measuring points labels.

Point no.	Label	Point no.	Label
Point 1	Glabela (G)	Point 17	Submandibular Left 1 (SML1)
Point 2	Medial Supraciliary Right (MSR)	Point 18	Submandibular Right 2 (SMR2)
Point 3	Medial Supraciliary Left (MSL)	Point 19	Submandibular Left 2 (SML2)
Point 4	Lateral Supraciliary Right (LSR)	Point 20	Submandibular Right 3 (SMR3)
Point 5	Lateral Supraciliary Left (LSL)	Point 21	Submandibular Left 3 (SML3)
Point 6	Infraorbital Right (IR)	Point 22	Submandibular Right 4 (SMR4)
Point 7	Infraorbital Left (IL)	Point 23	Submandibular Left 4 (SML4)
Point 8	Zygomatic Right (ZR)	Point 24	Parotid Right 1 (PR1)
Point 9	Zygomatic Left (ZL)	Point 25	Parotid Left 1 (PL1)
Point 10	Nasolabial Right (NLR)	Point 26	Parotid Right 2 (PR2)
Point 11	Nasolabial Left (NLL)	Point 27	Parotid Left 2 (PL2)
Point 12	Bucal Right (BR)	Point 28	Parotid Right 3 (PR3)
Point 13	Bucal Left (BL)	Point 29	Parotid Left 3 (PL3)
Point 14	Mental Right (MR)	Point 30	Parotid Right 4 (PR4)
Point 15	Mental Left (ML)	Point 31	Parotid Left 4 (PL 4)
Point 16	Submandibular Right 1 (SMR1)		

3 Results

Overall measured data contain measured values for 31 points in the face (Fig. 2) for each person, but because of their volume, only part of these results is given in **Table 2** (for males) and **Table 3** (for females). Maximum, minimum, and average values for all measured points are given in **Table 4**. In the last column of the table, the difference between average values for males and females is given.

Table 2

Part of measurement results for males (9 points out of 31 are given).

	G	**MSR**	**MSL**	**LSR**	**LSL**	**IR**	**IL**	**ZR**	**ZL**
Patient No.	Point1 [ºC]	Point2 [ºC]	Point3 [ºC]	Point4 [ºC]	Point5 [ºC]	Point6 [ºC]	Point7 [ºC]	Point8 [ºC]	Point9 [ºC]
1	34.25	33.87	33.98	34.63	33.96	34.53	34.16	33.92	33.36
2	34.18	34.76	34.38	33.17	33.73	34.37	34.27	33.60	33.94
3	34.26	34.68	34.22	33.14	33.14	34.23	34.13	33.60	33.35
4	34.53	34.46	34.43	34.42	34.00	34.80	34.62	34.79	35.15
5	34.02	34.04	33.64	33.76	33.49	33.83	33.70	33.62	33.04
6	32.21	32.34	32.30	32.32	32.34	32.78	32.34	32.44	31.44
7	32.21	32.88	32.90	32.16	31.38	32.69	32.59	32.53	32.62
8	33.07	32.66	32.62	33.03	32.31	33.10	33.10	32.55	32.55
9	32.94	33.34	33.46	33.50	33.00	33.53	33.60	33.21	33.05
10	34.43	34.68	33.84	34.36	33.70	34.94	34.19	34.56	34.00
11	34.19	34.84	34.73	33.18	32.86	34.48	34.25	34.04	33.57
12	33.80	34.48	34.59	33.95	33.15	34.85	34.56	34.19	34.64
13	32.14	33.39	33.17	32.23	32.63	33.59	32.82	33.09	32.55
14	34.17	34.15	34.15	33.24	32.20	34.31	34.06	34.66	34.40

Table 3

Part of measurement results for females (9 points out of 31 are given).

	G	**MSR**	**MSL**	**LSR**	**LSL**	**IR**	**IL**	**ZR**	**ZL**
Patient No.	Point1 [ºC]	Point2 [ºC]	Point3 [ºC]	Point4 [ºC]	Point5 [ºC]	Point6 [ºC]	Point7 [ºC]	Point8 [ºC]	Point9 [ºC]
1	34.17	33.82	33.94	34.33	33.65	34.12	33.78	33.42	33.68
2	33.59	33.06	32.91	34.05	33.57	34.33	33.59	32.32	31.47
3	33.74	34.29	34.19	34.88	34.00	33.29	33.31	33.15	32.70
4	34.37	34.92	34.77	33.44	33.07	34.33	34.12	33.44	33.26
5	34.60	35.24	35.15	34.61	34.36	34.99	34.96	34.75	34.19
6	35.38	35.66	36.06	34.59	34.70	35.23	35.42	34.77	34.46
7	33.91	34.09	33.79	34.49	34.27	34.17	34.50	34.82	34.57
8	33.36	33.49	33.57	33.95	34.14	34.11	34.12	33.04	32.88
9	34.58	35.04	34.38	35.14	35.09	34.37	34.04	34.15	33.71
10	34.15	34.53	34.55	34.89	35.12	34.19	33.55	34.32	32.91
11	33.32	33.90	33.99	33.82	34.54	33.82	33.85	33.17	32.92
12	32.32	33.37	33.05	33.13	32.92	33.44	33.28	32.87	32.47
13	32.67	33.02	32.33	32.24	31.90	32.27	32.90	30.64	30.45
14	32.59	32.97	32.39	33.38	33.91	32.93	32.68	32.17	32.56
15	33.30	33.39	33.68	33.28	33.27	33.05	32.99	33.14	33.10
16	33.03	34.19	33.77	34.11	32.21	33.46	33.57	32.83	33.31

Table 4
Maximum, minimum and average values for all measured points.

	MALE			FEMALE			Average values difference [ºC]
	Maximum value [ºC]	Minimum value [ºC]	Average value [ºC]	Maximum value [ºC]	Minimum value [ºC]	Average value [ºC]	
Point 1	34.53	32.14	33.60	35.38	32.32	33.76	-0.16
Point 2	34.84	32.34	33.90	35.66	32.97	34.13	-0.23
Point 3	34.73	32.3	33.74	36.06	32.39	34.01	-0.27
Point 4	34.63	32.16	33.36	35.14	33.13	34.14	-0.78
Point 5	34	31.38	32.99	35.12	32.21	33.92	-0.93
Point 6	34.94	32.69	34.00	35.23	32.93	33.99	0.01
Point 7	34.62	32.34	33.74	35.42	32.68	33.85	-0.11
Point 8	34.79	32.44	33.63	34.82	32.17	33.49	0.14
Point 9	35.15	31.44	33.40	34.57	31.47	33.21	0.19
Point 10	35.15	32.6	34.10	35.57	31.77	34.00	0.10
Point 11	35.2	32.49	33.82	35.80	32.26	33.95	-0.14
Point 12	35.13	31.83	33.51	35.27	32.16	33.82	-0.31
Point 13	34.6	30.87	33.31	35.52	32.37	33.78	-0.47
Point 14	35.44	31.13	33.94	35.56	33.01	34.16	-0.22
Point 15	35.52	31.77	33.99	35.41	33.07	34.15	-0.16
Point 16	35.38	32.64	34.13	34.86	32.20	33.64	0.49
Point 17	35.43	33.11	34.36	34.70	32.90	33.84	0.52
Point 18	35.49	32.93	34.26	34.80	32.82	33.81	0.45
Point 19	35.26	32.96	34.23	35.18	32.56	33.71	0.52
Point 20	35.28	33.18	34.32	35.18	32.38	33.85	0.47
Point 21	35.41	33.27	34.36	34.94	32.87	33.94	0.42
Point 22	35.42	32.91	34.32	34.86	32.93	33.90	0.42
Point 23	35.84	32.47	34.12	34.59	32.67	33.64	0.48
Point 24	34.46	31.22	33.37	34.82	31.71	33.34	0.02
Point 25	34.89	31.68	33.55	34.30	32.71	33.50	0.04
Point 26	34.5	32.92	33.64	34.41	32.84	33.61	0.02
Point 27	34.68	32.74	33.58	34.90	33.00	33.80	-0.23
Point 28	34.52	31.51	33.46	34.37	32.61	33.55	-0.08
Point 29	34.73	32.09	33.47	34.00	32.32	33.43	0.05
Point 30	34.65	31.95	33.55	34.2	32.66	33.55	0.00
Point 31	34.34	32.39	33.48	34.53	32.86	33.80	-0.32

4 Discussion

Infrared thermography and thermographic examination is non-invasive, non-ionizing radiation and quickly performed diagnostic imaging modality which captures and transforms infrared radiation emitted by the human skin into images that reflect the microcirculatory dynamics of the skin surface [14].

To obtain valid measurement results, it is necessary to adhere to the recommendations regarding the preparation of respondents for measurements as well as environmental conditions that must be under established standards [8, 16 – 18].

An analysis of data from a few studies shows that the published results often do not match. Some studies, for example, show that, in healthy individuals, there is a significant difference in the average temperature of the right and left sides of the face, with the temperature of the right side higher [19]. Other studies indicate that the temperature is bilaterally symmetrical [10]. Also, in some studies, it is claimed that the facial temperature in females is on average higher than in men [19], which is justified by genetic and hormonal factors and the fact that men's skin contains more collagen [20]. Other studies state that the temperature is higher in men, which is explained by differences in circulation or elevated levels of basal metabolism in men [1].

In our research, the higher temperature of the right side of the face is confirmed, but the differences are lower. In men, the ratio of mean values of temperature of all measured points of the right half of the face to the left is 33.83°C: 33.74°C, while in women, the same ratio is 33.79°C: 33.76°C, i.e. the temperature is on average higher on the right side by 0.09°C in men and 0.03°C in women.

When it comes to the female-male relationship, our results give almost identical, slightly higher values of the average temperature in men, 33.78°C: 33.77°C, i.e. the difference is 0.01°C. Our results coincide with the results of Weinstein et al. [20], who also did not find a statistically significant difference in temperatures between the gender. In contrast to these results, the work of Haddad et al. shows that facial skin temperature in males is higher than in females with DT (frontal) 0.27°C and DT (lateral) 0.34°C [14], while in the study of Christensen et al. the authors found a higher difference in male-female temperature, corresponding to 0.7°C [22].

Similar to a study conducted in Russia [6, 21], our results show that the temperature in female subjects at points G, MSR, MSL, LSR, LSL is on average 0.5°C higher than in male subjects. The same applies to the points ZR, ZL, BR, BL, and NLR and NLL, except that the temperature difference is smaller and amounts to about 0.3°C on average. In contrast to the above study, the submandibular region or points SMR 1, 2, 3, 4 and SML 1, 2, 3, and 4 are significantly warmer in our study in men with an average temperature difference of +0.46°C. For the difference from the submandibular region, the temperature values of the parotid region, i.e. at points PR1, 2, 3, 4 and PL 1, 2, 3, and 4 are almost identical (temperature difference averaged 0.05°C).

5 Conclusion

There is a constant need to develop new diagnostic tools that will meet the criteria of precision, specificity, sensitivity, harmlessness to the patient, ease of handling, and low cost. The thermal camera meets all these conditions and, in the future, it can be developed into a reliable diagnostic tool. One of the first steps in this path, which should result in the development of diagnostic software for the analysis of thermograms with pathological conditions, is the determination of the temperature patterns and temperature map of the region of the face and neck in healthy people, which is the main goal of this paper. A small number of studies have dealt with this issue. Although there is some disagreement our study shows, in accordance with others, the values of physiological differences in temperature (up to 0.4°C) of symmetrical regions of the face, which suggests that larger differences are probably associated with a pathological condition. Undoubtedly the conclusion is that this study is just the beginning of research in this field and that it is necessary to continue working to obtain relevant and significant results that can be used to implement a thermal camera as a new diagnostic tool for head and neck diseases.

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7 References

[1] D.- J. Han, K.- S. Kim: Reliability of Thermographic Imaging in the Orofacial Region, Journal of Oral Medicine and Pain, Vol. 26, No. 4, December 2001, pp. 355 – 367.

[2] A. K. Khrgian: Meteorology: v. 1: A Historical Survey, Israel Program for Scientific Translations, Jerusalem, 1970.

[3] K. Kelly: The History of Medicine: The Scientific Revolution and Medicine, Facts On File, Inc., New York, 2010.

[4] D. G. Fahrenheit: VIII. Experimenta et Observationes de Congelatione Aquae in Vacuo Factae, Philosophical Transactions, Vol. 33, No. 382, December 1724, pp. 78 – 84.

[5] G. J. Tattersall: Infrared Thermography: A Non-Invasive Window into Thermal Physiology, Comparative Biochemistry and Physiology, Part A, Vol. 202, December 2016, pp. 78 – 98.

[6] E. A. Durnovo, Y. P. Potekhina, M. S. Marochkina, N. A. Yanova, M. Y. Sahakyan, D. V. Ryzhevsky: Diagnostic Capabilities of Infrared Thermography in the Examination of Patients with Diseases of Maxillofacial Area, Sovremennye Tehnologii v Medicine, Vol. 6, No. 2, June 2014, pp. 61 – 65.

[7] M. Champy, P. Bourjat, J.- M. Schnebelen: Thermograpic Exploration of the Parotid Region, Journal of Maxillofacial Surgery, Vol. 4, No. 3, May 1976, pp. 163 – 171.

[8] M. Ammoush, M. Gzawi, A. Warawreh, R. Hijazin, H. Jafar: Clinical Evaluation of Thermography as a Diagnostic Tool in Oral and Maxillo-Facial Lesions, Journal of the Royal Medical Services, Vol. 25, No. 3, December 2018, pp. 45 – 49.

[9] A. Ghahramani, G. Castro, B. Becerik-Gerber, X. Yu: Infrared Thermography of Human Face for Monitoring Thermoregulation Performance and Estimating Personal Thermal Comfort, Building and Environment, Vol. 109, November 2016, pp. 1 – 11.

[10] J. Christensen, M. Vaeth, A. Wenzel: Thermographic Imaging of Facial Skin – Gender Differences and Temperature Changes over Time in Healthy Subjects, Dentomaxillofacial Radiology, Vol. 41, No. 8, December 2012, pp. 662 – 667.

[11] T. Harshavardhan, N. Vijayalaxmi, M. Mudavath, D. Meesala: Thermography: A Newer Diagnostic Assessment Tool in Dentistry, Journal of Mahatma Gandhi Institute of Medical Sciences, Vol. 22, No. 2, September 2017, pp. 87 – 92.

[12] A. Ćosić, I. Jovanović, M. Andrejević Stošović, D. Krasić, D. Mančić: Temperature Characteristics of Tumor of the Parotid Region Recorded by Thermal Imaging Camera, Proceedings of the 20th Congress of Dentists of Serbia, Belgrade, Serbia, September 2021, pp. 71 – 72. (in Serbian)

[13] A. Ćosić, I. Jovanović, I. Kostić, M. Andrejević Stošović, D. Krasić, D. Mančić: Temperature Characteristics of the Face Region of Healthy People Obtained using Thermal Imaging Camera, Proceedings of the 15th International Online Conference on Applied Electromagnetics - ΠΕC 2021, Niš, Serbia, August 2021, pp. 125 – 128.

[14] D. S. Haddad, M. L. Brioschi, M. G. Baladi, E. S. Arita: A New Evaluation of Heat Distribution on Facial Skin Surface by Infrared Thermography, Dentomaxillofacial Radiology, Vol. 45, No. 4, April 2016, pp. 1 – 10.

[15] I. A. Cruz-Albarran, J. P. Benitez-Rangel, R. A. Osornio-Rios, L. A. Morales-Hernandez: Human Emotions Detection based on a Smart-Thermal System of Thermographic Images, Infrared Physics & Technology, Vol. 81, March 2017, pp. 250 – 261.

[16] J. Rustemeyer, J. Radtke, A. Bremerich: Thermography and Thermoregulation of the Face, Head & Face Medicine, Vol. 3, No. 17, March 2007, pp. 1 – 8.

[17] The American Academy of Thermology, 2015 v2, 2019, Available at: https://aathermology.org/wp-content/uploads/2018/04/AAT-Oral-Systemic-Guidelines-2022.pdf

[18] E. F. J. Ring, K. Ammer: Infrared Thermal Imaging in Medicine, Physiological Measurement, Vol. 33, No. 3, March 2012, pp. 33 – 46.

[19] E. A. Durnovo, Y. P. Potekhina, M. S. Marochkina, D. A. Mochalova: Development and Analysis of the Peculiarities of the Thermal Maps of Maxillofacial Region Depending on the Age and Sex, Russian Journal of Dentistry, Vol. 17, No. 3, 2013, pp. 4 – 9. (in Russian)

[20] S. A. Weinstein, G. Weinstein, E. L. Weinstein, M. Gelb: Facial Thermography, Basis, Protocol, and Clinical Value, Cranio, Vol. 9, No. 3, July 1991, pp. 201 – 211.