DIAGNOSTIC CAPABILITIES OF INFRARED THERMOGRAPHY IN THE EXAMINATION OF PATIENTS WITH DISEASES OF MAXILLOFACIAL AREA

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The aim of the investigation was to evaluate the possibility to apply infrared thermography for the diagnosis of pathological maxillofacial conditions.

Materials and Methods. 250 patients with different maxillofacial pathological conditions underwent an examination, thermographic analysis and comprehensive treatment. All patients were divided into three groups: group 1 (n=114) — patients with inflammatory diseases of maxillofacial area; group 2 (n=40) — patients with traumatic maxillofacial injuries; group 3 (n=96) — patients with benign (n=54) and malignant (n=42) neoplasms of the maxillofacial area.

Results. Local temperature indices of the maxillofacial area were found to change significantly in inflammatory diseases. The decrease of temperature indices was revealed in the centre of radicular cysts (by 0.1–0.3°C), in central and peripheral (by 1.3–2.3°C) points over chronic osteomyelitis, in acute purulent periostitis (by 1.2–1.9°C), in acute osteomyelitis (by 1.5–1.9°C), in acute grandular abscess (by 2.0–2.3°C), in odontogenic phlegmon of maxillofacial area (by 1.4–3.0°C), and odontogenic abscess (by 1.8–2.4°C). We found significant increase of temperature indices in traumatic injuries: in lower type LeFort fractures (by 1.3–1.5°C), in medial type LeFort fractures (by 1.2–1.6°C), in mandibular fractures (by 0.2–0.6°C). Significant increase of temperature indices was observed over malignant neoplasms — in the range of 2.8–3.6°C, while temperature indices over benign tumors and tumor-like masses did not exceed 1.4°C.

Conclusion. Infrared thermography is a reliable, highly informative, non-invasive and safe method, requiring no trained staff. It can be used for diagnosis, differential diagnosis and prognostic studies in various diseases of maxillofacial area.

Key words: infrared thermography; diseases of maxillofacial region; oral mucosa; thermogram.

Accessible and qualitative diagnosis of different pathological conditions of maxillofacial area is of great importance for practical medicine [1, 2].

According to the epidemiological data analysis of the recent years [3, 4] the prevalence of inflammatory ailments of the maxillofacial area in the specialized dental facilities reaches 56.3%, of which 82.5% are acute inflammatory processes, and 17.5% — chronic ones. Acute nonodontogenic inflammatory diseases comprise only 16% of the acute inflammatory illnesses, while the prevalence of tumors and tumor-like formations of the maxillofacial area equals to 13% of the total number of the diseases of the given localization.

A high prevalence of pathological conditions in the maxillofacial area together with their late revealing often leads to the development of heavy complications. For successful and timely treatment of these pathologies more accurate and adequate diagnostic methods are required. One of such methods is infrared thermography, i.e. registration of infrared radiation emitted by the examined surface of the human body [5–8]. In the available Russian and foreign literature information on the application of the contact infrared thermography in the diagnosis of maxillofacial diseases and oral mucous membrane has not been found. Absence of such data does not allow to draw parallels between thermographic and clinical picture of many pathological conditions in order to make a diagnostic level higher, and, therefore, the quality of medical aid already at the early stages of the maxillofacial ailments.

In the basis of thermography lies the increase of infrared radiation intensity over the pathological

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foci or reduction of its intensity in the areas with the decreased regional blood flow [9–11]. Availability of pathological changes is characterized by one of the three qualitative thermographic signs: 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 [12–15].

The aim of the investigation is to evaluate the possibility of using infrared thermography in diagnosing pathological conditions of the maxillofacial area.

Materials and Methods. The investigation included 250 patients with various pathological conditions of the maxillofacial area, who underwent thermographic and complex examination complying with the Declaration of Helsinki (the Declaration was passed in Helsinki, Finland, June, 1964 and revised in October, 2000 (Edinburgh, Scotland). The investigation was approved by the ethic committee of Nizhny Novgorod State Medical Academy. Written informed consent was obtained from every patient.

All patients were divided into 3 groups.

Group 1 (n=114) presented patients with inflammatory diseases of the maxillofacial area, of them 20 had radicular cysts of the jaws, 38 suffered from such inflammations as periostitis and osteomyelitis. Diseases of the lymphatic nodes in the form of acute purulent lymphadenitis were noted in 13 cases, odontogenic abscess of the maxillofacial area — in 23, and odontogenic phlegmon — in 20 cases.

Group 2 (n=40) comprised patients with traumatic injuries (TI) in the maxillofacial area: fractures in the mandibular area were in 25 patients, in the maxilla with lower type (I) and medial type (II) LeFort fracture — 15 cases.

Group 3 (n=96) included patients with benign (n=54) and malignant (n=42) neoplasms in the maxillofacial area.

The occurrence of the pathological process was established on the basis of clinical signs, findings of the clinical and laboratory investigations, additional methods of investigations, results of histological studies, and infrared thermography. All additional and special diagnostic techniques were used according to the standards of examining patients with different nosological forms.

Local temperature was measured in several points over the pathological focus and in symmetrical points on the healthy side. Measurements were performed using a thermographic complex CEM®-ThermoDiagnostics, consisting of medical infrared thermograph CEM®-Thermography and computer program (LLC "Connection of the East and West Medicine" Ltd., Russia). Points for measurement of the temperature gradient and their number were randomly selected enabling the examination of the areas of different sizes (Fig. 1).

Fig. 1. Diagnostic points over the pathological focus and in symmetrical points on the healthy side

The results were presented in quantitative values — degrees Celcius, and in qualitative parameters – building thermograms. Describing the thermograms obtained during thermographic examination, the regions of thermal glow with different colors and shades were revealed [16]. Blue color corresponded to low temperature (hypothermia). Zones with higher temperatures displayed green, yellow and yellow-orange glow (isothermia). The highest temperatures on the thermogram were shown up as orange-red and red glow (hyperthermia)

Statistical data processing was made using Microsoft Excel. Median (Me) and mean error (m) were determined for each quantitative parameter. For numeric data comparison Student t-criterion for small samples and Fisher tables for the groups with observed values less than 30 and more than 10 were used. Nonparametric method, Mann–Whitney U-criterion, was applied for unconnected populations. Differences at $p \leqslant 0.05$ (95% level of significance) were considered to be statistically significant. Connection between the values was evaluated by the results of Pearson correlation (r).

Results.

1. Thermographic investigation of inflammatory diseases of maxillofacial area and oral mucous membrane.

Tomography in patients with ***radicular cysts (K04.8)*** revealed the reduction of the temperature values in the central point of the cyst, on average, by 0.2±0.1°C, and the increase of the temperature in peripheral points by 0.6±0.1°C ($p \leqslant 0.05$). The cyst membrane is presented by the two lines of glow, which surrounded a blue region in the center of the pathological focus (Fig. 2, *a*). The blue color in the center of the thermogram corresponded to the cyst content projection. The thermogram adequately reflected the structure of the radicular cyst and was consistent with the radiographic picture (Fig. 2, *b*).

Quantitative temperature values of ***periostitis region (acute purulent phase) (K10.2)*** in the central point of the pathological focus were elevated relative to the symmetrical healthy side, on average, by 1.7±0.2°C, in the peripheral points — by 1.4±0.3°C. The thermographic map (Fig. 3) looked stratified, had a high intensity of the yellow and red glow. These zones corresponded to the localization of the purulent process. Such image of the

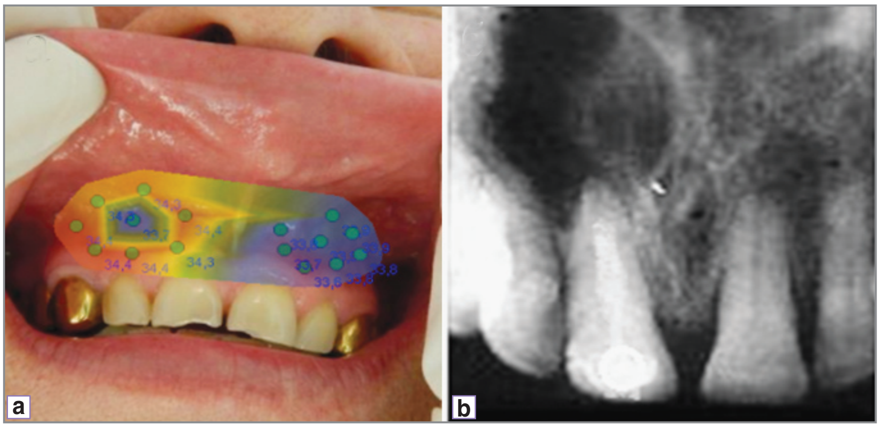

Fig. 2. Radicular cyst in the teeth area 1.1, 1.2: *a* — thermogram, *b* — intraoral radiograph

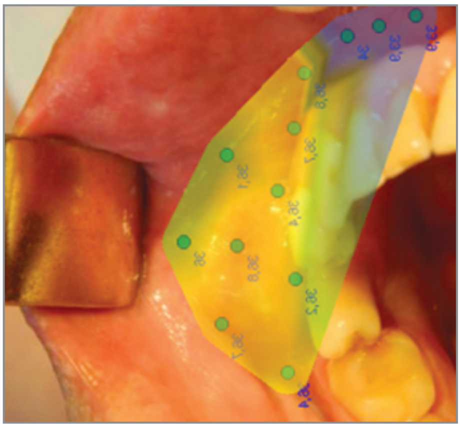

Fig. 3. Thermogram of the acute phase of periostitis

thermal field determined the formation of the suppurative infiltrate and dissociation of the periosteum fibers.

A thermographic map of ***acute osteomyelitis (K10.2)*** was characterized by the yellow-orange glow, spreading to the both sides of the alveolar ridge (Fig. 4). Separate red inclusions on the thermogram corresponded to the altered vessels and fluctuation zone (Fig. 4, *a*). The temperature in the region of vestibular and oral jaw surfaces over the infiltrate and on the symmetrical healthy side in the central points differed, on average, by 1.8±0.1°C, in the peripheral points — by 1.7±0.1°C.

In the ***chronic phase of osteomyelitis (K10.2)*** independently on localization a region of the marked hypothermia over the pathological focus was displayed. Cavities outlined on the thermogram by the yellow lines corresponded to the sequestral capsule (Fig. 4, *b*). Thermographic picture agreed with the radiographic one, as zones of the blue glow matched the necrotized area of the jaw (Fig. 4, *c*). The temperature values over the chronic osteomyelitis focus were lower compared to the symmetrical healthy side: in the central point — on average by 2.8±0.2°C, in the peripheral points — by 1.8±0.6°C.

Quantitatve temperature values in lymphodenitis differed from those of the symmetrical healthy side. In ***acute suppurative lymphodenitis (L04.0)*** the difference in the central point was, on average, 2.2±0.1°C, in peripheral points — 2.1±0.1°C. The thermorgram looked like a zone of yellow glow, which appeared due to the enlargement of the lymphatic node, and the presence of hyperemic dilated vessels in it (Fig. 5).

Thermographic image of ***phlegmons (L03.2)*** of the maxillofacial area (Fig. 6, *a*) was characterized by diffused zone of hyperthermia with unclear boundaries, increase of the glow in the direction of inflammation

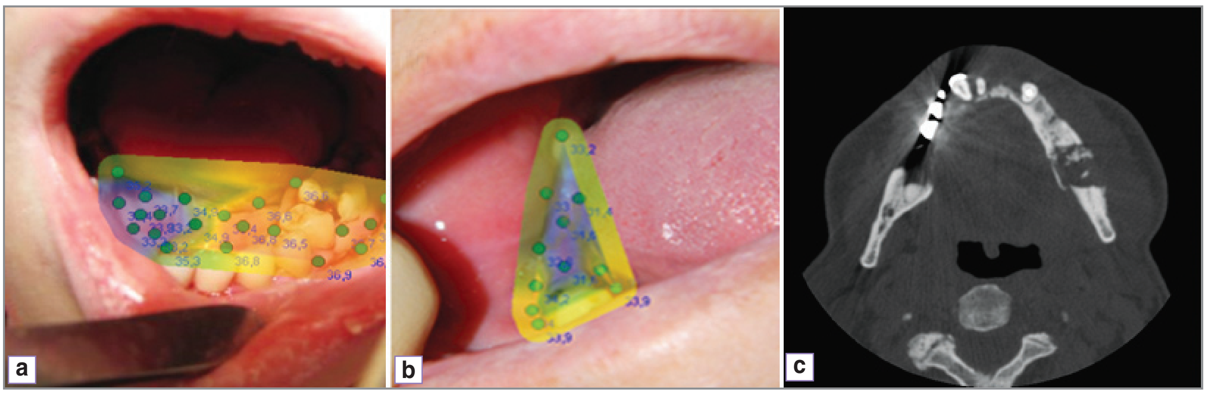

Fig. 4. Thermograms of the acute (*a*) and chronic (*b*) phase of osteomyelitis, and computed tomogram of chronic osteomyelitis in the lower jaw on the right (*c*)

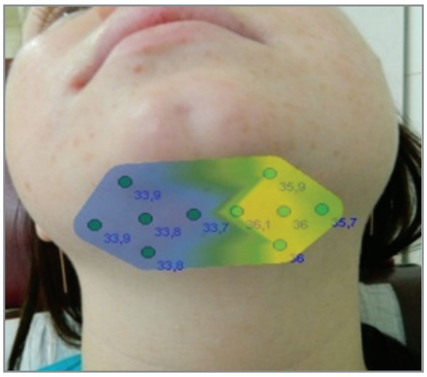

Fig. 5. Thermogram of acute suppurative lymphadenitis

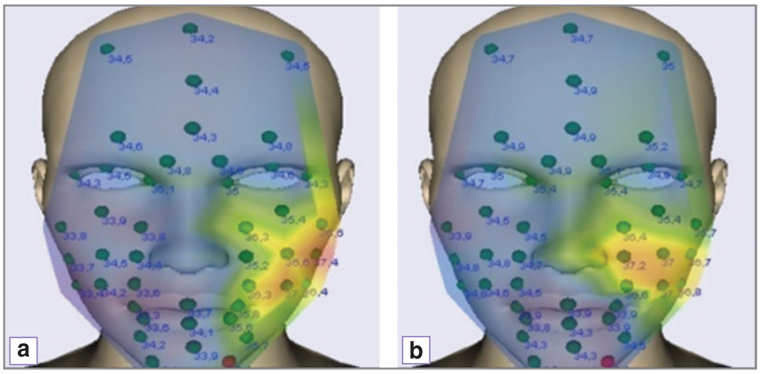

Fig. 6. Thermograms of odontogenic processes: phlegmon (*a*), and abscess (*b*)

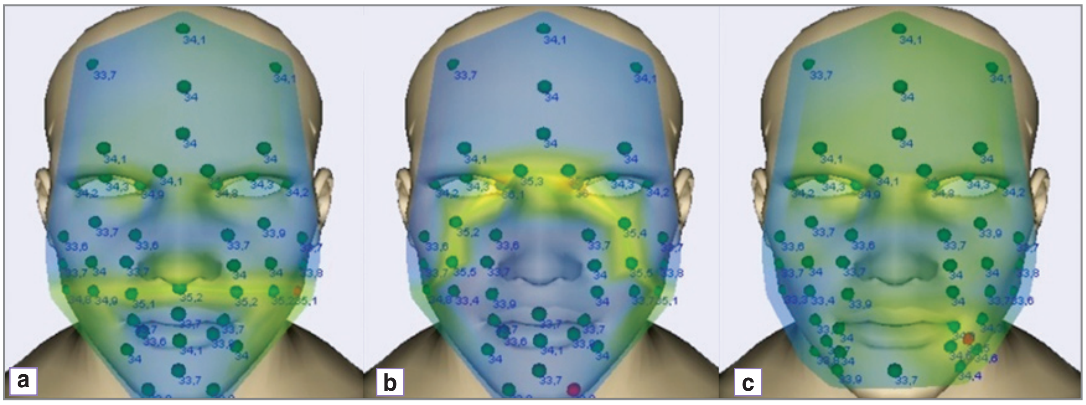

Fig. 7. Thermograms of low type LeFort maxillar fracture (*a*), medial type LeFort fracture (*b*), and mandible fracture (*c*)

spreading, and formation of leakages. Yellow regions — necrosis sites – were seen on the background of the red glow. The temperature above the phlegmon was higher than above the symmetrical healthy side by 2.2±0.8°C.

A thermal field in ***abscess (K12.2)*** had clear contours and less intensive glow (Fig. 6, *b*).

The temperature in the points over the pathologic focus differed from that of the symmetrical points on the healthy side, on average, by 2.1±0.3°C.

2. Thermographic studies of traumatic injuries of maxillofacial area.

Comparing normal temperature values of the maxillofacial area with the values above the line of the lower type LeFort fracture, it was estimated that they were lower than above the fracture line, on average, by 1.4±0.1°C; above the line of the medial type LeFort fracture, on average, by 1.4±0.2°C. In case of uncomplicated fracture of the lower jaw the temperature difference amounted to 0.2–0.6°C.

Thermograms in lower type LeFort fractures featured by the presence of isothermia line going in the projection of the fracture line on the skin (Fig. 7, *a*). In median type LeFort fractures there appeared the zone of yellow glow on the background of green isothermia (Fig. 7, *b*) which was connected with the elevation of the temperature in the region of the inner angles of the eye orbit. On the thermogram a uniform zone of green glow displayed itself over the injury in the projection of the mandible fracture (Fig. 7, *c*).

3. *Thermographic examination of neoplasms of the maxillofacial area and oral mucous membrane.*

When examining patients with neoplasm of the maxillofacial area, it was found that the temperature values in malignant process elevated, on average, by 3.2±0.4°C. The generation of the thermographic image depended on several factors: firstly, the character of the thermal field was influenced by the compression of the vessels by the tumor; secondly, processes of anaerobic glycolysis prevailed in the neoplasm tissues; thirdly, infiltrative neoplasm growth resulted in the development of the perifocal inflammation in the tissues surrounding the tumor, contributing further to the formation of new vessels. The hyperthermia focus over the malignant process corresponded to the tumor localization, and manifested itself by the hyperthermia region directly over the tumor tissues (Fig. 8, *a*). The color of the focus depended on the degree of the tumor cell differentiation: the lower the tumor the brighter was the color of the thermal field, as the number of mitoses increased.

The rise of the temperature over the tumor within 0.4–1.4°C corresponded to the benign process. Zones of the marked hyperthermia were absent (Fig. 8, *b*).

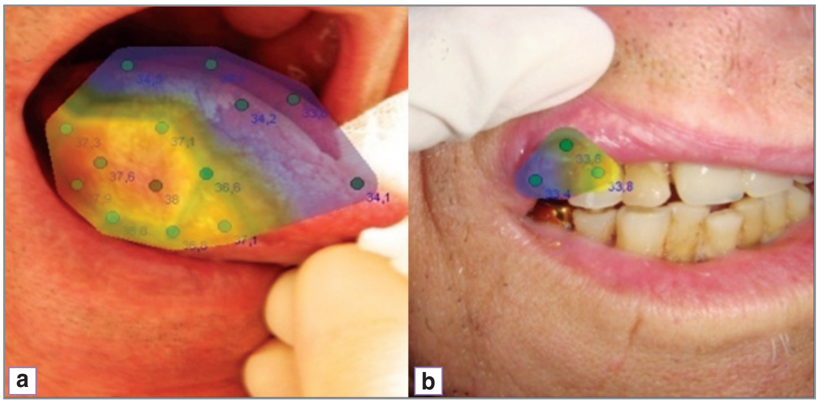

Fig. 8. Thermogram in malignant (*a*), and benign (*b*) processes

Thus, the temperature values of the maxollofacial area and oral mucosa change significantly in terms of statistics in inflammatory diseases and traumatic injuries. Infrared thermography technique enables to conduct differential diagnosis of benign and malignant neoplasms at the early stages.

Conclusion. Infrared thermography is a reliable, highly informative, noninvasive, and safe method, not requiring special training for performing the diagnostic procedure, a differential diagnosis, and prognostic studied in different diseases of the maxillofacial area.

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