

THERMAL ASSYMETRY OF THE ORAL MUCOSA RELATED TO INFECTIOUS AND PROSTHETIC FACTORS: A THERMOGRAPHIC STUDY

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ABSTRACT

Aim of the study. Infrared thermography can be successfully used to obtain data about the functionality of the denture bearing mucosa of removable denture wearers. The purpose of the study was to test the distribution of the thermal field as concerns the symmetry and uniformity at the level of the support maxillary mucosa of mobile prosthesis wearers, with or without *Candida*-associated denture stomatitis (CADS). **Materials and Methods.** A cross-sectional study was conducted upon subjects with different prosthetic status (n=66) placed into five groups: G1- complete denture wearers on the maxillary arch with CADS (n=22); G2- complete denture wearers on the maxillary arch with recent prostheses (n=12); G3- complete denture wearers on the maxillary arch with old prostheses (n=12); G4 - edentulous subjects without maxillary dentures (n=10); G5- dentate subjects (n=10). Biological samples for *Candida* were taken from all subjects, with inoculations on Sabouraud Dextrose medium enriched with chloramphenicol and thermography with ThermoCAM PM350 at the level of the maxillary mucosa and of the inner sides of the upper dentures for the subjects distributed in G1-G3. **Results.** The proportion of subjects for which the distribution of the thermal field at the level of the mucosa showed neither symmetry nor uniformity was significantly higher for the cases with CADS compared to the other 4 groups (symmetry/uniformity: $p < 0.0001$); the share of subjects for which the distribution of the thermal field showed neither symmetry nor uniformity was statistically significantly higher among the edentulous with CADS, compared to the other 2 groups (symmetry $p < 0.0001$; uniformity $p = 0.004$). Although the statistical threshold was not reached, among all the clinical cases with intact maxillary mucosa, the most frequent disturbances of the thermal architecture were found among the wearers of long-standing maxillary prostheses. **Conclusion.** Asymmetrical temperature distribution on the maxillary denture bearing mucosa as detected from thermal images coincides well with infective-inflammatory conditions such as *Candida*-associated denture stomatitis but can also be frequently detected in healthy maxillary mucosa in wearers of old complete dentures.

Key words: infrared thermography, oral mucosa, maxillary denture, thermal symmetry, thermal uniformity, *Candida* associated denture stomatitis, denture wearer, thermal pattern

INTRODUCTION

The treatment of total or partial edentulousness by applying removable dentures to the oral cavity for restorative purposes, by using a

conventional prosthesis or on implants, has advantages, but also disadvantages. The prophylaxis of the support tissues is an issue

that should be taken into account for the entire duration of using a denture. A factor that favors the occurrence of frequent oral mucosal lesions of the denture wearer, but also of peri-implantitis in implant-supported overdentures, is the increase in temperature under the base of the prosthesis, an increase that initiates the pathogenization of the initially saprophytic microbial flora and its toxic action, mainly of fungi of *Candida* genus(1, 2).

Denture wearers are usually geriatric people, with frequently deficient immunity and multiple general pathologies. For them, the occurrence of *Candida*-associated denture stomatitis (CADS) is reported more frequently compared to the young, the condition being defined as an inflammatory infectious process of the supporting mucosa with a strongly recurrent manifestation among the elderly (3, 4). While aging, the visual accuracy and the tactile sensitivity decrease, which leads to not noticing the biofilm on prostheses, and implant attachments (5, 6) In addition, the degenerative diseases along with the decline of manual dexterity among this category of patients often do not allow the efficient removal of the biofilm that forms over time on implant attachments or any type of dentures, causing a significant increase in the microbial load in the oral cavity (2).

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tactile sensitivity decrease, which leads to not noticing the biofilm on prostheses, and implant attachments (5, 6). In addition, the degenerative diseases along with the decline of manual dexterity among those patients often do not allow the efficient removal of the biofilm that forms over time on implant attachments or any type of dentures, causing a significant increase in the microbial load in the oral cavity (2).

The recent, rapid and far-reaching technical development of infrared thermography (IRT) cameras has opened new prospects on their use, both in general medicine and in dentistry. The possibility of using thermography and its introduction in the investigation of oral mucosal diseases of the patients with mobile prostheses, in particular of the CADS, has been certified by a series of own researches (7, 8). This rapid, non-invasive functional diagnostic approach starts from the observation of the uniqueness, symmetry and uniformity of the thermal scene in non-pathological cases at the level of the skin and mucosa, the technique being the basis for diagnosing the most incipient surface metabolic disorders in the form of thermal signals, which anticipate the clinical manifestation of the inflammation (9). The IRT is thus based on capturing the thermal energy emitted predominantly in the form of infrared radiation with the help of sensors (the thermal imaging cameras mentioned above) and transforming them into visible images, called thermograms. These are evaluated comparatively at the level of the right half and of the left half of the body, any deviation from symmetry having a diagnostic value. In "normal" (normality being the absence of pathology) circumstances, the surface

temperature of the human body has a symmetrical emissive pattern in relation to the anatomical median axis, any deviation from this symmetry indicating the presence of a functional, yet not anatomical anomaly for that area (10). The thermogram of an area anatomically consisting of two identical halves will therefore have a symmetrical thermal field (11). Differences of up to 0.2° C between similar areas are detected in real time, recent reports indicating the differences greater than 0.5 C compared to the areas of a corresponding healthy body as being pathologically significant (12) At the same time, the fact that the thermal groups registered at the level of that area remain within close percentage limits (differences <5%) is considered a uniform distribution of the thermal field specific to non-pathological cases, the high percentage differences (>5%) between most thermal values per unit area signaling the uneven distribution of the thermal field associated with pathological functional disorders (13-15).

Our study thus aimed to evaluate the distribution of the thermal field of the supporting maxilla mucosa as concerns the symmetry and uniformity, in edentulous patients with or without CADS, starting from the null hypothesis that there is no causality between the asymmetries of the thermal field and the wearing of prostheses, or the stated pathology.

MATERIALS AND METHODS

The retrospective cross-sectional study was carried out by clinical and paraclinical investigation of the oral mucosa of the maxilla (both microbiological and thermographic examination) of subjects from the Dental Prosthetics Department of the Faculty of Dentistry, "Carol Davila" UMF in Bucharest. The enrolled cases were consecutive, the study

being carried out in accordance with the ethical principles of the "Declaration of Human Rights" from the Helsinki Declaration of 1975, revised in 2000. The subjects of the study received written information about the thermography method and then expressed their consent to participate by signing the informed consent document. The study was carried out at the Prosthodontic Department of the Department with logistical and specialized support from the Department of Materials Technology and Welding, Faculty of Engineering and Management of Technological Systems, within the Polytechnic University of Bucharest.

66 subjects from among patients presented for treatment, also from students and academic staff of the Prosthodontic Department were selected. The subjects were divided into 5 groups, as follows: G 1, n=22 (12 women and 10 men, 57-87 years old), complete maxillary denture wearers diagnosed by microbiological exam with CADS; G2, n=12 (4 women and 8 men, 53-86 years old, with recent removable maxillary prostheses (denture applied ≤ 5 years); G3: n=12 (4 women and 8 men, 71-83 years old) with old removable maxillary prostheses (denture applied > 5 years); G 4: n=10 (5 women and 5 men, 60-90 years old), totally or partially edentulous without mobile prosthesis in the past or at the time of the thermographic investigation; G 5, n=10 (6 women and 4 men, 23-44 years), dentate subjects. For G1-G3, the following exclusion criteria were applied: other prosthetic status than a removable one in the maxilla, major cognitive, mental or locomotor deficiencies, physiological or pathological conditions that could involve thermal homeostasis disorder, as well as refusal to participate in the study. For G4, exclusion was applied to patients with a history of removable prosthodontic treatment in the maxilla, and for G5, the cases with any type of prosthetic treatments for maxilla were excluded, from both groups the subjects to

whom the general criteria mentioned for G1-G3 could apply being excluded.

The investigation of *Candida* colonies with pathogenic appearance at the level of the maxillary oral mucosa was carried out by serial harvesting and cultivation on a specific Sabouraud Dextrose medium added with chloramphenicol from the areas considered significant, by using a sterile prefabricated swab repeatedly passed over the mucosal surfaces of the maxilla. After discharging the swab on the culture medium, the resulting inoculum was spread on the surface of the solid medium distributed in tubes or Petri plates, by using a microbiological loop, the loop exhaustion technique. The seeded media were incubated for 24-72 hours at a temperature of 37°C.

A portable thermographic system ThermoCAM PM350 (Inframetrics/FLIR, USA) with optimal applicability in the medical field was used. In order to limit thermal artifacts, the procedure followed a specifically protocol, namely the tests were conducted in a room with an area of approx. 14 m², uniform ambient temperature of 20-24°C, air humidity in the range of 45-60%, placing computer equipment away from the place of investigation; excluding any interference with infrared sources other than those to be investigated, by closing and covering windows with opaque textiles, closing artificial lighting sources. The subjects were asked to exclude exposure to special thermal conditions and use of nicotine, alcohol, coffee and tea during the day of the procedure, to exclude acupuncture, electrostimulation, ultrasound or anti-inflammatory medication treatments 24 hours

prior to thermography, to stop ingesting solids or liquids one hour before the procedure. On the day of the investigation, after arriving at the dental office, the subjects rested for 30 minutes in order to adjust themselves to the ambient temperature.

Also, before thermography, the device was manually calibrated in infrared. The emissivity specific to the human body, namely $\varepsilon = 0.98$, the humidity, the ambient temperature, the color range, with image focus and use of the thermal range between -10°C and 65°C, with the setting of the optimal sub-range within it, were adjusted. After the thermal adaptation period, sterile spacers were applied to the patients in the oral cavity, the investigation being performed in clinostatic position, with adequate cephalic support. The maxillary mucosa was scanned by a distance of 25-30 cm and the result of the scan could be viewed in real time by the examiners.

The color ranges were selected differently by the thermography camera, which can automatically "perceive" the minimum and maximum values on the thermal scene. Analysis of the thermograms consisted in tracking and interpreting the thermal values, not the colors themselves, which are just a quantitative coding of the temperature. The thermal images were stored on the PCMCIA card in TIFF format, specific to the ThermoGram Pro 95 software, for analysis and interpretation. These were transferred to the computer and for each patient a study file was prepared, in which the thermal image was accompanied by the corresponding clinical image, as exemplified in Fig. 1.

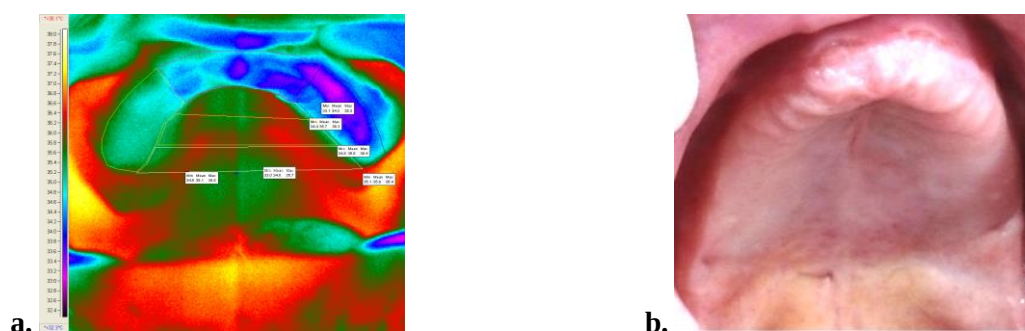


Figure 1. Thermogram of an old maxillary denture wearer, with healthy support mucosa:
Thermographic (a) and Clinical (b)

In addition, for G1-G3 we investigated the temperature of the inner surface of the maxillary prosthesis, immediately after removing the prostheses from the oral cavity, as shown in Fig. 2.

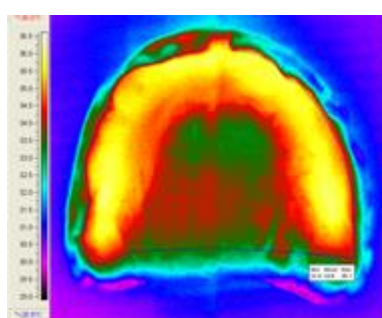


Figure 2. Thermal image of the intaglio surface of a complete maxillary prosthesis

The distribution of the thermal field characterized by symmetry and uniformity was established both for the maxillary mucosa and for the inner surface of the maxillary prosthesis by using the ThermoGram 95 Pro software. The symmetry was evaluated in relation to the mediosagittal suture, the thermal field being considered symmetrical or asymmetrical following the comparative evaluation of the thermograms, by drawing the median axes (white lines) on each of them (Fig. 3 and 4).

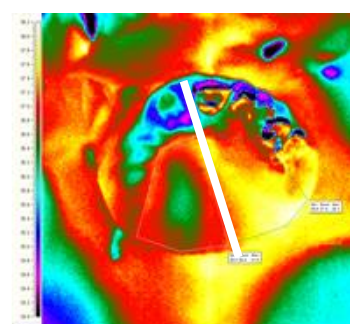


Figure 3. Asymmetrical thermal field, maxillary denture bearing mucosa

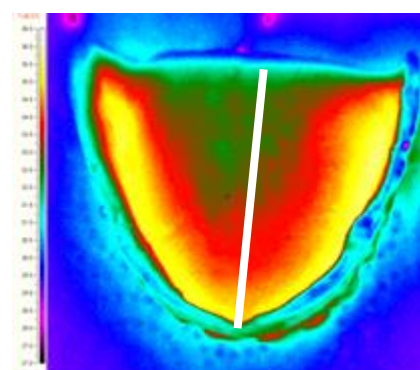


Figure 4. Symmetrical thermal field, inner surface, complete maxillary prosthesis

In order to establish the uniformity of the thermal field for the maxillary mucosa and the inner area of the maxillary prosthesis, the entire perimeter of interest was selected on thermograms. By using the ThermoGram 95 Pro software, we calculated the minimum, maximum and average values for the entire area selected at this level. Based on these, the

program provided histograms, as well as thermal profiles for each thermogram.

The fact that the thermal groups registered for that area remained within close percentage limits (differences <5%), as indicated by the histograms and the related thermal profiles (Fig. 5), was associated with the uniform distribution of the thermal field, the high percentage differences (>5%) between most of the thermal values per unit area signaling the uneven distribution of the thermal field (Fig. 6).

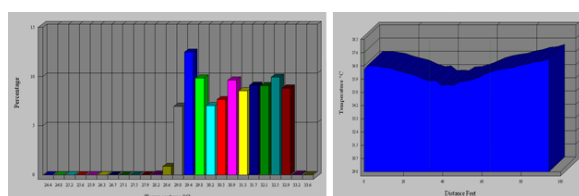


Figure 5. Area with uniform distribution of the thermal field, histogram (a), linear thermal profile (b)

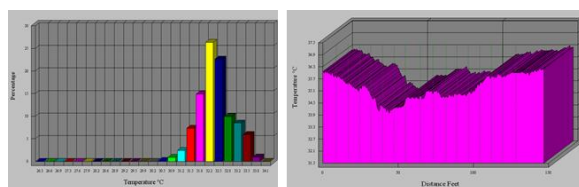


Figure 6. Area with uneven distribution of the thermal field, histogram (a), non-linear thermal profile (b)

The dates collected were included in a database designed in the SPSS 22 program, which was used to process them statistically. The testing of the statistical significance of the

differences among proportions was performed by using the square-chi test, while the testing of the statistical significance of the differences among the averages of 3 or more independent groups was performed by using the ANOVA test (for parametric variables). The threshold chosen for statistical significance was $p \leq 0.05$. Based on the results of the descriptive statistics, a bivariate correlation analysis was conducted in order to calculate the Spearman correlation coefficient and to test the null hypothesis of the study.

RESULTS AND DISCUSSIONS

The maxillary mucosal temperatures of the dentate subjects and of those with CADs were statistically similar, but they were significantly higher than those registered for the others with recent prostheses, old prostheses or without prostheses (36.59°C vs. 36.19°C vs. 34.78°C vs. 35.3°C vs. 34.79°C ; $F = 16.333$; $p < 0.0001$) (Table 1). Among the patients with dentures, the highest temperature values for the inner side of the maxillary prosthesis were registered for the cases with CADs (Table 1), their values being statistically significantly higher than those registered for the patients with recent or old prostheses without CADs (34.19°C vs. 33.33°C vs. 33.92°C vs. 33.89°C ; $F = 3.571$; $p = 0.037$).

Table 1. Average temperature at specific areas in the investigated subjects

TEMPERATURE ($^{\circ}\text{C}$) AVERAGE $\pm$ D.S (MIN-MAX) VARIABLE	DENTATE	DENTURE WEARERS WITH CADS	RECENT DENTURE WEARERS	OLD DENTURE WEARERS	EDENTULOUS WITHOUT DENTURES	P*
Denture bearing maxillary mucosa	36.59 ± 0.52 (36,1-37,47)	36.19 ± 0.77 (34,53-37,42)	34.78 ± 1.09 (33,43-37,42)	35.31 ± 0.29 (34,71-35,72)	34.79 ± 0.51 (34,17-35,31)	<0.00 01

TEMPERATURE (°C) AVERAGE±D.S (MIN-MAX) VARIABLE	DENTATE	DENTURE WEARERS WITH CADS	RECENT DENTURE WEARERS	OLD DENTURE WEARERS	EDENTULOUS WITHOUT DENTURES	P*
Intaglio side of maxillary prosthesis	.	34.19±1.05 (31,1-35,8)	33.33±0.81 (32-34,3)	33.92±0.60 (33,3-34,8)	.	0,037

*ANOVA; NS = statistically not significant ($p > 0.05$)

There were no differences between the 4 groups of edentulous as concerns the thermal field distribution (Table 2), both its symmetry and its uniformity having statistically similar proportions (presence of symmetry – 100% vs. 31.8% vs. 83.3% vs. 66.7% vs. 75%; $\chi^2 = 1.129$; $p = 0.770$; presence of uniformity – 9.1% vs. 50% vs. 66.7% vs. 50%; $\chi^2 = 4$; $p = 0.261$). However, the proportion of subjects for whom the heat field distribution showed neither symmetry nor uniformity was

statistically significantly higher among the patients with CADS compared to the other 4 groups (absent symmetry – 0% vs. 68.2% vs. 16.7% vs. 33.3% vs. 25%; $\chi^2 = 20.304$; $p < 0.0001$; absent uniformity – 90.9% vs. 50% vs. 33.3% vs. 50%; $\chi^2 = 21.059$; $p < 0.0001$). Last but not least, all the dentate subjects showed a mucosal thermal field both symmetrical and uniform.

Table 2. Distribution of the thermal field of the maxillary oral mucosa in the investigated subjects

MUCOSAL THERMAL FIELD (CT_m) VARIABLE	DENTATE	DENTURE WEARERS WITH CADS	RECENT DENTURE WEARERS	OLD DENTURE WEARERS	EDENTULOUS WITHOUT DENTURES	P*
Symmetry CT_m – n (%)						
Present	10 (100)	7 (31.8)	10 (83.3)	8 (66.7)	8 (80)	NS
Absent	0 (0)	15 (68.2)	2 (16.7)	4 (33.3)	2 (20)	< 0.0001
Uniformity CT_m – n (%)						
Present	10 (100)	2 (9.1)	6 (50)	8 (66.7)	6 (60)	NS
Absent	0 (0)	20 (90.9)	6 (50)	4 (33.3)	4 (40)	< 0.0001

*square chi; NS = statistically insignificant ($p > 0.05$)

Regarding the 3 groups with removable prostheses, there were no significant differences as concerns the distribution of the thermal field of the maxillary prosthesis (Table 3), both its symmetry and its uniformity having statistically similar proportions (presence of symmetry – 34.2% vs. 83.3% vs. 83.3%; $\chi^2 = 0.286$; $p = 0.867$; presence of uniformity – 22.7% vs. 50% vs.

66.7%; $\chi^2 = 0.737$; $p = 0.692$), but the part of patients for whom the heat field distribution showed neither symmetry nor uniformity was statistically significantly higher among patients with CADS, compared to the other 2 groups [absent symmetry – 63.6% vs. 16.7% vs. 16.7%; $\chi^2 = 16$; $p < 0.0001$; absent uniformity – 77.3% vs. 50% vs. 33.3%; $\chi^2 = 10.889$; $p = 0.004$].

Table 3. Distribution of the thermal field of the inner side of prostheses in investigated patients

PROSTHETIC THERMAL FIELD (CT_P) VARIABLE	DENTURE WEARERS WITH CADS	RECENT DENTURE WEARERS	RECENT DENTURE WEARERS	P*
Symmetry CT_p – n (%)				
Absent	14 (63,6)	2 (16,7)	2 (16,7)	< 0.0001
Present	8 (34,2)	10 (83,3)	10 (83,3)	NS
Uniformity CT_p – n (%)				
Absent	17 (77,3)	6 (50)	4 (33,3)	0,004
Present	5 (22,7)	6 (50)	8 (66,7)	NS

*square chi; NS = statistically insignificant ($p > 0.05$)

The correlation analysis highlighted the following associations between the distribution of the thermal field of the maxillary mucosa and CADS (Table 4):

- The symmetry of the thermal field of the maxillary mucosa was more frequently associated with the cases without CADS, while its asymmetry was more frequently associated with the cases with the disease. [$r_s = -0.429$; $r_s^2 = 0.184$ $p = 0.001$];

- The thermal uniformity of the maxillary mucosa was more frequently present in cases without CADS, while its absence was more frequently associated with the chronic condition [$r_s = -0.480$; $r_s^2 = 0.230$ $p < 0.0001$];

Table 4. Associations between the mucosal thermal field and CADS

VAR.1	VAR.2	RS	RS2	P
Symmetry of the maxillary mucosa	CADS	- 0.429	0.184	0.001
Uniformity of the maxillary mucosa	CADS	- 0.480	0.230	< 0.0001

Further, the following associations were identified between the distribution of the thermal field at the level of the intaglio surfaces of the maxillary prostheses and CADS (Table 5):

- The symmetry of the thermal field of the maxillary prosthesis was correlated more frequently with the cases without CADS,

while its asymmetry was more present associated in subjects with CADS ($r_s = -0.481$; $r_s^2 = 0.231$ $p = 0.001$);

- The uniformity of the thermal field at the level of the maxillary prosthesis was more frequently associated with the cases without CADS, while its absence was more often correlated with the cases with CADS [$r_s = -0.361$; $r_s^2 = 0.130$ $p < 0.0001$].

Table 5. Associations between the maxillary prosthetic thermal field and CADS

VAR.1	VAR.2	RS	RS2	P
Symmetry of the of the inner surfaces of the maxillary prostheses	CADS	- 0,481	0,231	0,001
Uniformity of the of the intaglio surfaces of the maxillary prostheses	CADS	- 0,361	0,130	0,014

IRT is an objective diagnostic method that highlights the thermal changes in the oral mucosa and the corresponding denture bearing areas, with clinical and practical significance in patients wearing removable prostheses. These changes are the result of the transposition into thermal values of the earliest and lowest disorders that anticipate the clinical manifestation of the inflammation, and the capture of the infrared radiation emitted by the oral tissues covered by the base of the mobile prostheses enables capturing of the image of the first structural changes in tissues (16-18), prior to the visible clinical changes.

The basic criterion for evaluating the functional state and/or organic changes is the relative increase or decrease of the thermal emission, and also the deregulation of the local symmetry or architecture. So far, several studies regarding the maxillofacial area have certified the deregulation of the thermal field in various pathological cases. Thus, Fricova J. et al. detected pronounced thermal asymmetries between the right half and the left half of the face of the patients with acute and chronic orofacial pain syndrome, as well as correction of these gaps following specific treatments (19). Periapical regions of suspect asymptomatic but without radiographic signs (teeth with necrotic pulp, pulpless teeth and endodontically treated teeth with inadequate root filling) and contralateral healthy teeth were thermographic analysed by Wziątek-

Kuczmik D. et al., the authors detecting significant temperature asymmetries between the periapical regions of the suspect and healthy teeth at 30s of mouth opening (20). Infrared thermography was also used to capture different patterns of heat distribution between healthy and pathological temporomandibular joints (21-23), for this purpose Schiavon G. et al. summarizing the feasibility of using the symmetry/asymmetry distribution of temperatures to discriminate between normal or abnormal thermal patterns, as well as between normal or pathological joints (24).

Our study identified differences related to the distribution of the thermal field generated by the maxillary mucosa captured in various clinical cases, with the preservation of the thermal architecture (namely preservation of the symmetry and uniformity of the thermal values) for dentate subjects, maxillary edentulous subjects without prosthesis or subjects with prostheses more recent than 5 years, or changes in it (materialized by asymmetry, namely lack of uniformity of the thermal field) in the case of the chronic infectious-inflammatory process of the CADS. However, our results invalidated the working hypothesis since, although the old subjects wearing removable prostheses had a clinically maxillary mucosa and average temperatures similar to those registered for the patients without prostheses or for the patients with recent prostheses (35.31°C vs. 34.79°C, vs. 34.78 °C), in the

same group we noticed an almost double percentage of cases with asymmetric distribution and non-uniform thermal field.

In this context, the disturbances of the distribution of the thermal field, even in the absence of clinically obvious pathological phenomena, may suggest the first local disturbances, requiring certain preventive measures. In addition, the thermal behaviour of the maxillary mucosa without prosthesis similar to that of the mucosa with a recent prosthesis may signal the fact that, in the first years after their insertion in the oral cavity, there are no significant inflammatory phenomena at the level of the supporting mucosa, as well as the fact that, during the same period of time, the prostheses do not develop a significant microbial load. It can therefore be noted that, although the three cases are similar as concerns the temperatures registered, as well as the clinical picture of the uninjured maxillary mucosa, for the patients with prostheses older than 5 years, their wearing can induce the first local disorders consisting in frequently uneven and asymmetrical distribution of the thermal field generated by the maxillary oral mucosa, compared to the other subjects.

Similar to the thermal behaviour of the maxillary oral mucosa, the temperatures registered at the level of the inner areas of the prostheses in the subjects with recent prostheses (33.33°C) and old prostheses (33.92°C) were similar, on average, although there was a thermal increase of more than half a degree (0.59°C) for the inner area of the prostheses worn for periods longer than 5 years. A similar difference of 0.53 C° was found between the temperature registered for the entire maxillary mucosal support area in old prostheses (35.31°C) and in recent prostheses (34.78 C°), the observation confirming the heat transfer from the biological areas of the maxillary oral mucosa to the inert polymeric material of which most

mobile prostheses are made. Another argument supporting the fact that the acrylic material adopts the thermal behaviour results from the analysis of the distribution of the thermal field on the inner sides of the recent prostheses, compared to the old prostheses. As in the case of the maxillary oral mucosa, the uneven distribution of the thermal field in prostheses worn for periods longer than 5 years was reported in a higher percentage for patients in the group with old prostheses, compared to the group with recent dentures (66.7% vs. 50%). This difference, although not statistically supported, exists and is important, requiring confirmation by subsequent studies on larger groups.

The average temperature of the maxillary mucosa was similar for the subjects wearing removable maxillary prostheses with CADS and for the dentate subjects (36.19°C vs. 36.59°C), the decisive factor in the equalization of temperatures therefore seems to be the occurrence of the infectious-inflammatory process, not the long-term wearing of mobile prostheses. However, the similar thermal behaviour as concerns the thermal values of the maxillary oral mucosa in dentate subjects and in patients with mobile prostheses and CADS did not include the distribution of the thermal field for the same area. Thus, while the mucosa of the dentate patients showed a uniform and symmetrical distribution of the thermal field for all the cases we investigated, that of the patients with CADS frequently showed an asymmetrical and uneven thermal picture.

The asymmetrical and uneven distribution of the thermal field at the mucosal level was significantly associated with the presence of CADS, the results suggesting that the most frequent source of such thermal field disorders, which can also be encountered in clinical cases with uninjured or apparently uninjured oral mucosa, is the existence of a local infectious-inflammatory phenomena.

Thus, in denture wearers, in the absence of clinically obvious pathological phenomena, but with disorders of the local heat distribution, certain prophylactic measures are required, as well as investigations into the causes that contributed to these changes.

Also, in support of the observation that the denture adopts the distribution of the thermal field of the mucosa on which it supports (even if the thermal values registered on the acrylic inner area are lower by more than 1°C than on the corresponding mucosal areas), the correlational analysis established associations similar to the previous ones. Thus, as in the case of the maxillary oral mucosa, the prostheses showed an asymmetrical and uneven thermal pattern on their inner sides significantly associated with cases with CADS.

The limitations of our study start from the general drawbacks of infrared thermography, and they consist in the possibility of detecting only superficial pathological changes (7, 8), without providing information on the structures in depth, as well as in the high cost of the equipment. However, given the frequency of dispensary sessions required for the wearers of mobile prostheses, of CADS and its effects on the support structures, the definite usefulness of the infrared thermography in dentistry would justify equipping of university clinics with it. It is worth highlighting the prophylactic potential of the method against the strong pathogenic potential of the removable denture microbiome (25) that can be clinically exploited, considering the risk of bone resorption, following inflammation of the supporting mucosa, peri-implantitis development in implant supported-overdentures (25-28), but also the decrease in the quality of life in relation to oral health,

especially in the frail elderly (29). Other limitations of our research are related to the small number of patients taken in the study, as well as the short duration of the follow-up, the patients being examined at a given time, without the possibility of prospectively follow-up of the CADS cases or of the supporting mucosa of the wearers of old dentures, an issue that we propose for ourselves for the future.

CONCLUSIONS

The thermographic study highlighted several peculiarities of the oral mucosa, of its pathophysiology, and some effects exerted by removable dentures on the supporting tissues. Thus, wearing old prostheses in the maxilla favours the slight overheating of the supporting tissues, thermal changes occurring even in the absence of clinically and microbiologically evidenced pathological phenomena. Under the same conditions related to the removable prosthesis, our study signals the occurrence of disorders in the distribution of the thermal field, in terms of frequent asymmetries and lack of uniformity, which can be detected thermographic, both on the mucosa and on the inner areas of the mobile prostheses. These thermal signals have clinical relevance, warning the practitioner about the possibility of pathological phenomena, even long before they become obvious. Last but not least, the quality of the polymeric materials of which most of the removable dentures are made can be monitored thermographic over time until microbial imbibition phenomena, and specific and directly visible aging and degradation, occur.

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