Electronic Facial Thermography: An Analysis of Asymptomatic Adult Subjects

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Vascular heat emissions that present on the human face can provide physiologic indicators of underlying health or disease. Electronic thermography may serve as a nonionizing, noninvasive alternative for solving diagnostic problems. This study was designed to quantify normal values of vascular heat emissions of the face. Electronic thermograms were taken of 102 subjects using an Agema 870 unit, at 0.1°C accuracy, under controlled conditions. Results indicated a high degree of mean thermal symmetry about the face. Using frontal and lateral electronic thermogram projections, the mean temperatures of 25 selected right-versus-left-side anatomic zones were within 0.1°C of each other. Analysis of frontally and laterally projected electronic thermograms also produced a new mapping of thermally distinct facial zones. Of greatest importance, the right-versus-left-side thermal differences (ΔT) between many specific facial regions for individual subjects were demonstrated to be much smaller (< 0.4°C) than previously reported ΔT values of the same facial regions in a wide variety of chronic disorders. These differences in ΔT values between asymptomatic subjects and patients with various facial pain syndromes may prove to be useful thresholds for determining normal versus abnormal facial thermograms.
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During the past 40 years, extensive research on the temperature characteristics of the human body has contributed to the discipline of *thermography*, a generic term given to various methods of heat pattern identification and analysis. Clinical application of thermography is based on the ability to conveniently image natural heat emissions of the human body. The resultant thermal image indicates the amount of heat given off by blood flowing within and beneath the skin and muscles. As the amount of blood circulating within and beneath the skin layers varies, so does the skin temperature. Only the body surface and a superficial layer 6 to 10 mm in depth is surveyed and recorded using thermography.[1]

Quantitative and qualitative changes in infrared heat emission by the skin have been reported to occur in a variety of diseases.[2–20] These changes include conditions involving facial structures, such as temporomandibular joint (TMJ) disorders,[21–34] atypical facial pain (atypical odontalgia),[35,36] nerve damage and repair following oral surgery,[37–39] headache,[40–46] inflammation of the lacrimal drainage system,[47] and psychogenic facial pain.[48] Thermography has been shown to not be useful in the assessment of periapical granuloma.[49]

To date, the literature describes the normal facial thermogram in only a limited manner.[31,50,51] These reports suggest that the majority of asymptomatic adult subjects demonstrate a high level of thermal symmetry of selected points on the face.[50] However, a small but unspecified group of asymptomatic subjects reporting a history of eye surgery, impaired vision, arthritis, dry mouth, sensitivity to cosmetics, wisdom tooth extraction, or previous use of orthodontic appliances (braces) may demonstrate areas of facial thermal asymmetry in the absence of any symptomatology.[52] These results indicate that additional large-scale thermographic studies need to be conducted to further define the normal adult facial thermogram.

This study was designed to quantify normal ranges of vascular heat emission of diagnostically important anatomic zones of the face, and differences (ΔT) between these zones (from side to side), in a large asymptomatic adult population.

Materials and Methods

Population Studied

One hundred two subjects were chosen from adult volunteers aged 18 and older who did not have facial pain. The majority of subjects (89) randomly appeared at the UCLA Medical Center as individuals accompanying patients who required health care. They were asked, "Are you in pain at this time?" If they replied, "No," they were asked to participate in this study. Subjects did not receive any compensation. The study population was not restricted by any medical or dental condition (or medical or dental history of any disease or disorder). It therefore represented subjects "just off the street," without any attempt to obtain a selected group of "normal" or "supernormal" subjects. The median age of subjects was 27.0 years, ranging from 18 to 56 years, including 54 men and 48 women. Ethnic diversity included 72 whites, 23 Asians, four Hispanics, and three blacks. All 102 subjects were imaged, including subjects with mustaches, orthodontic appliances, eye glasses, contact lenses, hearing aids, facial blemishes, facial scarring, and other facial lesions.

Thermography Equipment

Thermography was performed using an Agema 870 thermovision unit (Agema, Secacus, NY) coupled to a 35-mm camera. Facial thermograms also were displayed on a color video monitor, enabling viewing and computer-aided temperature measurements of selected anatomic zones. Room conditions for conducting the thermographic examination included a draft-free environment (no windows or open doors) with temperature control (ranging from 20°C to 22°C), variable lighting, a swivel chair for patient positioning, and a small handheld electric fan (General Electric, Milwaukee, WI).

Facial Imaging

All subjects were imaged according to the recommendations of the Academy of Neuro-Muscular Thermography.[53] Facial thermograms were taken using frontal projections and right and left lateral projections (Figs 1 and 2, respectively), employing two different thermal color ranges (0.5°C and 1.0°C). Before the examination, each patient's face was cleared of hair (hair was tied back). The face was wiped with a damp cloth and then air dried for 20 to 30 seconds using the small electric fan. Fifteen minutes was allowed for facial temperature equilibration, and then one series of facial thermograms was obtained.

Thermographic Image Analysis

Objective temperature measurements (at 0.1°C accuracy) were made from thermograms of 25 specific anatomic regions, which were superimposed over the facial thermograms seen on the color video monitor. Eleven areas were analyzed on the frontal projections, including: *(1)* the entire half face; *(2)* the superior (higher) orbital region; *(3)* the superior (lower) orbital region; *(4)* the frontal region (middle of forehead); *(5)* the orbit; *(6)* the maxillary sinus; *(7)* the nasal region (or nose); *(8)* the anterior maxilla; *(9)* the upper lip; *(10)* the lower lip; and *(11)* the chin (Fig 3). Fourteen areas were analyzed on the lateral projections, including: *(1)* the whole side of the face (half face); *(2)* the superior (higher) orbital region; *(3)* the superior (lower) orbital region; *(4)* the orbit; *(5)* the anterior temporal muscle; *(6)* the nasal region (or nose); *(7)* the cheek; *(8)* the anterior maxilla; *(9)* the upper lip; *(10)* the lower lip; *(11)* the chin; *(12)* the mandible; *(13)* the superficial masseter region; and *(14)* the TMJ (Fig 4). These 25 areas of interest were selected based on anatomic features, and on previous thermographic studies indicating specific locations of chronic orofacial pain disorders.[34,54–57]

Analyses of the 25 regions were made for thermal symmetry by comparing the temperature distribution (T) within each anatomic region with the

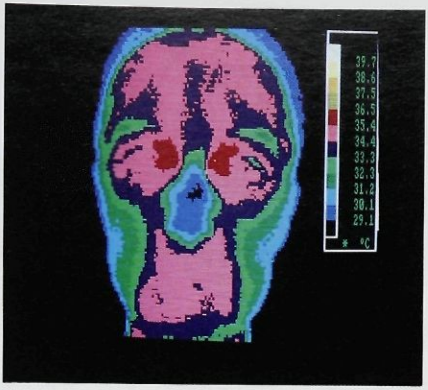

Fig 1 Example of frontally projected facial thermogram (imaged at color range of 1.0°C) taken from a 25-year-old white woman.

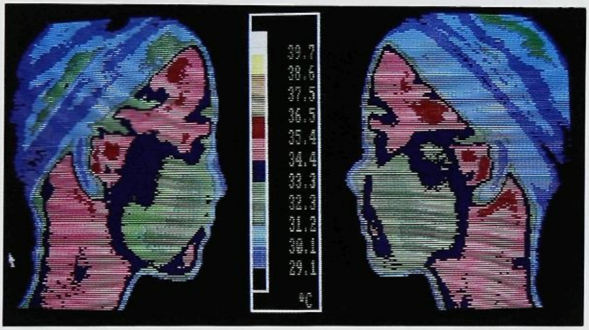

Fig 2 Facial thermogram of subject in Fig 1, demonstrating right and left lateral projection.

corresponding region of the opposite side of the face. The absolute temperature difference (ΔT) was calculated and recorded for each anatomic region of each subject.

Statistical Analysis

For each of the 25 facial regions, the mean and standard deviation (SD) were determined for the following four values: *(1)* right side zone temperature (Right T); *(2)* left side zone temperature (Left T); *(3)* the absolute change in zone temperature from side to side (ΔT); and *(4)* the average temperature (Ave T) between right and left sides. The mean Ave T was obtained by first computing an average of Right and Left T values, and then calculating a mean of the average scores.

To compare ΔT and Ave T of the 25 facial regions, analysis of variance (ANOVA) was used to test the null hypothesis of equal means. This was followed by paired comparisons between regions, using Fisher's least significant difference test.

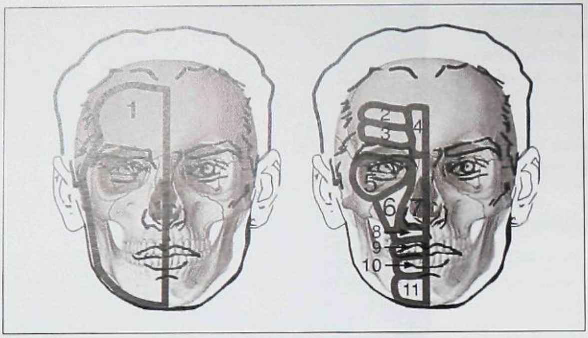

Fig 3 Diagram of 11 diagnostic zones assessed for thermal symmetry on frontal projection.

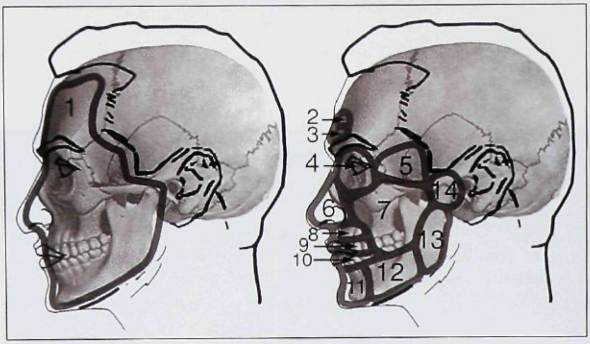

Fig 4 Diagram of 14 diagnostic zones assessed for thermal symmetry on lateral projection.

Histograms were generated for each region demonstrating the relative frequency (percentage of subjects) versus ΔT values for each region. Cumulative distribution functions of T values by each region were calculated. For Ave T scores, Pearson's correlation coefficients were calculated to investigate the degree of linear association between Right and Left T values, and therefore justify using average temperature (Ave T) scores in analysis. A highly significant correlation was found for all regions.

An additional ANOVA was performed separately, to test for a statistically significant difference in means among groups by gender, ethnicity, and age. The ethnicity variable was dichotomized into whites ($n = 72$) versus others ($n = 30$). Age was stratified about the median age of the 102 subjects (18 to 24 years versus 25 to 56 years). The *P* values were determined from ANOVA tables ($P < .05$). All tests were two tailed.

Results

Tables 1 and 2 present the means and SD of temperatures in frontal and lateral projections for each of the 25 facial areas studied. Fisher's least significant difference test of paired comparisons are also given to identify statistically significant mean temperature differences between facial regions. On the frontal projection (Table 1), statistically significant differences were found, dividing the 10 areas into five temperature groups (A, AB, B, C, and D). On the lateral projections (Table 2), statistically significant differences were also found, dividing the 14 areas into seven temperature groups (A, B, BC, C, CD, D, and E). Each of these thermal areas was color coded, and the resulting facial thermal maps are shown in Figs 5 and 6, respectively.

The results of temperature measurements taken using frontal and lateral projections are shown in Tables 3 and 4, respectively. Frontally projected

Fig 5 Five significantly different temperature regions (color coded) found on frontally projected facial thermograms.

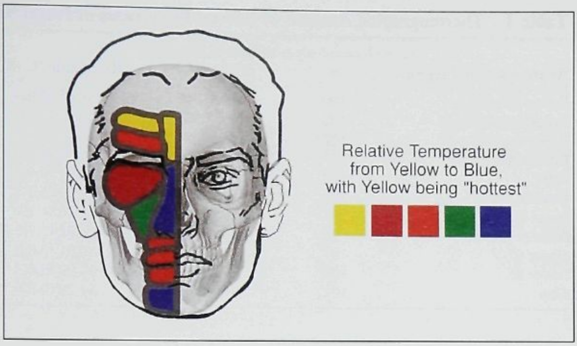

Fig 6 Seven significantly different temperature regions (color coded) found on laterally projected facial thermograms.

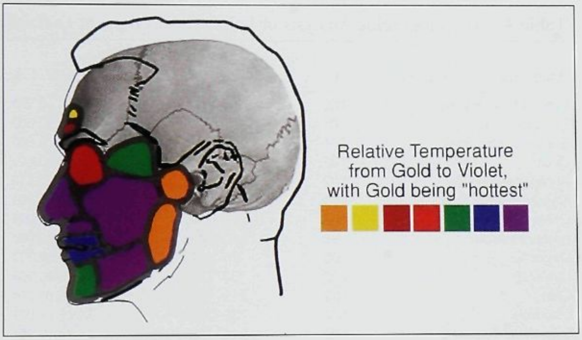

Table 1 Results of Frontal Projections of Facial Regions

Anatomic facial regions	n	Mean Ave T* °C (SD)	Statistical ranking†	Color code‡
Frontal (forehead)	101	35.3 (0.6)	A	1
Superior orbit (high)	100	35.2 (0.6)	A	1
Orbit	102	35.1 (0.5)	AB	2
Superior orbit (low)	100	35.0 (0.6)	B	3
Upper lip	97	35.0 (0.6)	B	3
Lower lip	102	35.0 (0.6)	B	3
Anterior maxilla	97	34.9 (0.7)	B	3
Entire half of face	102	34.7 (0.6)	C	4
Maxillary sinus	102	34.6 (0.8)	C	4
Chin	102	34.3 (0.8)	D	5
Nasal (nose)	101	34.3 (1.2)	D	5

*Mean Ave T = mean average temperature obtained by first computing an average of the right and left temperatures, and then calculating a mean of the averages.
†From Fisher's least significant difference paired comparisons on Ave T. Means with the same letter are not significantly different. AB is not significantly different from A or B.
‡Coding for Fig 3.

Table 2 Results of Lateral Projections of Facial Regions

Anatomic facial regions	n	Mean Ave T* °C (SD)	Statistical ranking†	Color code‡
TMJ	101	35.5 (0.5)	A	1
Anterior temporalis	102	35.4 (0.5)	A	1
Superior orbit (high)	101	35.1 (0.6)	B	2
Superior orbit (low)	101	34.9 (0.6)	BC	3
Orbit	102	34.8 (0.5)	C	4
Superficial masseter	102	34.7 (0.7)	CD	5
Chin	102	34.7 (0.8)	CD	5
Lower lip	102	34.7 (0.7)	CD	5
Upper lip	98	34.6 (0.8)	D	6
Side of face (half face)	102	34.6 (0.7)	D	6
Nasal (nose)	100	34.3 (1.0)	E	7
Anterior maxilla	98	34.2 (0.9)	E	7
Mandible	102	34.2 (1.0)	E	7
Cheek	102	34.1 (1.0)	E	7

*Mean Ave T = mean average temperature obtained by first computing an average of the right and left temperatures, and then calculating a mean of the averages.
†From Fisher's least significant difference paired comparisons on Ave T. Means with the same letter are not significantly different. BC is not significantly different from B or C, and CD is not significantly different from C or D.
‡Coding for Fig 4.

Table 3 Thermographic Analysis of Frontal Projections of Facial Regions

Anatomic facial region	n	Size of zone pixels (SD)	Right side °C (SD)	Left side °C (SD)	ΔT °C (SD)
Entire half of face	102	3,668 (574)	34.66 (0.62)	34.66 (0.60)	0.10 (0.08)
Superior orbit (high)	100	181 (54)	35.22 (0.63)	35.25 (0.64)	0.16 (0.14)
Superior orbit (low)	100	194 (54)	35.02 (0.59)	35.04 (0.59)	0.16 (0.17)
Frontal (forehead)	101	280 (74)	35.25 (0.62)	35.25 (0.62)	0.13 (0.12)
Orbit	102	513 (113)	35.07 (0.49)	35.11 (0.49)	0.18 (0.13)
Maxillary sinus	102	185 (55)	34.60 (0.81)	34.65 (0.86)	0.22 (0.18)
Nasal (nose)	101	321 (83)	34.26 (1.17)	34.28 (1.14)	0.22 (0.21)
Anterior maxilla	97	189 (41)	34.92 (0.70)	34.94 (0.68)	0.22 (0.19)
Upper lip	97	157 (44)	35.01 (0.63)	35.03 (0.62)	0.23 (0.17)
Lower lip	102	152 (40)	34.99 (0.62)	35.02 (0.60)	0.20 (0.17)
Chin	102	229 (61)	34.29 (0.83)	34.32 (0.79)	0.17 (0.15)

Table 4 Thermographic Analysis of Lateral Projections of Facial Regions

Anatomic facial region	n	Size of zone pixels (SD)	Right side °C (SD)	Left side °C (SD)	ΔT °C (SD)
Side of face (half-face)	102	4,698 (997)	34.57 (0.70)	34.54 (0.72)	0.13 (0.12)
Superior orbit (high)	101	79 (24)	35.03 (0.60)	35.13 (0.59)	0.20 (0.15)
Superior orbit (low)	101	103 (28)	34.87 (0.66)	34.93 (0.66)	0.23 (0.17)
Orbit	102	311 (97)	34.79 (0.52)	34.83 (0.52)	0.24 (0.20)
Anterior temporalis	102	168 (74)	35.45 (0.51)	35.37 (0.56)	0.23 (0.20)
Nasal (nose)	100	253 (67)	34.26 (1.10)	34.25 (1.05)	0.36 (0.35)
Cheek	102	1,565 (441)	34.05 (1.02)	34.10 (1.02)	0.21 (0.18)
Anterior maxilla	98	150 (47)	34.25 (0.96)	34.24 (0.99)	0.41 (0.38)
Upper lip	98	73 (29)	34.54 (0.77)	34.57 (0.81)	0.39 (0.28)
Lower lip	102	82 (25)	34.71 (0.73)	34.69 (0.74)	0.36 (0.31)
Chin	102	213 (59)	34.75 (0.79)	34.68 (0.77)	0.25 (0.22)
Mandible	102	738 (210)	34.16 (1.02)	34.18 (1.01)	0.21 (0.18)
Superficial masseter	102	341 (88)	34.74 (0.72)	34.68 (0.78)	0.20 (0.17)
TMJ	101	116 (48)	35.54 (0.52)	35.52 (0.51)	0.17 (0.13)

thermograms demonstrated a high level of thermal symmetry, with all 11 anatomic regions showing mean temperatures within 0.1°C of the opposite side. Similarly, laterally projected thermograms were also found to have a high level of thermal symmetry, with all 14 anatomic regions having mean temperatures within 0.1°C of the opposite side. These results were confirmed when the relation between Right and Left Ave T values was assessed using Pearson's correlation coefficients ($P < .0001$).

The measured area of each specific facial region varied from patient to patient and from region to region (Tables 3 and 4). The half-face region was the largest area measured, encompassing 4,698 pixels on lateral projection and 3,668 pixels on frontal projection. Each half-face region had a standard deviation in size of approximately 20%. Similarly, variations were noted in the size of each of the 23 other facial areas measured, from the cheek region (1,565 pixels) to the TMJ region (116 pixels). Again, standard deviations in size were approximately 20%.

Mean ΔT values ranged from 0.10°C to 0.41°C. For frontally projected thermograms, values ranged from a low of 0.10°C (the half-face region) to a high of 0.23°C (the upper lip region). On the laterally projected thermograms, 10 of the 14 regions demonstrated mean ΔT values equal to or below 0.25°C. These regions were the half-face region, the superior orbital (high), the superior orbital (low), the orbit, the chin, the cheek, the mandible, the anterior temporal muscle, the TMJ, and the superficial masseter regions. The other four regions had ΔT values above 0.26°C, involving the nasal, the anterior maxilla, and the upper and lower lip regions.

Table 5 Analysis of ΔT Values for Frontal Projections

Anatomic facial region	n	ΔT values °C (cumulative percent of total) 0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0+
Entire half-face	102	28 (28)	48 (75)	21 (95)	5 (100)							
Superior orbit (high)	100	21 (21)	31 (52)	30 (82)	10 (92)	3 (95)	3 (98)	2 (100)				
Superior orbit (low)	100	25 (25)	30 (55)	27 (82)	8 (90)	7 (97)	1 (98)	0 (98)	0 (98)	0 (98)	1 (99)	1 (100)
Frontal (forehead)	101	27 (27)	37 (63)	23 (86)	9 (95)	3 (98)	2 (100)					
Orbit	102	17 (17)	32 (48)	24 (72)	22 (93)	3 (96)	3 (99)	1 (100)				
Maxillary sinus	102	16 (16)	26 (41)	28 (69)	11 (79)	10 (89)	4 (93)	2 (95)	4 (99)	1 (100)		
Nasal (nose)	101	17 (17)	30 (47)	18 (64)	18 (82)	6 (88)	5 (93)	2 (95)	1 (96)	2 (98)	1 (99)	1 (100)
Anterior maxilla	97	20 (20)	18 (39)	22 (62)	16 (78)	12 (91)	3 (94)	2 (96)	1 (97)	2 (99)	1 (100)	
Upper lip	97	5 (5)	33 (39)	20 (60)	24 (85)	6 (91)	4 (95)	1 (96)	2 (98)	1 (99)	0 (99)	1 (100)
Lower lip	102	13 (13)	37 (49)	24 (73)	10 (82)	7 (89)	4 (93)	6 (99)	1 (100)			
Chin	102	23 (23)	29 (51)	28 (78)	12 (90)	6 (96)	2 (98)	0 (98)	2 (100)			

Table 6 Analysis of ΔT Values for Lateral Projections

Anatomic facial region	n	ΔT values °C (cumulative percent of total) 0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0+
Side of face (half-face)	102	24 (24)	45 (68)	22 (89)	7 (96)	2 (98)	0 (98)	1 (99)	1 (100)			
Superior orbit (high)	101	16 (16)	24 (40)	29 (68)	14 (82)	13 (95)	3 (98)	1 (99)	0 (99)	1 (100)		
Superior orbit (low)	101	14 (14)	24 (38)	20 (57)	18 (75)	16 (91)	5 (96)	2 (98)	1 (99)	1 (100)		
Orbit	102	11 (11)	35 (45)	18 (63)	11 (74)	14 (87)	6 (93)	3 (96)	2 (98)	0 (98)	1 (99)	1 (100)
Anterior temporalis	102	15 (15)	30 (44)	18 (62)	19 (80)	6 (86)	7 (93)	5 (98)	1 (99)	0 (99)	0 (99)	1 (100)
Nasal (nose)	98	11 (11)	22 (33)	12 (45)	13 (58)	12 (70)	10 (80)	5 (85)	5 (90)	3 (93)	1 (94)	6 (100)
Cheek	102	13 (13)	36 (48)	22 (70)	13 (82)	11 (93)	1 (94)	1 (95)	2 (97)	3 (100)		
Anterior maxilla	98	4 (4)	18 (22)	18 (41)	16 (57)	6 (63)	12 (76)	7 (83)	6 (89)	4 (93)	0 (93)	7 (100)
Upper lip	98	8 (8)	11 (19)	15 (35)	18 (53)	12 (65)	11 (77)	6 (83)	6 (89)	3 (92)	2 (94)	6 (100)
Lower lip	102	10 (10)	15 (25)	19 (43)	18 (61)	13 (74)	9 (82)	2 (84)	3 (87)	4 (91)	3 (94)	6 (100)
Chin	102	13 (13)	32 (44)	20 (64)	11 (75)	8 (82)	7 (89)	7 (96)	0 (96)	2 (98)	1 (99)	1 (100)
Mandible	102	12 (12)	37 (48)	21 (69)	13 (81)	7 (88)	8 (96)	1 (97)	2 (99)	0 (99)	1 (100)	
Superficial masseter	102	15 (15)	33 (47)	25 (72)	17 (88)	5 (93)	3 (96)	1 (97)	1 (98)	1 (99)	0 (99)	1 (100)
TMJ	101	20 (20)	29 (49)	30 (78)	14 (92)	4 (96)	5 (99)	0 (99)	1 (100)			

Analyses of the distribution of ΔT computations by subject for frontal and lateral projections are shown in Tables 5 and 6, respectively. Using an 80% level of inclusion, five of the 25 facial regions had ΔT values within 0.0°C to 0.2°C: the frontal projections included were the entire half-face region (95%), the superior orbit (high) region (82%), the superior orbit (low) region (82%), and the mid-forehead region (86%); the lateral projections included the entire side-of-face (half-face) region (89%).

At an 80% level of inclusion, 16 of 25 regions had ΔT values within 0.0°C to 0.3°C. At an 80% level of inclusion, 21 of 25 regions had ΔT values of 0.0°C to 0.4°C. The four regions having ΔT values greater than 0.4° all involved lateral-projection thermograms (nasal, anterior maxilla, and upper- and lower-lip regions).

There was a statistically significant difference in ΔT values on both frontal ($P = .044$) and lateral projections ($P < .005$) of men and women. Men had higher Ave T values ($P < .001$) in all 25 regions. Analysis by ethnicity also showed a statistically significant difference between groups. The P value was highly significant for lateral projections ($P = .010$), and almost significantly different for Ave T values ($P = .053$). Whites consistently demonstrated higher Ave T values at all 25 regions ($P < .001$) when compared to the combined group of other races. However, analysis by age showed no statistically significant difference between the two stratified groups (18 to 26 years versus 27 to 56 years). For laterally projected thermograms, the Ave T $P = .703$; and for ΔT, $P = .765$).

Discussion

The high degree of facial thermal symmetry (low range of ΔT calculations for individual patients) is of considerable clinical significance in establishing the range of normal thermographic variation encountered in asymptomatic subjects, especially since substantially higher ΔT values are reported to occur in a number of facial disorders. All 11 anatomic regions measured on frontally projected thermograms appear to be diagnostically useful (ΔT values in asymptomatic subjects below 0.4°C, using an 80% inclusion rate). Using laterally projected thermograms, 10 of the 14 selected regions were found to have similarly low ΔT measurements. It therefore appears that specific regional ΔT facial thermography values (areas including the forehead, the cheeks, the jaws, the TMJ, etc) can be used in the diagnostic assessment of several chronic facial pain conditions, which often are confused with chronic toothache.[57]

According to Weinstein,[53] differences in the temperature of skin surface (ΔT) of 0.5°C or greater are indicative of a clinically significant disorder. This standard was based on empiric observation by experienced thermographers and their cumulative experience involving thermograms predominately involving the trunk and limbs. However, their large study (involving 102 asymptomatic adult subjects) employed selected spot temperature measurements on the face.[53] Our results suggest that even more rigid criteria of 0.4°C-regional ΔT values may be of use in determining normal versus abnormal facial conditions.

In a wide variety of abnormal facial conditions, the mean regional ΔT values far exceed 0.4°C. For example, among the neuropathic facial pain disorders, patients with sympathetically maintained pain in the facial region have mean regional ΔT values of +1.0°C; patients with traumatic neuralgia ("hot" thermograms) have mean regional ΔT values of +0.9°C; and patients with traumatic neuralgia ("cold" thermograms) have a mean regional ΔT values of −0.7°C.[54,57]

In the assessment of asymptomatic subjects for inferior alveolar nerve deficit, normal chin zone ΔT values were found to be 90% inclusive at 0.4°C and 82% inclusive at 0.3°C, whereas inferior alveolar nerve deficit is reported to have ΔT values of +0.5°C.[56] These findings suggest that ΔT measurements of the chin on frontal projections may be useful in the assessment of inferior alveolar nerve deficit.

Similar results are observed in evaluating TMJ disorders. The ΔT values in asymptomatic subjects have been reported to be 0.1°C to 0.2°C.[31,34] The results of this study confirm this degree of thermal symmetry in the TMJ region, because 92% of asymptomatic subjects had ΔT values of less than 0.3°C on laterally projected thermograms. Previous thermographic studies of osteoarthrosis and internal derangement of the TMJ have indicated mean TMJ-region ΔT values of +0.4 to +0.5°C.[32,33]

In the assessment of facial pain disorders seen by dentists, maxillary sinus diseases may sometimes be confused with toothache pain. The results of this study demonstrate that for frontally projected thermograms, 89% of asymptomatic subjects have ΔT values of the maxillary sinus region less than 0.4°C. This is clinically relevant because in previously published reports on electronic thermography of maxillary sinus disease, the corresponding ΔT values were +1.0°C.[54]

Finally, in patients with carotid occlusive disease, ΔT values ranged from −0.5°C to −0.8°C on the forehead region of the face (the superior orbital regions, high and low),[55] whereas in this study the use of frontally projected thermograms of asymptomatic subjects at a 0.4°C ΔT value resulted in inclusion rates of 95% for the superior (high) orbital region and 91% for the superior (low) orbital region. This suggests that facial electronic thermography may have clinical utility in the assessment of carotid occlusive disease.

The results of this study also demonstrated five to seven statistically different temperature zones about the face. These new, more standardized zones (see Figs 5 and 6) may prove useful in the conduct of future ET studies. For example, documentation of the normal range of differences in temperature between zones may prove useful in the identification of bilateral conditions, for which asymmetry would not be expected (eg, bilateral maxillary sinus disease, bilateral TMJ disorders, and bilateral carotid occlusion).

The results of this study indicated a statistically significant difference between the absolute facial temperature of men versus that of women. Men had higher facial temperatures over all 25 zones measured. Blaxter[58] reported that the basal metabolic rate for an asymptomatic 30-year-old man (1.7 m tall [5 ft 7 inches], weighing 64 kg [141 lbs]), who has a surface area of approximately 1.6 m^2, is approximately 80 W; therefore, he dissipates about 50 W/m^2 of heat.[58] On the other hand, the basal metabolic rate of a 30-year-old woman (1.6 m tall [5 ft 3 inches], weighing 54 kg [119 lbs]), who has a surface area of 1.5 m^2, is about 63 W, so that she dissipates about 41 W/m^2.[58,59] Assuming that there are no other relevant differences between men and women, women's skin should be cooler since there is less heat lost per unit of body surface area. The results of this study are among the first to objectively demonstrate this theoretical principle.[60]

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Resumen

Termografía Facial Electrónica: Análisis de Adultos Asintomáticos

Las emisiones de calor vascular que se presentan en la cara humana pueden proveer indicadores fisiológicos de la salud o enfermedad subyacente. La termografía electrónica puede servir como una alternativa no invasiva, no ionizante para resolver problemas de diagnóstico. Este estudio fue diseñado para cuantificar los valores normales de las emisiones de calor vascular de la cara. Se tomaron termogramas electrónicos de 102 personas, por medio del uso de una unidad Agema 870, con una exactitud de 0,1°C, bajo condiciones controladas. Los resultados revelaron un alto grado de simetría térmica media alrededor de la cara. Al utilizar proyecciones de termogramas electrónicos laterales y frontales, las temperaturas medias de 25 zonas anatómicas seleccionadas del lado derecho versus el lado izquierdo, estaban a 0,1°C entre sí. El análisis de los termogramas electrónicos proyectados lateralmente y frontalmente también produjo una nueva planimetría de zonas faciales térmicamente precisas. De gran importancia fue el hecho de demostrar que las diferencias térmicas (ΔT) del lado derecho versus el lado izquierdo, entre muchas regiones faciales específicas en ciertas individuos, eran mucho menores (< 0,4°C) que los valores ΔT de las mismas regiones faciales que se habían reportado previamente, en una amplia variedad de desórdenes crónicos. Estas diferencias en los valores ΔT entre las personas asintomáticas y los pacientes con varios síndromes de dolor facial podrían ser umbrales útiles para determinar los termogramas normales versus los anormales.

Zusammenfassung

Elektronische Thermographie des Gesichts: Eine Analyse an symptomfreien Erwachsenen

Die Abstrahlung vaskulärer Wärme vom menschlichen Gesicht kann als physiologischer Indikator zugrundeliegender Gesundheit oder Erkrankung dienen. Die elektronische Thermographie wird als nichtionisierende, nichtinvasive Alternative zur Lösung diagnostischer Probleme verwendet. Diese Studie soll die Normalwerte der vaskulären Wärmeabstrahlung des Gesichts quantifizieren. Von 102 Probanden wurden mit dem Agema-870-Gerät elektronische Thermogramme genommen; mit 0.1° Genauigkeit und unter kontrollierten Bedingungen. Die Resultate zeigten einen hohen Grad von Symmetrie der mittleren Temperatur über das Gesicht. Auf frontalen und lateralen Projektionen der elektronischen Thermogramme entsprachen sich 25 ausgewählte rechts-links-Vergleichszonen im Bereich von 0.1°. Die Analyse frontal und lateral projizierter elektronischer Thermogramme ergab eine neue Darstellung thermisch definierter Gesichtsregionen. Die rechts-links-Temperaturunterschiede (ΔT) spezifischer Gesichtsregionen von Individuen waren viel geringer (< 0.4°C) als die früher publizierten ΔT-Werte für die selben Gesichtsregionen bei einer grossen Vielzahl von chronischen Leiden. Die Unterschiede der ΔT-Werte asymptomatischer Probanden und Patienten mit verschiedenen Gesichtsschmerzsyndromen könnten nützliche Schwellenwerte darstellen zur Unterscheidung normaler und nicht-normaler Gesichtsthermogramme.