Thermographic Characterization of Internal Derangement of the Temporomandibular Joint

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This study assessed the ability of electronic thermography to identify internal derangement of the temporomandibular joint. The study population consisted of 30 patients with internal derangement verified by temporomandibular joint arthrotomography. Electronic thermography was conducted using an Agema 870 thermographic unit. Thermal assessments included: (1) pattern recognition; (2) pattern symmetry; (3) absolute temperature measurements; (4) ΔT measurements; and (5) mean temperature measurements and differences within five designated anatomic zones. Results indicated: (1) low levels of thermal symmetry in patients with internal derangement of the temporomandibular joint, and (2) absolute temperature measurements and mean temperature zone measurements showing large ΔT values (0.4°C to 0.8°C). Demonstration of characteristic thermal temporomandibular joint changes suggests that electronic thermography may have potential for assessing internal derangement of the temporomandibular joint. However, more extensive studies are needed before thermographic procedures can be accepted clinically.

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Internal derangement of the temporomandibular joint (TMJ) is an abnormal relationship of the articular disc to the glenoid fossa, mandibular condyle, and articular eminence and may include a deformation, perforation, or displacement of the disc and/or posterior attachment of the disc.[1] The current diagnostic imaging methods for the assessment of patients with internal derangement of the TMJ include arthrotomography, arthroscopy, and magnetic resonance (MR) imaging. These diagnostic techniques either require ionizing radiation, are invasive, or are expensive. An alternative diagnostic imaging method, electronic thermography (ET), is inexpensive, nonionizing, and noninvasive. If ET can reliably detect internal derangement in patients having TMJ symptoms, it would be a useful advance in craniomandibular diagnostic imaging.

Electronic thermography systems have been shown to record symmetric thermal patterns in normal human subjects and asymmetric thermal patterns in patients with a variety of disorders.[2] Today, vascular heat emissions from the human face may be imaged using noncontact, infrared ET systems. Physical disorders that are related to the TMJ and have been reported to produce abnormal facial thermograms include (but are not limited to) myofascial pain syndromes,[3,4] myositis,[5] TMJ disorders,[6–16] motor and sensory radiculopathy,[17] and the inflammation of arthritis[18] and bursitis.[19]

The present authors have recently described common thermal patterns and characteristics of the normal TMJ, including varia-

tions from this pattern.[15,20] Thermography patterns of the TMJ were found to demonstrate a high level of symmetry in comparisons between the right and left sides of normal subjects. The difference in temperature between similar (right vs left) structures of the body is termed ΔT. The ΔT value for the TMJ was found to be small (< 0.2°C), which suggests that the range of normalcy is sufficiently narrow to permit thermal differentiation of some TMJ-related diseases. In normal subjects, TMJ thermal patterns demonstrate a high level of thermal symmetry, both in the region of the TMJ and within the surrounding regions of the face.[15] Therefore, ET appears to have some promise as a diagnostic test of the normal TMJ. Additional and more extensive studies are needed before thermographic diagnosis of the TMJ can be accepted clinically.

The literature has not adequately defined the abnormal TMJ as imaged on facial thermograms and has not described historical or clinical findings that may alter TMJ thermal patterns emitted from the face in patients having an internal derangement. This study is designed to characterize the thermal patterns found on the face of patients having internal derangement of the TMJ. This manuscript is written as the third paper in a series of four manuscripts assessing the use of ET in the assessment of TMJ disorders.

Materials and Methods

Population Studied

The study population consisted of 30 consenting adult volunteer TMJ patients (mean age 36.9 years, female to male ratio of 4:1). All patients were suspected of having internal derangement of the TMJ based upon history and clinical evaluation. All patients had chronic symptoms of pain and dysfunction for more than 3 months. All patients underwent TMJ arthrotomographic examination conducted by an experienced radiologist-arthrographer. The study population of 30 patients was divided into three groups, based upon the result of the written arthrotomography report. Group 1 consisted of patients with unilateral, verified internal derangement of the TMJ. In this group, the contralateral TMJ was not deranged. Group 2 also represented patients with verified internal derangement of the TMJ, however the contralateral TMJ was not examined by arthrotomography. Group 3 consisted of patients with verified bilateral internal derangement of the TMJ.

Thermography Equipment

Facial thermography was conducted using an Agema 870 thermovision unit including an infrared scanner, control unit, thermal image computer TIC-8000 and Meds 1.0 software cables, stands, supports, and color monitor (Agema Infrared Systems, Secaucus, NJ) coupled to a 35-mm camera using color print film. Room conditions for thermographic examinations included a draft-free environment (no windows, closed doors), temperature control (ranging from 21°C to 23°C), variable lighting, a patient-positioning chair, and a small hand-held electric fan.

Facial Imaging

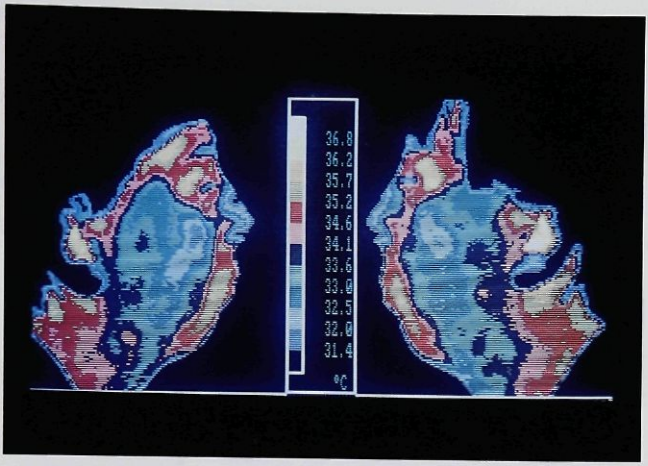
Facial thermograms were taken using right and left lateral projections at two imaging sensitivities (0.5°C and 1.0°C). Before the examination, each patient's face was cleared of hair (tied back), and the face was wiped with a damp cloth and then air dried using a small electric fan. The patient was seated, a 15-minute period was allowed for facial temperature equilibration (the 15-minute period was clinically tested for thermal stability), and then the full series of facial thermograms was made. Images were stored on computer disc and also photographed for evaluation.

Methods of Image Characterization

Subjective thermal image assessments were made including: *(1)* thermal pattern characterization of individual TMJ images, and *(2)* thermal pattern assessments comparing paired TMJ images. Objective thermal assessments also were made including: *(1)* absolute (spot) temperature measurements, *(2)* differences in absolute (spot) temperature measurements of paired TMJ images (calculation of ΔT, defined as the temperature difference [°C] between contralateral body parts, eg, the temperature measured over the right side TMJ area minus the temperature measured over the left side TMJ), *(3)* mean temperature measurements of five designated anatomic zones related to the TMJ, and *(4)* differences in the mean temperatures of the same five anatomic zones (obtaining additional ΔT measurements).

Thermal Pattern Characterization

Color photographs (9 × 12.5 cm) of paired TMJ thermal images (Figs 1 and 2) were evaluated independently by two examiners. The specific question



Figs 1a and 1b Color lateral facial thermograms of 45-year-old female patient with internal derangement of the left TMJ. TMJ images of the left side of the patient's face (in both thermograms) are examples of the most "common" thermal pattern seen when imaging an internal derangement of the TMJ.

Fig 1a Imaged using 0.5°C color sensitivity.

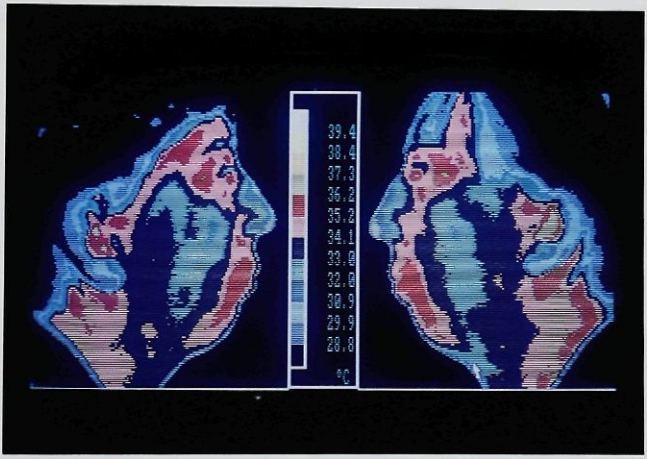


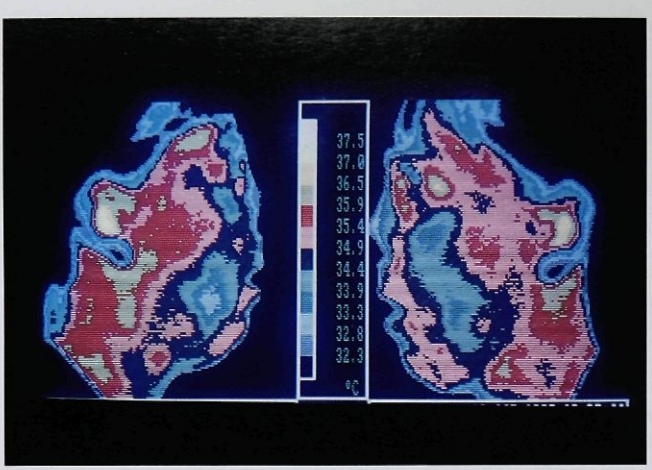
Fig 1b Imaged using 1.0°C color sensitivity.

asked of each examiner was, "How would you best characterize the thermal pattern of the TMJ?" Image characterizations were made using lateral projection images, taken at 0.5°C and 1.0°C imaging sensitivity (Table 1). An estimation (by percentage) was made of the occurrence of the most common pattern.

Assessment of Thermal Image Symmetry

The same color prints used in the subjective thermal pattern characterization were used for assessment of thermal symmetry, by comparing the temperature distribution (color patterns) over the anatomic region of the TMJ with the corresponding region of the opposite side of the face. Scoring ranged from 0 to 6 using the following scale:

0 = cannot be evaluated (poor image, poor geometry, etc)
1 = >80% symmetry of region
2 = 65% to 80% symmetry
3 = 50% to 64% symmetry
4 = 35% to 49% symmetry



Figs 2a and 2b Color lateral facial thermograms of bilateral internal derangements of the TMJ imaged using 0.5°C color sensitivity. Both images are examples of "uncommon" thermal patterns seen when imaging TMJ internal derangements.

Fig 2a

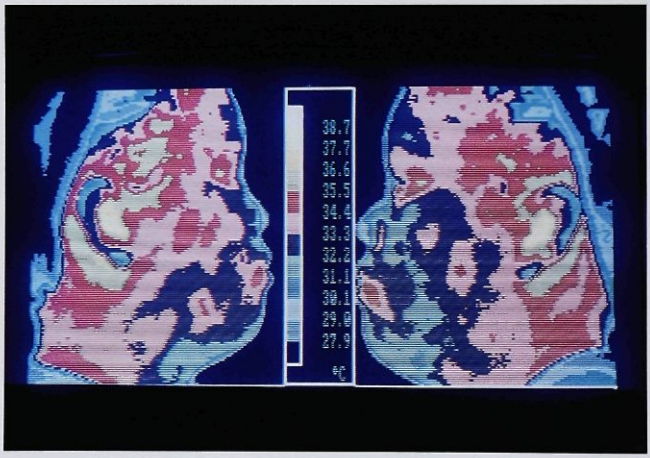


Fig 2b

5 = 20% to 34% symmetry
6 = <20% symmetry

This scale was selected because its discriminant points were easy to estimate on a repeatable and routine basis. Matching assessments were made using lateral projections at 0.5°C and 1.0°C imaging sensitivity.

Absolute (Spot) Temperature Measurements

All 60 TMJ images were measured for absolute temperature with a measurement error of ± 0.1°C (according to manufacturer's specifications), as verified using a noncontact, infrared hand-held thermometer (with manufacture's accuracy of ± 0.1°C, Horida IT-330, Miyanohigashi, Japan). Measurements were made of the following regions: *(1)* the hot central TMJ spot (hot yellow inner core), *(2)* the variable region around the hot yellow core, and *(3)* the surrounding field (in normal subjects this is a pink area around the hot yellow zone or zones) (Fig 3). In addition, an absolute (spot) temperature measurement was made of

Table 1 Subjective Thermal Pattern Classifications of 30 Subjects With Internal Derangement of the TMJ

Imaging sensitivity	Side	n	Color thermal patterns: Common (%)	Other (%)
Group 1: unilateral internal derangement (with opposing side normal)				
0.5°C	Affected	4	0 (0%)	4 (100%)
	Normal	4	0 (0%)	4 (100%)
	Total	8	0 (0%)	8 (100%)
1.0°C	Affected	4	0 (0%)	4 (100%)
	Normal	4	0 (0%)	4 (100%)
	Total	8	0 (0%)	8 (100%)
Group 2: unilateral internal derangement with opposing side unknown				
0.5°C	Affected	11	6 (55%)	5 (45%)
	Opposing	11	3 (27%)	8 (73%)
	Total	22	9 (41%)	13 (59%)
1.0°C	Affected	11	6 (55%)	5 (45%)
	Opposing	11	6 (55%)	5 (45%)
	Total	22	12 (55%)	10 (45%)
Group 3: bilateral internal derangement				
0.5°C	Right	15	10 (67%)	5 (33%)
	Left	15	11 (73%)	4 (27%)
	Total	30	21 (70%)	9 (30%)
1.0°C	Right	15	7 (47%)	8 (53%)
	Left	15	8 (53%)	7 (47%)
	Total	30	15 (50%)	15 (50%)
Total of 3 Groups				
0.5°C		60	30 (50%)	30 (50%)
1.0°C		60	27 (45%)	33 (55%)

the hot yellow area over the external auditory meatus (EAM, or ear canal).

Differences in Absolute (Spot) Temperature Measurements

The right- and left-sided absolute (spot) temperature measurements were compared for each subject. Calculation of differences produced four ΔT values for each set of paired TMJ thermal images.

Mean Temperature Measurements Over the TMJ and Related Anatomic Zones

Five anatomic zones related to the TMJ were measured for mean temperature (Fig 4). Zone 1 included the area directly over the TMJ; zone 2 included a large area over and anterior to the TMJ; zone 3 was limited to the region over the body of the mandible; zone 4 included the whole mid-region of the face, including the TMJ region; and zone 5 covered the entire one-half face, including the TMJ. Mean temperature measurements were made using all 60 TMJ images.

Differences in Mean Temperature Measurements Over the TMJ and Related Anatomic Zones

Differences in the mean temperatures measured for the five anatomic zones were calculated, which produced ΔT values for each set of paired images.

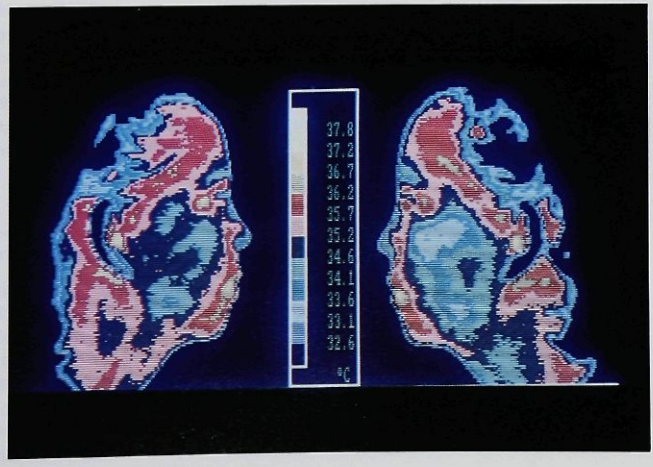


Fig 3 Lateral TMJ thermogram demonstrating the four regions (measured at 0.1°C accuracy and imaged at 0.5°C color sensitivity: region 1 = central TMJ region, region 2 = red ring around region 1, region 3 = pink field between regions 2 and 4, and region 4 = central EAM).

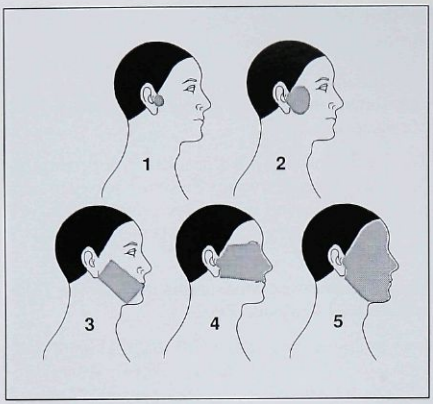


Fig 4 Chart indicating the five designated anatomic zones of the face that are related to the TMJ as measured in this study.

Statistical Methods

Standard computations and common statistical methods were employed in this study. Temporomandibular joint thermal pattern classification assessments were made by calculating the percentage of observations. Thermal pattern symmetry assessments were tabulated by observation. Absolute temperature measurements were recorded and averaged, and standard deviations were calculated. In addition, regional, zone, and ΔT temperature values were calculated by averaging and by obtaining the difference in temperature between contralateral sides and averaging (on an individual basis).

Results

Thermal Pattern Characterization

Results of the subjective characterizations of color TMJ thermal patterns are shown in Table 1. Observer reliability was calculated to 85%. Half of the subjects (30/60) demonstrated a common pattern, and the other half demonstrated a range of other patterns. At 0.5°C imaging sensitivity, the most common thermal color pattern over the TMJ consisted of a large yellow (relatively hot) region continuous from the TMJ to the EAM. This yellow region was found to be variable in size and shape but was always at least twice (and on occasion 5 times) the size of the expected yellow (relatively hot) zone seen on normal thermal images of the TMJ.[15] Figure 1a demonstrates the most common thermal color pattern seen on internally deranged TMJ patients imaged at 0.5°C sensitivity.

Results from the subjective 1.0°C imaging characterization of the color TMJ thermal patterns also resulted in a variety of patterns being identified. At 1.0°C imaging sensitivity, the standard color pattern (27/60 or 45% of the subjects) consisted of a large yellow (relatively hot) region over the TMJ, within a red field covering the EAM (Fig 1b). This yellow region was found to be variable in size and shape but was always larger than the size of the expected yellow zone seen on normal thermal images of the TMJ.[15]

Figure 2 demonstrates examples of other (less common) thermal patterns found when imaging internally deranged TMJ patients at 0.5°C sensitivity.

Assessment of Thermal Image Symmetry

Results of the subjective thermal image symmetry assessment are shown in Table 2. Observer reliability was calculated to 83%. Facial thermographic images taken at 1.0°C demonstrated a slightly higher level of thermal symmetry than those taken at 0.5°C (50% vs 37% symmetry, respectively, when judged at a >64% level). In general, high levels of thermal image symmetry (>80% symmetry) were found to occur in less than 10% of the cases assessed. Poor levels of thermal symmetry (35% to 64% symmetry) were found to occur in slightly more than half the cases. Finally, very low levels of thermal symmetry (<35% symmetry) were found to occur in almost 10% of the cases. Overall, patients with internal TMJ derangement demonstrated poor thermal symmetry using both 0.5°C and 1.0°C imaging sensitivity (Figs 1a and 2).

Absolute Temperature Measurements

Results of the objective measurements of absolute temperature are shown in Table 3. In all three groups of internal derangement cases, the region around the ipsilateral EAM demonstrated the area of highest relative temperature. Similarly, the spot temperature over the region of the involved TMJ also demonstrated increased temperature compared to the normal or less affected TMJ.

Table 2 Subjective Assessment of Thermal Pattern Symmetry Assessing 30 TMJ Thermograms Imaged at 0.5°C and 1.0°C Sensitivity on Patients With Internal Derangement of the TMJ

Imaging sensitivity	n	Symmetry rating (% thermal symmetry)					
		>80%	65–80%	50–64%	35–49%	20–34%	<20%
Group 1: unilateral internal derangement (with opposing side normal)							
0.5°C	4	0	1	2	1	0	0
1.0°C	4	0	3	1	0	0	0
Group 2: unilateral internal derangement with opposing side unknown							
0.5°C	11	1	3	5	2	0	0
1.0°C	11	2	3	3	3	0	0
Group 3: bilateral internal derangement							
0.5°C	15	1	5	5	2	1	1
1.0°C	15	0	7	1	6	1	0
Total of 3 groups							
0.5°C	30	2	9	12	5	1	1
1.0°C	30	2	13	5	9	1	1

Table 3 Absolute Temperature Measurements (SD) in °C of the Four Regions Around the TMJ Seen on Thermograms of 30 Internal Derangement TMJ Patients

Group 1: unilateral internal derangement (contralateral side normal, N = 4)			
Region measured	Affected side	Normal side	ΔT
TMJ-center	34.9 (0.50)	34.3 (0.25)	0.6 (0.12)
TMJ-ring	34.6 (0.40)	34.3 (0.25)	0.3 (0.08)
TMJ-field	34.7 (0.42)	34.6 (0.49)	0.2 (0.07)
EAM	35.3 (0.53)	35.0 (0.52)	0.3 (0.08)
Group 2: unilateral internal derangement (contralateral side unknown, N = 11)			
Region measured	Affected side	Opposing side	ΔT
TMJ-center	35.7 (0.44)	35.4 (0.65)	0.3 (0.28)
TMJ-ring	35.2 (0.56)	35.1 (0.51)	0.1 (0.11)
TMJ-field	34.6 (0.53)	34.6 (0.62)	0.2 (0.11)
EAM	36.3 (0.37)	36.1 (0.36)	0.2 (0.13)
Group 3: bilateral internal derangement (N = 15)			
Region measured	Most affected side*	Least affected side**	ΔT
TMJ-center	35.7 (0.60)	35.3 (0.61)	0.5 (0.38)
TMJ-ring	35.1 (0.64)	34.9 (0.74)	0.3 (0.18)
TMJ-field	34.5 (0.69)	34.3 (0.65)	0.3 (0.22)
EAM	36.5 (0.72)	36.2 (0.91)	0.4 (0.47)

*Most affected side is defined as the side having the greatest amount of patient discomfort with the greatest limitation in function.

**Least affected side is defined as the side demonstrating less patient discomfort with greatest although limited function.

Differences in Absolute Temperature Measurements (ΔT)

Results of the differences in absolute temperature (ΔT) are shown in Table 3. All three groups demonstrated large ΔT values for the spot immediately over the TMJ (ΔT values of 0.6°C, 0.3°C, and 0.5°C for groups 1, 2, and 3, respectively). Group 1 patients (unilateral internal derangement vs arthrotomography-proved normal TMJ) demonstrated the greatest mean ΔT value (0.6°C). ΔT values for all groups were significantly different ($P < .05$) from those of normal TMJ subjects, who have mean ΔT values of 0.1°C.[15]

Mean Temperature Measurements Over the TMJ and Related Anatomic Zones

Results of the mean temperature measurements of the five anatomic zones are shown in Table 4. The small zone immediately over the TMJ was found

Table 4 Mean Temperature Measurements (SD) (N = 60) and ΔT (SD) in °C of the Five Anatomic Zones Seen on Facial Thermograms of 30 Patients With Internal Derangement of the TMJ

Group 1: unilateral internal derangement (contralateral side normal, N = 4)			
Anatomic zone	Affected side	Normal side	ΔT
Small TMJ	34.8 (0.14)	34.0 (0.14)	0.8 (0.18)
Large TMJ	34.7 (0.35)	34.3 (0.28)	0.4 (0.07)
Mandible	34.2 (0.28)	34.3 (0.14)	0.3 (0.14)
Midface	34.2 (0.35)	34.2 (0.21)	0.1 (0.04)
Entire 1/2-face	34.4 (0.49)	34.5 (0.07)	0.3 (0.14)
Group 2: unilateral internal derangement (contralateral side unknown, N = 11)			
Anatomic zone	Affected side	Opposing side	ΔT
Small TMJ	35.1 (0.45)	34.8 (0.39)	0.4 (0.21)
Large TMJ	34.5 (0.53)	34.3 (0.51)	0.4 (0.18)
Mandible	33.7 (0.68)	33.7 (0.70)	0.3 (0.19)
Midface	33.9 (0.60)	33.8 (0.67)	0.3 (0.22)
Entire 1/2-face	34.1 (0.51)	33.9 (0.58)	0.2 (0.15)
Group 3: bilateral internal derangement (N = 15)			
Anatomic zone	Most affected side*	Least affected side**	ΔT
Small TMJ	35.0 (0.73)	35.0 (0.51)	0.4 (0.26)
Large TMJ	34.1 (0.77)	34.1 (0.71)	0.2 (0.19)
Mandible	33.3 (0.70)	33.3 (0.88)	0.2 (0.18)
Midface	33.7 (0.67)	33.6 (0.63)	0.2 (0.15)
Entire 1/2-face	33.8 (0.56)	33.7 (0.67)	0.2 (0.16)

*Most affected side is defined as the side having the greatest amount of patient discomfort with the greatest limitation in function.
**Least affected side is defined as the side demonstrating less patient discomfort with greatest although limited function.

to have the highest temperature (about 35°C) in all three groups. Similarly, the large area over and around the TMJ has the next highest temperature (about 34.5°C). In all three groups, the region over the mandible demonstrated the lowest relative temperature (about 34°C).

Differences in Mean Temperature Measurements (ΔT) Over the TMJ and Related Anatomic Zones

Results of calculating the differences in mean temperature (ΔT) by anatomic zone are shown on Table 4. The small zone immediately over the TMJ was found to have the greatest ΔT (ranging from 0.4°C to 0.8°C). Similarly, the large area over and around the TMJ had the next greatest temperature difference (ranging from 0.2°C to 0.4°C). The three other zones measured (the mandible, the midface, and the entire half face) had temperature differences ranging from 0.1°C to 0.3°C.

Discussion

Our subjective assessment of ET among patients with internal derangement of the TMJ consisted of two parts: pattern recognition and right side vs left side thermal symmetry assessments. A common thermal pattern was found in 50% of the 30 subjects studied. At 0.5°C imaging sensitivity, the common pattern is described as a variable (in size and shape) yellow or red (hot) region surrounding both the TMJ and EAM regions. This appearance differs markedly from the pattern commonly seen on normal TMJ thermograms,[15] which involves no prominent hot spot.

Subjective thermal symmetry of TMJ images was also evaluated side vs side. It appears that images taken at both 0.5°C and 1.0°C were useful in the assessment of side vs side thermal symmetry. A relatively low level of thermal symmetry for internally deranged TMJ subjects was found, with 30% of the images rated as showing less than a 50% level of thermal symmetry. Fewer than half of the images were rated highly symmetric (symmetry level 65% to 100%). These observations differ substantially from those made on normal subjects. In a previous study, it was found that 90% of normal TMJs demonstrate greater than 65% thermal symmetry.[15] Thus, the present observation of thermal asymmetry associated with internal TMJ derangement appears to be consistent with other investigators, indicating the presence of thermal asymmetries in patients with TMJ disorders.[10,13]

The objective part of the present study, consisting of absolute temperature measurements and ΔT calculations, demonstrated areas of distinct thermal differences between the TMJ and the EAM. The mean temperatures of five anatomic zones near to the TMJ were analyzed (Fig 3) and the ΔT was calculated (differences in temperature from side to side) for each of the five anatomic zones. Results indicate that the region over the TMJ demonstrated the highest temperatures and also had the greatest ΔT value (ranging from 0.4°C to 0.8°C, average standard deviation = 0.2°C). This observation was found to be dramatically different from ΔT values seen in normal patients (ranging from 0.0°C to 0.1°C standard deviation = 0.1°C).[15] It is believed that the ΔT findings in this study have promise as an objective assessment tool and when combined with subjective ET assessments (described previously) and clinical TMJ findings, an alternative method of assessment may be available to aid both treatment planning and treatment assessment. However, it is important to note that similar increases in temperature with other TMJ disorders (osteoarthrosis, myositis, etc) may make it difficult to distinguish among various abnormal conditions. More research, involving multiple disorders and larger samples of subjects, is needed to determine the clinical significance of observed thermographic differences between groups of normal vs abnormal patients and among individual patients known to have TMJ disorders.

Acknowledgments

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References

1. Dolwick MF, Katzberg RW, Helms CA. Internal derangements of the temporomandibular joint: Fact or fiction? J Prosthet Dent 1983;49:415–418.
2. Abernathy M, Abernathy TB. International bibliography of medical thermology. Thermology 1987;2:117–533.
3. Fischer M, Chang CH. Temperature and pressure threshold measurements in trigger points. Thermology 1986;1:212–215.
4. Fischer M, Chang CH. Thermographic documentation of trigger points: Corroboration by pressure threshold measurement. In: Abernathy M, Vematsu S (eds). Medical Thermology. Washington, DC: American Academy of Thermology, 1986:115–119.
5. Ignacio DR, Pavot A, Azer RN, Jackson H. Thermography and decompensated shoulder syndrome. In: Medical Thermology. Washington, DC: American Academy of Thermology, 1986:120–123.
6. Berry DC, Yemm R. Variations in skin temperature of the face in normal subjects and in patients with mandibular dysfunction. Br J Oral Surg 1971;8:242–247.
7. Berry DC, Yemm R. A further study of facial skin temperature in patients with mandibular dysfunction. J Oral Rehabil 1974;1:255–264.
8. Johansson A, Kopp S, Haraldson T. Reproducibility and variation of skin surface temperature over the temporomandibular joint and masseter muscle in normal individuals. Acta Odontol Scand 1985;43:309–313.
9. Tegelberg A, Kopp S. Skin surface temperature over the temporomandibular and metacarpophalangeal joints in individuals with rheumatoid arthritis. Odontologiska Kliniken, Report Series No. 31, Goteborg, Sweden, 1986:1–31.
10. Pogrel MA, Erbez G, Taylor RC, Dodson TB. Liquid crystal thermography as a diagnostic aid and objective monitor for TMJ dysfunction and myogenic facial pain. J Craniomandib Disord Facial Oral Pain 1989;3:65–70.
11. Weinstein SA. Temporomandibular joint pain syndrome—The whiplash of the 1980s. In: Abernathy M, Vematsu S (eds). Thermography and Personal Injury Litigation, ed 1. New York: Wiley, 1987:157–164.
12. Weinstein SA, Gelb M, Weinstein EL. Thermophysiologic anthropometry of the face in homo sapiens. J Craniomand Pract 1990;8:252–257.
13. Steed PA. The utilization of liquid crystal thermography in the evaluation of temporomandibular dysfunction. J Craniomand Pract 1991;9:120–128.
14. Gratt BM, Sickles EA, Ross JB. Electronic thermography in the assessment of internal derangement of the TMJ: A pilot study. Oral Surg Oral Med Oral Pathol 1991;71:364–370.
15. Gratt BM, Sickles EA, Wexler CE. Thermographic characterization of the asymptomatic (normal) temporomandibular joint (TMJ). J Orofacial Pain 1993;7:7–14.
16. Gratt BM, Sickles EA, Wexler CE. Thermographic characterization of osteoarthrosis of the temporomandibular joint (TMJ). J Orofacial Pain 1993;7:345–353.
17. Getty CJ. "Bony sciatica"—The value of thermography, electromyography, and water-soluble myelography. Clin Sports Med 1986;5:327–342.
18. De Silva M, Kyle V, Hazleman B, Salisbury R, Page Thomas P, Wraight P. Assessment of inflammation in the rheumatoid knee joint: correlation between clinical, radioisotopic, and thermographic methods. Ann Rheum Dis 1986;45:277–280.
19. Bird HA, Ring EFJ. Diagnosis of infected prepatellar bursa by thermography. Acta Thermographica 1976;1:80–92.
20. Gratt BM, Pullinger A, Sickles EA, Lee JJ. Electronic thermography of normal facial structures: A pilot study. Oral Surg Oral Med Oral Pathol 1989;68:346–351.

Resumen

Caracterización termográfica de los malfuncionamientos internos de la articulación temporomandibular

Este estudio evaluó la habilidad de la termografía electrónica para identificar el malfuncionamiento interno de la articulación temporomandibular (ATM). La población de este estudio estuvo compuesta de 30 pacientes que sufrían de malfuncionamientos internos, los cuales fueron verificados por artrotomografía de la ATM. La termografía electrónica fue realizada por medio del uso de una unidad termográfica Agema 870. Las evaluaciones termales incluyeron: (1) el patrón de reconocimiento; (2) la simetría del patrón; (3) las medidas de temperatura absoluta; (4) medidas de los cambios en la temperatura absoluta (ΔT); las medidas y diferencias de temperatura media dentro de cinco zonas anatómicas designadas. Los resultados indicaron lo siguiente; (1) niveles bajos de simetría termal en pacientes con malfuncionamientos internos de la ATM (2) medidas de temperatura absoluta y medidas (medias) de la temperatura de la zona mostrando grandes ΔT (0.4°C a 0.8°C). La demostración de cambios termales características de la ATM, indica que la termografía electrónica podría utilizarse para la evaluación de los malfuncionamientos internos de la ATM. Sin embargo, se necesitan efectuar mas estudios extensos antes de que los procedimientos termográficos puedan ser aceptados clínicamente.

Zusammenfassung

Thermographische Befunde bei Diskusverlagerungen im Kiefergelenk

Diese Studie hatte zum Ziel, die diagnostischen Möglichkeiten der Thermographie bei Diskusverlagerungen im Kiefergelenk zu ermitteln. Die Testgruppe umfasste 30 Personen mit arthrotomographisch verifizierter Diskusverlagerung. Die elektronische Thermographie wurde mit Agema 870 - Thermographiegeräten durchgeführt. Die Messungen beinhalteten: 1. erfassen des Musters, 2. erfassen der Mustersymmetrien, 3. absolute Temperatur, 4. Temperaturdifferenzen, 5. mittlere Temperaturen an und Temperaturunterschiede zwischen fünf bestimmten anatomischen Regionen. Die Resultate: 1. Patienten mit Diskusverlagerungen zeigten wenig symmetrische thermische Muster, 2. sowohl in der absoluten wie auch in der mittleren Temperaturmessung zeigen diese Patienten grosse Temperaturunterschiede (0.4°C–0.8°C). Da es gelang, charakteristische thermische Veränderungen in Kiefergelenken festzustellen, ist der elektronischen Thermographie ein gewisser diagnostischer Wert für Diskusverlagerungen in Kiefergelenken beizumessen. Weitergehende Studien sind aber nötig, bis die Thermographie Eingang in die Klinik finden wird.