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Qualitative thermograhic analysis of psoriatic skin lesions

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Abstract— **Psoriasis vulgaris affects about 2% of the human population all over the world. The aim of this study was to evaluate usefulness of thermography in estimation of psoriatic lesion activity. A series of patients with plaque type psoriasis vulgaris were included. ThermaCam INFRAMETRICS 290E thermocamera with temperature resolution of 0.1 °C was employed. Both visual and thermal images of the patients were taken. Clinical severity of the lesions was evaluated by Plaque Severity Score (PSS, scale 0-4). We discovered higher temperature over psoriatic plaques and further vastly expanding beyond the visually documented borders of the lesions thus not corresponding to the individual shapes of the lesions, suggested that those lesions presented an active phase of the disease (developing over the last 2-3 weeks). To the contrary, areas of the increased temperature over chronic psoriatic plaques (already developed at least 8 weeks before without signs of visible progression) corresponded quite well to the shapes of clinically visible lesions i.e. single lesions could be differentiated within the area of the increased temperature. The above observations would allow to introduce more aggressive local treatment only to the selected lesions thus as much as possible sparing the rest of them from probable side-effects.**

Keywords— **thermal imaging, thermography, non-contact, psoriasis vulgaris, skin lesions**

I. Introduction

Thermal imaging methods gain more and more applications in medicine including evaluation of allergic both patch and prick skin tests, morphea, basal cell carcinoma, chilblains, port wein stains, melanocytic naevi and melanoma extensivity, deep vein thrombosis, burn depth, diabetic foot, Raynaud's phenomenon, thyroid gland changes, pneumonia development, arthropathy and many other pathological conditions [1, 2, 3, 4, 5, 6, 7].

Psoriasis is a complex, multifactoral, inflammatory with Th1 cytokine predominance, non-contagious with strong genetic component, recurrent skin disease skin disease involving 1-4 % of human population whereas arthropatic variant is observed in about 0.02-0.1% of the total population [8, 9, 10, 11]. Taking into account psychological, social and economical burden of this virtually incurable skin disease, quick and reliable method of evaluation of this disease severity would be most helpful in planning the most suitable treatment for an individual patient [8, 11, 12]. As regards histopathology a few distinct features can be observed: hyperparakeratosis and lack of granular layer in the epidermis, inflammatory infiltrate in the upper parts of the dermis and vascular changes i.e. new blood vessel formation and widening of their lumen [8, 10]. All of the above mentioned abnormalities could lead to surface body temperature changes. It seems that the more active lesions the more pronounced the above histopathological features. Microvascular abnormalities and inflammation are considered to be of key importance in the development of psoriatic plaques [8, 13, 14, 15]. Blood vessels are increased in number, elongated, tortuous and dilated [16, 17]. It was demonstrated that structural expansion and increased tortuosity of the dermal capillary loops occurs early in the formation of the lesion, before epidermal hyperplasia can be detected both clinically or histopatologically [18, 19]. What is more, vascular abnormalities might persist even after an apparently successful treatment when the lack of all epidermal disturbances is clearly observed and subsequently they can be responsible for recurrence of the disease [8, 10]. Increased blood flow is observed through such pathologically changed blood vessels [13, 16]. Additionally, it was demonstrated that cutaneous blood flow in psoriasis was 10 times greater in psoriatic lesions compared with the normal healthy skin [13]. Other studies reported 2-9 fold increase in the blood flow in psoriatic lesions comparing with clinically normal skin [20, 21]. It is accepted that increased blood flow leads to increased skin temperature. Inflow from the blood to the epidermis of activated polymorphonuclear cells, forming pustules and abscesses there, together with vastly increased number of activated T lymphocytes residing in the elongated dermal papillae add further to temperature increase [8, 22].

Psoriasis exerts a strong negative impact on patients both psychological and physical well-being comparable to neoplastic and cardiovascular system diseases [8, 23]. It is an incurable disease with sometimes quite long remission periods. So, development of the methods facilitating introduction of more individually oriented treatments would be most appreciated.

The aim of this study was to evaluate usefulness of thermography in estimation of psoriatic lesion activity (active vs stable lesions).

II. Methodology

A series of newly admitted in-patients presenting plaque type psoriasis vulgaris were included in the present study. A total of 250 psoriatic plaques were analyzed. The

patients did not take any systemic treatment in the last 2 weeks and local one, except for emollients for the last week. The disease duration ranged from 6 to 15 years. Based on the past medical history the selected patients did not suffer from psoriatic arthritis and they presented both active plaques (developing over the last 2-3 weeks) and stable ones (already developed at least 8 weeks before without signs of visible progression). On the day of thermographic procedure all the patients were not applying any local treatment to the skin in order to avoid its irritation and additional stimulation of blood flow they were also asked to refrain from smoking and drinking coffee. They were also instructed not to eat anything for 3 hours before the thermographic examination. Just before the procedure, they were prepared in a special room with controlled temperature for 30 minutes (20^{o}C). Based on the past medical history, after a thermographic examination all the patients were put on classical antipsoriatic treatments i.e. either on Ingrahm's method (local anthralin plus UVB) or Goeckerman's method (local prodermine plus UVB). Clinical evaluation as regards either resistance or progression of the examined plaques was also recorded.

Thermocamera ThermaCam INFRAMETRICS 290E was employed in the study. Temperature resolution was 0.1 ^{o}C, temperature range, mean and standard deviation were calculated. All thermal images have been captured and processed through high-speed Peripheral Component Interconnect (PCI) interface. This interface links up to 4 CCD cameras and 1 thermal camera with the powerful computer, and offers the high performance of 32-bit data transfer an optional burst mode that provides accelerated throughput of data across the bus of 132 MB/s. ThermalStudio software was used. Both thermal and visual images of all the patients were recorded [3].

The severity of the disease was evaluated by PASI (Psoriasis Area and Severity Index) and expressed in whole numbers (points). The following parameters were estimated – area of involvement = A (expressed in % and then recalculated to points – scale 0-6); infiltration =I (evaluated by palpation; scale 0-4); erythema = E (scale 0-4); desquamation =D (scale 0-4). PASI formula: PASI= Head{[(I+E+D)x A]x 0.1}+Trunk{[(I+E+D)x A]x 0.3}+Upper limbs{[(I+E+D)x A]x 0.2}+Lower limbs{[(I+E+D)x A]x 0.4} [24]. Since 1978 PASI has been most widely used clinical evaluation of psoriasis severity [25, 26]. For the evaluation of individual psoriatic plaques Plaque Severity Score (PSS) was employed [26]. Each plaque was estimated as for erythema (scale 0-4), desquamation (0-4) and infiltration (0-4).

III. Results

PASI was evaluated by a dermatologist at the time of thermographic procedure and ranged from 3.2 to 16.7. Detailed data of the selected patient (XY) are presented in Table 1.

TABLE 1
CLINICAL EVALUATION OF PSORIAS BASED ON PSORASIS AREA AND SEVERITY INDEX (PASI) IN THE SELECTED PATIENT (XY)

Estimated parameters	Estimated Areas						
Range: 0-6 (area), 0-4 (others); 0-28.8 (partial PASI), 0-72 (total PASI)	Head	Trunk		Upper limbs		Lower limbs	
		front	back	front	back	front	back
Erythema	1	3	2	2	1	2	2
Infiltration	1	3	3	3	3	2	2
Desquamation	2	2	2	3	4	2	2
Area	3	3		2		2	
Partial PASI	1.2	7.2		3.2		4.8	
Total PASI	16.4						

Thermograms for the whole silhouette of all the examined patients were also recorded at the same time. Subsequently, all psoriatic plaques situated over the skin of the trunk, lower and upper limbs were evaluated in each patient together with temperature measurement.

We observed an inter-individual variation of temperature measurements between individual patients presenting plaques comparable as regards clinical evaluation of erythema (ranged from 1 to 3), induration (ranged from 1 to 3) and desquamation (ranged from 1 to 4).

Skin lesions developing and further expanding over the last 2-3 weeks were classified as active, whereas lesions already developed at least 8 weeks before without showing clinical signs of progression were regarded as stable. We observed that based on medical history of individual lesion progression, active rather expanding plaques demonstrated increased temperature over the plaques themselves and surroundings which did not correspond to the shapes of clinically visible lesions (Figure 1).

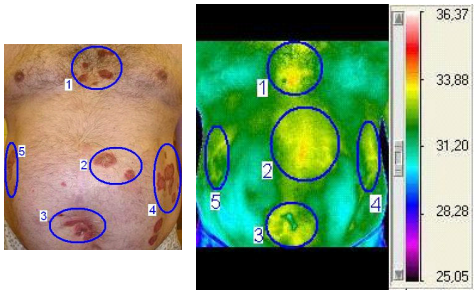

Fig. 1. Patient XY- active lesions – shape of the areas of higher temperature does not correspond to the shape of visible psoriatic plaques) situated over the trunk (front) –clinical and thermographic images. Areas of interest encircled.

We also found that chronic not progressing plaques showed increased temperature over the plaques themselves thus allowing differentiation of their shapes and also increased temperature expanding further beyond the plaques (Figure 2).

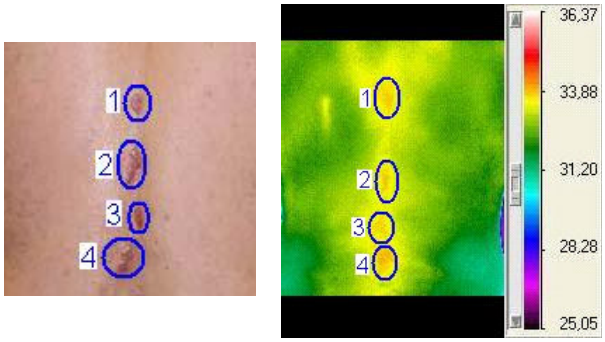

Fig. 2. Patient XY- stable lesions – shape of the areas of higher temperature seems tot correspond to the shape of visible psoriatic plaques) situated over the trunk (back) – clinical and thermographic images. Areas of interest encircled.

Detailed data of the selected patient (XY) presenting both active and stable lesions are presented in Table 2.

TABLE 2
THERMOGRAFIC AND CLINICAL ANALYSIS OF THE SELECTED PATIENT (XY)

Localization of the lesions	Number of the area	Temperature range; mean ± SD (°C)	Plaque Severity Score (PSS) (scale 0-4)			
			Erythema	Induration	Desquamation	Total
Trunk - front	1	31.52-34.08; 33.08±0.43	3	3	2	8
	2	32.45-33.95; 33.14±0.26	3	3	2	8
	3	30.24-33.86; 32.81±0.56	3	3	2	8
	4	31.46-33.61; 32.71±0.42	3	3	2	8
	5	31.14-33.41; 32.37±0.38	3	3	2	8
Trunk - back	1	32.59-33.29; 32.94±0.15	2	3	2	7
	2	32.44-33.37; 32.92±0.19	2	3	2	7
	3	32.5-33.21; 32.94±0.13	2	3	2	7
	4	32.51-33.50; 33.06±0.19	2	3	2	7

IV. DISCUSSION

Thermographic imaging is wider and wider employed in medical diagnosing, evaluation of disease severity and treatment planning, especially associated in conditions characterized by an increased blood flow or inflammation development [1]. It is well documented that in the evolution of psoriatic lesions increased blood flow, hyperkerparakeratosis and inflammation are observed [8, 13]. All these findings seem to influence surface body temperature measurements.

First literature data using thermography in psoriasis patients both suffering from psoriasis vulgaris and/or psoriatic arthritis, dates back to the early seventies of the last century [27, 28, 29]. Mustakallio introduced contact thermography to study influence of dithranol staining properties on erythema estimation in psoriasis [30]. Psoriasis continued to attract attention as regards thermography implementation further also in the eighties [31, 32, 33, 34]. Warshaw and Lopez made a very interesting observation that psoriatic patients presented disturbed reaction to a cold challenge i.e. the majority of them did not react to decreased temperature by immediate drop in temperature of the limbs in contrast to the healthy people [32]. Ippolito et al employed thermographic methods to study the blood flow in psoriatic patients treated with cyclosporin and observed prolongation of the thermal recovery time together with plaque clearance [35]. Literature data on arthritic changes is much better represented [29, 36, 37]. Maleszka et al studied psoriatic arthritis and reported that the skin lesions covered with scales seemed to be hypothermic because excessive scales (hyperkeratosis) acted as an isolation layer and only papular lesions on erythematous base demonstrated increased temperature. Because of those effects, the authors examined only joints, over which no psoriatic lesions have been observed, demonstrating increased temperature [38].

Our previous preliminary study demonstrated fairly increased skin temperature on thermography over the lesions which were in an active phase and over the clinically uninvolved skin, which later transferred into psoriatic plaques [39].

Current study comprised patients with a long medical history of psoriasis vulgaris in which psoriatic arthritis was previously excluded. Active lesions demonstrated increased temperature over the clinically visible plaques and their surroundings whereas stable lesions showed increased temperature virtually only over the plaques themselves. This observation as regards active, inflammatory lesions seems to be in agreement with other literature data evaluating active inflammatory localized scleroderma skin lesions [5].

In our opinion, psoriatic lesion thermography performed before treatment implementation may be very useful in distinguishing active, progressing lesions which require a more potent regimen.

It seems useful to correlate temperature measurements of symmetrically localized skin lesions with different parameters severity (erythema, infiltration, desquamation) in a more numerous group of psoriatic lesions and establish a proper standarisation, which is a mandatory procedure.

V. CONCLUSION

Higher temperature observed on thermographic images presenting shapes not corresponding to the shapes of the

clinically visible skin lesions may identify active progressing lesions and thus justify introduction of more potent additional local agents to prevent progression of those lesions.

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