http://dx.doi.org/10.21611/qirt.2012.276

QIRT 2012

11th International Conference on
Quantitative InfraRed Thermography

# Thermal signature of melanoma and non-melanoma skin cancers

by F.J. González*, C. Castillo-Martínez**, R. Valdes-Rodríguez**, E.S. Kolosovas-Machuca*, Uriel Villela-Segura** and B. Moncada**

* Coordinación para la Innovación y la Aplicación de la Ciencia y la Tecnología, Universidad Autónoma de San Luis Potosí, San Luis Potosí, México, *javier.gonzalez@uaslp.mx*

** Dermatology Department, Hospital Central 'Dr Ignacio Morones Prieto', Universidad Autónoma de San Luis Potosí, San Luis Potosí, México

**Abstract**

In this work the thermal signature of melanoma and non-melanoma skin cancers is investigated in order to be used as a non-invasive aid in the diagnosis and the vascular assessment of these types of skin cancers. Thirty patients with melanoma and non-melanoma skin cancers were examined in order to obtain their temperature profile. The results show that there is a characteristic thermal signature for different types of skin neoplasms which not necessarily depend exclusively on their vascularity. Basal cell carcinomas and squamous cell carcinomas showed a larger range of vascularity, while the thermal profile remained basically constant for squamous cell carcinomas and varied a lot for basal cell carcinomas. In the case of melanomas they showed a high vascularity and an almost constant thermal signature which indicates that metabolic heat production is more relevant in assesing agressiveness. Basal cell carcinomas showed a big range in temperature profiles and a big range in vascularity, a correlation between vascularity and temperature profile was observed when analyzing each subtype of basal cell carcinoma, which indicates that the thermal behavior of basal cell carcinomas is highly dependent on their subtype. With squamous cell carcinoma a big range in vasculature was measured however the temperature range of their thermal profile did not change significantly which indicates that there might be a metabolic heat production – vasculature parameter that appears to remain constant. These results are a step forward in designing a thermal model for skin neoplasms.

## 1. Introduction

Elevated body temperature has been used as an index of illness and often as an indicator of the progression of a disease [1]. The temperature distribution of human skin has been used for diagnosis [2, 3], for monitoring the effectiveness of treatment [4] and for studying physiological functions in normal subjects [5]. However, it is nonspecific and patterns of temperature need to be interpreted by a trained eye. A hot or cold spot in the temperature distribution may be an indicator of the presence of a tumor forming within the body, or of inflammation as in the case of arthritic joints, of infection, of loss or over-activity of sympathetic nerve function, or of a host of other dysfunctions [6].

Skin neoplasms (also known as "skin cancer") are skin growths with differing causes and varying degrees of malignancy. The three most common malignant skin cancers are basal cell carcinoma, squamous cell carcinoma, and melanoma, each of which is named after the type of skin cell from which it arises.

Basal cell carcinoma (BCC), first described by Jacob in 1827, is the most common malignant neoplasm of humans [7]. Lesions occur on both sun-protected and sunexposed skin, but often have a different biology and morphology in these locations [7]. Typically, BCCs occur in the fourth decade of life and beyond although exceptions to this occur, in particular in the setting of specific genodermatoses or in patients with immune compromise [7]. As sun exposure plays a role in the development and transformation of BCC, patients with light skin phenotypes are particularly predisposed [7].

Rippey classified BCCs into 4 subtypes: nodular, infiltrative, superficial, or mixed BCC [8]. More recently Crowson classified BCC as belonging to indolent growth or aggressive-growth subsets [7], the former including superficial and nodular BCCs and the latter infiltrative, metatypical, and morpheaform or sclerosing BCCs. Three subtypes are relevant to come to an appropriate treatment choice [9]. Superficial BCC and nodular BCC are both indolent-growth subtypes and have a low risk for incomplete treatment and recurrence. The third, a high-risk subtype, includes all BCCs that exhibit aggressive growth, such as infiltrative/morpheaform BCC, micronodular BCC, and BCC with squamous differentiation [9].

Cutaneous squamous cell carcinoma (SCC) is a malignant tumor of epithelial keratinocytes that shows varying degrees of maturation and keratin formation. It is the second most common form of skin cancer in whites, and its incidence is increasing rapidly [10]. SCC is significantly more common in men than in women with a ratio that may be as high as 3:1. SCC is most common in fair individuals who burn easily and occurs most frequently on the sun exposed skin of the head and neck [10]. Although SCC may occur in young patients with fair

skin and a strong history of sun exposure, it is most commonly a tumor of the elderly [10]. One of the more curious associations of SCC is its prevalence at sites of chronic inflammation and scarring [10]. There are several histologic variants of SCC, with some evolving more aggressively than others. This being the case, delineation of subtype can help direct clinicians to guide treatment and follow-up [11].

Melanoma is a skin cancer that arises from the malignant transformation of melanocytes. Although it is typically considered a pigmented lesion, the clinical presentation of melanoma can vary greatly. Although melanoma accounts for only 4 percent of all dermatologic cancers, it is responsible for 80 percent of deaths from skin cancer; only 14 percent of patients with metastatic melanoma survive for five years [12].

Tumor-induced neovascularization, i.e. angiogenesis, is important in neoplastic development and progression, since both tumor growth and metastatic dissemination of tumor cells depend on vascular support [13], and angiogenesis is known to induce a local increase in temperature due to the increase in blood perfusion in the area.

In this work the thermal signature of melanoma and non-melanoma skin cancers is investigated in order to be used as a non-invasive aid in the diagnosis and the vascular assessment of these types of skin cancers.

## 2. Method

Thirty patients with melanoma and non-melanoma skin cancers were examined at the Department of Dermatology, Hospital Central “Ignacio Morones Prieto”, San Luis Potosi, Mexico, using a FLIR T400 infrared camera (FLIR Systems, Wilsonville, OR, USA) which has a 320 × 240 Focal Plane Array of uncooled microbolometers with a spectral range of 7.5–13 μm and a thermal sensitivity of 50 mK at 30°C.

The thermal images were analyzed in order to obtain the temperature difference between the cancer lesion and an unaffected reference skin area (Figure 1).

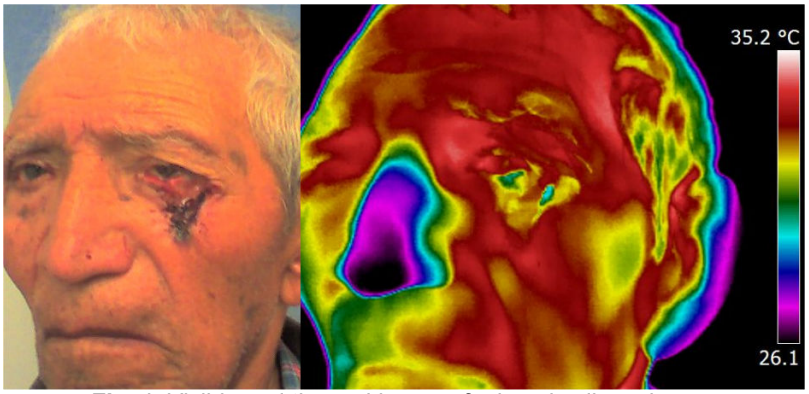


***Fig. 1.*** *Visible and thermal image of a basal cell carcinoma.*

The diagnosis of skin cancer was done clinically and by using histopathology with hematoxylin- eosin-stained sections (Figure 2). Image analysis was done with a 10x magnification of the 4 μm processed sections. The images were photographed with a digital camera (Olympus SP-320), mounted on a microscope (Olympus CX31) connected to a PC. Two experienced dermatopathologists reviewed the pathologic slides independently.They counted the the number of tumor blood vessel in one field. Once captured, images were processed using the public domain software ImageJ v1.44 (U.S.A. National Institutes of Health).

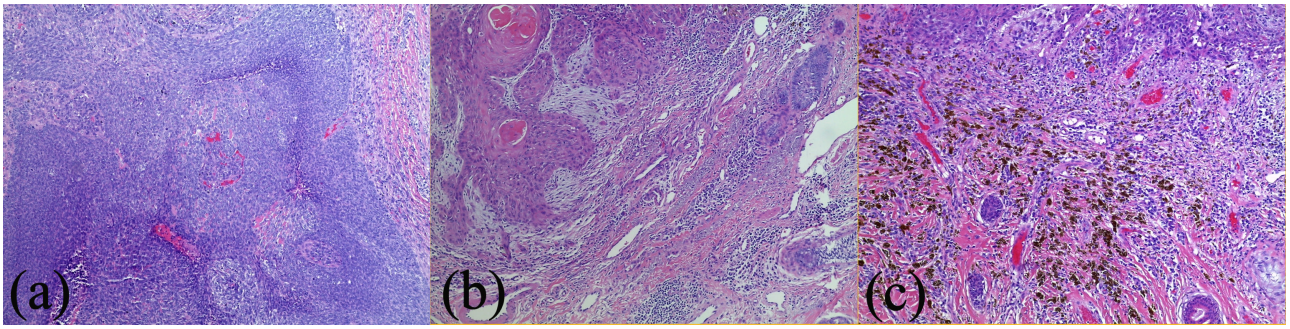


***Fig. 2.*** *Histopathology of (a) Basal cell carcinoma, (b) Squamous cell carcinoma and (c) melanoma.*

http://dx.doi.org/10.21611/qirt.2012.276


## 3. Results

The clinical diagnosis and vascularity of each type of neoplasm was analyzed as a function of the tumor local temperature, and as the difference between the lesion and an unaffected skin region, also known as the ΔT parameter.

Figure 3 shows the ΔT parameter as a function of the type of neoplasm, it resulted negative for the basal cell carcinoma and positive for the melanoma and squamous cell carcinoma, which is consistent with the vascular nature of these types of skin cancers.

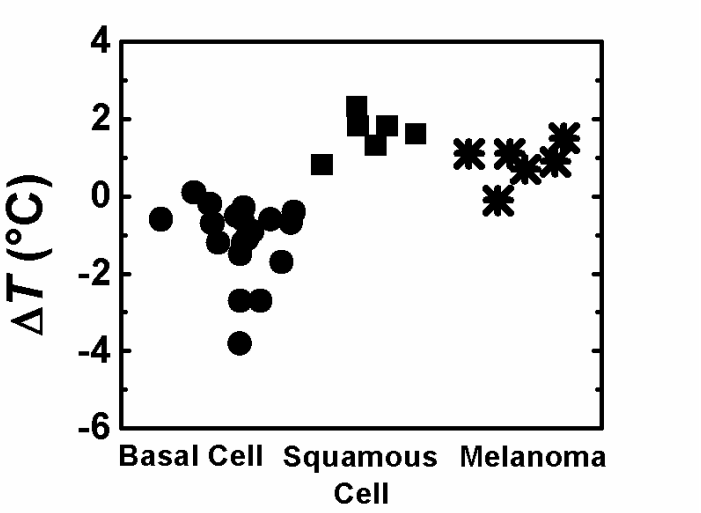


***Fig. 3.*** *Temperature difference (ΔT) for three different types of skin cancers.*

Even though a different thermal signature was observed for different types of skin cancer, no relation to the vasculature could be observed as a function of the ΔT parameter, when the vasculature of each tumor was analyzed as a function of the local tumor temperature then a correlation could be observed.

Figure 4 shows the temperature of the lesion for squamous cell carcinomas and melanomas as a function of their vascularity, even though the number of analyzed tumors is small, it can be seen how for squamous cell carcinomas there is a tendency of an increase in the local lesion temperature as a function of vascularity and in the case of melanoma even though the local temperature increases there is no increase in vascularity of the tumor, which indicates that that in melanoma there is a higher variation in metabolic heat produced by the tumor than the variation of its vascularity.

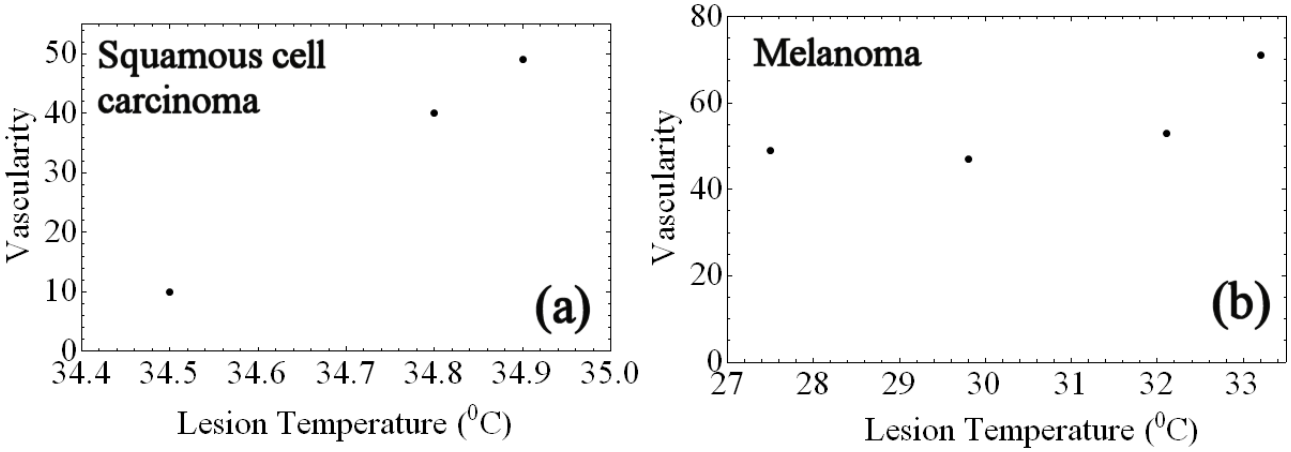


***Fig. 4.*** *Lesion temperature as a function of the vascularity (in vessels/field(10x)) of (a) squamous cell carcinomas and (b) melanomas.*

In the case of basal cell carcinomas no correlation was observed between the ΔT parameter or the local temperature lesion with their vascularity when analyzing all the samples (Figure 5), however when the basal cell carcinoma was analyzed by subtypes then a clear correlation was observed (Figure 6).

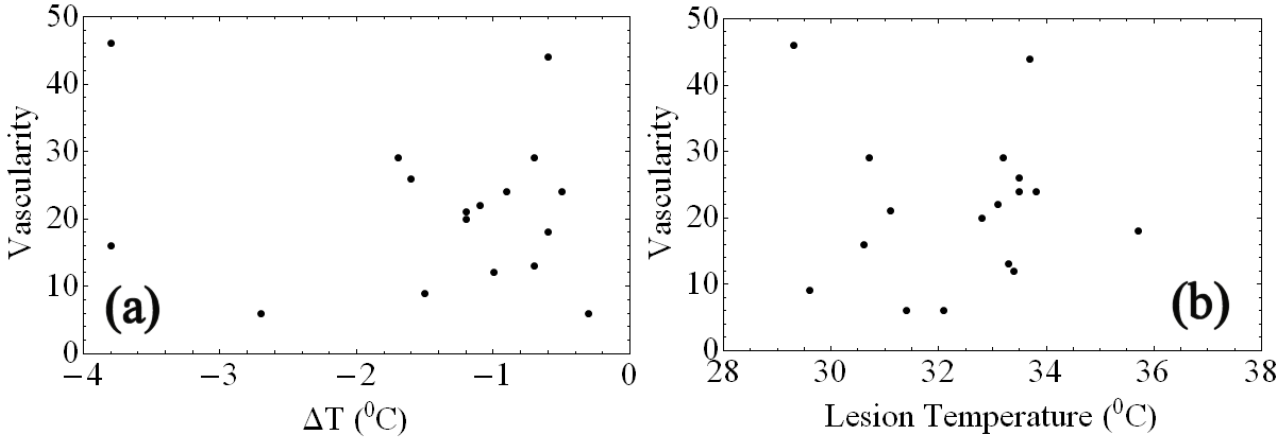


***Fig. 5.*** *Vasculature of basal cell carcinomas as a function of their thermal signature (a) ΔT parameter and (b) Lesion Temperature.*

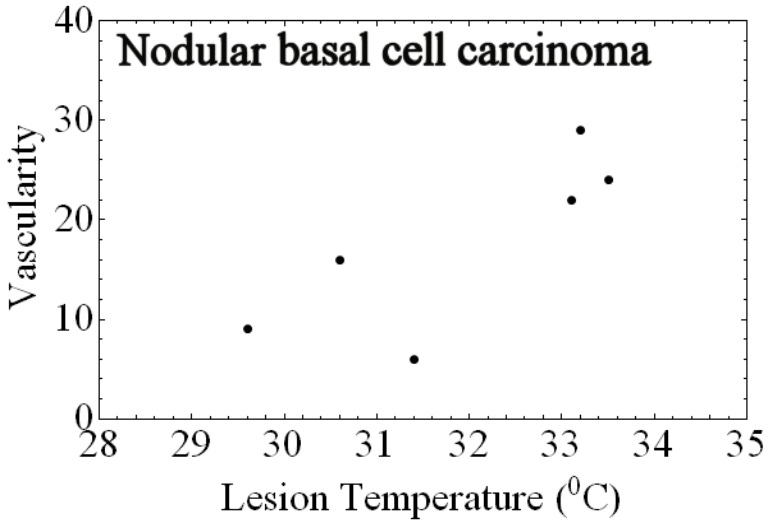


***Fig. 6.*** *Vascularity (in vessels/field(10x)) as a function of local temperature of the lesion for nodular basal cell carcinomas.*

## 4. Conclusion

These results show that there is a characteristic thermal signature for different types of skin neoplasms, basal cell carcinomas showed a cold profile compared to squamous cell carcinomas and melanomas, which is consistent with the vascular nature of these three types of skin cancer.

When compared the thermal signature of melanoma and non-melanoma skin cancers as a function of their vasculature, basal cell carcinomas and squamous cell carcinomas showed a larger range of vascularity than melanomas which showed great vascularity but the tumors did not vary a lot in vascularity, however their thermal signature did vary which indicates that in the case of melanomas metabolic heat production is more relevant in assesing agressiveness than vascularity since it remains basically constant.

Basal cell carcinomas showed a big range in temperature profiles and a big range in vascularity, a correlation between vascularity and temperature profile was observed when analyzing each subtype of basal cell carcinoma, which indicates that the thermal behavior of basal cell carcinomas is highly dependent on the subtype.

With squamous cell carcinoma a big range in vasculature was measured however the temperature range of their thermal profile did not change significantly which indicates that there might be a metabolic heat production – vasculature parameter that appears to remain constant in the case of squamous cell carcinomas.

These results are a step forward in designing a thermal model for skin neoplasms.

## REFERENCES

[1] R. P. Clark and M. R. Goff, “Medical Thermography - Current Status,” Proc of SPIE Vol. 1320, 1990, pp. 242-250.
[2] D. Park, N. H. Seung, J. Kim, et al., “Infrared thermography in the diagnosis of unilateral carpal tunnel syndrome,” Muscle and Nerve, Vol. 36, No. 4, 2007, pp. 575-576.
[3] F. M. M. Ya'ish, J. P. Cooper, M. A. C. Craigen, “Thermometric diagnosis of peripheral nerve injuries - Assessment of the diagnostic accuracy of a new practical technique,” Journal of Bone and Joint Surgery, Vol. 89B, No. 7, 2007, pp. 933-939.
[4] L. Weibel, M. C. Sampaio, M. T. Visentin, et al., “Evaluation of methotrexate and corticosteroids for the treatment of localized scleroderma (morphoea) in children,” British Journal of Dermatology, Vol. 155, No. 5, 2006, pp. 1013-1020.
[5] V. Shusterman, K. P. Anderson and O. Barnea, “Spontaneous skin temperature oscillations in normal human subjects,” Am J Physiol Regul Integr Comp Physiol, Vol. 273, 1997, pp. R1173-R1181.
[6] B. F. Jones, “A reappraisal of the use of infrared thermal image analysis in medicine,” IEEE Transactions on Medical Imaging, Volume 17, Issue 6, 1998, pp. 1019 - 1027.
[7] A. N. Crowson, “Basal cell carcinoma: biology, morphology and clinical implications,” Modern Pathology (2006) 19, S127–S147.
[8] J. J. Rippey, “Why classify basal cell carcinomas?” Histopathology 1998; 32 : 393-8.
[9] K. Mosterd, M. R. T. M. Thissen, A. M. W. van Marion, P. J. Nelemans, B. G. P. M. Lohman, P. M. Steijlen, and N. W. J. Kelleners-Smeets, “Correlation between histologic findings on punch biopsy specimens and subsequent excision specimens in recurrent basal cell carcinoma,” J AM ACAD DERMATOL FEBRUARY 2011, pp. 323-327.
[10] G. D. Goldman GD, “Squamous cell cancer: a practical approach.” Seminars in Cutaneous Medicine and Surgery, Vol 17, No 2 (June), 1998: pp 80-95.
[11] C. L. Kane, C. A. Keehn, E. Smithberger, L. F. Glass, “Histopathology of cutaneous squamous cell carcinoma and its variants.” Semin Cutan Med Surg. 2004 Mar;23(1):54-61.
[12] A. J. Miller, and M. C. Mihm, Jr, “Melanoma,” N Engl J Med 2006; 355:51-65, (2006).
[13] B. Loggini, L. Boldrini, S. Gisfredi, S. Ursino, T. Camacci, K. De Jeso, G. Cervadoro, et. al., “CD34 Microvessel Density and VEGF Expression in Basal and Squamous Cell Carcinoma,” Pathology - Research and Practice, Volume 199, Issue 11, Pages 705-712, (2003).