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Original

Speckle-variance optical coherence tomography: a novel approach to skin cancer characterization using vascular patterns

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Abstract

Non-invasive imaging devices are currently being utilized in research and clinical settings to help visualize, characterize, and diagnose cancers of the skin. Speckle-variance optical coherence tomography (svOCT) is one such technology that offers considerable promise for non-invasive, real time detection of skin cancers given its added ability to show changes in microvasculature. We present four early lesions of the face namely sebaceous hyperplasia, basal cell skin cancer, pigmented actinic keratosis, and malignant melanoma *in situ* that each display different important identification markers on svOCT. Up until now, svOCT has mainly been evaluated for lesion diagnosis using transversal (vertical) sections. Our preliminary svOCT findings use dynamic *en face* (horizontal) visualization to differentiate lesions based on their specific vascular organizations. These observed patterns further elucidate the potential of this imaging device to become a powerful tool in patient disease assessment.

Keywords: speckle-variance optical coherence tomography, sebaceous hyperplasia, basal cell skin cancer, pigmented actinic keratosis, and malignant melanoma *in situ*

Abbreviations: svOCT=speckle-variance optical coherence tomography; BCC=basal cell carcinoma; MMIS= malignant melanoma *in situ*; AK= actinic keratosis

Introduction

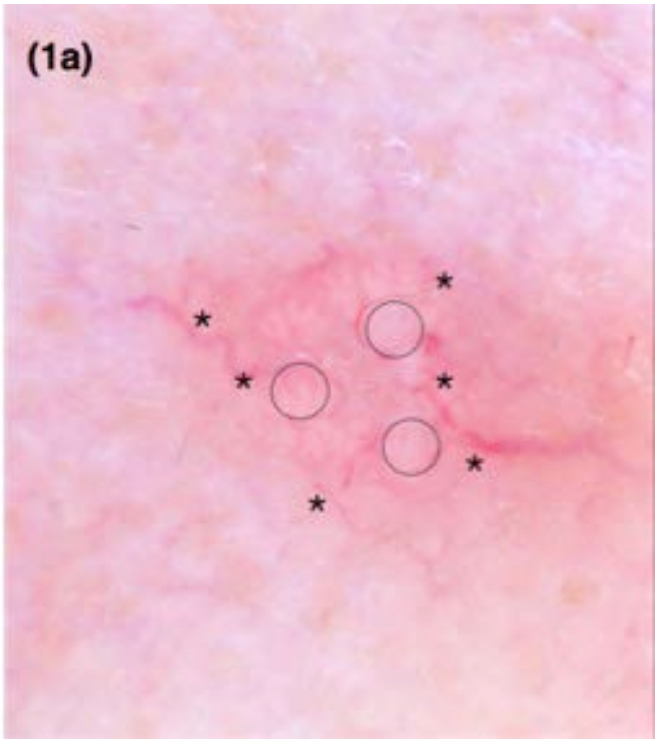
Over the last decade, various non-invasive imaging devices have been implemented in both research and clinical settings to assist in the diagnosis of skin cancers. Speckle-variance optical coherence tomography (svOCT) is one such novel imaging technique that can be used to visualize microvascular blood flow using the scattering properties of red blood cell movement. The optical coherence tomography devices have applications in skin tumor biology as well as oral tissue, neuroscience, embryologic tissue, tracing nanoparticles, and in ophthalmology [1]. Specifically, the svOCT technology (Michelson Diagnostics Ltd., Orpington, Kent, UK) has recently been demonstrated to identify micro-angiographic changes of a junctional nevus compared to a melanoma *in situ* [2] and to monitor the microvascular disappearances occurring before and after PDT treatment on skin [3]. Thus far, the applications of svOCT have relied on dynamic vertical and cellular data visualization to evaluate lesions' vascular distribution.

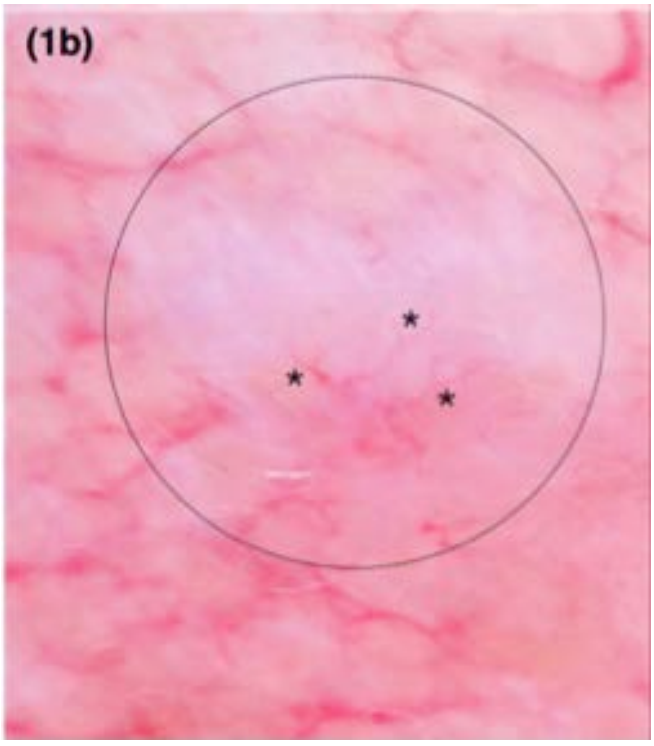
Dynamic *en face (*horizontal) visualization is a new method for using svOCT to observe lesion specific vascular features and patterns to aid with diagnosis.

We present four relatively early facial lesions (sebaceous hyperplasia, basal cell skin cancer, pigmented actinic keratosis and malignant melanoma *in situ*) that each display different important identification characteristics on svOCT. Our preliminarily svOCT findings demonstrate the utility of *en face* visualization of the scans using only vascular information removing any echogenic cellular data to differentiate different types of skin lesions (Table 1).

Diagnosis	Features	Dermoscopy	svOCT
Sebaceous hyperplasia (1 ace)	**Vascular Pattern** **a. Type of vessels** **b. Distribution**	a. Linear and curved vessels (*) b. Uniform crowning around the lobules; Never crossing the center	a. Thick radiating appearing vessels (*) b. Focal, uniform distribution along the periphery of the lesion consisting of a moderate vessel density
	Additional criteria	Aggregated pale yellow and white lobules at the center of lesion (dashed circle)	N/A
Non-pigmented Basal cell carcinoma (1 bdf)	**Vascular Pattern** **a. Type of vessels** **b. Distribution**	a. Telangiectasias: thin, irregular tree-like arborizing vessels (*) b. Branching	a. Thin, fine irregular vessels (*) b. Well-demarcated, focal disorganized pattern throughout the lesion consisting of a high vessel density (circle) surrounded by normal anatomic facial telangiectasias (dashed arrows)
	Additional criteria	A translucent, white-to-pinkish background (dashed circle)	N/A
Pigmented Actinic keratosis (2 ace)	**Vascular Pattern** **a. Type of vessels** **b. Distribution**	None	a. Thick (circle) and thin (dashed arrows) branching vessels b. Thick normal anatomic telangiectasias focally organized consisting of a high vessel density (circle) surrounded by thinner, broken, less organized vessels at the periphery consisting of a marked reduction in vessel density (dashed arrows)
	Additional criteria	Scale (dashed arrows) Annular-granular pattern around pigmented follicular openings (*)	N/A
Pigmented Malignant melanoma *in situ* (2 bdf)	**Vascular Pattern** **a. Type of vessels** **b. Distribution**	None	a. Thin, irregular vessels (dashed arrows) b. Densely dispersed throughout the *en face* field (circle)
	Additional criteria	Lacked scale Gray dots granules around follicular openings (*) Formation of early rhomboidal structures (dashed arrows)	N/A

Table 1. **Table 1.** Summary of lesion specific characteristics examined under dermoscopy and with speckle-variance optical coherence tomography.





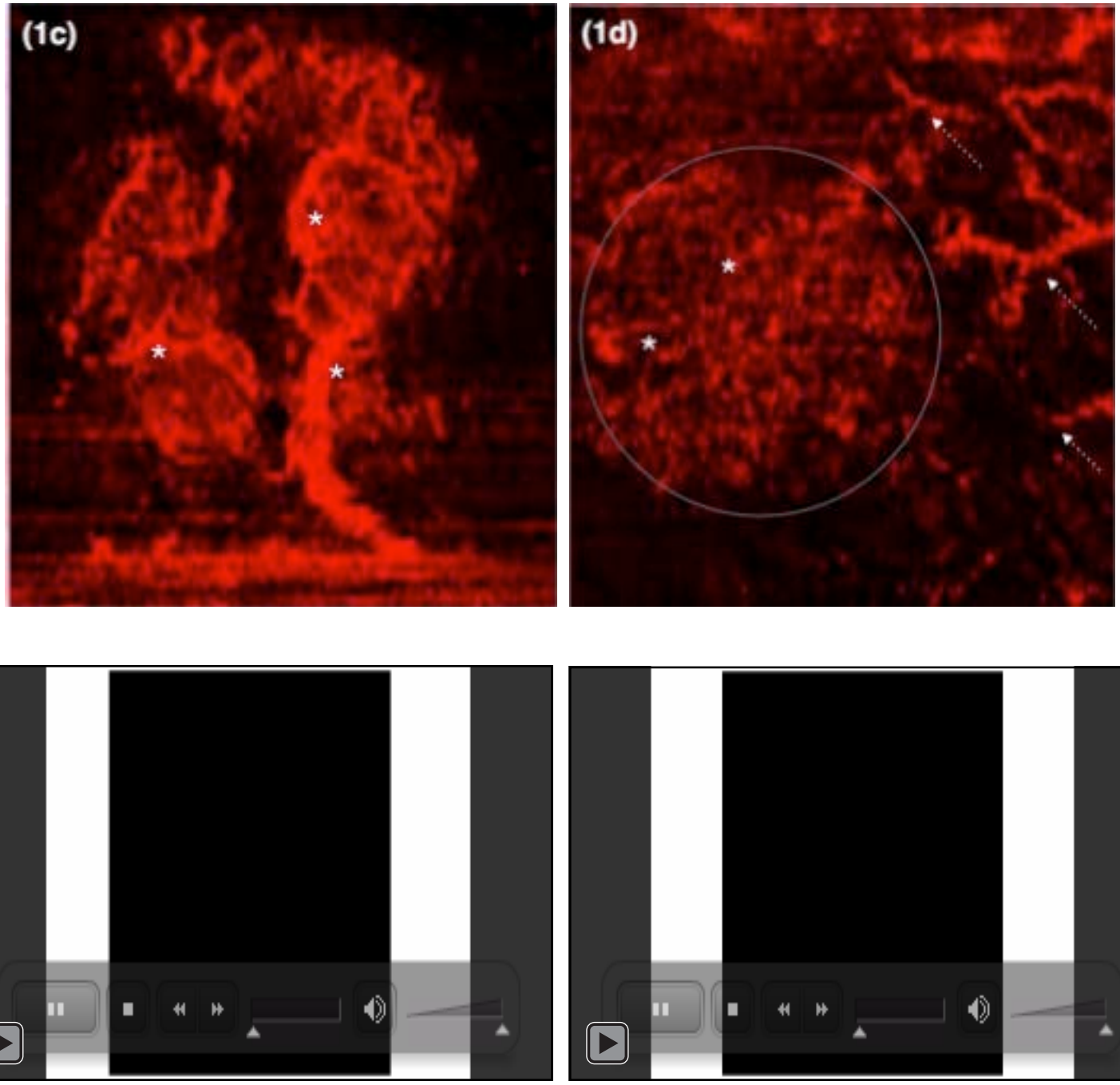
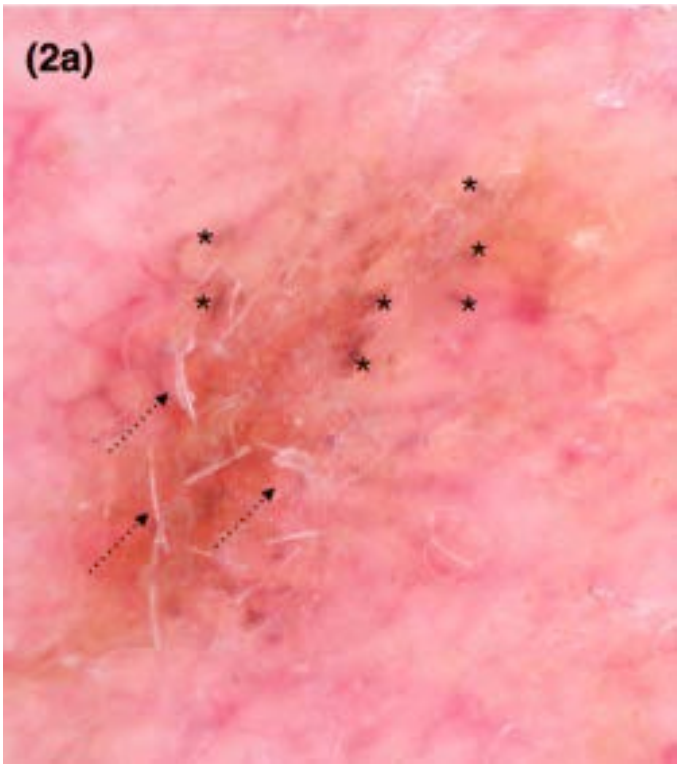
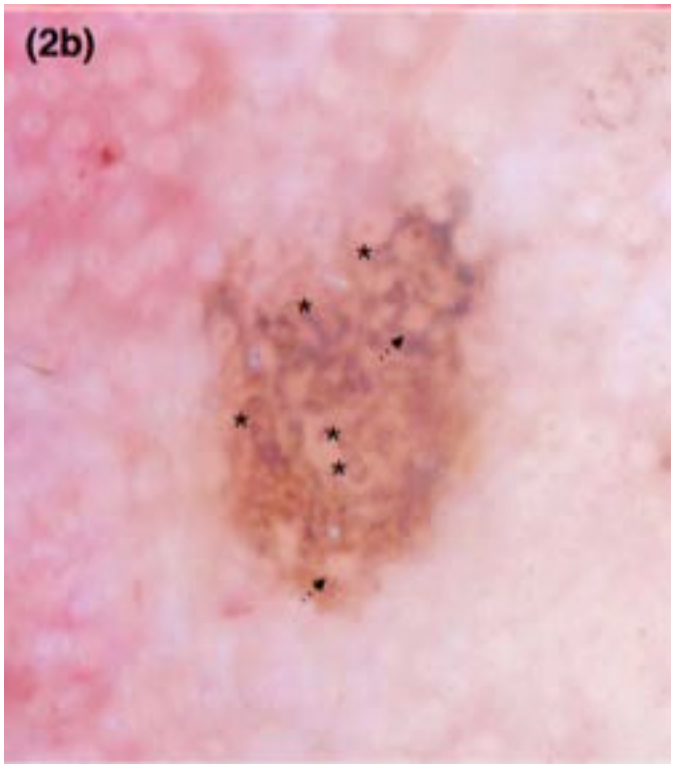


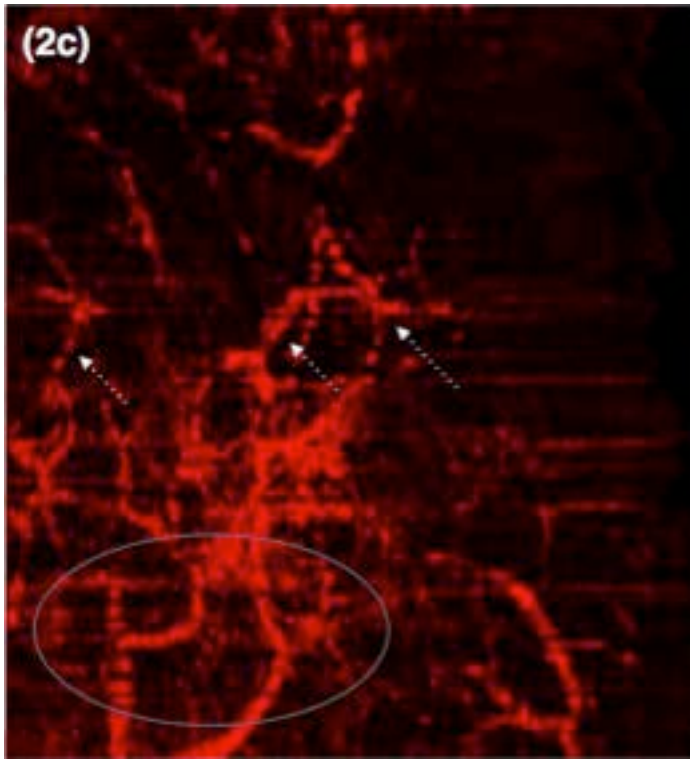
Figure 1. Dermoscopic (A-B) and non-invasive svOCT *en face* images (C-D) and dynamic animations (E-F) of facial sebaceous hyperplasia and basal cell carcinoma (BCC) skin cancer. The sebaceous hyperplasia lesion shows the characteristic crowning of linear and curved vessels (*) around aggregated pale yellow and white lobules at the center of the lesion (dashed circle) under dermoscopy (1a). The svOCT image of the sebaceous hyperplasia reveals the same thick, radiating appearing vessels (*) focally distributed along the periphery of the lesion consisting of a moderate vessel density (1c). In contrast, the non-pigmented BCC lesion showed thin, irregular tree-like arborizing vessels (*) with a translucent, white-to-pinkish background (dashed circle) under dermoscopy (1b). However, the svOCT image of the BCC shows a disarray of thin, irregular vessels (*) and a well-demarcated, focal disorganized pattern consisting of a high vessel density throughout the lesion (circle) surrounded by normal anatomic facial telangiectasias (dashed arrows) (1d). 1e and 1f show the svOCT dynamic animations of the lesions where both present with focal vascular patterns yet the basal malignancy shows a more irregular vascular distribution with finer vessels more densely organized compared to the benign sebaceous tumor.

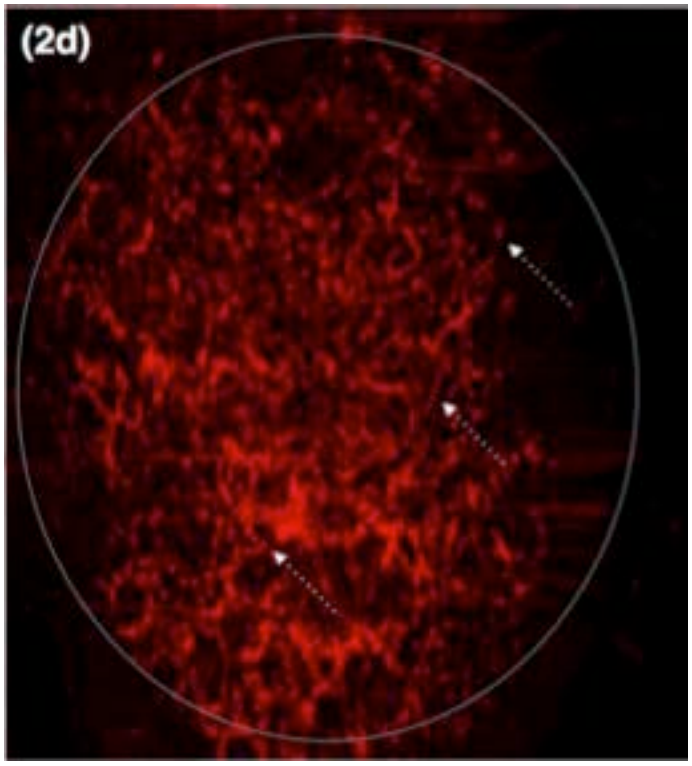
One common set of skin colored papules of the face that are difficult to differentiate is sebaceous hyperplasia and basal cell carcinoma. Under dermoscopy (Dermlitephoto, 3Gen, S. Juan Capistarano, CA, USA), the sebaceous hyperplasia lesion showed the characteristic crowning of linear and curved vessels surrounding pale yellow-white lobules at the center of the lesion (Fig 1a) [4, 5]. The corresponding svOCT image for sebaceous hyperplasia revealed the same thick, radiating appearing vessels focally distributed along the periphery of the lesion consisting of moderate vessel density (Fig 1c) mirroring the “crowned vessels” typical of sebaceous hyperplasia under dermoscopy. In contrast, the non-pigmented basal cell carcinoma (BCC) lesion showed thin,

irregular tree-like arborizing vessels and a translucent, white and shiny background under dermoscopy (Fig 1b), features consistent with basal cell cancer [4, 5]. However, the corresponding svOCT image of the BCC showed a different vascular pattern than dermoscopy with a disarray of thin, irregular vessels well-demarcated and focally distributed throughout the lesion consisting of high vessel density surrounded by normal anatomic facial telangiectasias (Fig 1d). Both lesions presented with a focal vascular pattern on svOCT dynamic animations, yet the basal malignancy showed a more erratic vascular organization with finer, more densely distributed vessels compared to the benign sebaceous tumor (Fig 1c, 1e).









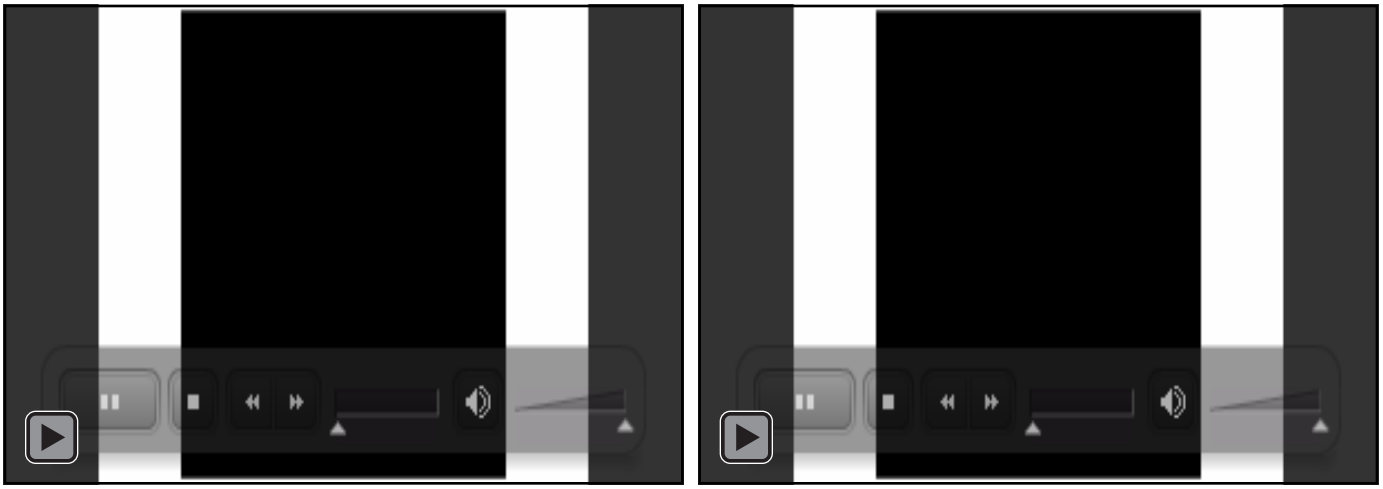


Figure 2. Dermoscopic (A-B) and non-invasive svOCT *en face* images (C-D) and dynamic animations (E-F) of facial pigmented actinic keratosis (AK) and malignant melanoma *in situ* (MMIS). The pigmented AK shows scale (dashed arrows) and an annular-granular pattern around pigmented follicular openings (*) on dermoscopy (2a), whereas the corresponding svOCT image illustrates thick (circle) and thin (dashed arrows) branching vessels with the thick normal anatomic facial telangiectasias focally organized consisting of a high vessel density (circle) surrounded by thinner, broken, less organized vessels at the periphery consisting of a marked reduction in vessel density (dashed arrows) (2c). The pigmented MMIS shows gray dots granules around follicular openings (*) as well as the formation of early rhomboidal structures (dashed arrows) on dermoscopy (2b), whereas the corresponding svOCT image illustrates diffuse thin, irregular vessels (dashed arrows) spanning the entire *en face* field (2d). 2e and 2f show the svOCT dynamic animations of the lesions where both show some vascular irregularity yet the MMIS shows a more erratic and diffuse disorganization with thinner more densely distributed vessels compared to the pigmented AK.

Another set of facial lesions that are difficult to differentiate is pigmented actinic keratosis (AK) and malignant melanoma *in situ* (MMIS). Dermoscopic observation of the biopsy-proven pigmented AK showed an annular-granular pattern around pigmented follicular openings with scale (Fig 2a) [4, 6] whereas the pigmented MMIS lacked scale and had the classic dermoscopic gray dots granules around follicular openings in addition to the formation of early rhomboidal structures (Fig 2b) [4, 7]. The corresponding svOCT pattern for the pigmented AK illustrated thick and thin branching vessels with the thicker normal anatomic facial telangiectasias focally organized surrounded by thinner, broken, less organized vessels at the periphery consisting of a marked reduction in vessel density (Fig 2c). In contrast, the svOCT of the MMIS revealed diffuse thin, irregular vessels dispersed throughout the entire *en face* field irrespective of the small lesion size (Fig 2d). Both lesions showed some vascular irregularity on svOCT dynamic animations, yet the MMIS revealed the presence of a diffuse more irregular vascular pattern with thinner more densely distributed vessels compared to the minimal vascular irregularity seen in the pigmented AK (Fig 2c, 1e).

Discussion

The most common non-invasive technique demonstrated to increase diagnostic accuracy in *en face* mode is dermoscopy. Dermoscopy, as an adjunct to clinical examination, permits the recognition of specific patterns making it useful to diagnose both pigmented and non-pigmented skin lesions. Optical coherence tomography, another non-invasive modality, has also been used to facilitate diagnosis of non-melanoma skin cancer using cellular architecture. The novel svOCT method now enables the visualization of micro-vascular changes for not only non-melanoma skin cancers but potentially for melanoma and other pigmented lesions.

To date, OCT findings have focused on the trans-vertical imaging technique. Our preliminary data demonstrates the ability of the dynamic *en face* visualization method to identify different vascular patterns while eliminating cellular information. Specifically, when differentiating varying skin malignancies both vessel organization and vascular thickness are useful features. In summary, thin irregular vessels are minimally seen in actinic keratosis followed by their presence throughout the basal cell tumor, and their diffuse spanning of the entire *en face* field in MMIS. However, the benign sebaceous hyperplasia showed well-organized thick vessels lacking the irregularity seen in the malignant lesions. These observations suggest the clinical value of this innovative method to help characterize both pigmented and non-pigmented early skin cancers. Our findings from these four cases should be confirmed in future studies with a larger series to verify these conclusions.

References

1. Mahmud MS, Cadotte DW, Vuong B, Sun C, Luk TWH, Mariampillai A, Yang VXD. Review of speckle and phase variance optical coherence tomography to visualize microvasular networks. Journal of Biomedical Opetics. 2013;18(5):509-1001. [PMID: 23616094]
2. De Carvalho N, Ciardo S, Cesinaro AM, Jemec GBE, Ulrich M, Welzel J, Holmes J, Pellacani G. In vivo micro-angiography by means of speckle-variance optical coherence tomography (SV-OCT) is able to detect microscopic vascular changes in naevus to melanoma transition. JEADV. 2015.
3. Lee KKC, Mariampillai A, Yu JXZ, Cadotte DW, Wilson BC, Standish BA, Yang VXD. Real-time speckle varience swept-source optical coherence tomography using a graphics processing unit. Biomed Opt Express. 2012;3(7):1557-1564.
4. Kittler H, Marghoob AA, Argenziano G, Carrera C, Curiel-Lewandrowski C, Hofmann-Wellenhof R, Malvehy J, Puig S, Rabinovitz H, Stolz W, Saida T, Soyer HP, Siegel E, Stoecker WV, Scope A, Tanaka M, Thomas L, Tschandl P, Zalaudek I, Halepern A. Standardization of terminology in dermoscopy/dermatoscopy: Results of the third consensus conference of the International Society of Dermoscopy. J Am Acad Dermatol. 2016. [PMID: 26896294]
5. Markowitz O, Utz S. Differentiating Early Stage Cystic Keratoacanthoma, Nodular Basal Cell Carcinoma, and Excoriated Acne Vulgaris by Clinical Exam, Dermoscopy, and Optical Coherence Tomography: A Report of 3 Cases. 2015;8(41):48-50. [PMID: 26060518]
6. Laureano A.Melanoma in situ or superficial basal cell carcinoma?. Dermatol Online J. 2015;21(6). [PMID:26158373]
7. Bugatti L, Filosa G. Dermoscopy of lichen planus-like keratosis: a model of inflammatory regression. J Eur Acad Dermatol Venereol. 2007;21(10):1392-7. [PMID: 17958847]