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Comparative analysis of total body vs. dermatoscopic photographic monitoring of nevi in similar patient populations at risk for cutaneous melanoma

Agnessa Gadeliya Goodson, MD^a, Scott R. Florell, MD^a, Mark Hyde, PA-C^b, Glen M. Bowen, MD^{a,b}, and Douglas Grossman, MD, PhD^{a,b}

^aDepartment of Dermatology, University of Utah Health Sciences Center

^bHuntsman Cancer Institute, University of Utah Health Sciences Center

Abstract

Background—Our previous experience monitoring nevi in high risk patients by serial digital epiluminescence microscopy (DELM) photography achieved low biopsy rates, but was limited by melanomas presenting as new lesions or arising from nevi that had not been photographed.

Objective—To determine whether biopsy rates, efficiency of melanoma detection, and melanoma origin (*de novo* vs. nevus-derived) differed in a similar patient population monitored by total body (TB) photography.

Methods—1076 patients (including 187 from prior cohort) underwent TB photography and were monitored using photographs obtained at the initial visit. Risk factors and median monitoring periods for these patients were comparable to patients previously monitored by DELM photography.

Results—275 biopsies were performed in 467 patients on follow-up visits. Of 12 melanomas detected on follow-up, five were invasive; five presented as changing lesions and two as new lesions; nine arose *de novo* and the remainder was nevus-derived.

Conclusions—In our experience with both approaches, monitoring patients at risk for melanoma by TB (compared to DELM) photography was associated with lower biopsy rates and lower nevus to melanoma ratios, and facilitated detection of both new and changing lesions. In both cohorts, the majority of melanomas detected on follow-up arose *de novo*.

INTRODUCTION

Effective early detection of melanoma can greatly decrease patient mortality, and screening efforts are most effective when directed at patients with established risk factors, such as personal or family history of melanoma¹ and presence of numerous nevi or clinically atypical nevi.^{2, 3} There is currently no consensus, however, regarding the most effective melanoma screening modality or strategic approach to the patient with nevi.⁴

Although multiple non-invasive modalities are currently available and on the horizon which may augment visual detection,⁴ histologic examination following biopsy remains the gold standard for melanoma diagnosis. Unfortunately, this often leads to numerous unnecessary biopsies in some patients. Morphologic change in a lesion may be the most sensitive

indicator of melanoma development, as several monitoring studies have revealed that most early melanomas exhibit observable changes over a period of months.^{5, 6} Hence, the addition of the letter “E” for *evolving* to the ABCD acronym to increase its sensitivity and specificity.⁷ While patients are often able to detect new and changing lesions by self-skin examination,⁸ confirmation of change can only be reliably accomplished with “side-by-side” comparisons in which individual lesions can be viewed simultaneously at two points in time. There are two established photographic approaches in which previously taken photographs are referred to during the clinical examination for the purpose of documenting changes in nevi over time. The first approach, described in several studies,⁹⁻¹¹ involves monitoring suspicious nevi using digital epiluminescence (dermatoscopic) microscopy (DELM) photographs taken both at initial and follow-up visits, and is geared towards detecting subtle changes in pre-existing nevi. An alternate approach, also documented in several studies,^{3, 5, 12, 13} entails photographing existing nevi as well as uninvolved areas of skin by total body (TB) photography, and then using these regional photographs as a baseline for comparison during follow-up examinations. This method is well-suited to detect new lesions, although its capacity to detect changing lesions may be limited by the resolution of the photographs.

We have had the opportunity over the past decade to utilize both these methods of photographic comparison in our early melanoma detection program. During the period 1999-2004, we monitored 5,945 lesions on 297 patients at increased risk for melanoma by serial DELM photography.¹⁴ While we achieved a low biopsy rate (1.1 biopsies per patient over a 4.5 year period), only one of six melanomas detected on follow-up was biopsied due to photographic change, while the remaining melanomas arose *de novo* or from clinically non-suspicious nevi not initially photographed. Over the past five years (2004-2009), we monitored a similar group of patients using TB photography. Our objective was to determine prospectively whether biopsy rates, rate of melanoma detection, and melanoma derivation (nevus-derived vs. *de novo*) differed in a similar patient population monitored by TB vs. DELM photography. We report here that monitoring patients by TB photography was associated with lower biopsy rates and lower nevus to melanoma ratios than DELM photography, and facilitated detection of both new and changing lesions. In addition, TB photography was found to be a more time-efficient approach.

METHODS

Patient population

A total of 1076 individual patients were seen in the Mole Mapping Clinic at the Huntsman Cancer Institute during the study period. This number included 889 new patients and 187 established patients (out of 297 from our previously described cohort monitored by serial DELM photography using the MoleMax system from 1999-2004).¹⁴ One hundred ten of the previously monitored patients were lost to follow-up and did not return during the study period. Patients were primarily from Salt Lake City and its environs, but also included many patients referred throughout the intermountain West. Patients included those having one or more of the following melanoma risk factors: ≥ 3 clinically atypical nevi (77%), 50-100 nevi (40%, with 28% having greater than 100 nevi), personal history of melanoma (26%), and ≥ 2 family members with history of melanoma (10%). A small number of patients (1-2% of total) did not have one of these risk factors, but were also monitored by photography if they had extensive lentiginosis (such that detecting new or changing nevi would be difficult) or were referred by other dermatologists who deemed them to be at increased risk. The study population consisted of patients with roughly the same proportions of risk factors as those in the previous DELM-based study.¹⁴

Study design

This study was approved by the Institutional Review Board of the University of Utah. From July 2004 to May 2009, biopsies of all melanocytic lesions, and the physician notes dictated on the day biopsies were performed, were reviewed during the course of the study. The identity of the lesion, the motivation for performing the biopsy, and the role of photographic comparison were ascertained. Biopsies of non-melanocytic lesions and all re-excision specimens were excluded from the study.

Clinical examination and photography

At the initial visit, all patients underwent complete skin examination. In a separate dedicated room, approximately 27 regional photographs were taken based on standard poses¹⁵ to capture both nevus-bearing and “nevus-free” areas of skin. In some cases additional photographs were taken to monitor more closely clinically atypical lesions identified either in other locations (such as the scalp, pubic area, between toes) or on curved surfaces (such as the shoulder or hip). A FinePix S2 Pro digital camera (Fujifilm U.S.A., Valhalla, NY) was used with a SB-800 AF Speedlight flash (Nikon Inc., Melville, NY). All photos were taken at a resolution of 3024 × 2016 pixels, and stored using password-protected MIRROR™ DermaGraphiX software (Canfield Imaging Systems, Fairfield, NJ) on our institution's server. For most patients, the photography session was completed in approximately 15 minutes. Photographs were also stored as jpg files on a CD-ROM which was placed in the patient's chart, to be used in the event of a problem with the wireless connection or the server. Patients were charged for the physician visit, but not for photography. Patients were asked to return at 6 or 12 month intervals (based on perceived risk) for follow-up, and were counseled on the importance of sun protection as well as monthly self-skin examinations.

At each follow-up visit, patients underwent complete clinical examination. All clinically suspicious lesions were then assessed by hand-held non-contact dermatoscopy (Dermlite II Pro HR, 3Gen, San Juan Capistrano, CA). Photographs from the initial visit were retrieved via a 50 Mb per sec wireless connection and projected on a Compaq 8710w mobile workstation with a 17-inch screen (Hewlett-Packard, Palo Alto, CA). New lesions were appreciated by “side-by-side” comparisons with baseline photographs. To assess changes in pre-existing lesions, comparisons were facilitated using the DermaGraphiX built-in zoom function to magnify particular lesions within baseline images.

Biopsies: indications and technique

Lesions suspicious for melanoma (including those representing “ugly ducklings”¹⁶ or the most clinically atypical lesion on the patient), as well as those associated with patient concern (subjective change in appearance or symptoms), were biopsied prior to photography on new patients. In addition, lesions were removed if deemed poorly suited for photographic surveillance – such as very dark lesions in which pigmentary changes would be difficult to assess. Indications for biopsy on follow-up visits included patient concern or physician concern for melanoma, new lesions that were clinically atypical or arising in patients over age 50,¹⁷ and pre-existing lesions that demonstrated significant photographic (particularly asymmetric) changes.

Biopsies were performed using either standard shave or punch technique, or in some cases elliptical excision, such that the entire clinical lesion was removed. Shave biopsies were generally used for macular or larger lesions, while punch biopsies were performed on smaller and/or papular lesions. In some cases, re-excision was subsequently performed to ensure complete lesion removal.

Histologic review

All biopsies were evaluated by one of three dermatopathologists, one of whom (S.R.F.) also re-reviewed all of the melanomas and any cases where there was insufficient information in the pathology report. The histologic diagnosis of common nevi (CN, banal and congenital), dysplastic nevi (DN), and melanomas was based on architectural and cytologic criteria.¹⁸ Pigmented spindle cell nevi, Spitz nevi, and blue nevi were grouped as “other nevi”. For DN, architectural disorder was defined by irregular placement of melanocytic theques along the tips and sides of elongated and fused rete. Concentric eosinophilic fibroplasia of the papillary dermis was present. “Mild” cytologic atypia of melanocytes was characterized by nuclear enlargement similar to the size of a keratinocyte nucleus with finely granular pigmented cytoplasm. Dermal melanocytes were arrayed in nests that showed nuclear and cytoplasmic maturation with progressive descent. “Moderately” atypical DN demonstrated prominent fibroplasia of the dermis with entrapment of dermal melanocytic nests and a host response of lymphocytes. “Severely” atypical DN demonstrated asymmetry, poor circumscription, and stretches where single melanocytes predominated over nests with limited pagetoid scatter of single melanocytes above the dermoepidermal junction. Melanoma in-situ (MIS) showed asymmetry, poor circumscription, and prominent pagetoid scatter of single and nested melanocytes. Invasive melanomas revealed atypical melanocytes forming irregular nests and sheets with lack of nuclear or cytoplasmic maturation with descent, and mitotic activity in dermal melanocytes.¹⁹

Statistics

Statistical analysis was performed using R 2.8.0 statistical software (Copyright 2008, The R Foundation for Statistical Computing, Vienna, Austria). P values of ≤ 0.05 were considered statistically significant. For comparison of biopsy rates, a Poisson distribution was assumed, and a likelihood ratio test based on a Poisson regression model was used. For comparison of ratios (melanoma rates, melanoma detection rates, melanoma derivations), a two-sided Fisher's Exact test was used.

RESULTS

Patient monitoring

During the study period, 1076 patients underwent TB photography. Of these 1076 patients, 467 patients (43%) returned for at least one follow-up visit, 253 had at least two follow-up visits, and 141 had three or more follow-up visits. The fraction of patients not returning for at least one follow-up (57%) was lower than in our previous cohort,¹⁴ and primarily consisted of patients who changed their health insurance carrier, moved out of state, or were not due for follow-up examination prior to the study end date (i.e. newly-seen patients). The total monitoring period for individual patients with at least one follow-up visit ranged from 2 to 54 (median 24) months, and was comparable to the previous cohort.¹⁴ Of the 467 patients with at least 1 follow-up visit, 71 patients had less than one year of follow-up, 396 patients had at least one year of follow-up, 238 patients had at least two years of follow-up, and 30 patients had over four years of follow-up.

Biopsies performed

A total of 548 biopsies were performed in 1076 patients during the study period, corresponding to overall biopsy rates of 0.51 per patient and 0.27 per visit. Approximately half (50%) of the biopsies were performed on the initial visit, while the remainder were on follow-up visits. Biopsies on initial and follow-up visits yielded a similar distribution of melanocytic lesions: most were nevi (DN more predominant than CN) and the remaining

were relatively small numbers of Spitz nevi, DN with severe dysplasia, MIS, and invasive melanomas (Figure 1A).

Of 273 biopsies performed on the initial visit, the majority (91%) were nevi (53% DN, 38% CN). One hundred ninety-nine of these 273 (73%) lesions represented the most atypical or “ugly duckling” nevus; 130 (65%) of these were DN (including three with severe dysplasia), 45 (23%) were CN, and 16 (8%) were melanomas (8/16 invasive, see below). Of 275 biopsies performed on follow-up visits, 243 (88%) were nevi with DN predominating over CN (55% vs. 33%). Eight of the DN were severely dysplastic, and in addition 12 melanomas (five invasive, see below) were biopsied on follow-up visits.

Role of photographic comparison

Of the 275 biopsies performed on follow-up visits, 168 (61%) were motivated by photographic comparison, which identified either a new or changing lesion. The remaining 107 (39%) of biopsies corresponded to lesions where there was no photographic change (primarily biopsied due to patient concern) or the photograph was not helpful (lesion out of focus or obscured). In a few cases, the photograph was not reviewed. Changing lesions were more commonly biopsied than new ones, but in both groups there was a similar distribution of melanocytic lesion subtypes, with DN being most common for each (Figure 1B). There were 148 lesions that demonstrated significant photographic change, the majority of which (91%) proved to be nevi, with DN predominating over CN (74% vs. 17%). The remaining lesions were eight pigmented spindle or Spitz nevi, three MIS, and two invasive melanomas (Figure 1B). Thus for lesions exhibiting significant photographic change, the majority proved to be DN and only five were melanomas (see below). The most common types of observed changes prompting biopsy were altered (usually increased) pigmentation or color that was non-uniform throughout the lesion, asymmetric enlargement, change in shape/border, or a combination of these features. Lesions demonstrating symmetric enlargement (particularly in younger patients), or uniform pigmentary/color change (thought to be secondary to sun exposure or irritation), were generally not biopsied. Of 148 lesions biopsied due to photographic change, patient concern was only noted in 22 (15%), two of which proved to be melanoma.

Of 20 new lesions detected by photography that were biopsied, 13 (65%) were nevi that were almost exclusively DN (12 DN vs. 1 CN) and the remaining lesions consisted of four pigmented spindle cell or Spitz nevi, two melanomas (one invasive, see below), and one blue nevus (Figure 1B). We identified many additional new lesions, but the majority of these were not biopsied since in most cases the patient was not concerned, the lesions presented in younger patients¹⁷ and tended to be symmetric and uniformly pigmented, and did not represent ugly duckling-type lesions. Thus while TB photography was useful in identifying new lesions, these other factors often played a role in the decision to biopsy. Nevertheless, only 5/20 (25%) of new lesions biopsied were associated with patient concern, and two of these proved to be melanoma.

There were 56 lesions biopsied on follow-up that did not appear to have changed by photographic comparison, and in all 56 cases the biopsy was motivated by patient concern. In most cases the lesion had been irritated, traumatized, or was associated with subjective symptoms such as itching. Most (46/56, 82%) of these lesions proved to be CN, while the remainder consisted of eight DN and two pigmented spindle cell nevi.

Finally, 51 lesions were biopsied for which the baseline photograph was not deemed useful. The most common reasons for this included the lesion of interest being covered by undergarments or hair, or lacking sufficient focus in the photograph. In 13 cases the physician did not review the photograph, usually because the lesion did not clinically appear

to be melanocytic, or the patient was concerned about a lesion which clinically appeared benign. Three lesions for which the photograph was not viewed proved to be melanoma (see below).

Melanomas

A total of 28 melanomas were detected during the study period, 16 of them on the initial visit and 12 on follow-up visits (incidence 0.026 per patient) (Figure 1A). Of the 16 melanomas diagnosed on the initial visit, eight (50%) were invasive, ranging from 0.25 to >3 mm in depth (average depth 0.83 mm, median 0.39 mm). Figure 2A illustrates the role that TB photography played in the detection of melanomas and DN with severe dysplasia. Melanomas were categorized with respect to motivation for biopsy and the role of photographic comparison. As indicated, all 16 melanomas represented the most clinically atypical lesion on initial examination (Figure 2A).

Of the 12 melanomas detected on follow-up, five were invasive, ranging from 0.19 to 0.65 mm in depth (average depth 0.38 mm, median 0.36 mm). For three of five patients diagnosed with invasive melanoma on follow-up, an extended period of time had elapsed since the previous visit (one patient, 1.5 years; two patients, 3 years). Five melanomas were detected due to morphologic changes (Figure 3A), and two presented as new lesions (Figure 3B). The two melanomas presenting as new lesions were 3 mm and 4 mm in diameter at the time of biopsy. As indicated in Figure 2A, for two melanomas it was unclear from prior photos whether the lesion had changed, and there were three melanomas in which prior photos were not assessed (two of which were clinically amelanotic and biopsied to rule out basal cell carcinoma). Importantly, no melanomas were detected when there was no photographic change (Figure 2A).

Slides for all melanomas were re-reviewed to assess whether or not they arose within pre-existing nevi. Melanomas detected on initial and follow-up visits are categorized in Figure 2B with respect to derivation. While only 6/16 (38%) of melanomas diagnosed on the initial visit arose *de novo*, this was the case for most (9/12, 75%) lesions diagnosed on follow-up visits. For both initial and follow-up visits, the nevus-derived melanomas were more likely to have arisen from pre-existing DN rather than CN (Figure 2B). For the MIS, 9/15 (60%) arose *de novo*; of the six remaining lesions, five were associated with DN and one with CN. For the invasive melanomas, 6/13 (46%) arose *de novo*, four were associated with DN, and three were associated with CN. There were no melanomas derived from pre-existing Spitz nevi (Figure 2B).

In addition to the 28 melanomas detected during the course of this study, 11 DN with severe dysplasia were also re-reviewed. The majority of these lesions were identified by photographic comparison. Six DN with severe dysplasia presented as changing lesions, one was identified as a new lesion (Figure 3C), and three were identified as the most atypical lesion on new patients.

Comparative analysis of photographic approaches

We determined the overall biopsy rate, melanoma detection rate, and origin (nevus-derived vs. *de novo*) for all the melanomas. A comparison of these key parameters with those obtained in the previous cohort monitored by DELM photography¹⁴ is detailed in Table 1. A total of 275 biopsies were performed in 467 patients on follow-up visits, giving a rate of 0.59 biopsies per patient (vs. 1.1 per patient in the prior cohort, $p<.001$). Twelve melanomas were represented in these 275 biopsies, corresponding to a melanoma detection rate of 4.4% (vs. 1.9% in the prior cohort, $p=.093$). If lesions biopsied without photographic change are excluded, the detection rate increases to 5.5% (vs. 2.2% in the prior cohort, $p=.088$) and the

difference approaches statistical significance. Of the 12 melanomas detected on follow-up, only three (or 25%) were nevus-derived (vs. 1/6 or 17% in the prior cohort, $p=1.00$). Thus, we found that monitoring patients by TB photography was associated with a lower biopsy rate and higher melanoma detection rate (lower nevus to melanoma ratio) than in our prior study using DELM photography. Similar to our finding in the prior cohort, the majority of melanomas detected on follow-up arose *de novo* rather than from pre-existing nevi.

DISCUSSION

Several groups have recently reported their experiences monitoring patients at risk for melanoma with either serial DELM photography^{10, 11, 20} or TB photography.^{5, 12, 17, 21} Compared to prior studies using TB photography reported in the literature,^{3, 5, 12, 17, 21-25} our study presented here describes the largest number of patients and melanomas detected (to our knowledge). More importantly, we have been able to evaluate this approach in the context of our prior experience with serial DELM photography¹⁴ involving the same physicians seeing a similar patient population. Five years ago, we began using TB photography to address critical limitations we found in our preceding experience with serial DELM photography¹⁴ – namely melanomas presenting as new lesions or arising in benign-appearing nevi that had not been previously photographed.

The validity of comparing the results here with those from our previous photographic study¹⁴ is justified by a similar composition of melanoma risk factors in the patients from each cohort. In fact, over 60% of the patients in the prior study were part of the second cohort described here. Moreover, we found comparable rates of melanoma incidence in the two groups (0.026 vs. 0.020 per patient, $p=.81$) monitored by TB compared to serial DELM photography, consistent with the two populations representing individuals with similar melanoma risk. We monitored a greater number of patients with TB photography (467 vs. 297), but the range (2-54 vs. 3-52 months) and median (24 vs. 22 months) for the monitoring periods were comparable (Table 1). For both cohorts, far fewer lesions were biopsied compared to what one might expect from the common practice of many dermatologists to remove one or two atypical nevi at each visit.⁴ One study of melanoma patients (approximately one third with numerous nevi) in which photography was not used, reported an average of 17 nevi (from those with numerous nevi) and three nevi (from entire cohort) removed per patient over a four-year period.²⁶ By contrast, we achieved extremely low biopsy rates on follow-up visits with both approaches (0.59 biopsies per patient with TB photography vs. 1.1 per patient with DELM photography,¹⁴ $p<.001$, Table 1). The significantly higher biopsy rate with DELM photography may be a consequence of the greater sensitivity for detecting morphologic changes in nevi due to higher resolution of these photographs, and the fact that we were more likely to biopsy lesions exhibiting photographic change. In the previous study,¹⁴ however, we had only one case where a changing nevus proved to be a melanoma. Thus serial DELM photography appears more likely to identify morphologic changes that are histologically (or clinically) insignificant.

We found a higher rate of melanoma detection in patients monitored by TB photography (5.5% vs. 2.2%, Table 1). Our previous finding that lesions exhibiting subtle dermatoscopic changes rarely proved to be melanoma¹⁴ may account for the lower detection rate with DELM monitoring. On the other hand, the higher detection rate we found with TB photography suggests that this method may be more specific for melanoma detection. Although the invasive lesions detected in both cohorts on follow-up were all stage IA, a greater fraction of melanomas were *in situ* (7/12 vs. 2/6, Table 1) in patients monitored by TB photography. We might have expected to detect more melanomas with TB photography given its predicted capacity to detect melanomas arising *de novo* and from clinically non-atypical nevi, although prescient removal of DN with severe dysplasia (eight lesions) on

follow-up visits could have decreased the detection rate since some of these lesions may have progressed to melanoma and been detected later.

Although not a primary motivator for changing our monitoring approach, we had found serial DELM photography to be very cumbersome given the time required (up to 45 min) to photograph numerous atypical nevi on the initial and (every) follow-up visit. While most patients required 30-50 min at each visit for clinical examination and photography or photographic comparison, we found that with TB photography the photographs could be obtained in 15 min such that the initial visit required 20-30 min and follow-up visits only 10-20 min (Table 1). Thus TB photography was more time-efficient, and may have accounted for a higher follow-up compliance rate than we observed in our prior study.¹⁴

In evaluating the role of photography on the physician's decision to biopsy, we acknowledge the influence of several potential confounding factors. These include patient concern, which motivated biopsies in cases where there was no photographic change, and patient age and lesion morphology, which played a significant role in the decision to biopsy new lesions. In comparing our two cohorts, it is worth noting that patient concern also likely played a role in the prior study in which a similar patient population was monitored by the same physicians operating in the same medicolegal environment. Of 168 lesions biopsied as a result of photographic comparison, however, patient concern was only noted in 27 (16%), thus TB photography identified many new and changing lesions that patients were unaware of. Photographic change may be more reliable than patient history, as the melanoma detection rate was 3/141 (2.1%) for lesions biopsied in which there was photographic change but no patient concern, and 0/56 (0%) for lesions biopsied solely because of patient concern.

We recognize that these two photographic approaches have inherent limitations that may bias which lesions are selected for biopsy. While serial DELM photography is highly sensitive for detecting changes in nevi over time, this approach is necessarily limited to detecting changes in a subset of pre-existing nevi and cannot detect new lesions. On the other hand, TB photography is geared towards detecting new lesions and its capacity to detect changing lesions is necessarily limited by the resolution of the photographs. Given these considerations, we might have expected a greater proportion of melanomas detected by DELM monitoring to be nevus-derived and a greater fraction of those detected by TB photography to present as new lesions. In both cohorts however, we found that a similarly small fraction of the melanomas (25% vs. 17%) detected on follow-up were nevus-derived, with the majority arising as *de novo* lesions (Table 1). Our findings are consistent with other monitoring studies^{3, 5} and histologic studies,²⁷⁻²⁹ suggesting that most melanomas arise *de novo* rather than from pre-existing nevi. Given this tendency of melanoma origin, one would predict that TB photography is better suited than serial DELM as a solitary strategy for early melanoma detection. Such would be particularly true for older patients with fewer nevi in whom melanoma would be more likely to present as a new lesion rather than as a changing nevus. Serial DELM, however, may be better suited for young individuals with a few clinically atypical nevi who will likely develop many new lesions, making it difficult to establish a baseline using TB photography. Thus a combined approach, in which selected regional photographs are used along with DELM monitoring, or in which DELM photographs of a subset of the most clinically atypical nevi are taken in patients monitored by TB photography, is probably optimal. However, incorporating two photographic systems will not be feasible for most practitioners. When we switched from serial DELM monitoring to TB photography five years ago, our hope was that the photographs would be of sufficient resolution to detect clinically significant changes. While it is possible that DELM monitoring could have detected some of the melanomas earlier, most (4/5) invasive melanomas we detected on follow-up were not nevus-derived. Thus DELM monitoring may only have resulted in earlier detection of these lesions if photography was performed *after*

the melanomas developed. In these cases of invasive melanoma detected on follow-up, the most important factor associated with delayed diagnosis was increased amount of time since the previous visit (1.5 years for one patient, 3 years for two patients). Therefore, as with any planned medical intervention, patient compliance is always a significant limitation of efficacy.

In summary, we have had the unique opportunity to compare two conventional photographic approaches in a similar patient population at increased risk for melanoma. In our experience, monitoring by TB photography appears to have advantages over serial DELM photography: it is more time-efficient and associated with lower biopsy rates and higher melanoma detection rates. Its greatest limitation appears to be patient compliance with timely follow-up examinations.

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Abbreviations

CN	common nevi (benign, congenital)
DELM	digital epiluminescence (dermatoscopic) microscopy
MIS	melanoma <i>in situ</i>
DN	dysplastic nevi
TB	total body

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Fig 1. Histologic distribution of melanocytic lesions biopsied in this study. **(A)** Breakdown of total (548) biopsies by initial and follow-up visits. **(B)** Breakdown of 275 biopsies performed on follow-up visits by whether lesions were judged to be changing or new (based on comparison to baseline photographs).

Fig 2.

Analysis of melanomas detected in this study. **(A)** DN with severe dysplasia, MIS, and invasive melanomas (MM) categorized by presentation and role of photography in the decision to biopsy. **(B)** The 28 melanomas in the study are categorized by detection on initial and follow-up visits, and broken down as to whether they arose *de novo* or from a pre-existing nevus.

Fig 3.

Examples of lesions identified by photographic comparison in this study. Baseline photographs in left panel, and photographs taken of same region on follow-up visit (lesion of interest denoted by arrow) in right panel. Dates of each photograph are indicated. **(A)** Invasive melanoma (depth 0.20 mm) detected as changing lesion on the back of a 41-year-old male. It had been three years since the previous visit. **(B)** Lentigo maligna (MIS) detected as a new lesion on the cheek of a 47-year-old male. It had been eight months since the previous visit. **(C)** DN with severe dysplasia identified as a new lesion on the back of a 50-year-old female. It had been 15 months since the previous visit.

Table 1

Comparison of photographic approaches

	1999-2004^a	2004-2009^b
Photographic approach	Serial DELM photography	TB photography
Time for initial visit (clinical exam and photography)	30-50 min	20-30 min
Time for follow-up visit (exam and photo comparison)	30-50 min	10-20 min
Patients with ≥ 1 follow-up visit	297	467
Monitoring period	3-52 (median 22) months	2-54 (median 24) months
Biopsies on follow-up visits	324 (1.1 per patient)	275 (0.59 per patient), $p < .001$
Melanomas on follow-up visits	6 (2 MIS, 4 invasive) 0.020 per patient	12 (7 MIS, 5 invasive) 0.026 per patient, $p = .81$ odds ratio 0.81 (0.24-2.28) ^c
Melanoma detection rate on follow-up visits	1.9% (nevus : melanoma ratio = 53) 2.2% ^d (nevus : melanoma ratio = 45) ^d	4.4%, $p = .093$ odds ratio 2.41 (0.82-7.95) ^c (nevus : melanoma ratio = 22) 5.5%, $p = .088$ ^d odds ratio 2.57 (0.88-8.51) ^d (nevus : melanoma ratio = 17) ^d
Depth of invasive melanomas on follow-up visits	0.23-0.35 mm	0.19-0.65 mm
Derivation of melanomas on follow-up visits	1/6 nevus-derived (1 DN)	3/12 nevus-derived, $p = 1.0$ odds ratio 1.61 (0.096-100) ^c (1 CN, 2 DN)

^a As described in Fuller et al.¹⁶^b Present study.^c Odds ratios (95% confidence intervals) computed with second odds (present study) in numerator.^d Excluding lesions biopsied without photographic change.