Improved Identification of Potentially Dangerous Pigmented Skin Lesions by Computerized Image Analysis

Maria Jasmin Jamora, MD; Brent D. Wainwright, MD; Shane A. Meehan, MD; Jean-Claude Bystryn, MD

Background: Melanoma is completely curable if resected early. Unfortunately, early melanoma can be difficult to differentiate from other pigmented lesions. Computerized image analysis instruments have now been developed to assist in determining whether a pigmented lesion is potentially dangerous and requires biopsy. To evaluate whether one such instrument can improve the management of pigmented lesions, we obtained biopsy specimens from 52 pigmented lesions that appeared clinically benign to an experienced dermatologist but were suspicious by image analysis.

Observation: Histologically, 9 (17%) of the lesions that were removed based solely on computer recommendation were potentially dangerous and should have been removed. These included 1 malignant melanoma in situ and 8 dysplastic nevi with moderate to severe cytologic atypia.

Conclusion: The results of the present study indicate that computerized image analysis can improve the evaluation of pigmented skin lesions by identifying clinically unsuspicious, but potentially dangerous, lesions that might have otherwise been neglected.

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METHODS

The study included 187 patients with a history of melanoma or dysplastic nevi who were returning for periodic follow-up examinations. All patients underwent a complete skin examination by the same physician (J-C.B.). Biopsy specimens were obtained from lesions that were clinically suspicious. In addition, a number of lesions that were somewhat unusual, but not sufficiently so to trigger the clinical decision to perform a biopsy, were scanned with a computerized image analysis system, and biopsy specimens were also obtained from those read as suspicious (computer score, ≥0.5).

A commercially available computerized image analyzer (DermoGenius System; Rodenstock Prazisionsoptik, Munich, Germany) was used in the study. Individual pigmented lesions were scanned using a hand-held dermoscope attached to a 3-chip charge-coupled video camera that acquired color digital images that were then stored in a compatible computer (IBM). The dermoscope was used with water immersion. The images were acquired within a field of 11 × 11 mm, at a magnification of ×20, with a horizontal resolution greater than 700 television lines and 752 × 582 effective picture elements. Before use, the camera was calibrated daily for shading and color corrections (DermoGenius Operator Manual; Rodenstock Prazisionsoptik).

Images were automatically segmented and then analyzed using the 1.01 version of an algorithm based on the ABCD system of Nachbar et al. The parameters assessed included asymmetry of color and shape, border cutoff, color variegation, and homogene-
ity. Structural components were analyzed using a scaling index method that extracted variety, homogeneity, and asymmetry in structure.

A digitally standardized dermatologic score was produced that was based on a database of more than 10,000 lesions that were captured using an earlier version of the system. The classifier was developed with 749 histologically confirmed lesions, 189 of which were melanomas. The score lies typically between −2.5 and 6. The higher the score, the greater the chance of melanoma. In this study, we applied a score of 0.5 as a threshold above which a biopsy was performed on the lesion.

All lesions were examined by a dermatopathologist (S.A.M.) who was unaware of the reason for removal of the lesion. The degree of atypia was graded into one of 3 categories, based on the degree of atypia (mild, moderate, and severe). Lesions were graded as mild atypia if they exhibited architectural atypia with, at most, rare cells that demonstrated cytologic atypia, so-called random cytologic atypia; as moderate atypia if there was architectural atypia and if the majority of cells exhibited cytologic atypia; and as severe atypia if the degree of architectural and/or cellular atypia was such that the diagnosis of melanoma in situ was strongly considered or could not be excluded. Architectural atypia was defined as proliferation of melanocytes within the epidermis that extended beyond the dermal component of the lesion and/or as bridging or fusion of intraepidermal melanocytic nests across adjacent rete. Cytologic atypia was defined as nucleomegaly, hyperchromasia, or irregular nuclear contours. Lesions were considered potentially dangerous if they were classified as showing moderate to severe atypia or as melanoma in situ.

**RESULTS**

Biopsies were performed on 177 lesions in 137 patients solely on the basis of clinical judgment. According to histologic diagnosis of the specimens, 47 (27%) of the lesions were potentially dangerous and needed to be removed. These included 9 melanomas (7 in situ and 2 invasive [0.18 and 3 mm]), 28 dysplastic nevi with moderate to severe atypia, and 10 other skin cancers (squamous cell and basal cell carcinomas). Clinical analysis also revealed 57 dysplastic nevi with little atypia, 31 melanocytic nevi, and 42 other benign lesions.

An additional 440 pigmented lesions in 120 patients were scanned with the image analyzer because their clinical appearance was somewhat abnormal, but not sufficiently unusual to trigger the clinical decision to perform a biopsy. Of these, biopsy specimens were obtained from 52 lesions in 45 patients solely on the basis of computerized image analysis (score, ≥0.5). All specimens were examined histologically. Nine (17.3%) lesions were potentially dangerous and needed to be removed. These included 1 melanoma in situ (Figure 1) and 8 dysplastic nevi with moderate to severe atypia (Figure 2). Histologically, the remaining lesions consisted of 27 dysplastic nevi with little atypia, 5 melanocytic nevi, and 11 other benign lesions.

The impact of supplementing clinical judgment with computerized analysis of dermoscopic images on the early detection of melanoma and other potentially dangerous pigmented lesions is summarized in the Table. Among 229 biopsy specimens, there were 56 potentially dangerous pigmented lesions (melanomas, dysplastic nevi with moderate to severe atypia, and other cancers). Of these, 9 (16%) were detected and removed solely on basis of the computer recommendation for biopsy, resulting overall in a ratio of 3 benign lesions removed for each lesion that needed to be removed.

**COMMENT**

The most important result of this study is that computerized analysis of dermoscopic images can improve the management of pigmented skin lesions by identifying potentially dangerous lesions on which a biopsy would not...
have been performed and that would not have been removed on the basis of clinical judgment alone.

Early diagnosis is a critical step in the management of melanoma, as this cancer is completely curable if resected early. The key to achieving this outcome is the identification of potentially dangerous pigmented skin lesions that require biopsy and removal. This can be a challenge, as early melanoma can resemble benign lesions such as dysplastic nevi. Furthermore, there is controversy as to the type of pigmented lesions that are potentially dangerous and need to be removed. There is agreement that melanoma can arise from dysplastic nevi and that the presence of dysplastic nevi is an increased risk factor for melanoma, but the consensus is less clear as to the degree of histologic atypia that dysplastic nevi must demonstrate to be considered dangerous. The absence of hard data correlating the degree of atypia within dysplastic nevi to increased chance of malignant transformation is an argument for not considering these lesions potentially dangerous. However, there are also no data to the contrary. Unfortunately, these data cannot be generated, as evaluation of atypia requires that the nevi be removed, an act that precludes any further evaluation of evolution into melanoma. In our opinion, it seems logical that the chance of malignant evolution increases as the degree of atypia increases. In the absence of data to the contrary (ie, showing that dysplastic nevi with severe atypia do not have a greater risk for malignant transformation), it seems prudent to remove such lesions.

Computerized digital imaging systems have been developed to assist in the evaluation of pigmented skin lesions. These systems, and the manner in which they are used, fall into 2 categories: (1) instruments that provide a photographic record or map of the appearance and location of lesions on the body and that are used to track changes in the appearance of lesions over time; and (2) instruments that analyze the appearance of individual lesions using proprietary algorithms and that are used to help determine in real time whether the lesion is likely to be a melanoma. The usefulness of computerized digital imaging systems in the clinical management of pigmented lesions is still unclear, in part because their ability to differentiate benign from malignant lesions in the clinical setting remains to be established. While published data suggest that both the sensitivity (the detection of lesions that are melanoma) and the specificity (the avoidance of classifying benign lesions as malignant) of these instruments can be more than 88%, the results depend entirely on the lesions that are examined. Both sensitivity and specificity will be high if the instruments are used in a research setting to analyze lesions that are clearly ordinary nevi or are obviously malignant. However, few data are available to judge effectiveness in the real world, where the appearance of pigmented lesions often lies in a gray zone between clearly benign and clearly malignant. Unfortunately, many early melanomas fall into this category.

To address this issue, we evaluated the ability of a computerized image analysis instrument to supplement a physician's ability to identify pigmented lesions that require biopsy because they are potentially dangerous. Complete skin examinations were performed in 187 sequential patients with a history of melanoma or dysplastic nevi who were returning for routine follow-up examinations. According to convention, biopsy specimens were obtained from lesions that appeared unusual to an experienced dermatologist. Biopsies were performed on a total of 171 lesions solely on the basis of clinical judgment. Forty-seven (27%) of the lesions were potentially dangerous and required biopsy. These included 9 melanomas, 28 dysplastic nevi with moderate to severe atypia, and 10 other types of skin cancers. As is usually the case when pigmented skin lesions are examined, a number of additional lesions were somewhat unusual in their appearance, but not sufficiently so to trigger the decision to perform a biopsy. A total of 440 such lesions in 120 patients were scanned through a dermoscopic device and subjected to real-time computerized image analysis. Fifty-two of these lesions were interpreted as suspicious by the instrument and consequently underwent biopsy. Of these, 9 (17%) were potentially dangerous and should have been removed. These included 1 melanoma in situ and 8 dysplastic nevi with moderate to severe atypia. Thus, the use of real-time computerized analysis to supplement clinical judgment improved the detection of lesions that required biopsy by 16%. The results of the study do not allow identification of the features of these lesions that were detected by the algorithm yet missed by the clinician, nor do they allow determination of the extent to which the improved detection of lesions that required biopsy was a result of the improved image that was visible under dermoscopy or of the image analysis that was conducted by the computer. Also, we cannot formally exclude the possibility that the instrument might have correctly but accidentally classified lesions as requiring biopsy as a result of serendipitous error due to chance or to an imaging or other artifact.

In our opinion, the ultimate aim of computerized image analysis is not to diagnose melanoma, but simply to help determine whether a lesion requires biopsy. This goal needs to be accomplished in a cost-effective manner in order to reduce the number of needless biopsies that are performed and to minimize increases in costs and morbidity. In the present study, computerized image analysis achieved this objective. It increased the detection of skin lesions that needed to be removed by 16%, and did so well within recommended limits of sensitivity. It has been recommended that these limits should

![Table](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAAbAAAAAgcCAYAAAAWzg4DAAAAA3NCSVQICAjb4U/gAAAAAlwSDeRyHBUOOGjwAAAAABAQDAwJXoEAAAAABJRU5ErkJggg==)
result in no more than 12 benign lesions removed for each one that is dangerous, a ratio that has been achieved by dermatologists in Australia. The ratio that was achieved by the combination of clinical judgment and computerized image analysis as used in our study was 3 to 1.

Finally, it is important stress that these results were achieved by using computerized image analysis to supplement, not to replace, the judgment of an experienced dermatologist. They do not indicate that computerized image analysis can replace clinical judgment, nor do they provide any information regarding the relative value of this procedure compared with dermoscopy. For the same reason, the value of such instruments in the hands of non-expert remains to be established.

In summary, real-time computerized image analysis of dermoscopic images can improve the management of pigmented skin lesions by recommending biopsy of clinically unsuspicious, but potentially dangerous, lesions that would have otherwise been neglected. These instruments may reduce mortality from melanoma by increasing the detection of early lesions that are still completely curable by surgical resection.

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Corresponding author and reprints: Jean-Claude Bystryn, MD, Ronald O. Perelman Department of Dermatology, New York University School of Medicine, 550 First Ave, New York, NY 10016 (e-mail: bystryn@nyu.edu).

REFERENCES


