# The ABCD System of Melanoma Detection

## *A Spectrophotometric Analysis of the Asymmetry, Border, Color, and Dimension*

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**BACKGROUND.** The ABCD (Asymmetry, Border, Color, and Dimension) criteria represent a commonly used clinical guide for the diagnosis of early melanoma. The authors revised these criteria in the light of objective measurements of the features of pigmented skin lesions obtained by telespectrophotometric analysis (TS) in the visible and near-infrared wavelengths.

**METHODS.** This study involves a consecutive series of 186 patients with 195 cutaneous pigmented lesions (53 melanomas and 142 nonmelanoma lesions). Each lesion was subjected to TS in vivo, before surgery. For this purpose, the authors used four spectrophotometric parameters that could be closely related to the four criteria of the ABCD guide, namely, roundness (an estimate of how a lesion contour resembles a circle), smoothness (an indicator of the regularity of a lesion border), mean reflectance (the ability of a lesion to diffuse or reflect the incident light), and size (the greatest dimension of a lesion).

**RESULTS.** When melanomas and nonmelanoma lesions were compared by univariate analysis, all four spectrophotometric parameters considered proved to be significantly different ($P = 0.05$). Multivariate logistic analysis showed that mean reflectance in the infrared ($P < 0.01$) and size ($P = 0.03$) were parameters independently associated with melanoma. Melanoma showed lower reflectance and greater size than benign lesions.

**CONCLUSIONS.** Information provided by TS substantially validates the importance of the ABCD clinical guide and suggests that color is the most important parameter in discriminating melanoma from nevi. In particular, melanoma appears darker than other pigmented lesions. ***Cancer* 1999;85:72–77.**
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**KEYWORDS: melanoma, nevi, diagnosis, computer.**

Early detection and prompt excision of melanoma give the patient the best chance of cure.[1] Because cutaneous melanoma (CM) can be diagnosed very early in its development,[2,3] primary care physicians and specialists are learning to recognize earlier and "thinner" lesions. The Asymmetry, Border, Color, and Dimension (ABCD) criteria for facilitating the visual recognition of early melanoma were introduced in 1985.[4] In its initial stages, CM may not be easily diagnosed by applying this mnemonic rule. Nevertheless, this mnemonic continues to be of practical value in current clinical settings and represents a guideline for the early diagnosis of CM. As with any clinical diagnosis, the evaluation of a pigmented lesion with the ABCD criteria is to a large extent subjective. In an attempt to evaluate objectively the involved clinical characteristics, a telespectrophotometric method based on measurements of lesion reflectance (i.e., the fraction of light reflected or diffused by a pigmented lesion) images has been developed.[5] By this method, we revisited the ABCD criteria with an analysis

of the features of pigmented skin lesions in visible and near-infrared spectral bands.

## PATIENTS AND METHODS

### Patients

Between January 1995 and December 1996, 186 patients (117 females and 69 males) with 195 cutaneous pigmented lesions were enrolled in this study at the Istituto Nazionale Tumori of Milan. These patients, bearing lesions that required surgical biopsy for diagnosis, were consecutively seen in our unit, all on the same day of the working week, for the early diagnosis of melanoma. Lesions excluded were those frankly appearing as thick, large melanomas and awkwardly situated lesions, such as those in the interdigital spaces, on the ears, on the nose, on the eyelids, etc. In fact, a lesion can be accurately imaged by our telespectrophotometric system (TS) if surrounded by a portion of almost planar skin 5 mm or more distant from its margins. We also excluded lesions on the scalp due to hair interference with reflectance. The average age of the patients was 40 years (range, 12–95 years). One hundred twenty-three lesions (63%) were located on the trunk, 62 (32%) on the limbs, and 10 (5%) on the head and neck. The sizes of the lesions ranged from 3 mm to 39 mm in maximum linear extent, with a median value of 9 mm. Images of the 195 pigmented lesions were acquired in vivo before surgery. The clinical diagnoses were suspected melanoma in 77 cases and probably benign lesions in 118 cases (including 3 cases of markedly hypomelanotic melanomas). The slides were evaluated by one of us (G.T.) according to widely accepted criteria for the histopathologic diagnoses of the various pigmented lesions.[6] Well-established histopathologic criteria were also used for diagnosing dysplastic nevi.[7] The distribution of the lesions according to the histologic diagnosis are represented in Table 1. The thickness of the 46 invasive melanomas ranged from 0.16 mm to 3.01 mm (mean 0.88 mm, median 0.79 mm). Of the 53 melanomas, 34 were thin lesions (tumor thickness $<1$ mm or Level I). Six melanoma lesions had greatest dimensions not exceeding 6 mm.

**TABLE 1**
**Histologic Diagnosis of 195 Pigmented Lesions**

| Diagnosis | No. (%) |
|---|---|
| Melanoma | 53 (27.2) |
| Invasive | 46 (23.6) |
| In situ | 7 (3.6) |
| Nonmelanoma | 142 (72.8) |
| Compound nevus | 66 (33.8) |
| Dysplastic nevus | 27 (13.8) |
| Junctional nevus | 18 (9.2) |
| Dermal nevus | 7 (3.6) |
| Lentigo simplex | 6 (3.1) |
| Spindle cell nevus | 5 (2.6) |
| Spitz nevus | 3 (1.5) |
| Basal cell carcinoma | 3 (1.5) |
| Blue nevus | 2 (1) |
| Seborrheic keratosis | 2 (1) |
| Other | 3 (1.5) |
| Total | 195 (100) |

### The Telespectrophotometric System

The telespectrophotometric system consists mainly of a charge-coupled device (CCD) camera that is provided with a set of 17 interference filters and a personal computer (PC) to allow imaging of moles at selected wavelengths from 420 to 1040 nm. The acquired 17 spectral images are stored in the PC for offline processing. Intensity levels, as well as the dimensions of the image picture elements (pixels), were calibrated according to a set of four reflectance standards and a geometric reference frame, respectively. Details on the system's features have been reported elsewhere.[5]

### Spectrophotometric Measurements

For each spectral image, the system provided several descriptors related to the color and shape of the imaged lesion. To fit the aim of the current study, we chose four descriptors to represent the clinical features included in the ABCD rule, as follows: 1) *mean reflectance*, i. e., the mean fraction of light reflected or diffused by the lesion; 2) *roundness*, defined as $(4\pi \cdot \text{lesion area})/(\text{lesion perimeter})^2$; 3) *smoothness*, i. e., the ratio between the perimeter of the convex hull of the lesion and the lesion's perimeter; and 4) *size*, i. e., the greatest dimension (in mm) of the lesion. Because our device did not provide a satisfactory evaluation of color variegation, this parameter was not considered in the current study. Mean reflectance measures the ability of a lesion to reflect or diffuse the incident radiation, roundness is an estimate of how a lesion contour resembles a circle, smoothness is an indicator of regularity in a lesion border, and size is an indicator of the extent of a lesion. For our purpose, the clinical parameter of asymmetry (A) was evaluated by roundness, borders (B) by smoothness, color (C) by mean reflectance, and dimension (D) by size.

The variables related to lesion shape features (i. e., roundness, smoothness, and size) were determined for wavelengths $<700$ nm, where the contrast between skin and lesion border allowed the system to recognize the lesion contour for all cases. Mean reflectance was evaluated for all visible and near-infrared wavelengths

**TABLE 2**
**Mean, Standard Deviation, and Median of the Spectrophotometric Parameters for Melanoma and Nonmelanoma Lesions**

| | CM | | | OL | | | |
|---|---|---|---|---|---|---|---|
| Overall index of: | Mean | SD | Median | Mean | SD | Median | *P* value[a] |
| Mean reflectance (vis) | 0.19 | 0.05 | 0.18 | 0.22 | 0.04 | 0.21 | $P < 0.0001$ |
| Mean reflectance (ir) | 0.36 | 0.08 | 0.37 | 0.43 | 0.07 | 0.43 | $P < 0.00001$ |
| Roundness | 0.63 | 0.16 | 0.66 | 0.71 | 0.12 | 0.74 | $P < 0.01$ |
| Smoothness | 0.87 | 0.10 | 0.90 | 0.92 | 0.07 | 0.94 | $P < 0.01$ |
| Size (mm) | 13.38 | 6.69 | 13.21 | 9.59 | 4.01 | 9.31 | $P < 0.001$ |

CM: cutaneous melanoma; OL: other lesions; SD: standard deviation; vis: visible; ir: infrared.
[a] Significance of the differences between the CM and OL groups.

on the basis of the contour determined by the wavelength of maximum contrast between lesion and skin (500 nm).

For each parameter, an overall normalized value was calculated as the ratio between the integral of the wavelength-dependent curve of each descriptor and the corresponding wavelength range.

Because human visual perception fails in the infrared spectral region, we split the overall reflectance information according to visible (until 700 nm) and near-infrared (between 700 and 1040 nm) wavelengths, respectively.

### Statistical Analysis

Univariate comparisons between groups (melanomas versus nonmelanomas) were performed with Student's *t* test. Multiple logistic regression was further performed to assess the independent contribution of each parameter in recognizing melanoma. In the multivariate model, the spectrophotometric variables were adjusted according to patient gender and age.

## RESULTS

Results of univariate analysis for the considered spectrophotometric measurements are represented in Table 2. All the differences between the considered variables were statistically significant ($P < 0.05$) when melanomas were compared with other lesions. In particular, reflectance showed the most significant difference between the two groups, both in the visible ($P < 0.0001$) and the infrared ($P < 0.00001$).

Age- and gender-adjusted multivariate logistic analysis indicated that mean reflectance in the infrared ($P < 0.01$) and size ($P = 0.03$) were parameters that made a significant independent contribution to the recognition of the presence of melanoma, whereas roundness ($P = 0.74$), smoothness ($P = 0.72$), and mean reflectance in the visible ($P = 0.69$) did not reach statistical significance. Because human visual perception fails to detect infrared radiation, another logistic analysis was carried out, excluding the infrared reflectance from the model. In this analysis, mean reflectance in the visible ($P = 0.001$) and size ($P = 0.008$) were independently related to melanoma, whereas roundness and smoothness had no significant relevance.

Collaterally, mean reflectance was also tested for the subgroup of dysplastic nevi that was compared with both melanomas and the other nonmelanoma lesions. Reflectance of the last group was not shown to be significantly different from that of dysplastic nevi ($P > 0.57$), whereas a highly significant difference ($P < 0.01$) was found when the dysplastic nevi were compared with melanomas.

Figure 1 shows scatterplots for all measured parameters according to three groups of melanomas, common nevi, and dysplastic nevi. Also represented are the three cases of amelanotic melanoma, which did not have the same behavioral parameters, except reflectance. The small number of these lesions prevented any evaluation.

## DISCUSSION

There are useful generalizations that may be made in regard to the clinical evaluation of pigmented skin lesions. Generally, when melanoma and nevi are compared, the latter tend to be smaller, more symmetric, and regular, with little or no variegation. These features form the basis of the ABCD diagnostic system. Although not incorporated into this guide, Friedman et al.[4] stated that historical features of a changing, preexisting lesion or the development of a new lesion should alert the clinician to the possibility of melanoma. Precision in the clinical evaluation of ABCD features are reported in two studies.[8,9] The results of these studies, performed only on benign pigmented lesions, showed a moderate degree of interobserver agreement. The usefulness of the ABCD system in

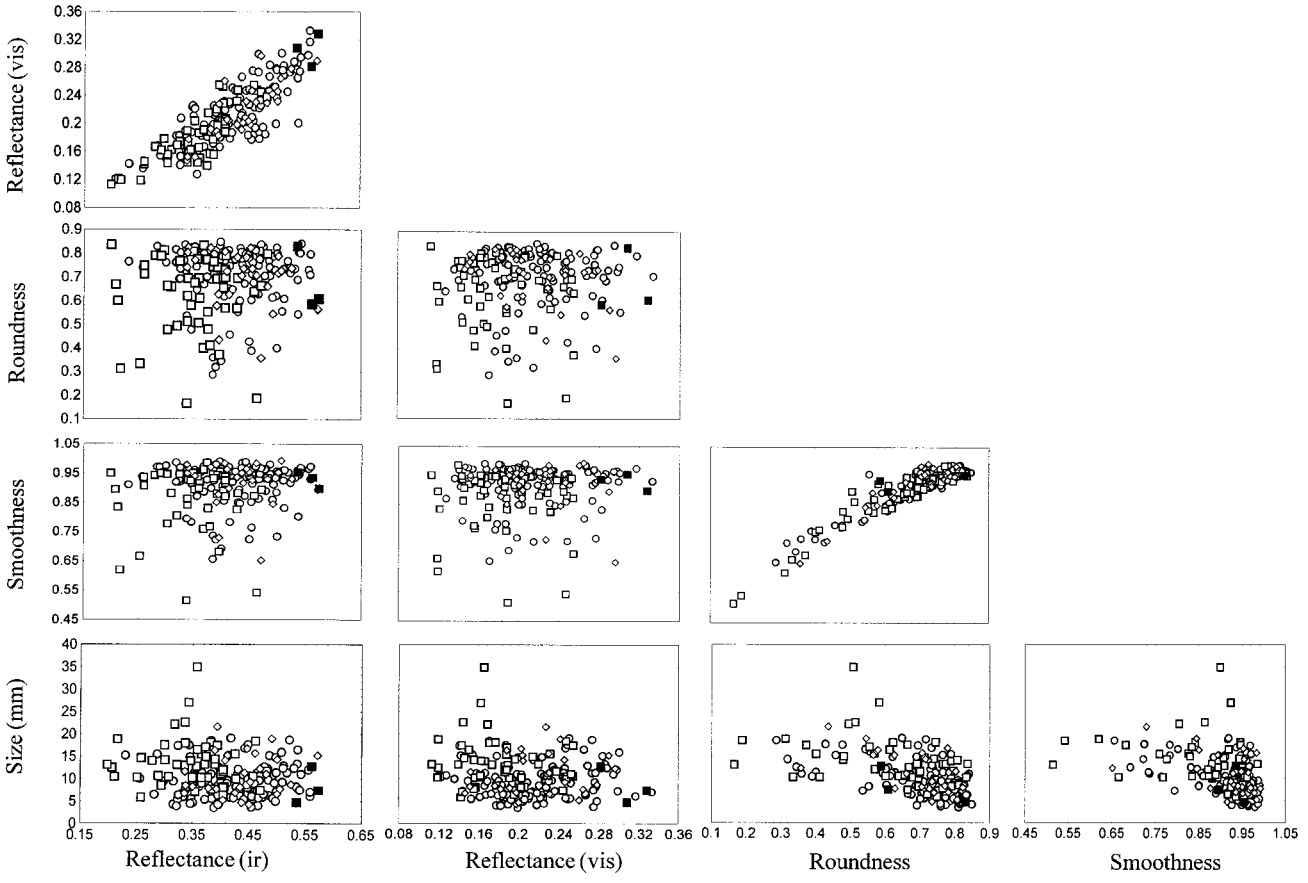


**FIGURE 1.** Scatterplots of all evaluated parameters according to three groups: melanomas (squares), common nevi (circles), and dysplastic nevi (diamonds). Closed squares represent amelanotic melanomas (three cases). Although melanomas show a different distribution than benign lesions, considerable overlapping between common and dysplastic nevi can be seen.

distinguishing melanoma from benign pigmented lesions has not been conclusively described.[10,11] The guide appears to be highly sensitive when a positive test result does not require all four features to be present.[10] The accuracy of the ABCD when a positive test result requires the presence of all four features has not been determined. There is less documentation regarding the specificity of the ABCD; it was only considered in a single study.[11]

The results of our study, in which objective data were obtained, stress the importance of all four features included in the acronym of the ABCD. This guide to the signs of early melanoma is simple, and we recommend it as a means of education for patients and medical personnel. However, mixed observations can be made about the usefulness of this diagnostic system. A change in the characteristics of a lesion is an important feature (not included in the classic ABCD) to assess during a visit, and taking it into consideration could enhance diagnostic accuracy. Furthermore, requiring a lesion to be greater than 6 mm for diagnosing melanoma could result in missed malignant lesions, because all de novo melanomas are smaller than 6 mm in greatest dimension during their early clinical life. In fact, the existence of small (6 mm) in situ and invasive melanomas is well documented.[2,3,12] These data indicate that the figure of more than 6 mm for greatest dimension should be modified.

In our study, the information provided by TS showed that reflectance was the most important variable considered in discriminating melanoma from nevi. In our series, melanoma demonstrated a highly significant darker hue (minor reflectance) with respect to that of the benign lesions. Our results are also noteworthy because they were obtained by studying a randomly selected series of pigmented lesions for which the diagnosis was dubious but which were all clinically abnormal enough to warrant surgical removal and generally darker than common nevi. Although color variegation was not considered in our analysis, data indicate that C would be well represented by "color darkness" and not merely by "color

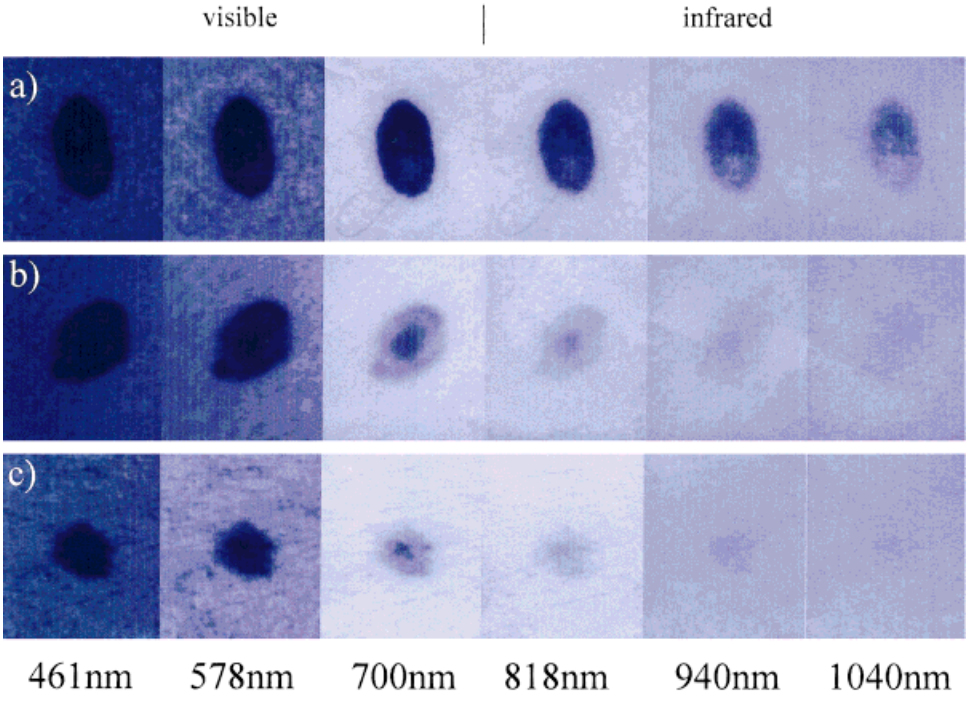


**FIGURE 2.** Telespectrophotometric acquisition is represented, at selected wavelengths (nm) of (a) cutaneous melanoma, (b) dysplastic nevus, and (c) compound nevus.

variegation," as usually intended. Such an interpretation could obviate the remark that ABCD criteria are unworkable in the clinical diagnosis of melanoma, because these criteria apply equally to dysplastic nevus as they do to melanoma.[13] In fact, if C represents color darkness and not color variegation, a clinical diagnostic differentiation among the two entities can probably be more easily performed. Indeed, dysplastic nevi are usually brown or tan, with some variegation of hue and depth, but without black in most cases.[14,15] In our study, reflectance in the dysplastic nevi group was significantly higher than in the melanoma group (see Fig. 2) and quite similar to that in the common nevi group, i.e., both dysplastic and common nevi were lighter than melanomas. The designation of C as color darkness is supported by clinical data. In fact, of 319 small CM, 44.1% had uniform color (dark brown, brown-black, black, or reddish-brown) and 22.4% had both uniform color and regular borders.[16] Therefore, it is necessary to stress this fact in educational messages regarding early diagnosis, in which color is usually designated as color variegation. According to the above considerations, would it not be wise to use an ABCD in which C *may* indicate color variegation but *must* indicate color darkness? This statement is in accordance with the classic name given to this neoplasm. In fact, the ancient Greek root of the word melanoma, $\mu\epsilon\lambda\varsigma$, means "black." However, the clinician must be reminded of the existence of hypomelanotic or amelanotic melanomas that are represented by a light lesion, flat or nodular, or a red plaque. These rare, atypical lesions, which were also present in our series, may be suspected because of a change in size or shape and represent an elusive exception to the color rule.

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